PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. CHAS. MCCREA, *Minister of Mines* THOS. W. GIBSON, *Deputy Minister*

THIRTY-SECOND ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXII, PART I, 1923

Statistical Review
of
Ontario's Mineral Industry in 1922

By W. R. Rogers

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LETTER OF TRANSMISSION

TO HIS HONOUR HENRY COCKSHUTT,

Lieutenant-Governor of the Province of Ontario.

SIR,—I have the honour to transmit to you herewith, for presentation to the Legislative Assembly of the Province of Ontario, the Thirty-second Annual Report of the Department over which I have the honour to preside.

I have the honour to be, Sir,

Your obedient servant,

CHAS. MCCREA,
Minister of Mines.

Department of Mines,
Toronto, 1923.

INTRODUCTORY LETTER

To the Honourable Chas. McCrea,
Minister of Mines.

Sir:—

Herewith I beg to submit to you the Thirty-second Annual Report of the Department of Mines, being for the year 1923. The Report consists of seven parts, published separately, as follows:—

Part I.—Statistical Review of Ontario's Mineral Industry in 1922, by W. R. Rogers. This review gives a complete account of the industry for the year, compares the production with that of previous years, and presents a large number of tables and much other information pertinent to the long and varied list of the metals and non-metallic substances produced in the Province.

Part II.—Geology of the Ontario-Manitoba Boundary. That part of the boundary extending from the Winnipeg River to the Bloodvein River was covered by E. M. Burwash and H. A. Rickaby in 1921, and the remainder of the line as far north as the Twelfth Base Line of the Dominion system of surveys, where the boundary is deflected to the northeast on its way to Island lake and thence to the shore of Hudson bay, by Mr. Rickaby in 1922.

Part III.—This Part contains a description of the geology of the country traversed by the Base Line running west from near Mile 19, on the western boundary of the Nipigon Forest Reserve, by W. F. Green; and also of the geology of certain Base and Meridian Lines west of Lake Nipigon, by W. L. Swanson. A Third Report included in this Part is by E. W. Todd, who made a geological examination of an area adjacent to Kenogamissi lake and including the townships of Denton and Keefer.

Part IV.—The important Kirkland Lake Gold Area is reviewed and its deposits described by P. E. Hopkins and A. G. Burrows. The townships of Lebel and Gauthier, on the eastern extension of Kirkland Lake camp proper, are dealt with separately by Mr. Hopkins. The Kirkland Lake Area is rapidly growing in output and importance, and this revision and enlargement of the Report of 1920 by the same authors will meet the demand for fuller information concerning its geology and structural relationships.

Part V.—Natural Gas in 1922 and Petroleum in 1922, by R. B. Harkness, deals with the production of these substances, the former of so much local importance as the chief domestic fuel of a large part of Southwestern Ontario, and the latter whose yearly declining yield now supplies only a fraction of the oil requirements of the Province. The falling off in the output of gas is in part due to the restrictions placed upon its use by the Legislature, and in part to the natural depletion of the fields.

Part VI.—The Mines of Ontario, by T. F. Sutherland, Chief Inspector, J. G. McMillan, Jas. Bartlett, Geo. E. Cole and A. R. Webster, Inspectors, describes the operating mines in detail. There is also a chapter on the Mining Accidents for the year, and an account of the Instruction Classes for Prospectors, carried on by Dr. W. L. Goodwin in the mining centres of the Province.

Part VII.—This Part, by Madeleine Fritz, W. S. Dyer and W. A. Parks, completes the series begun in the 29th Report descriptive of the Stratigraphy and Paleontology of Toronto and Vicinity.

A limited number of the several parts making up the complete volume, containing the accompanying maps and bound in buckram, are available for individuals and institutions who may wish to possess them in this more permanent form.

I have the honour to be, Sir,

Your obedient servant,

Thos. W. Gibson,
Deputy Minister of Mines.

Department of Mines,
Toronto, 1924.

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STATISTICAL REVIEW OF ONTARIO'S MINERAL INDUSTRY IN 1922

STATISTICAL REVIEW OF ONTARIO'S MINERAL INDUSTRY IN 1922

By W. R. Rogers

The mining industry of Ontario showed very satisfactory progress during 1922. There was a period of a year or more following the war in which an abnormally large output was stimulated by high prices. During the autumn of 1920 these prices broke sharply and the following year, 1921, was one of severe depression throughout Canada. During 1922 it became evident that the large stocks of metal on hand for war purposes, and the large volume of scrap originating from manufactured war materials no longer necessary, had been absorbed, and also that a demand for many commodities existed. The revival in the nickel-copper industry during the latter part of the year was a case in point, while a keener demand for cobalt and white arsenic assisted the metallurgical plants and indirectly the mines supplying them. Coupled with this recovery in the base metal trade was a decrease in the cost of materials and labour, which was of considerable advantage to gold mining. During 1922 the United States dollar on the average was worth only $1.01½ in Canadian currency as against $1.11½ in 1921. Since all new gold was paid for in New York funds by the Federal Government, such a decrease would have been injurious, but the better economic conditions prevailing offset this loss and 1922 proved to be a banner year for Ontario gold mining.

Since the major portion of the new wealth created in Ontario each year by the mining industry comes from the gold, silver-cobalt, and nickel-copper mines, a study of these groups will indicate the state of the metal mining industry, and comparative figures of the quantity and value of these metals produced from year to year may be used as a barometer of progress. For the year 1922 the value of the gold production increased from $14,692,357 in 1921 to $20,579,569 or 40.1 per cent., silver from $5,763,908 in 1921 to $7,800,029 or 35.3 per cent., nickel-copper from $5,152,331 in 1921 to $9,108,026 or 76.7 per cent. These marked increases, implying growth in wages paid and cost of materials consumed, give an indication of the general business improvement caused by the mining industry to the country at large.

The activity displayed in building and construction work was indicative of noteworthy advances in the production of clay products, cement, stone, sand and gravel and other materials. Production of gypsum, salt, quartz and talc in increasing volume showed that the mining industry had regained much of its old-time prosperity, with the future bright for continued expansion.

During 1922 the total value of the mineral production amounted to $68,466,454 as against $54,564,209 in the previous year, or a gain of 25.5 per cent. The value of the metallics increased from $28,777,581 to $40,290,157, or 40 per cent., while non-metallics advanced from $25,786,728 in 1921 to $28,176,297 in 1922, or 9 per cent. Wages rose from $14,518,487 to $16,323,326.

Details regarding output and conditions in the several phases of the mining industry are noted under separate headings. The value of metalliferous production exceeded that of any pre-war year, while the combined valuation of non-metallics, construction materials and clay products was the greatest in Ontario's history. Table I, which follows, gives a summary of Ontario's mineral statistics for 1922.

TABLE. 1—SUMMARY OF MINERAL STATISTICS OF ONTARIO FOR 1922

Product		Quantity	Value	Employees	Wages
METALLIC:					
Gold	ounces	995,623	$20,579,569	3,554	$5,285,521
Silver	"	10,925,305	7,800,029	1,300	1,290,579
Copper in matte (*a*)	short tons	7,774	1,554,731	1,035	1,339,036
Nickel in matte (*a*)	"	8,689	3,475,649		
Iron ore (*b*)	"	4,304	25,261	2	2,640
Iron, pig (*c*)	"	14,052	340,730	227	334,670
Copper, metallic	lbs.	4,503,358	515,093	(*d*) 462	676,523
Nickel	"	11,175,326	3,171,434		
Nickel oxide	"	2,399,887	391,119		
Platinum metals	ounces	11,788	924,712		
Cobalt, metallic and in residues	lbs.	109,067	282,602	(*e*) 203	187,193
Cobalt oxide	"	398,697	798,271		
Other Cobalt and Nickel compounds and residues	"	1,070,935	255,034		
Lead, pig	"	2,895,695	173,742	113	110,082
Zinc (*f*)	"	100,283	2,181		
Total metallic			40,290,157	6,896	9,226,244
NON-METALLIC:					
Actinolite	tons	50	575	....	....
Arsenic, white	"	2,058	299,940	(*e*)	(*e*)
Clay products—($6,944,218):					
Brick, common	M	148,831	2,614,120	2,452	2,415,910
Brick, rug and pressed	"	108,778	2,179,104		
Tile, drain	"	13,790	368,180		
Tile, building and floor tile	tons	....	720,101		
Pottery		....	88,889	48	53,637
Sewer pipe		....	973,824	223	252,450
Construction materials—($13,640,166):					
Cement, Portland	bbls.	3,104,386	6,235,370	784	990,997
Lime—					
Hydrated	tons	36,408	455,980	442	408,731
Quicklime	bush.	3,939,954	1,311,563		
Sand and gravel	tons	3,576,420	1,816,320	805	437,094
Sand-lime brick	M	52,749	851,007	199	233,287
Stone, building, trap, granite, etc.	tons	2,317,265	2,969,926	846	800,694
Feldspar	"	15,255	120,576	136	67,782
Fluorspar	"	284	3,905	7	1,570
Graphite, crude and refined	"	626	34,124	19	9,125
Gypsum, crushed, ground and calcined	"	110,227	621,668	150	143,685
Iron pyrites	"	11,235	39,763	21	19,028
Mica	"	2,229	56,480	25	15,501
Mineral water	Imp. gals.	209,072	10,528	2	249
Natural gas	M. cu. ft.	8,568,301	4,024,767	520	434,872
Peat	tons	3,000	14,500	23	17,350
Petroleum, crude	bbls.	164,732	466,587	134	132,402
Quartz and silica brick	tons	82,387	146,446	89	69,610
Salt	"	176,741	1,573,657	409	539,813
Talc, crude and ground	"	12,874	178,397	46	53,295
Total non-metallic		....	28,176,297	7,380	7,097,082
Add metallic		....	40,290,157	6,896	9,226,244
Grand Total		....	$68,466,454	14,276	$16,323,326

(*a*) Copper and nickel in the matte valued at 10 and 20 cents per pound respectively.
(*b*) Exports and shipments to points other than Ontario blast furnaces. Total shipments of iron ore, 16,191 tons, valued at $52,054.
(*c*) Production from Ontario ore only. Total output of blast furnaces, 293,662 tons of pig iron, worth $6,493,513.
(*d*) Employees and wages for nickel-copper refineries.
(*e*) Employees and wages for silver-cobalt smelters and refineries (Southern Ontario).
(*f*) Recovery from concentrates shipped in 1919 and not previously reported.

The following comparative statement shows the course of the mining industry, as indicated by the value of the total production, during the five-year period, beginning with 1918, the year of maximum output:

TABLE II.—VALUE OF MINERAL PRODUCTION, 1918 TO 1922.

Product	1918	1919	1920	1921	1922
METALLIC:	$	$	$	$	$
Gold	8,502,480	10,451,709	11,686,043	14,692,357	20,579,569
Silver	17,415,882	12,904,312	10,873,496	5,763,908	7,800,029
Platinum metals	....	200,000	1,996,535	862,034	924,712
Cobalt (*a*)	1,615,130	868,107	1,603,736	502,370	1,080,873
Nickel (*b*)	27,840,422	11,925,220	15,689,131	4,050,601	7,038,202
Other Nickel and Cobalt compounds	73,347	188,083	16,959	114,258	255,034
Copper, metallic and in matte	8,532,790	3,709,687	3,970,744	1,101,730	2,069,824
Iron ore (*c*)	624,364	48,341	60,981	459	25,261
Pig iron (*d*)	1,364,736	1,200,793	2,204,205	1,588,751	340,730
Lead, pig	149,841	94,507	179,714	191,113	173,742
Molybdenite	59,067	....	....	....	....
Zinc (*e*)	....	....	....	....	2,181
Total	66,178,059	41,590,759	48,281,553	28,777,581	40,290,157
NON-METALLIC:					
Actinolite	2,508	1,176	1,160	975	575
Arsenic	566,332	485,360	432,434	233,763	299,940
Barite	900	....	....	....	....
Corundum	26,120	....	27,000	55,965	....
Feldspar	111,173	88,663	268,295	150,457	120,576
Fluorspar	153,190	60,389	67,381	1,744	3,905
Graphite	208,848	99,841	132,882	63,439	34,124
Gypsum	151,564	278,111	404,162	433,053	621,668
Iron pyrites	1,144,737	366,422	618,283	101,306	39,763
Mica	49,575	56,199	54,169	28,891	56,480
Mineral water	133,808	19,290	15,059	14,438	10,528
Natural gas	2,498,769	2,583,324	3,163,500	2,975,502	4,024,767
Peat fuel	....	1,750	15,600	6,664	14,500
Petroleum, crude	781,097	632,789	724,145	559,193	466,587
Phosphate of lime (apatite)	....	31	....	....	....
Quartz (silica)	452,711	179,070	366,441	220,806	146,446
Salt	1,287,039	1,395,368	1,544,867	1,649,626	1,573,657
Talc, crude and ground	246,691	240,399	306,319	140,390	178,397
Total	7,815,062	6,308,182	8,141,796	6,724,646	7,591,913
CONSTRUCTION MATERIALS:					
Cement, Portland	1,910,839	3,659,720	4,377,814	6,424,356	6,235,370
Lime	872,177	1,268,290	1,799,763	1,344,188	1,767,543
Sand and gravel	553,638	501,666	1,390,704	1,496,729	1,816,320
Sand-lime brick	91,508	367,815	407,766	534,531	851,007
Stone, building, crushed, etc	869,239	1,230,922	3,944,972	4,167,582	2,969,926
Total	4,297,401	7,208,413	11,921,019	13,967,386	13,640,166
CLAY PRODUCTS:					
Brick, common	665,454	1,966,711	2,209,265	2,025,643	2,614,120
Brick, fancy and pressed	396,698	539,908	809,126	1,241,375	2,179,104
Tile, drain	309,899	354,700	359,373	397,104	368,180
Tile, building and floor	195,588	186,592	369,530	421,127	720,101
Pottery	88,275	119,551	127,049	69,984	88,889
Sewer pipe	362,536	609,100	860,811	939,463	973,824
Total	2,018,450	3,776,562	4,735,154	5,094,696	6,944,218
Grand Total	**80,308,972**	**58,883,916**	**73,079,522**	**54,564,209**	**68,466,454**

(*a*) Cobalt oxide, metallic cobalt, and cobalt content of residues marketed.
(*b*) Nickel in matte, oxide and metallic nickel.
(*c*) Exports and shipments to points other than Ontario blast furnaces.
(*d*) Product from Ontario ore only.
(*e*) Shipped in 1919 but not reported until 1922.

In Table III is given the aggregate value of the metals and metallic products since the several substances began to be produced in Ontario down to the end of 1922. It should be pointed out that since 1914 the statistics of annual production credit the Province only with the value of the pig iron product made from Ontario ore. This is but a small part of the total output, since the great bulk of the iron ore charged into the blast furnaces of the Province is "lake" ore from the mines of Michigan, Minnesota and Wisconsin. Conversely, part of the iron ore raised in Ontario is exported to the United States in the form of briquettes produced from low-grade magnetite ores. In the production tables credit is taken only for the ore exported or shipped to points other than Ontario blast furnaces, since to include the value of the domestic ore converted into pig iron in Ontario furnaces would involve a duplication of this item.

TABLE III.—VALUE OF TOTAL PRODUCTION OF METALS IN ONTARIO.

Metal or Product	Production to 31st December, 1921	Production 1922	Production to 31st December, 1922
	$	$	$
Gold	87,900,442	20,579,569	108,480,011
Silver	214,479,306	7,800,029	222,279,335
Platinum metals	4,358,569	924,712	5,283,281
Cobalt, including cobalt oxide	8,893,112	1,080,873	9,973,985
Nickel, including nickel oxide	169,675,494	7,038,202	176,713,696
Other cobalt and nickel compounds	550,077	255,034	805,111
Copper	58,729,241	2,069,824	60,799,065
Iron ore	9,411,693	25,261	9,436,954
Pig iron	83,919,666	340,730	84,260,396
Lead	975,929	173,742	1,149,671
Zinc ore	92,410	2,181	94,591
Molybdenite	209,735	....	209,735
Total	639,180,462	40,290,157	679,485,831

Gold

Because of the fixed standard value of gold ($20.671834 per fine ounce) the gold mining industry did not benefit as did all other mineral producers during the period of rising prices which obtained throughout the war, and although in great demand, the output, due to the stress of labour shortage, high wages and greatly increased cost of materials, was, as a consequence, greatly curtailed. As the cost of production increased the margin of profit declined. With the close of hostilities and the resulting period of depression and falling prices the condition of the industry changed, with the result that gold mines increased both their output and net profits as compared with the war years. The increase noted during 1922, in which the production was the largest to date, reflected this reversal of economic conditions.

The output of gold from all sources, amounting to 995,623 fine ounces and having a selling value of $20,579,569, exceeded the 1921 production by 40.7 per cent. or $5,887,212, and showed the same advance approximately over California, the next largest producer among the provinces or states on the American continent. Such a record in a year when the world's production of gold ($319,420,063)[1] was the lowest for two decades, has attracted the attention of investing capital both at home and abroad.

[1] Annual report of the Director of the United States mint.

In addition to the producing mines, considerable development work was carried on at Porcupine by the Night Hawk Peninsular, Northcrown, Porcupine Davidson, March Gold, Hayden, Beaumont, etc., and at Kirkland Lake by the Hunton, Continental, Bidgood, Goodfish, Harvey Kirkland, King Kirkland, Argonaut and others.

Two noteworthy features regarding operating conditions among the mines was the shortage of hydro-electric energy which prevented an expansion of milling capacity and output from the Porcupine gold mines, and the disastrous forest fire early in October which destroyed several miles of transmission line between Cobalt and Kirkland Lake. A serious condition curbing the rapid development of Ontario gold mines lies in the power situation. Due to limited storage facilities on the Mattagami river there has been a yearly curtailment of operations during the late winter and early spring months. In 1922 two new hydro-electric power plants were being constructed, one at Sturgeon Falls on the Mattagami and one at Indian Chutes on the Montreal river, while the Hollinger had planned to secure a lease of Island Falls on the Abitibi river about seventy-five miles to the north of the mine. When these developments are completed the extra power will permit an increase in milling capacity on which the expansion of the mines depend. Towards the close of the year the Hollinger treated approximately 4,500 tons daily, the Dome 1,000 tons, and the McIntyre 500 tons. The total average daily tonnage treated in the Kirkland Lake camp was between 500 and 600 tons.

Details of production from gold mines (gold $20,579,569 and silver $107,532) are given in the table which follows:

TABLE IV.—ONTARIO'S GOLD PRODUCTION, 1922

Source	Ore milled, tons	Bullion shipped		Total value bullion, less exchange*
		Gold, fine ounces	Silver, fine ounces	
PORCUPINE				$
Dome	368,400	201,124	29,250	4,178,936
Hollinger Consolidated	1,491,381	590,385	104,444	12,274,114
McIntyre	217,208	97,229	17,711	2,021,811
Clifton Porcupine	....	80	21	1,664
Porcupine Paymaster	....	134	23	2,800
Total	2,076,989	888,953	151,449	18,479,325
KIRKLAND LAKE				
Kirkland Lake	37,489	10,814	1,279	224,396
Kirkland Lake Proprietary (1919)	16,108	5,144	1,870	97,481
Lake Shore	24,279	22,737	1,974	471,340
Ontario-Kirkland	6,496	483	143	10,082
Teck-Hughes	41,194	28,780	2,322	596,495
Wright-Hargreaves	66,181	36,521	4,866	762,753
Total	191,747	104,479	12,454	2,162,547
MISCELLANEOUS				
Cobalt Frontenac	....	50	26	1,056
White Rock	....	47	10	987
Nickel-Copper refining	....	†2,094	....	43,186
Total	....	2,191	36	45,229
GRAND TOTAL	2,268,736	995,623	163,939	20,687,101

*Exchange premium received by gold mines on bullion marketed was $208,612.

†Includes small quantity of iridium and ruthenium not separated from gold recovered in nickel refining.

The following operators produced gold in 1922:

PRODUCING GOLD MINES, 1922

Name of Company	Name of Mine	Locality	P.O. Address of Manager, etc.
Clifton Porcupine Mines, Ltd.	Clifton Porcupine	Deloro township	South Porcupine
Cobalt Frontenac Mining Co.	Cobalt Frontenac	Kaladar township	Flinton
Dome Mines Company, Ltd., The	Dome	Tisdale township	South Porcupine
Hollinger Consolidated Gold Mines, Ltd.	Hollinger	Timmins	Timmins
Kirkland Lake Gold Mining Company, Ltd.	Kirkland Lake	Teck township	Kirkland Lake
Kirkland Lake Proprietary (1919) Ltd.	Tough-Oakes and Burnside	Teck and Lebel townships	Kirkland Lake
Lake Shore Mines, Ltd.	Lake Shore	Teck township	Kirkland Lake
McIntyre Porcupine Mines, Ltd.	McIntyre	Schumacher	Schumacher
Ontario Kirkland Gold Mines, Ltd.	Ontario Kirkland	Kirkland Lake	Kirkland Lake
Teck-Hughes Gold Mines, Ltd.	Teck-Hughes	Teck township	Kirkland Lake
White Rock Mining Co.	White Rock	W. Shiningtree	Sudbury
Wright-Hargreaves Mines, Ltd.	Wright-Hargreaves	Teck township	Kirkland Lake

In the following table the total gold output of the Province is given, also that from Porcupine and Kirkland Lake, beginning in 1910 and 1913 respectively:

TABLE V.—TOTAL GOLD PRODUCTION OF ONTARIO

Year	Total Production Value $	Porcupine		Kirkland Lake	
		Value $	Per Cent.	Value $	Per Cent.
1866–1891	190,258*				
1892–1909	2,509,492				
1910	68,498	35,539	51.8		
1911	42,637	15,437	36.2		
1912	2,114,086	1,730,628	81.8		
1913	4,558,518	4,294,113	94.1	65,260	1.2
1914	5,544,979	5,206,006	93.8	114,154	2.0
1915	8,501,391	7,462,111	88.6	551,069	6.5
1916	10,339,259	9,391,408	90.8	702,761	6.8
1917	8,698,735	8,229,744	94.5	404,346	4.6
1918	8,502,480	7,767,907	91.4	632,007	7.4
1919	10,451,709	9,941,803	95.1	486,809	4.7
1920	11,686,043	10,597,572	90.7	1,033,478	8.8
1921	14,692,357	13,103,526	89.3	1,524,851	10.4
1922	20,579,569	18,374,658	89.3	2,159,581	10.5
Total	108,480,011	96,150,452	88.7	7,674,316	7.0

*Estimated.

The following statement of output by the leading gold-producing countries for the last pre-war year, for 1915 (year of maximum world production) and for the post-war period, has been abstracted chiefly from annual reports of the Director of the United States mint. It will be noted that Canada now holds third place among the gold-producing countries of the world, and for this the Province of Ontario is chiefly responsible.

OUTPUT BY LEADING GOLD-PRODUCING COUNTRIES AND STATES
(Millions of Dollars)

Source	1913	1915	1919	1920	1921	1922
World	459.9	468.7	365.8	337.0	330.2	319.4
Transvaal	182.0	188.0	172.2	168.0	167.7	145.1
United States	88.9	101.0	60.3	51.2	50.1	47.3
Canada	16.6	19.0	15.9	15.8	19.1	26.1
ONTARIO	**4.6**	**8.5**	**10.5**	**11.7**	**14.6**	**20.7**
*Australasia	51.8	49.0	26.1	22.6	20.7	18.8
Australia	....	....	....	....	15.6	15.9
Mexico	19.3	6.6	15.2	15.3	14.2	15.5
California	20.4	21.4	17.4	14.8	15.7	14.7
West Australia	27.1	25.0	15.2	12.8	13.7	11.1
Rhodesia	14.1	18.9	12.3	11.4	12.1	13.5
India	11.2	11.5	10.5	10.3	9.7	9.0
Russia	....	26.3	11.0	1.4	0.9	3.0

Maximum World production............468.7 million dollars in 1915.
Maximum U.S. production..............101.0 " " "

*Includes New Zealand.

Dividends.—The important period of gold mining in Ontario began with the opening of the Porcupine mines in 1910. Since that time the gold mines have paid out in returns to shareholders a total of $28,096,699.80, details of which are given in Table VI.

TABLE VI.—DIVIDENDS AND BONUSES PAID BY GOLD MINING COMPANIES TO DECEMBER 31, 1922.

Name of Company	Date of Incorporation	Authorized Capital	Capital Stock Issued	Par value per share	Dividends and Bonuses paid to end of 1921, Amount	Dividends and Bonuses paid during 1922, Amount	Rate per cent., 1922	Total of Dividends and Bonuses paid to Dec. 31st, 1922	Date when last Dividend or Bonus paid
		$	$	$ c.	$ c.	$ c.		$ c.	
*Dome Mines Company, Ltd.	Mar. 27, 1911	4,500,000	4,290,003	9 00	2,395,833 75	715,005 50	16.7	3,110,834 25	Oct. 26, 1922
†Hollinger Cons. Gold Mines, Ltd.	May 25, 1916	25,000,000	24,600,000	5 00	16,558,000 00	3,198,000 00	13	19,756,000 00	Dec. 30, 1922
Lake Shore Gold Mines, Ltd.	Feb. 25, 1914	2,000,000	2,000,000	1 00	400,000 00	80,000 00	2	480,000 00	Nov. 15, 1922
McIntyre-Porcupine Mines, Ltd.	Mar. 16, 1911	4,000,000	3,640,283	5 00	2,540,698 10	546,042 45	15	3,086,740 55	Sept. 1, 1922
Porcupine Crown Mines, Ltd.	May 26, 1913	2,000,000	2,000,000	1 00	840,000 00	....	......	840,000 00	July 15, 1917
Rea Consolidated Gold Mines, Ltd.	April 5, 1911	1,000,000	200,000	5 00	12,000 00	....	......	12,000 00	1915
#Schumacher Gold Mines, Ltd.	Jan. 6, 1914	2,000,000	1,850,000	1 00	....	....	......	....	....
Tough-Oakes Gold Mines, Ltd.	July 15, 1913	3,000,000	2,657,500	5 00	398,625 00	....	......	....	....
Wright-Hargreaves Mines, Ltd.	June 16, 1916	2,750,000	2,750,000	1 00	....	412,500 00	15	412,500 00	Oct. 2, 1922
Total	....	....	....	......	23,145,156 85	4,951,542 95	......	28,096,699 80	....

*Dividends in 1921 include $4,079 paid to former Dome Extension shareholders. On April 20th, 1922, a disbursement of $476,667.00 was made to shareholders, being $1.00 per share on the issued stock, thus reducing the authorized capital from $5,000,000 to $4,500,000 and the par value from $10 to $9. This was in addition to the "Dividends and Bonuses" mentioned above.

†Hollinger Consolidated Gold Mines, Limited, is a consolidation of the Acme Gold Mines, Limited; Millerton Gold Mines, Limited; and Hollinger Gold Mines, Limited. Dividends include $160,000 paid by Acme prior to the amalgamation.

#The Schumacher mine was sold to the Hollinger in 1922 and $647,500 or 35 per cent. of the assets distributed to shareholders.

Silver-Cobalt

Although the average price of silver remained at a low point (67.52 cents per ounce) silver mining was more profitable during 1922 on a basis of each ounce produced than at any time since the collapse of the price of the metal in 1921. The price during 1922 was, however, considerably better than the average quotation for the previous year and, as a result, several idle properties were enabled to reopen. It should be mentioned, however, that, in addition to the low price, shortage of power during 1920 was the original cause of the cessation of operations on the part of these mines. The demand for and price of silver are influenced by several factors, among which are the requirements of India and China, where good trade conditions require quantities of silver for the marketing of produce, and the needs of European countries for silver as a medium of coinage. During 1922 good markets for the metal were reflected in Ontario by increased activity in silver mining.

Production from the old established mines at Cobalt was well maintained during the year, while large shipments of high-grade ore and concentrates were made from rich deposits in South Lorrain, first noted in 1921. Both the Keeley company and Mining Corporation of Canada were active during the year in this area. In Gowganda the Miller Lake O'Brien and Castle-Trethewey both made shipments. The output of silver from all sources in Ontario amounted to 10,925,305 fine ounces, having a selling value of $7,800,029 in 1922 as against 8,435,593 fine ounces worth $5,673,908 in 1921.

Mines shipping over a quarter million ounces of silver in 1922 are given in order:

Mine.	Ounces.
Nipissing	3,864,291
Mining Corporation of Canada	2,272,828
Coniagas	1,899,571
O'Brien	896,195
Keeley	775,349
La Rose	434,560
McKinley-Darragh-Savage	254,308

In addition to the silver content, of ores, concentrates, residues, etc., producing mines are paid for the cobalt content, provided the percentage is sufficiently high. Mine shippers in 1922 were paid $268,700 for 792,238 pounds of cobalt. Mines shipping flotation concentrates are paid for the copper content, which totalled 25,170 pounds worth $1,950 in 1922.

From weekly statements issued by the General Freight and Passenger Agent of the Temiskaming and Northern Ontario Railway, showing railway shipments of ore, concentrates, etc., from the Cobalt area, the following information has been compiled: Total shipments, 6,811 tons, of which 5,796 were consigned to southern Ontario and 1,015 tons to United States smelters and refineries.

Classified according to source, shipments of silver in 1922 were derived as follows:

	Fine Ounces.
Cobalt	9,239,147
South Lorrain	1,284,307
Gowganda	170,651
Casey township	1,028
Silver Islet	15,994
Recovered from gold ores	163,939
Recovered from nickel-copper refining	50,239
Total	10,925,305

The producers of silver are given in the following list:

SILVER PRODUCERS IN 1922.

Operator	Mine or Source	Location
Bailey Silver Mines, Ltd.	Bailey and Silver Cliff.	Cobalt.
Beaver Consolidated Mines, Ltd.	Beaver.	Cobalt.
Canadian Casey Cobalt Mining Company, Ltd.	Casey (clean-up).	Casey township.
Cann and McKinney.	Orillia smelter (clean-up).	Orillia.
Castle-Trethewey Mines, Ltd.	Castle.	Gowganda.
Coniagas Mines, Ltd.	Coniagas and Trethewey.	Cobalt.
Crown Reserve Mining Company, Ltd.	Crown Reserve.	Cobalt.
Dominion Reduction Company.	Dominion.	Cobalt.
Hermo Mining Company, Ltd.	Reliance.	Cobalt.
Islet Exploration Company, Ltd.	Silver Islet.	Thunder Bay district.
Keeley Silver Mines, Ltd.	Keeley.	South Lorrain.
La Rose Mines, Ltd.	La Rose.	Cobalt.
McKinley-Darragh-Savage Mines of Cobalt, Ltd.	McKinley-Darragh-Savage.	Cobalt.
Mining Corporation of Canada, Ltd., The.	Cobalt Lake, Townsite-City, Buffalo.	Cobalt.
Lorrain Operating Co., Ltd.[1]	Haileybury Frontier.	South Lorrain.
Nipissing Mining Company, Ltd.	Nipissing.	Cobalt.
O'Brien, M. J., Ltd.	O'Brien.	Cobalt.
" " "	Miller Lake O'Brien.	Gowganda.
Peterson Lake Silver Cobalt Mining Company, Ltd.	Peterson Lake.	Cobalt.
Sweet, Joseph L. (lessee).	Cobalt Silver Queen.	Cobalt.

[1]Controlled and operated by the Mining Corporation of Canada, Ltd.

In Table VII are shown the shipments of ore, concentrates and bullion from the mines of Cobalt, South Lorrain, Gowganda and outlying silver areas since mining began in 1904. By "shipment" is meant consignment to outside points, whether in Canada or abroad, but not movements within the camp, for example: ore shipped from a mine to a concentrating or reduction plant in Cobalt itself. It will be noted that the quantity of ore shipped away from the camp has been reduced to small proportions in recent years.

TABLE VII.—SHIPMENTS FROM SILVER MINES, 1904-1922.

Year.	Producing Mines.	Ore.			Concentrates and Residues.			Bullion.	Total.	
		Tons.	Silver content, Ounces.	Av. per ton, Oz.	Tons.	Silver content, Ounces.	Av. per ton, Oz.	Silver, Ounces.	Silver, Ounces.	Value, $
1904	4	158	206,875	1,309	......	....	......	....	206,875	111,887
1905	16	2,144	2,451,356	1,143	......	....	......	....	2,451,356	1,360,503
1906	17	5,335	5,401,766	1,013	......	....	......	....	5,401,766	3,667,551
1907	28	14,788	10,023,311	677	......	....	......	....	10,023,311	6,155,391
1908	30	24,487	18,022,480	736	1,007	1,415,395	1,244	....	19,436,875	9,133,378
1909	31	27,729	22,436,355	809	2,948	3,461,470	1,714	....	25,987,825	12,461,576
1910	41	27,437	22,581,714	821	6,845	7,082,834	1,030	980,633	30,645,181	15,478,047
1911	34	17,278	20,318,626	1,176	9,375	8,056,189	858	3,132,976	31,507,791	15,953,847
1912	30	10,719	15,395,504	1,436	11,214	9,768,228	871	5,080,127	30,243,859	17,408,935
1913	35	9,861	13,668,079	1,386	10,016	8,489,321	770	7,524,575	29,681,975	16,553,981
1914	32	4,302	6,504,753	1,511	12,152	8,915,958	733	9,742,130	25,162,841	12,765,461
1915	24	2,865	6,758,286	2,359	11,996	10,001,548	834	7,986,700	24,746,534	12,135,816
1916	28	2,177	4,672,500	2,146	8,561	7,598,011	887	7,644,579	19,915,090	12,643,175
1917	28	2,288	3,271,353	1,429	13,720	6,445,243	469	8,053,318	19,401,893	16,121,013
1918	38	1,456	1,401,050	962	17,958	5,793,756	323	10,466,888	17,661,694	17,341,790
1919	33	850	806,341	949	15,208	4,024,764	265	6,383,764	11,214,317	12,738,994
1920	35	578	668,081	1,152	9,757	3,777,812	387	6,402,423	10,846,321	10,654,471
1921	28	948	986,597	1,041	3,101	2,962,771	955	4,312,603	8,261,931	5,564,594
1922	22	1,485	1,712,878	1,154	7,897	1,675,055	212	7,323,194	10,711,127	7,658,802
Total	......	156,885	157,285,905	1,002	142,885	89,477,803	626	85,033,910	333,419,562	205,909,212

TABLE VIII.—TOTAL SHIPMENTS FROM SILVER MINES, SMELTERS AND REFINERIES, 1904 TO 1922.

Year	Copper (a)		Lead (a)		Nickel (b)		Cobalt (c)		Arsenic		Silver		Total Value
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Ounces	Value	
		$		$		$		$		$		$	$
1904	....	....	....	....	14	3,467	16	19,960	72	903	206,875	111,887	136,217
1905	....	....	....	....	75	10,000	118	100,000	549	2,693	2,451,356	1,360,503	1,473,196
1906	....	....	....	....	160	....	321	80,704	1,440	15,858	5,401,766	3,667,551	3,764,113
1907	....	....	....	....	370	1,174	739	104,426	2,958	40,104	10,023,311	6,155,391	6,301,095
1908	....	....	....	....	612	....	1,224	111,118	3,672	40,373	19,437,875	9,133,378	9,284,869
1909	....	....	....	....	766	....	1,533	94,965	4,294	61,039	25,897,825	12,461,576	12,617,580
1910	....	....	....	....	504	....	1,098	54,699	4,897	70,709	30,645,181	15,478,047	15,603,455
1911	....	....	....	....	392	....	852	170,890	3,806	74,609	31,507,791	15,953,847	16,199,346
1912	....	....	....	....	429	14,220	934	314,381	4,166	80,546	30,243,859	17,408,935	17,818,082
1913	....	....	....	....	377	13,326	821	420,386	3,663	64,146	29,681,975	16,553,981	17,051,839
1914 (d)	....	....	....	....	90	28,978	351	590,406	2,030	116,624	25,162,841	12,765,461	13,501,469
1915	....	....	....	....	35	28,353	206	383,261	2,490	148,379	24,746,534	12,135,816	12,695,809
1916	....	....	....	....	79	59,380	400	805,014	2,160	200,103	19,915,090	12,643,175	13,707,672
1917	53	28,840	....	....	155	125,071	337	1,138,190	2,592	608,483	19,401,893	16,121,013	18,021,597
1918	72	35,712	3	453	186	156,893	380	1,640,310	2,545	566,332	17,661,694	17,341,790	19,741,490
1919	110	40,976	12	1,296	276	188,418	298	1,019,479	2,834	485,360	11,214,317	12,738,994	14,474,523
1920	50	17,494	5	792	127	93,233	283	1,605,365	1,883	431,527	10,846,321	10,654,471	12,802,882
1921	103	34,504	3	270	10	7,665	126	616,235	1,491	233,763	8,261,931	5,564,594	6,457,031
1922	93	26,346	16	1,891	61	34,987	(e) 776	1,333,676	2,059	299,940	10,711,127	7,658,802	9,355,642
Total	481	183,872	39	4,702	4,718	765,165	10,813	10,603,465	49,601	3,541,491	333,419,562	205,909,212	221,007,907

(a) Copper and lead are recovered from certain silver ores and concentrates shipped to United States refineries. These metals are valued at the average prices for the year, namely: copper, 13.382 cents and lead 5.734 cents per pound in 1922.
(b) Nickel metal and metallic contents of all Nickel compounds.
(c) Cobalt metal and metallic contents of all Cobalt compounds.
(d) Prior to 1914 an estimate based on assays was made of the nickel, cobalt and arsenic contained in the ores; subsequently actual recoveries have been reported.
(e) Includes 460 tons of speiss residues worth $153,116.

Since the discovery of silver at Cobalt in 1903, shipments from the camp and the most important outlying silver areas have been as follows:

TABLE IX.—SILVER SHIPMENTS BY CAMPS

Year	Average price, cents per ounce (New York)	Silver Shipments in Troy Ounces, 1904-1922					
		Total Ounces	Cobalt	Casey Township	South Lorrain	Gowganda	Montreal River and Maple Mountain
1904....	57.221	206,875	206,875	....	....	....	....
1905....	60.352	2,451,356	2,451,356	....	....	....	....
1906....	66.791	5,401,766	5,401,766	....	....	....	....
1907....	65.237	10,023,311	10,023,311	....	....	....	....
1908....	52.864	19,437,875	19,424,251	500	13,124	....	....
1909....	51.502	25,897,825	25,658,683	26,185	194,955	....	18,002
1910....	53.486	30,645,181	29,849,981	92,544	221,133	471,688	9,835
1911....	53.340	31,507,791	29,989,893	114,789	933,912	468,687	510
1912....	60.835	30,243,859	28,605,940	253,824	834,119	549,976	....
1913....	57.791	29,681,975	28,105,505	825,108	248,992	502,370	....
1914....	54.811	25,162,841	24,155,699	499,643	108,199	399,300	....
1915....	49.684	24,746,534	24,280,366	223,939	....	242,229	....
1916....	65.661	19,915,090	19,008,517	445,900	77,280	383,393	....
1917....	81.417	19,401,893	18,327,258	....	10,000	1,064,635	....
1918....	96.772	17,661,694	16,807,407	143,901	72,188	638,198	....
1919....	111.122	11,214,317	10,314,689	171,278	4,586	723,764	....
1920....	100.900	10,846,321	10,402,249	....	8,253	433,352	1,582
1921....	62.654	8,261,931	7,673,535	1,101	328,886	258,292	117
1922(*a*)..	67.528	10,711,127	9,239,147	1,028	1,284,307	170,651	....
	Total....	333,419,562	319,926,428	2,943,641	4,339,934	6,306,535	30,046

(*a*) *See* page 9 for further details.

Refineries.—The operations of the refining companies during 1922 are summarized in the table which follows:

OPERATIONS OF SILVER-COBALT REFINERIES IN ONTARIO, 1922.

Schedule	Production	Sales	
	Quantity	Quantity	Value
			$
Ore and concentrates treated..................tons	1,795	....	....
Residues treated............................ "	1,925	....	....
Silver...............................fine ounces	1,917,333	1,901,591	1,282,354
Silver content of matte and residues..........ounces	12,817	12,817	(*b*) 153,116
Arsenic, white...............................lbs.	3,335,613	4,118,695	299,940
Cobalt oxide................................ "	360,495	398,697	798,271
Cobalt-nickel oxides, unseparated............... "	86,730	123,605	99,687
Cobalt, metallic............................. "	106,274	109,067	282,602
Nickel oxide................................ "	115,341	10,047	1,721
Nickel sulphate and hydrate................... "	27,270	27,270	2,231
Nickel, metallic............................. "	18,789	109,853	31,035
Copper content of matte and sulphate........... "	17,028	17,028	2,335
Arsenate of iron............................ "	75,000	75,000	938
Total value of products marketed..........	....	....	$ 2,954,230

(*b*) Includes value of some cobalt.

The companies named hereunder, with plants situated in southern Ontario, treat silver-cobalt ores, concentrates and residues:

REFINERS OF SILVER-COBALT ORES, 1922.

Name of Company	Location of Works	P.O. Address
Deloro Smelting and Refining Co., Ltd.	Deloro	Deloro.
Coniagas Reduction Co., Limited	Thorold	St. Catharines.
Ontario Smelters & Refiners, Ltd.	Welland	Welland.

Late in 1921 the new insecticide plant of the Deloro Smelting and Refining Company commenced operations, the principal products being arsenate of lime and arsenate of lead. The price of white arsenic (arsenious oxide) rose as high as 20 cents per pound in 1920 and fell as low as six cents in 1921. Arsenic is in demand, calcium arsenate particularly, as an antidote for the boll weevil in the cotton-growing areas of the United States. Antimony was substituted for arsenic in glass manufacture during the war, owing to the latter being reserved for the manufacture of insecticides. Generally speaking, arsenic is preferred to antimony in the glass industry. In the Province the recovery of arsenic is entirely as a by-product in the treatment of silver-cobalt arsenides by southern Ontario refineries.

The following figures have been compiled from information furnished by refineries in the United States which treated products from Ontario silver mines:

	Quantity
Ore, concentrates, etc., treated, tons	1,460
Silver, recovered, ounces	924,499
Gold recovered, ounces	2
Copper, recovered, lbs.	196,862
Lead recovered, lbs.	32,578

Shipments were consigned to the following companies in the United States:

American Smelting and Refining Company, (Pueblo, Col., and Perth Amboy, N.J.).
Pennsylvania Smelting Co., (Carnegie, Pa.).
United States Metal Refining Co., (Chrome, N.J.).

Dividends.—Table X, which follows, gives a record of dividends and bonuses paid by silver mining companies from the discovery of Cobalt up to the end of 1922.

TABLE X.—DIVIDENDS AND BONUSES PAID BY SILVER MINING COMPANIES TO DECEMBER 31, 1922.

Name of Company	Date of Incorporation	Authorized Capital	Capital Stock Issued	Par value per share	Dividends and Bonuses paid to end of 1921	Dividends and Bonuses paid during 1922	Total Dividends and Bonuses paid to 31st Dec., 1922	Date when last Dividend or Bonus was paid
		$	$	$ c.	$ c.	$ c.	$ c.	
Aladdin Cobalt Company, Limited	Aug. 23, 1912	500,000	500,000	5 00	75,000 00	....	75,000 00	April 30, 1917
Beaver Consolidated Mines, Ltd.	Mar. 1, 1907	2,000,000	2,000,000	1 00	710,000 00	....	710,000 00	May 31, 1920
Buffalo Mines, Ltd., The (*a*)	April 27, 1906	500,000	500,000	50	2,787,000 00	....	2,787,000 00	May 28, 1914
Casey Cobalt Silver Mining Co., Limited	Dec. 19, 1906	100,000	100,000	1 00	203,249 33	....	203,249 33	April 22, 1914
Cobalt Central Mines Co., Ltd.	Dec. 13, 1905	5,000,000	5,000,000	1 00	192,845 00	....	192,845 00	Aug. 25, 1909
Cobalt Comet Mines, Ltd. (*b*)	April 16, 1913	1,000,000	1,000,000	1 00	230,000 00	....	230,000 00	April 1, 1915
Cobalt Silver Queen, Ltd.	April 1, 1906	1,500,000	1,500,000	1 00	315,000 00	....	315,000 00	Dec. 31, 1908
Coniagas Mines, Limited, The	Nov. 24, 1906	4,000,000	4,000,000	5 00	10,940,000 00	200,000 00	11,140,000 00	Nov. 1, 1922
Crown Reserve Mining Co., Ltd.	Jan. 16, 1907	2,000,000	1,999,957	1 00	6,190,849 00	....	6,190,849 00	Dec. 28, 1916
Foster Cobalt Mining Co., Ltd.	Feb. 14, 1906	1,000,000	915,588	1 00	45,000 00	....	45,000 00	Jan. 1, 1907
Hudson Bay Mines, Ltd.	July 16, 1909	3,500,000	3,200,050	5 00	778,909 42	....	778,909 42	Aug. 31, 1913
Kerr Lake Mining Company, Ltd. (*c*)	Aug. 9, 1905	40,000	40,000	100 00	9,475,000 00	380,000 00	9,855,000 00	Oct. 13, 1922
La Rose Mines, Ltd.	May 31, 1908	1,500,000	1,500,000	1 00	7,505,409 56	150,000 00	7,655,409 56	April 20, 1922
McKinley-Darragh-Savage Mines of Cobalt, Ltd.	April 27, 1906	2,500,000	2,247,692	1 00	5,955,391 86	....	5,955,391 86	Oct. 1, 1920
Mining Corporation of Canada, Ltd.	Nov. 23, 1916	8,300,250	8,300,250	5 00	5,498,874 97	....	5,498,874 97	Sept. 15, 1920
City of Cobalt Mining Co., Ltd. (*d*)	Oct. 5, 1906 Jan. 7. 1909	500,000 1,500,000	1,500,000	1 00	145,000 00	....	145,000 00	April 15, 1920
Cobalt Lake Mining Co., Ltd. (*d*)	Dec. 22, 1906	3,000,000	3,000,000	1 00	465,000 00	....	465,000 00	May 29, 1914

TABLE X.—*Continued.*

Name of Company	Date of Incorporation	Authorized Capital	Capital Stock Issued	Par value per share	Dividends and Bonuses paid to end of 1921	Dividends and Bonuses paid during 1922	Total Dividends and Bonuses paid to 31st Dec., 1922	Date when last Dividend or Bonus was paid
		$	$	$ c.	$ c.	$ c.	$ c.	
Cobalt Townsite Mining Co., Ltd. (*d*)	May 8, 1906	100,000	45,011	1 00	1,042,259 61	....	1,042,259 61	Nov. 11, 1914
Nipissing Mining Co., Ltd. (*e*)	Dec. 16, 1904	250,000	250,000	100 00	24,293,297 25	1,120,000 00	25,413,297 25	Oct. 20, 1922
Penn-Canadian Mines, Ltd. (*f*)	April 24, 1912	1,500,000	1,349,705	1 00	175,461 65	....	175,461 65	Sept. 10, 1917
Peterson Lake Silver-Cobalt Mining Co., Ltd.	April 11, 1906	3,000,000	2,469,802	1 00	462,350 35	....	462,350 35	Jan. 2, 1917
Right of Way Mining Co., Ltd.	July 13, 1906	500,000	499,518	1 00	324,643 93	....	324,643 93	Oct. 1, 1909
Right of Way Mines, Ltd.	Sept. 11, 1909	2,000,000	1,685,500	1 00	252,825 00	....	252,825 00	Mar. 17, 1917
Seneca-Superior Silver Mines, Ltd.	Sept. 29, 1911	500,000	478,884	1 00	1,579,817 20	....	1,579,817 20	Dec. 15, 1916
Temiskaming Mining Co., Ltd.	Nov. 5, 1906	2,500,000	2,500,000	1 00	2,159,156 25	....	2,159,156 25	Jan. 31, 1920
Temiskaming and Hudson Bay Mining Co., Ltd.	July 10, 1903	25,000	7,761	1 00	1,940,250 00	....	1,940,250 00	Nov. 10, 1914
Trethewey Silver Cobalt Mines, Ltd.	May 30, 1906 June 1, 1911	2,000,000	1,000,000	1 00	1,211,998 50	....	1,211,998 50	Jan. 2, 1919
Wettlaufer Lorrain Silver Mines, Ltd.	Nov. 30, 1908	1,500,000	1,416,590	1 00	637,465 50	....	637,465 50	Sept. 22, 1913
Total	....	....	....	.....	85,592,054 38	1,850,000 00	87,442,054 38	....

(*a*) In 1917 the capital stock of the company was reduced from $1,000,000 to $750,000, in 1918 from $750,000 to $500,000, and on December 21, 1919, from $500,000 to $150,000, by returning to shareholders amounts equal to the reduction in capital, leaving 300,000 shares issued of 50 cents each. The mine was sold to the Mining Corporation of Canada, and operated by it in 1920 and subsequently.

(*b*) Cash assets amounting to $50,000 paid on April 27, 1917.

(*c*) In addition a return of capital amounting to $600,000 was made on July 3, 1919, to stockholders of the Kerr Lake Mines, Ltd.

(*d*) Mining Corporation of Canada, Limited, owns and operates the City of Cobalt, Cobalt Lake and Cobalt Townsite mines.

(*e*) Includes $16,288,297.25 paid in dividends by the Nipissing Mines Co. (the holding company) to the end of 1916.

(*f*) Paid out of capital $40,491.15 on Sept. 10, 1917, and an equal amount on April 24, 1918.

Nickel-Copper and Platinum Metals

The nickel-copper industry, which in 1921 and during the first part of 1922 experienced a period of depression, made a remarkable recovery towards the end of the year, indicating an early resumption of its position as one of the leading metal-producing industries of Canada. This new activity is the result of much research in the work of applying nickel to the arts of peace instead of those of war, accelerated by a reduction in the selling price of the metal. New uses and fields for the product have been found, while further avenues of consumption are being vigorously prospected. It is confidently expected that the future will demonstrate that nickel may be employed just as widely as it has been heretofore when large quantities were consumed in the manufacture of nickel steel for warships. As a result of this work the plant and equipment which was much enlarged through the necessity of war will be utilized again to meet new industrial demands for the metal.

A few years ago engineers were confined to the use of steel, brass or bronze in the design and construction of plant and equipment, but research and experiment has changed this condition and now there are numerous alloys available, each with one or more outstanding properties, which make it particularly desirable for special applications. The use of nickel has figured largely in these alloys and the one most widely used is the natural alloy called "Monel" metal, which is produced by the International company directly from nickel-copper matte after the sulphur content has been eliminated. It is stronger than mild steel, retains its strength at high temperatures and has maximum resistance to corrosion and erosion. It resists crystallization and fatigue and will take a high nickel polish. Monel metal, though possessing a high melting point and high shrinkage, may be cast into any desired form and can be machined and polished readily. The annealing temperature is 850-1,000 degrees C. in a reducing atmosphere. This alloy may be welded either by oxy-acetylene or electric arc methods in the same manner as steel.

During the last quarter of the year both the International and the Mond companies largely increased the number of employees. The refinery of the former company resumed operations in September, while the Mond company exported its entire stock of matte towards the close of the year. The British America Nickel Corporation smelter and refinery were idle throughout the entire period.

The production of ore during the year from the several mines was as follows:

	Tons
International Nickel Company of Canada:—	
Creighton	55,980
Mond Nickel Company:—	
Levack, Garson, Worthington, Victoria No. 1, and Frood	203,589
Total	259,569

In Table XI, following, is indicated the course of the nickel industry during the last five years. That this metal takes on added importance during times of war is sufficiently shown by the fact that while in 1914 the quantity of ore smelted was 947,053 tons, it rose in 1918 to 1,559,892 tons, and fell again, as noted in the table, to 393,768 tons in 1921, and to 314,120 tons in 1922.

For the purpose of this table the nickel and copper in matte exported in 1922 were valued at 20 cents and 10 cents per pound, respectively.

TABLE XI.—NICKEL-COPPER MINING AND SMELTING, 1918-1922.

Schedule	1918	1919	1920	1921	1922
Ore raised....................tons	1,643,040	614,955	1,200,830	262,593	259,569
Ore smelted................ "	1,559,892	754,567	1,087,531	393,768	314,120
Bessemer matte produced...... "	87,184	42,735	57,938	19,498	17,324
Nickel contents of matte....... "	45,886	22,035	30,615	9,128	8,678
Copper contents of matte...... "	23,843	12,099	16,021	6,323	5,421
Matte exported*............. "	....	25,207	40,367	10,466	19,831
Matte refined in Canada....... "	5,334	10,911	17,297	5,558	10,340
Men employed...............No.	3,145	2,536	3,258	1,895	1,492
Wages paid.....................	$7,861,773	$3,382,154	$5,555,469	$1,557,696	$2,009,335

*All matte was exported prior to 1918 when refining in Canada began at Port Colborne, Ontario.

The following figures summarize the operations of the refinery of the International Nickel Company of Canada at Port Colborne and that of the British America Nickel Corporation at Deschênes on the Ottawa river:

TABLE XII.—NICKEL-COPPER REFINING, 1922.

Schedule	Quantity	Value
		$
Matte, treated...tons	10,340	....
Nickel oxide, marketed..................................lbs.	2,389,840	389,398
Metallic nickel, recovered................................ "	11,065,473	3,140,399
Blister copper and electrolytic copper, recovered............... "	4,382,922	502,293
Gold, recovered*.......................................ounces	2,094	43,187
Silver, recovered*..................................... "	50,239	33,695
Platinum metals, recovered*........................... "	11,788	924,712
Employees..No.	462	....
Wages paid...	....	676,523

*Includes recoveries by the Mond Nickel Company at Clydach in Wales.

Recoveries from Ontario silver ores treated show a total of 59,226 pounds of copper. In addition 109,853 pounds of nickel, 10,047 pounds of nickel oxide and 5,638 pounds of nickel contained in nickel sulphate were marketed by Southern Ontario silver refineries.

The average New York price of electrolytic copper was 13.382 cents per pound for the full year, as compared with 12.502 cents in 1921 and 17.456 cents in 1920.

Platinum Metals.—Ontario nickel-copper ores of the Sudbury area contain the precious metals, gold, silver and metals of the platinum group. The latter may be divided into two main sub-groups on a specific gravity basis as follows:

Metal	Specific Gravity	Metal	Specific Gravity
Palladium (Pd.)..................	12.16	Platinum (Pt.)..................	21.40
Rhodium (Rh.)..................	12.44	Iridium (Ir.)....................	21.42
Ruthenium (Ru.)................	12.10	Osmium (Os.)..................	22.50

In the last two annual reports figures were given showing platinum metals produced in Canada, United States and Great Britain from the refining of Ontario nickel-copper matte. Recoveries of platinum metals by the British America, International and Mond companies follow:

1922	Platinum	Palladium	Iridium, etc.*	Total
Quantity................Troy ounces	4,802	6,862	124	11,788
Value............................	$468,762	$446,030	$9,920	$924,712

*Iridium and rhodium in small amounts were grouped by the Mond Company with gold and are not recorded in the above figures.

At the Bayonne plant 3,112 tons of matte were treated, although the matte bears little relation to precious metals recovered as the residues treated accumulate over irregular periods. In the figures above given, platinum metals contained in precious metals cement shipped from Port Colborne to the refinery of the International Nickel Company, at Bayonne, N.J., are included with recoveries from the matte treated in the United States. The Bayonne refinery operated for a couple of months only during 1922 and was dismantled. Such machinery and equipment as could be used was shipped to Port Colborne, together with a small tonnage of matte on hand.

Average prices, as reported by the U.S. Geological Survey, were: platinum $97.62 per ounce troy, palladium $65, iridium $80 (containing 5 per cent. platinum).

Iron Ore

No iron ore was mined during 1922 in the Province of Ontario, although shipments were made during the period.

The total shipments, which amounted to 16,191 short tons having a value of $52,054, consisted of 15,891 tons of briquettes from Moose Mountain, and 300 tons of roasted siderite from the Magpie mine owned by the Algoma Steel Corporation. During 1921 the total shipments were 54,499 tons worth $227,134.

SHIPPERS OF IRON ORE, 1921

Company or Firm	Mine	Location	Kind of Ore	P.O. Address of Company
Algoma Steel Corporation, Limited...............	Magpie.......	Algoma dist......	Siderite.......	Sault Ste. Marie.
Moose Mountain, Ltd.....	Moose Mount'n	Hutton tp. (Sudbury dist.).....	Magnetite.....	Sellwood.

By Order-in-Council, dated 25th October, 1922, a Committee of six was appointed by the Provincial Government, their work to be under the general supervision of the Minister of Mines, "to make research, investigate and report upon the extent and quality of the deposits of low grade iron ores in Ontario, the best commercial methods of beneficiating the same, and generally, what steps or measures should be adopted to enable the low grade and other iron ores of this Province to be utilized in the production of pig iron and steel." The personnel of the Iron Ore Committee is as follows: J. G. Morrow, Hamilton; G. S. Cowie, Sault Ste. Marie; G. A. Guess and H. E. T. Haultain, University of Toronto; R. J. Hunt, Montreal, and Lloyd Harris, of Brantford. The last mentioned was appointed chairman and Mr. Balmer Neilly, 302 Bay Street, Toronto, was engaged as Engineer-Secretary. The Committee is at work preparing its report for the Ontario Legislature. Experiments are being carried on at the plant of the Steel Company of Canada, Hamilton, using Moose Mountain briquettes mixed with "lake" ores in varying percentages as a blast furnace charge.

Pig Iron, Steel and Ferro-Alloys

The depression noted in the iron and steel industry during 1921 became more acute during 1922. Prices returned practically to pre-war levels. The average Valley quotation for the year was $25.88 per gross ton (2,240 pounds) for basic pig iron at Pittsburgh.

During the year five blast furnaces operated part time, two of these at Sault Ste. Marie, two at Hamilton and one at Port Colborne. A total of 538,200 short tons of iron ore and briquettes were charged, of which 25,753 tons or 4.8 per cent. was of Ontario origin. The pig iron product was 293,661 tons, valued at $7,120,800. The figures in Table I represent only the proportional product from Ontario ore.

The following table gives particulars of the iron and steel-making industry of the Province for the last five years:

TABLE XIII.—IRON AND STEEL STATISTICS, 1918-1922.

Schedule	1918	1919	1920	1921	1922
Ontario ore smelted......short tons	99,852	97,514	152,176	126,653	23,398
Foreign ore smelted...... "	1,400,085	1,201,834	1,341,661	818,749	1,217,543
Limestone for flux....... "	405,683	343,907	349,960	221,761	137,852
Coke.................. "	869,729	736,872	818,698	420,358	336,301
Charcoal....................bush.	....	177,795	....	....	....
Pig iron produced........short tons	751,650	623,586	748,173	494,901	293,662
Value of pig iron produced........$	20,522,356	16,010,537	21,652,308	11,856,352	6,493,513
Steel made..............short tons	881,509	616,251	707,692	932,473	358,126
Value of steel made..............$	28,792,361	17,913,263	26,366,524	15,861,635	12,812,927

In January, 1923, *Canadian Machinery and Manufacturing News* reported as follows:

There has been an increasing demand for finished steel products, especially those required for the building industry. Merchant steel pipe is a striking example. Stocks are very low, not only in the States, but also in Canadian markets, where, owing to difficulties in securing materials, very short supplies are available. All conditions point to an aggressive building season with the coming spring, and Canadian dealers regard it as advisable to place a liberal estimate upon requirements. United States Steel Products report that bookings for first quarter in plates, bars and structural represent good volume and indicate that an active season is being anticipated. The railroads are again appearing on the scene, and tenders for extensive purchases are being considered.

Pig-iron markets continue strong, with more active buying than has appeared for months. Foundry pig iron in Western Ontario holds at $31.80 and at $34.15 in Quebec. American furnaces are holding strong at around $27, some are asking $28, and predictions are that $30 will soon be reached. Coke prices, an important factor, are very high, ranging from $9 to $9.50, as against $6.50 in December. Furnaces would lose money on pig iron at present figures, using coke at this price.

Conditions developing with the year-end, according to Pittsburgh reports, indicate that steel consumption will be heavy, mill operation at a high rate, and prices firm for, say, three months. Canadian industry appears to be in better position to more correctly reflect this activity.

BLAST FURNACES IN ONTARIO FOR THE PRODUCTION OF PIG IRON.

Company	Location	Furnaces		Remarks
		No.	Daily capacity, gross tons	
Algoma Steel Corporation, Ltd....	Sault Ste. Marie..	4	1,450	Active.
Atikokan Iron Company.........	Port Arthur.....	1	175	Idle since 1911.
Canadian Furnace Co., Ltd.......	Port Colborne....	1	325	Active.
Canadian Steel Corporation, Ltd..	Ojibway (near Windsor)......	2	1,100	Under construction.
Midland Iron and Steel Co., Ltd...	Midland.........	1	120	Idle since Feb., 1921.
Parry Sound Iron Co., Ltd.......	Parry Sound.....	1	90	Idle since Oct. 1, 1919.
Standard Iron Co., Ltd..........	Deseronto.......	1	60	Idle since June 9, 1919.
Steel Company of Canada, Ltd....	Hamilton.......	2	750	Active.

Note.—The first and last mentioned produce open-hearth steel as well as pig iron.

Ferro-Alloys.—The Algoma Steel Corporation produced 5,299 tons of spiegel valued at $180,216. Electro-Metals, Limited, of Welland, produced 14,049 gross tons of ferro-silicon valued at $587,852. For this output of several grades, ranging from 15 to 80 per cent. ferro, the following raw materials were used: 1,286 gross tons of pyrite cinder from the United States; 8,285 tons of steel turnings and 13,583 tons of Killarney quartzite containing 99 per cent. silica.

Lead and Zinc

The only producing lead mine in Ontario is that of the Kingdon Mining, Smelting and Manufacturing Company, Ltd., which also operates a smelter at Galetta, on the Ottawa river. Including a small recovery of lead in United States refineries from Ontario silver ores, the total sales amounted to 2,895,695 pounds worth $173,742. During the year 36,138 tons of ore were mined and concentrated. Shipments of pig lead were made to Canadian points. The average New York price for the year was 5.734 cents per pound. Prices at Montreal, the main Canadian market, are generally higher than in the United States, the Montreal average price being 6.219 cents per pound in 1922.

During the year the Kingdon company installed a blast furnace to treat lead-zinc slags which accumulate from treatment of concentrates in a Newnan hearth furnace. The zinc reported in the table resulted from a shipment of 180 tons of zinc concentrates in 1919 to the United States by the Jas. Robertson Estate, former owners of the Galetta mine. This shipment had not been reported previously to the Department. United States refineries recovered 34,979 pounds of lead from Ontario silver ores. Lead has been valued at 6 cents per pound.

NON-METALLIC MINERALS

Abrasives

No production was reported in 1922. During the previous year the entire production of 403 tons of corundum, a natural abrasive, valued at $55,965, was the output of Corundum, Limited, operating at Craigmont. This company milled 11,256 tons of tailings from lot 4, concession XVIII, Raglan township, in 1921. Shipments were made in "grain" form. Artificial abrasives, such as carborundum, are replacing corundum for many purposes.

Actinolite

Shipments during 1922 amounted to 50 tons, valued at $575. There is only one producer in the Province, namely, the Actinolite Mining Company, with a mill at the village of the same name, situated about four miles north of Tweed station on the Canadian Pacific railway. The mineral, which is found in serpentine rocks, is mined in the townships of Kaladar and Elzevir, Hastings county, and the head office of the company is Bloomfield, New Jersey. The product, which is fibrous in nature, is used principally for roofing purposes, as an ingredient in coal-tar compounds. Mining in a small way has been carried on intermittently for many years.

Barite (Barytes)

There was a production of barite (heavy spar) in 1921 by H. C. Bellew, 6 Saint Sacrament St., Montreal, Que., of approximately 200 tons, from a deposit which is located on lot 20, concession X, township of North Burgess, Lanark county. No shipments, however, were reported during 1921 or 1922.

Calcite and Dolomite

There has been a small demand for ground calcite and dolomite in the paint trade and for use in cleansing powders. From Palmerston township in Frontenac county, T. B. Caldwell, of Perth, shipped 70 tons of pure calcite to paint manufacturers, for experimental use, during 1921. No production was reported during the following year.

During 1921 a dolomite deposit was opened up at Baptiste lake, Herschel township, by the Ontario Dolomite Manufacturing Company, Limited. No shipments to the Toronto grinding plant of the company were made in either 1921 or 1922. This mineral is coming into use as a surface material in the manufacture of artificial stone.

Feldspar

For several years prior to 1920, Ontario's output of feldspar ranged from 12,000 to 20,000 tons per annum. In 1920 shipments jumped to 37,335 tons, worth $268,295, due to an increased demand by United States pottery and porcelain manufacturers. In the second half of 1921 shipments fell off, particularly those of second-grade spar. Prices dropped during that year from $9.00 per ton f.o.b. cars to $7.00 for No. 1 spar, and from $6.00 to $5.00 per ton for the No. 2 grade. The bulk of the supply was quarried in Frontenac and Hastings counties. During 1922 the output decreased to 15,255 tons, valued at $120,576 f.o.b. cars. The total value shown includes $27,332 as the increment value resulting from grinding 2,413 tons. Operations were widened considerably during 1922 and deposits in the vicinity of Perth and Sudbury were worked. The average value received was $6.65 per ton for crude spar. Shipments went chiefly to the pottery and porcelain centres of New York, New Jersey and Ohio.

Two companies were active during the year in the production of ground feldspar. The Feldspar Milling Company, Limited, of Toronto, which operated a grinding plant on Don Esplanade, having a milling capacity of 6,000 tons per year, ground some 1,845 tons; while the Frontenac Floor & Wall Tile Company at Kingston, having a capacity of 1,500 tons, ground 568 tons during the year. The output from these grinding plants was partly absorbed in the manufacture of floor and wall tile, while the balance found a market among the porcelain and enamelware manufacturers of Ontario. The building trades absorb a small quantity of pink spar chips in the construction of dwellings, for which it makes an attractive stucco dash.

Shippers in 1922 are noted hereunder:

FELDSPAR SHIPPERS, 1922.

Name	Location of Deposit	P.O. Address
Caradian Non-Metallic Minerals, Ltd	Dickens tp	207 James St., Montreal.
Campbell, A. M	Bathurst tp	Box 30, Perth.
Cleveland Feldspar and Products Co., Ltd	Monteagle tp	327 Union Bldg., Cleveland, Ohio, U.S.A.
Cross and Wellington	Huntingdon tp	Madoc.
Craig, T. H	....	Verona.
Dillon and Mills	Lot 23, Con. VI, Monteagle tp	Hybla.
Federal Feldspar, Ltd	Lot 25, Con. III, Bedford tp	46 Elgin St., Ottawa.
Feldspar Quarries, Ltd	Portland tp	60 Front St. E., Toronto.
*Feldspars, Limited	Richardson mine, Bedford tp	103 Bay St., Toronto.
Feldspar Mines Corporation, Ltd	Monteagle tp., Lots 16 and 17, Con. VIII	Toronto.
Industrial Minerals Corp. of Canada, Ltd	Lots 29 and 30, Con. XV, Monmouth tp	805 Bank of Hamilton Bldg., Toronto.
McPhee Bros	Dryden tp., Lot 9, Con. II	Wanapitei.
Orser-Kraft Feldspar, Ltd	S. Sherbrooke, Bathurst and Drummond tps	Box 366, Perth; 563 William St., Buffalo, N.Y., U.S.A.
Orser and Wilson	Lot 11, Con. IX, Loughborough tp	Perth, Ont.
Rock Products Company, The	Lot 10, Con. VI, Bathurst tp (Jas. Keays' quarry).	1154 Nicholas Bldg., Toledo, Ohio.
Treadwell, W. G	Loughborough tp., Lots 1 and 2, Con. XI	Hartington.
Verona Mining Co	Lots 18, 19 and pt. 20, Con. VII, Monteagle tp	Hybla and 404 Harrison Bldg., Philadelphia, Pa.
Wheeling Feldspar Company	Chapman tp., Lot 26, Con. II	Wheeling, W.Va.

*Operated, but did not ship.

Fluorspar

The output of this mineral, which declined from 3,704 tons in 1920 to 115 tons, worth $1,744, in 1921, amounted to 284 tons, valued at $3,905, in 1922. Curtailed operations in the steel industry was the primary cause of this situation. The maximum output was in 1918, when 7,286 tons were marketed.

There were only two shippers in 1922, as follows:

FLUORSPAR SHIPPERS, 1922.

Name	Location	Address
Cross and Wellington.........	Lot 11, Con. XIII, Huntingdon.	Madoc.
Mineral Products, Limited.....	Madoc tp..................	Madoc.

Graphite

The Black Donald Graphite Company, the only active producer, operating a mine and mill at Whitefish lake, near Calabogie, Renfrew county, treated 1,700 tons of crude ore during 1922. No ore was mined during the year. Of the total shipments, 95 tons were flake, and 531 tons were dusts, the total value being $34,124. Exports to the United States totalled 488 tons, and 138 tons were shipped to Canadian points. There remained on hand 746 tons of the material at the end of the year.

Artificial graphite, a product of the electric furnace, is manufactured by the Acheson Graphite Company of Niagara Falls, Ontario. The output in 1922 was 724,524 pounds, nearly twice that of any other post-war year.

Gypsum

The Ontario Gypsum Company is the only operating company in the Province, with mines and mills at Caledonia and Lythmore, in Seneca and Oneida townships, Haldimand county, and head office at Paris. When the Crown Gypsum Company's mill at Lythmore was purchased, a new mine at Lythmore, about five miles east of Hagersville on the Michigan Central railway, was opened up and the old Martindale mine abandoned. The company mines, crushes, grinds and calcines gypsum; manufactures wall plaster, plaster of Paris, and other gypsum products. Crushed and fine-ground gypsum marketed in 1922 totalled 44,171 tons, calcined gypsum 11,661, and calcined gypsum, used in manufactured products, 54,395 tons, a total of 110,227 tons, valued at $621,668. Gypsum products, including wall board and fireproof blocks, are finding an increasing market in the building industry.

Iron Pyrites

The market for pyrites was stagnant, the output in 1922 being considerably short of the 1921 figures. Production was 11,233 tons, valued at $39,763, in 1922 as against 27,785 tons, valued at $101,306, during the previous year. This industry flourished during the war period, when there was an abnormal demand for sulphuric acid. Native sulphur from the Gulf States has displaced pyrite to a large extent. Low cost production on a large scale has enabled the United States, during the past three years, to take first place as a producer of sulphur, about one-half of which is used in acid making. Prior to 1903, when the Frasch method of melting sulphur in wells by the use of steam or boiling water was introduced, Sicily supplied about 95 per cent. of the world's sulphur. In 1922 Ontario producers were the Grasselli Chemical Company and the Nichols Chemical Company. The sulphide property of the Nichols Company had a production, but the large deposits of this company at Goudreau and Northpines were not worked.

Following is a list of pyrite shippers in 1922:

IRON PYRITES SHIPPERS, 1922.

Name of Owner, Firm or Company	Location or Name of Mine	P.O. Address of Manager, etc.
Grasselli Chemical Co.	Caldwell	Flower Station.
Nichols Chemical Co., Limited, The	Sulphide	Sulphide.

Mica

The industry, which is centred in Eastern Ontario, revived considerably during 1922. Shipments totalled 2,229 tons, including 2,119 tons of scrap mica. The total value of all grades was $56,480, as compared with $28,891 in 1921, when 218 tons were marketed. Scrap mica is now being concentrated and ground to various degrees of fineness for a wide variety of uses, including the rubber trade, but principally for the manufacture of prepared roofing materials. The chief market is in the United States.

Although the total tonnage of mica marketed greatly exceeded that of 1921 or 1920, the proportion of scrap was large. Rough-cobbed mica sold was 86 tons, worth $21,955; thumb-trimmed, 24 tons, valued at $13,294; and scrap, 2,119 tons, worth $21,231. Owing to the occasional nature of sales to dealers, trimmers and splitters and to resales it is difficult to keep an accurate record of mica operations. Prices for thumb-trimmed mica, depending on quality, ranged as follows:

Size	Price per lb.	Size	Price per lb.
1" x 1"	7c. to 22c.	2" x 4"	60c.
1" x 2"	20c. to 30c.	3" x 5"	$1 50
1" x 3"	25c. to 30c.	4" x 6"	$2 00 to 2 25
2" x 3"	40c.		

Following is a list of mica shippers:

MICA SHIPPERS, 1922

Name of Owner or Producer	Location or Name of Mine	P.O. Address of Manager, etc.
Bennett, H. V.	Loughborough township, lot 12, Con. VII	Perth
Elliott, Wm. M.	Mica lake, Butt tp.	3433 Walnut St., Chicago, Ill.
Green, George	Bedford tp.	Perth Road
Kent Bros. and Estate J. M. Stoness	Bedford tp.	Kingston
Loughborough Mining Co., Ltd.	Loughborough tp.	Sydenham
Martin, A. G.	Sydenham	236 Besserer St., Ottawa
Tory Hill Marble and Mica Company, Ltd.	Lots 33, 34, Con. XIII, Glamorgan tp.	Tory Hill
Wildman and Burk	Otter lake	Perth

Mineral Waters

Statistics of production and valuation are not entirely satisfactory; for the reason that in many cases mineral waters are shipped from the springs in barrels or other containers to bottling works, and only a nominal valuation is given for such shipments. In other cases a much higher valuation is placed on the product where bottling works are located at the springs. The record does not include consumption of mineral waters for medicinal or bathing uses in connection with sanitaria, such as those located at St. Catharines and Preston Springs. Shipments reported were 209,072 imperial gallons, valued at $10,528.

Below are tabulated records of shipments for the past five years:

SHIPMENTS OF MINERAL WATERS, 1918–1922

	*1918	1919	1920	1921	1922
Imperial gallons	208,498	276,833	127,150	308,647	209,072
Value	$133,808	$19,290	$15,059	$14,438	$10,528

*The value includes containers in some cases.

Peat

Experimental work by the Peat Committee appointed jointly by the Ontario and Federal Governments was continued during the season of 1922 at the Alfred bog, east of Ottawa. The Fourth Report of this Committee, issued by the Ontario Department of Mines, was accompanied by an Appendix, being an interim statement, dated December 5, 1922, reviewing progress from 1918, the year of appointment.

The season for peat manufacture is about 100 days in southern Ontario. In 1921, 4,000 tons were made, but unfortunately a large part was lost through fire. In 1922 the output was 4,700 tons, of which 3,000 tons worth $14,500 were sold. A great improvement in the quality of peat made last year resulted from the use of a "Swing Hammer Pulverizer." In view of the fuel shortage in central Canada when the import of United States anthracite is curtailed, it is the part of wisdom to thoroughly investigate every possible source of a substitute fuel supply. Peat fuel has many good qualities, being best adapted for fall and spring burning and fireplace use. Its bulk, however, confines its use to within a radius of about 100 miles from point of manufacture.

To date some 46 Ontario peat bogs, convenient to transportation, have been surveyed by the Federal Department of Mines. These have a total area of 123,321 acres and contain approximately 110,000,000 short tons of peat fuel containing 25 per cent. moisture.

Petroleum

A report on "Petroleum in 1922," by R. B. Harkness, Natural Gas Commissioner, appears in Vol. XXXII, Part V. The following statistical tables, which are repeated here for convenience, are taken from the above-mentioned report.

CRUDE PETROLEUM PRODUCTION BY FIELDS, 1918–1922[1]

Field	1918	1919	1920[2]	1921	1922
	Bbls.	Bbls.	Bbls.	Bbls.	Bbls.
Petrolia and Enniskillen	65,467	70,087	65,082	68,484	64,934
Oil Springs	44,671	45,245	39,388	40,967	43,213
Moore township	6,367	4,029	7,036	7,536	7,274
Sarnia township	3,438	4,259	3,495	4,068	3,223
Plympton township	412	560	531	481	695
Bothwell	29,116	29,425	25,563	26,877	25,680
Dover, West } Tilbury	25,288	16,705	12,171	7,473	5,482
Tilbury, East } Tilbury		1,660	623	1,003	126
Raleigh township	....	....	(2)	3,320	663
Dutton	1,875	1,272	837	....	386
Onondaga township	1,186	197	341	566	489
Belle River	447	....	....	....	....
Mosa township	108,988	45,860	24,063	10,764	11,959
Thamesville	1,565	801	1,131	1,320	383
Dawn township	....	....	....	....	216
Total Production .... Bbls.	288,760	220,100	181,750	172,859	164,732
Value, including bounty	$781,097	$632,789	$724,145	$559,198	$466,587
Average price per bbl.[3]	$2.70½	$2.87½	$3.98½	$2.68½	$2.67

[1]Figures supplied by J. C. Waddell, Supervisor of Petroleum Bounties, Petrolia.

[2]Production for 1920 in Raleigh township was included with that of Dover, West.

[3]In addition, a bounty of 52½ cents per barrel (35 imperial gallons) is paid by the Federal Government under "The Petroleum Bounty Act."

Four refineries operated in the Province in 1922, as noted hereunder:

PETROLEUM REFINERIES, 1922

Company	Location of Refinery.	Days Operated	Head Office Address
British American Oil Co., Ltd	Toronto, Cherry St.	304	Toronto, Royal Bank Bldg.
Canadian Oil Companies, Limited	Petrolia	300	Toronto, Excelsior Life Bldg.
Cities Service Oil Co., Ltd	Wallaceburg	365	Wallaceburg
Imperial Oil, Limited	Sarnia	365	Sarnia

The table on page 27, summarized from annual reports of the Ontario Department of Mines for the years 1907-1920 and tables supplied by the Dominion Bureau of Statistics for 1922, shows refinery operations for the past five years:

CRUDE PETROLEUM AND REFINERY STATISTICS, 1918–1922

Schedule	1918	1919	1920	1921	1922[3]
Crude petroleum production					
Imp. gals.	10,106,615	7,703,515	6,361,234	6,050,062	5,756,602
[1]Value	$781,097	$632,789	$724,145	$559,198	$466,587
Imported Crude, distilled					
Imp. gals.	137,065,788	141,157,309	148,540,511	150,692,113	152,888,816
Value	$12,612,882	$12,486,174	$20,102,784	$14,537,339	$13,834,118
Ontario Crude, distilled					
Imp. gals.	9,513,222	7,693,385	6,402,118	5,880,086	5,612,645
Value	$781,703	$661,927	$769,775	$500,418	$462,346
Per cent. of total	6.49	5.17	4.13	3.75	3.54
Products					
Illuminating oil...imp. gals.	36,211,715	34,800,233	33,897,891	29,774,134	36,650,134
Value "	$4,239,816	$5,073,647	$6,331,706	$3,335,200	$4,077,350
Lubricating oil....imp. gals.	12,595,305	12,501,385	13,804,074	13,848,721	14,556,150
Value "	$2,118,002	$2,293,640	$3,276,569	$2,351,975	$2,558,278
Benzine, Naphtha, Gasoline.....imp. gals.	39,156,447	44,625,590	47,418,420	51,033,337	59,223,186
Value "	$10,244,328	$11,677,077	$14,485,935	$12,655,244	$13,920,089
[2]Gas and Fuel oil, Tar, imp. gals.	40,949,358	40,581,499	45,025,050	44,364,794	34,508,790
Value "	$2,943,503	$2,265,457	$5,486,636	$2,130,685	$2,510,427
Paraffin Wax and Candles, lbs.	13,650,128	10,903,202	10,398,127	10,777,994	12,063,768
Value "	$1,148,726	$1,044,798	$973,805	$310,267	$329,147
Employees..........Ave. No.	1,312	1,580	1,736	1,560	1,393
Wages paid	$1,486,677	$2,045,072	$2,695,507	$2,176,700	$2,018,765

[1]The value includes bounty paid to producers.

[2]Figures for 1921 and 1922 do not include Tar product, which was 18,971,400 pounds with selling value of $142,285 in 1921, and 8,186,013 pounds worth $265,150 in 1922.

[3]In 1922 there was also an output of 38,016 tons of acid and petroleum, valued at $263,034.

Quartz and Silica Brick

The production of quartz and silica brick during 1922 totalled 82,387 tons valued at $146,446 as against 72,068 tons worth $220,806 in the previous year. This large increase in quantity resulted from the resumption of mining quartzite at the Killarney quarry by the Electro-Metals, Limited, of Welland. At the same time the value, in common with those of many other commodities, fell off considerably. The bulk of shipments by this company go to Welland for the production of ferro-silicon. The Algoma Steel Corporation of Sault Ste. Marie manufactures its own silica brick and silica cement, the quartz coming from a quarry at Mile 19 on the Algoma Central Railway operated by Wright and Company. The Mond Nickel Company worked its quarry in Neelon township, the output going to the sme ter at Coniston for fluxing purposes. The quarry in Dill township of the International Nickel Company of Canada is drawn upon for fluxing material for the Copper Cliff smelter.

The following operated quarries and made shipments in 1922.

QUARTZ SHIPPERS, 1922.

Name of Owner, Firm or Company	P.O. Address of Operator	Location of Quarry
International Nickel Co. of Canada	Copper Cliff	Dill tp.
Mond Nickel Company	Coniston	Neelon tp.
Orser-Kraft Feldspar Company	Perth	Bathurst, Drummond and S. Sherbrooke tps.
Wright & Company	Sault Ste. Marie	Deroche tp.
Electro-Metals, Ltd	Welland	Killarney

Salt

The total quantity of salt sold or used by the nine producing companies during 1922 showed an increase of 15,717 pounds in quantity and a decrease of $69,870 in value. Details are given in the accompanying table. There were slight decreases in the quantities of fine, coarse, and pressed blocks including other grades. The nine salt plants operated are all situated in the south-western peninsula of the Province, between Kincardine on Lake Huron and Amherstburg on the Detroit river. Brine with salt equivalent of 48,253 tons was used in the chemical plant of Brunner Mond, Canada, Limited, at Amherstburg, and that of the Canadian Salt Company, Limited, at Sandwich. Chemicals produced include soda ash by the former company, while the latter turns out caustic soda, bleaching powder and liquid chlorine.

The following table gives details on Ontario's salt industry over a five-year period:

SALT STATISTICS, 1918–1922

Schedule	1918	1919	1920	1921	1922
Land ... tons	2,041	1,720	2,054	2,599	6,585
Coarse ... "	25,232	35,150	28,709	28,925	28,154
Fine ... "	53,908	47,571	39,663	36,074	34,684
Table and dairy ... "	34,324	34,396	42,474	40,931	41,119
Pressed blocks and other grades "	....	....	....	2,966	2,489
Brine (salt equivalent) ... "	16,221	29,275	93,712	50,529	63,710
Total sold or used ... "	131,726	148,112	206,612	161,024	176,741
Value "	$1,287,039	$1,395,368	$1,544,867	$1,643,527	$1,573,657
Employees* ... No.	312	296	338	264	409
Wages ...	$275,842	$319,463	$442,004	$311,205	$539,813

*Employees of chemical works are not included.

The list of companies producing brine or salt in 1922 was as follows:

OPERATING SALT COMPANIES, 1922

Name of Owner, Firm, or Company	Location of Wells or Works	P.O. Address of Manager, etc.
Brunner, Mond Canada, Limited	Amherstburg*	Amherstburg.
Canadian Salt Company, Limited, The	Windsor Sandwich*	Windsor.
Dominion Salt Company, Limited, The	Sarnia	Sarnia.
Elarton Salt Works Co., Ltd	Warwick	Watford, R.R. No. 5.
Exeter Salt Works Company, Limited	Exeter	Exeter.
Goderich Salt Co., Limited	Goderich	Goderich.
Western Canada Flour Mills Co., Ltd	Goderich	Goderich.
Western Salt Company, Limited	Courtright	Courtright.
Wingham Salt Works (Young Estate)	Wingham	Wingham.

*Chemical works using salt brine as raw material.

Talc and Soapstone

Shipments of crude and ground talc rose from 9,967 tons, valued at $140,390, in 1921, to 12,874 tons, worth $178,397 in 1922. There was a larger proportion of ground talc sold than in 1921, as the valuation figures indicate. The American Talc Corporation early in 1921 turned over its mill and the Connolly mine to the Asbestos Pulp Company, Limited. The latter company operated to September 1st, when the plant was shut down, becoming active again early in 1922 and continuing throughout the year. The Henderson mine, an adjacent property, delivered its entire output of 10,169 tons of crude talc to the mill of Geo. H. Gillespie and Company, Limited. Ground talc prices ranged from $12.83 to $14.13 per ton, depending on grade. The entire industry is centred at Madoc in Hastings county.

The United States is the largest talc-producing country. Consumption of ground talc in 1921, as reported by the United States Geological Survey, was as follows: paper, 38 per cent.; paint, 23; roofing, 18; rubber, 9½; textile, 4; toilet powder, 2½; other uses, 5 per cent.

A deposit of soapstone has been located near Wabigoon station, District of Kenora. It closely resembles the Alberene stone of Virginia in mineral composition. There is no record to date of soapstone of domestic origin having been used in a commercial way in this Province. The Wabigoon Soapstone Company, Limited, was organized during October to operate this deposit.

TALC STATISTICS, 1918-1922.

Schedule	1918	1919	1920	1921	1922
Crude talc shipped . . . tons	1,044	1,644	5,228	9,967	12,874
Ground talc shipped . . . "	16,421	15,927	15,131		
Total value of shipments	$246,691	$240,339	$306,319	$140,390	$178,397
Employees, mine and mill . . . No.	43	87	60	30	46
Wages paid	$41,936	$76,384	$77,818	$41,978	$53,295

The following companies and firms were engaged in the mining and milling of talc and soapstone during 1922.

TALC AND SOAPSTONE OPERATORS, 1922

Firm or Company	Location of Mine or Works	Address of Manager, etc.
Asbestos Pulp Company, Ltd	Huntingdon tp.	Madoc.
*Henderson Mines, Limited	Huntingdon tp.	Madoc.
Geo. H. Gillespie and Company, Ltd	Madoc (grinding mill).	Madoc.
Wood, H. H.	Mine Centre†	Mine Centre.

*The Henderson mine was operated under lease by Henderson Mines, Limited, the product going to the mill of Geo. H. Gillespie and Company.

†Soapstone deposit under development.

STRUCTURAL MATERIALS

After the general decline of wholesale prices which began in May, 1920, and a period of hesitation throughout 1921 in which large building programmes were held up through fear that the downward trend might continue, there followed in 1922 a marked expansion in the construction industry.

General Remarks

It was stated in the January, 1923, number of *The Canadian Building Review*[1] that in the whole field of Canadian business it was doubtful if the year 1922 could show any achievement more gratifying than the remarkable expansion of building. At the end of 1922 after two trying and uncertain years conditions were restored as nearly as possible to normal, as indicated by the greater productivity of labour, freer movement of capital and the comparative stability attained by material costs. During 1922 in Ontario the total cost of new work was placed at $166,628,000, of which $61,000,000 was credited to residential, $56,000,000 to engineering, $40,000,000 to business, and $10,000,000 to industrial construction. The figures for costs of new construction in this Province have shown a steady rise: in 1918, 33 millions; 1919, 87 millions; 1920, 108 millions; and in 1921, 114 millions of dollars, which increased in 1922 as mentioned above to 167 millions of dollars.

Reports received by the Dominion Bureau of Statistics from municipal officials showed that the value of the building permits issued in 25 cities in Ontario making returns increased during 1922 by $17,969,775 over the preceding year; the figures were $67,246,774 in 1922 as against $49,276,999 in 1921.

Clay Products

The clay products industry is widely distributed throughout Ontario but, as might be expected, depends on favourable deposits of clay advantageously situated with regard to transportation and large centres of population. The industry is therefore highly developed in York, Peel, Halton and Wentworth counties in proximity to the cities of Toronto and Hamilton, as well as in other counties of southwestern Ontario, where the bulk of drain tile production is consumed. Many of the smaller and less efficient clay-working plants which closed down during the war have not reopened as the present-day tendency is towards larger production in better equipped plants. The Canadian National Clay Products Association continued to influence the industry in the way of standardization of products and the application of improved methods of manufacture.

Like all other materials brick rose to its highest price level during 1920 and has since gradually declined. While the pre-war quotations may not soon be reached, decreases in fuel, labour and other costs will no doubt be reflected in the prices of clay products. In 1915 the average price of common brick was $7.96 per thousand, which advanced to $13.92 in 1919 and $17.74 in 1920; receded to $17.68 in 1921 and to $17.56 in 1922.

The total value of brick, drain and structural tile, sewer pipe and pottery increased from $5,094,696 in 1921 to $6,944,218 in 1922, and with the exception of drain tile showed gains in each commodity, as may be noted in the table, which follows:—

[1]MacLean Building Reports, Limited, Toronto.

VALUE OF CLAY PRODUCTS SOLD OR USED, 1913-22

Year	Brick		Pottery	Drain Tile	Sewer Pipe	Total
	Common	Pressed, Fancy, Building Tile, etc.				
	$	$	$	$	$	$
1913	3,283,894	1,162,860	52,875	292,767	600,297	5,392,693
1914	2,336,207	894,381	25,720	277,530	571,750	4,165,597
1915	763,591	375,865	49,387	321,253	361,283	1,871,379
1916	509,559	495,895	87,025	275,471	216,749	1,584,699
1917	713,824	776,302	94,501	546,040	379,923	2,509,590
1918	665,454	592,286	88,275	309,899	362,536	2,018,450
1919	1,966,711	726,500	119,551	354,700	609,100	3,776,562
1920	2,209,265	1,178,656	127,049	359,373	860,811	4,735,154
1921	2,025,643	2,059,606	69,984	397,104	939,463	5,094,696
1922	2,614,120	2,899,205	88,889	368,180	973,824	6,944,218

Following is a list of 150 brick and tile operators who reported an output in 1922:—

BRICK AND TILE PLANTS, 1922

Name	Address	Product
Atlas Brick Co., Ltd.	Toronto, 30 Toronto St.	Pressed brick.
Alvinston Brick and Tile Co., Ltd.	Alvinston	Common brick, Hollow tile.
Armstrong Brothers	Fletcher	Tile.
Batchelor, Samuel	Proton	Brick and tile.
Baird & Son, H. C.	Parkhill	Brick and tile.
Bechtel, B. E.	Waterloo	Brick.
Bennett, Robert	Dunnville, Box 21	Brick and tile.
Booth Brick and Lumber Co., Ltd.	New Toronto	Pressed brick.
Brampton Pressed Brick Co.	Brampton	Pressed brick and tile.
Broadwell & Son, B.	Kingsville	Tile, brick and blocks.
Brownscombe, H.	Cargill	Brick and tile.
Bond, Samuel	Woodstock, R.R. 5	Brick.
Campbell, Neil F.	West Lorne, R.R. 1	Brick and tile.
Canadian Pressed Brick Co., Ltd.	Hamilton, 36 Sun Life Building	Pressed brick.
Chapman, John	Napanee	Brick and tile.
Cheeseman, Peter	Hamilton, 670 King St., W.	Brick.
Cooksville Shale Brick Co., Ltd.	Toronto, 26 Queen St., E.	Brick.
Cornhill, Jas., & Sons, Ltd.	Chatham, Grand Ave. E.	Brick.
Cooper, W. H.	Hamilton, 104 Clyde Block	Brick.
Crang, Jethro	Toronto, 2 Regal Rd.	Brick.
Crawford Bros.	Hamilton, King and Macklin Sts.	Brick.
Curtin, Frank	Lindsay	Brick.
Curtis Bros.	Peterboro, Box 809	Brick and tile.
Dalton, Maurice	Dresden, R.R. No. 3	Tile.
DeLaplante, J. E., & Co.	Toronto, 1000 Gerrard St., E.	Brick.
Deller, Albert E.	Vienna	Brick, tile and blocks.
Deller Bros.	Norwich, R.R. No. 2	Brick, tile and hollow blocks.
Dockhart Brick & Tile Works	Arnprior	Brick and tile.
Dolan, John	Watford, R.R. No. 2	Tile.
Dominion Sewer Pipe and Clay Industries, Limited	Aldershot and Swansea	Brick, blocks and tile.
Don Valley Brick Works	Toronto, 714 Dominion Bank Building	Brick and blocks.
Dublin Brick and Tile Company	Dublin	Brick and tile.
Elliott, Charles	Bluevale	Brick and tile.

BRICK AND TILE PLANTS, 1922—*Continued*

Name	Address	Product
Elliott, Wm	Glenannan	Brick and tile.
Elliott, Jas., Jr	Sault Ste. Marie, 519 Wellington St. N	Common and rug brick.
Erie Clay Products, Ltd	Port Dover	Blocks and tile.
Forman, S. H	St. Marys	Brick and tile.
Fort William Brick and Tile Company	Fort William, 509 Victoria Avenue	Brick.
Fox, Geo. J	Dresden	Brick.
Fraser & Leith	Blyth	Brick and tile.
Frid Bros	Hamilton	Brick.
Frid, Geo., Company	Hamilton, Main St., W	Brick.
Gardiner, William	Blenheim	Brick and tile.
Godfrey & Co., Thos	Carleton Place	Brick.
Grigg, William	Thedford, R.R. No. 1	Tile.
Haines, W. H. J	Toronto, C.P.R. Bldg	Brick.
Hallatt, Wm	Merlin	Tile.
Hallatt & Son, H	Comber	Brick, tile and blocks.
Halton Brick Co., Ltd	Terra Cotta	Pressed brick.
Hamilton Pressed Brick Co., Limited	Hamilton, Kensington Ave. S	Pressed brick.
Hill, Aaron	Essex	Tile.
Hill, A. W	Coatsworth, R.R. No. 1	Brick and tile.
Hill, Jas. S., & Son	Madoc	Brick.
Hinde Bros	West Toronto	Brick.
Hircock Bros. & Company	Bowmanville	Brick and tile.
Hitch, D. A	Ridgetown	Brick and tile.
Hitch, Thos	St. Thomas, Box 254	Brick and tile.
Hodder, J. H	Dutton	Brick and tile.
Holland & Son, William	Ruscomb	Brick and tile.
Howlett, Fred	Petrolia	Brick and tile.
Huntsville Brick Co	Huntsville, Box 308	Brick.
Interprovincial Brick Co. of Canada, Ltd., The	Toronto, 30 Toronto St	Pressed brick.
Jackson Bros	Brantford	Brick.
Janes, D. A	Mt. Brydges	Brick and tile.
Jamieson Lime Co	Renfrew	Brick and tile.
Jasperson Brick and Tile Co	Kingsville	Brick, hollow blocks and tile.
Jervis & Son, John	Dorchester Station	Brick and tile.
Johnson, Jas., Sr	Pembroke, R.R. No. 3	Brick.
Kerr, Fred	Crediton	Brick.
Kerr and Pettman	Goderich	Brick and tile.
Koebel, Joseph Z	St. Clements	Tile.
Kruse Bros	Seaforth, R.R. No. 3	Brick and tile.
Kuhn, Henry H	Centralia, R.R. No. 2	Tile.
Lisbon Brick and Tile Yard	Wellesley, R.R. No. 1	Brick and tile.
Lowes, Gordon	Chatham, R.R. No. 3	Brick and tile.
Labey & Son, Geo. A	Foxboro	Tile.
Lindsay, Earl	Wallaceburg	Tile.
MacKay Bros	Dutton	Tile.
Martin Estate, David	Thamesville	Tile.
McCormick Bros	Watford, R.R. No. 5	Brick and tile.
McCoomb, Chester	Denfield, R.R. No. 2	Brick, blocks and tile.
McCue, T. J	Kincardine	Tile.
McGregor and Gammage	Dresden, R.R. No. 2	Tile.
McIvor Bros	Cobourg, Box 636	Brick.
McMahon, Robert	Kerwood, R.R. No. 2	Tile.
Midland and Penetanguishene Brick Works	Penetanguishene	Brick.
Merkley's, Ltd	Ottawa, 53 Queen St	Brick.
Middleton, Chas	Wyoming	Tile.
Milton Pressed Brick Co., Ltd	Milton	Pressed brick.
Miner, J. T	Kingsville, R.R. No. 2	Tile.
Missouri Tile Yard (W. H. Deller)	Thorndale, R.R. No. 4	Tile.
Moscow Brick and Tile Works	Greenock, R.R. No. 1	Brick and tile.
National Fire Proofing Co. of Canada, Ltd.	Toronto, 601 Dominion Bank Building	Tile and blocks.

BRICK AND TILE PLANTS, 1922—*Continued*

Name	Address	Product
National Slag Products, Ltd	Hamilton, Gage Ave. N	Blocks.
New, Edward	Hamilton, Dundas Rd	Brick.
O'Dell, & Sons, Wm	Ingersoll	Brick, tile and blocks.
Ontario Brick and Tile Plant	Mimico	Brick, tile and blocks.
Ontario Paving Brick Co., Limited	West Toronto	Brick.
Ollman Bros	Hamilton, Macklin St	Brick.
O'Reilly, T. E	Ottawa, 320 Bay St	Brick.
Ott Brick and Tile Mfg. Co., Ltd., The	Kitchener	Brick, tile and blocks.
Ottawa Brick Mfg. Co., Limited, The	Ottawa, 53 Queen St	Brick.
Owen Sound Brick Co., Limited, The	Owen Sound	Brick.
Paxton & Bray	St. Catharines, Queenston Street	Brick.
Pears & Son, James	Toronto, Eglinton Ave., W.	Brick.
Pembroke Brick Co., The	Pembroke	Brick.
Phillips & Son, Thos	Lucknow, R.R. No. 2	Tile.
Phippen & Field	Toronto, Dawes Road	Brick.
Parks, H. W	Dresden, Box 477	Tile.
Phinn Bros	London, St. James Park	Brick and tile.
Piggott & Co., Geo	Mount Dennis, 20 Guestville Ave	Brick.
Port Credit Brick Co., Limited, The	Port Credit	Pressed brick.
Price & Cumming	Humber Bay, Salisbury Avenue	Brick.
Price & Smith	Toronto, 458 Greenwood Avenue	Brick.
Price, Ltd., Jno	Toronto, 395 Greenwood Avenue	Brick.
Port Rowan Brick & Tile Co	Port Rowan	Brick, blocks and tile.
Quinte Brick Works, Bay of	Belleville, R.R. No. 4	Brick.
Red Star Brick and Tile Yard	Stratford	Brick.
Reid, Jas	Belmont, R.R. No. 3	Brick and tile.
Richardson & Son, James	Kerwood	Brick and tile.
Russell, J	Toronto, 329 Leslie St	Brick.
Russell Shale Brick, Ltd	Ottawa, Standard Bank Building	Brick.
Shale Products, Ltd	Inglewood	Brick.
Snelgrove, A	Beaverton	Brick and tile.
Sproat, Wm. M	Seaforth, R.R. No. 4	Brick and tile.
Standard Brick Co., Ltd	Toronto, 363 Broadview Avenue	Brick.
St. Joseph Brick & Tile Yard	Zurich	Tile.
Smith & Son, Alex	Dutton, R.R. No. 2	Brick and tile.
Steele, Edwin	Vankleek Hill	Brick.
Staples Brick & Tile Co	Staples	Tile.
Streetsville Brick Co., Ltd., The	Streetsville	Brick.
Stroh, M. C	Conestogo	Brick and tile.
Superior Tile Co., Limited	Fort William	Common and Tapestry Brick.
Sun Brick Co., Ltd	Toronto	Tile.
Tilbury Brick and Tile Co., Ltd., The	Tilbury	Brick, tile and blocks.
Tope Estate, Richard	Hamilton, 171 Queen St. S.	Brick.
Toronto Brick Co., Limited	Toronto, 60 Victoria St	Brick.
Tweed Brick & Tile Works	Belleville, R.R. No. 4	Brick.
Wagstaff and Co., A. H	Toronto, 348 Greenwood Avenue	Brick.
Wagstaff, Charles	Lindsay, R.R. No. 4	Tile.
Waite, John E	Forrester Falls	Brick and tile.
Wallace & Sons, R	North Bay	Brick.
Watson Brick Co	Crediton	Brick and tile.
Whitby Brick and Clay Products Co., Ltd.	Whitby, Box 96	Brick.
Wilson, Samuel, and Sons	Paisley, R.R. No. 2	Brick and tile.
Winch Bros	Paisley, Box 220	Brick and tile.
Windsor Brick and Tile Co	Windsor, 201 Exchange Building	Brick, tile and blocks.
Woodslee Brick and Tile Co	Woodslee	Brick and tile.
Wright & Sons, Geo	Comber, Box 56	Tile.

Sewer pipe is produced by three firms. Clay suitable for this ware is found at Aldershot, near Hamilton. Only the rougher types of pottery such as flower pots and crockery are made from domestic clay. Some finer glazed ware is produced but the clay is imported. Following are the makers of these two kinds of clay products:—

SEWER PIPE AND POTTERY WORKS, 1922

Name of Company	Location of Plant and P.O. Address of Manager, etc.
SEWER PIPE	
Dominion Sewer Pipe and Clay Industries, Ltd.	Swansea.
Hamilton & Toronto Sewer Pipe Co., Ltd.	Hamilton, Wentworth St. N.
Ontario Sewer Pipe & Clay Products, Ltd.	Mimico.
POTTERY	
R. Campbell's Sons	100 Locke St. South, Hamilton.
Davis & Son, John	601 Merton St., Toronto.
Foster Pottery Company	Main St. West, Hamilton.

Northern Ontario Clays

In 1921, D. G. H. Wright, now geologist for the Dome Mines, reported for the Department on the Black River area. Brick manufactured by the Matheson Brick Company from clays in the township of Bowman were taken for test to Queen's University and the laboratory work was done at Kingston in February, 1922, by William Greenwood, field assistant to Mr. Wright, under the supervision of Prof. Alexander Macphail. Mr. Greenwood reports as follows:—

The absorption test for the red brick showed an increase in weight of 15.9 per cent. when saturated and the white brick 18.9 per cent. In the transverse test the former showed a modulus of rupture of 923 pounds per square inch and the latter 151 pounds. The compressive strength of half bricks tested on edge averaged 3,240 pounds per square inch for the red brick and 2,630 pounds for the white.

All tests are those specified by the American Society for Testing Materials and were carried out as prescribed by them with the one exception that they call for at least five bricks of each kind to be tested whereas we had only one. On sheet No. 2 is given a table showing ratings as adopted by the A.S.T.M. and the requirements for these ratings.

On comparing these with the results obtained it will be seen that the red brick may be classed as a hard brick, which is the highest classification possible for a brick made by the wire-cut process. The white or tapestry brick did not show up nearly as well, but I do not think this brick should be taken as a representative one. Upon immersion in water it showed considerable evidence of containing quantities of lime localized at different points and the low transverse bending strength was undoubtedly caused by these particles of lime slaking during the absorption test, thus expanding and weakening the brick. While no cracks were visible on the surface of the brick after the absorption test, under the transverse test the brick cracked along several longtitudinal lines. This shows that the brick must have been weakened along these lines due to the expansion mentioned above, for under ordinary conditions the brick will only break crosswise under the transverse test.

STANDARDS OF AMERICAN SOCIETY FOR TESTING MATERIALS

Name of Grade of Brick	Absorption Limits		Compressive Strength on Edge. (Lbs. per sq. in.)		Modulus of Rupture (Lbs. per sq. in.)	
	Mean of 5 Tests	Individual maximum, per cent.	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Vitrified	5 or less	6.0	5,000 or over	4,000	1,200 or over	800
Hard	5 to 12	15.0	3,500 or over	2,500	600 or over	400
Medium	12 to 20	24.0	2,000 or over	1,500	450 or over	300
Soft	Over 20	No limit	1,000 or over	800	300 or over	200

Undoubtedly northern Ontario will require more brick in the future than in the past to meet requirements in mining camps and towns, and it would appear that local clays may be used for the purpose as long haulage makes the price of brick from southern Ontario prohibitive.

Portland Cement

The capacity of the plants operated during the year was 10,700 barrels per day. An average of 768 men were employed, and wages amounted to $990,997.

Following is a list of the operating plants:—

PORTLAND CEMENT PLANTS OPERATING IN 1922

Company	Location of Plant	Head Office Address
Canada Cement Company, Ltd.		Herald Bldg., Montreal, Quebec.
Plant No. 4	Thurlow tp.	
Plant No. 8	Port Colborne	
Hanover Portland Cement Co., Ltd., The	Hanover	Hanover.
St. Marys Cement Co., Limited	St. Marys	St. Marys.

The following table gives details of the industry during the past decade:—

PORTLAND CEMENT STATISTICS, 1913-1922

Year	No. of Operating Plants	Stock on hand Dec. 31st bbls.	Sales		Average Price per bbl. (350 lbs.)
			Barrels	Value	
				$	$
1913	13	450,213	3,802,321	4,105,455	1.08
1914	11	846,562	2,665,650	2,931,190	1.10
1915	7	755,799	2,302,242	2,534,537	1.10
1916	7	380,458	2,143,949	2,242,433	1.05
1917	6	567,261	2,063,231	2,934,271	1.42
1918	4	473,184	1,226,244	1,910,839	1.56
1919	5	278,188	2,022,575	3,659,720	1.81
1920	5	248,142	2,035,594	4,377,814	2.15
1921	5	174,686	2,723,072	6,425,266	2.37
1922	4	396,911	3,104,386	6,235,370	2.01

In the United States the factory price per barrel of 380 pounds ranged from $1.61 in Illinois to $2.40 in Washington, the average price being $1.76 per barrel.

Cement Products.—Although the value of these building materials is not included in Table I, the output of cement brick, artificial stone, concrete, drain tile and sewer pipe, blocks, caps, sills, etc., is considerable, as will be seen from the detailed statistics which follow covering the past five years:—

CEMENT PRODUCTS STATISTICS, 1918-1922

Schedule	1918	1919	1920	1921‡	1922‡
Brick	$1,290	$10,631	$11,117	$9,235	$25,244
Blocks, sills and caps	41,362	147,895	382,994	409,722	479,949
Drain tile	81,351	142,072	338,286	70,412	45,570
Sewer pipe and culvert tile				317,811	293,322
Artificial stone and other products	......	......	......	87,701	109,705
Total value of output	$124,003	$300,598	$732,397	$894,881	$953,790
Number of operating plants	......	......	48	86	103
Employees	72	148	218	230	210
Wages	$25,901	$90,653	$212,014	$212,372	$207,417

‡ Reported to Dominion Bureau of Statistics, Ottawa.

Lime

Statistics of both quicklime and hydrated lime marketed or used during the past five years are given in the following table:—

LIME STATISTICS, 1918-1922

Year	Hydrated Lime** Marketed			Quicklime Marketed or Used			Fuel Cost	Employees	Wages
	Tons	Total Value	Per Ton	Bush. (70 lbs.)	Value	Ave. Price per bush.			
		$	$		$	c.	$		$
1918	14,865	132,748	8.93	2,650,285	872,177	32.9	237,425	287	300,746
1919	22,743	226,455	9.96	3,341,772	1,041,835	30.8	302,144	363	366,686
1920	28,591	397,305	13.89	4,166,026	1,402,458	33.6	546,604	448	568,513
1921	26,863	381,749	14.58	2,763,062	962,439	34.8	....	366	341,826
1922	36,408	455,980	12.52	3,939,954	1,311,563	33.3	312,825	425	408,731

** Hydrated lime statistics for 1918 and 1919 from Mines Branch, Ottawa.

Below are given the names of producers and the location of plants operated in 1922:—

LIME PRODUCERS, 1922

Name of Owner or Company	Location of Kilns	Head Office Address
Alabastine Co., Paris, The (*)	Elora and Teeswater	Paris.
American Cyanamid Co (†)	Niagara Falls	Niagara Falls.
Beachville White Lime Co., Ltd	Beachville	Beachville.
Bergin, Patrick	Napanee	Napanee.
Brunner Mond Canada, Limited (†)	Anderdon tp., near Amherstburg.	Toronto, Bank of Commerce Building.
Biederman, A. G	Golden Lake	Golden Lake, R.R. No. 1.
Cameron, W. M	Carleton Place	Carleton Place.
Chalmers Lime Works	Owen Sound	Owen Sound.
Christie, Henderson & Co., Limited	Hespeler (*), Galt, Puslinch, Kelso.	Toronto, 201 Crown Office Building.
Dominion Sugar Company (†)	Chatham, Wallaceburg and Kitchener.	Chatham.
Flieler, Edward	Clarendon tp	Fernleigh.
Gallagher Lime and Stone Co., Limited	Barton tp	Hamilton.
Harvey, E., Limited	Rockwood	Guelph.
Jamieson Lime Co	Renfrew	Renfrew.
Jamieson, J. M	Ross tp	Forrester Falls.
Marshall, James	Barton tp	Hamilton.

*Producers of hydrated lime. †For use in chemical plants.

LIME PRODUCERS, 1922—*Continued*

Name of Owner or Company	Location of Kilns	Head Office Address
O'Donohue, Michael	Campbellford	Campbellford.
Parks Bros	Beverley tp	Troy.
Robertson Co., Limited, D	Nassagaweya tp	Toronto, 26 Queen St. E.
Smith, John S	Kincardine	Kincardine.
Standard White Lime Co., Limited	Beachville, Guelph (*)	Guelph.
Standard Chemical Company, Ltd. (*)	Eganville	906 Drummond Bldg., Montreal, Que.
Toronto Brick Co., Limited	Coboconk	Toronto, 60 Victoria St.
Toronto Lime Co., Limited	Dolly Varden	Toronto, 26 Queen St. E.
Toronto Plaster Co., Limited, The (*)	Teeswater	Teeswater.
Vogan, Samuel	Wiarton	Wiarton.
Weppler, Henry	Glenelg tp	Priceville, R.R. No. 2.

*Producers of hydrated lime.

Sand-Lime Brick

Brick are made from sand and lime by compressing these materials in moulds and subjecting the resulting product to a steam bath. These brick find a ready market, particularly as inside brick, the cost being less than for the clay product. The industry is confined almost exclusively to Toronto and vicinity. Two new plants (Don Valley and Harbour Brick) commenced operations in 1922.

Eleven plants operated in 1922, the output being 52,749 thousand worth $851,007, or an average of $16.13 per thousand. The industry gave employment to 199 men whose wages totalled $233,287. Production in 1921 was 36,482 thousand, worth $534,531, or an average of $14.64 per thousand.

The following plants were operated during the year:—

SAND-LIME BRICK PRODUCERS, 1922

Name	Location of Plant	Address
Caledon Brick Co., Ltd	Caledon E	171 Yonge St., Toronto.
Canada Sand-Lime Pressed Brick Co., Ltd.	West Toronto	28 Symes Rd., Toronto.
Don Valley Brick Works, Ltd	Toronto	Dominion Bank Bldg., Toronto.
Harbour Brick Company, Ltd	Bathurst St. Dock, Toronto	Lumsden Bldg., Toronto.
Toronto Brick Co., Limited	Scarboro and Swansea	60 Victoria St., Toronto.
West Lake Brick and Products Co	West Lake	R.R. No. 1, Picton.
Willcox Lake Brick Co., Ltd	Whitchurch tp	Richmond Hill.
York Sandstone Brick Co., Ltd	Gerrard St. and Victoria Avenue.	E. Toronto.

Sand and Gravel

Exclusive of the material excavated by railway companies and used as ballast or for concrete, the sand and gravel production in Ontario during 1922 totalled 3,576,420 tons with a selling value of $1,816,320. Sales consisted of 154,440 tons of moulding sand, worth $105,864; 1,160,833 tons building sand, worth $836,920; core sands, 104,962 tons, value $33,620; sand for concrete and road building, 1,911,849 tons, worth $712,330; railway ballast supplied by private producers, 130,950 tons, valued at $62,427; and crushed gravel, 113,386 tons, worth $65,159. Railway companies produced and consumed 367,854 tons for various purposes.

During the period, seventeen companies licensed by the Ontario Department of Mines, carried on dredging operations in the Great Lakes, Rainy lake, St. Clair, Thames and Niagara rivers, and produced 860,979 tons of sand and gravel worth $447,090, which is included in the figures given above and also in Table I.

Following is a list of sand and gravel pit operators who marketed or used 1,000 cubic yards or more during the year:—

SAND AND GRAVEL OPERATORS, 1922

Name of Owner or Company	Material G=Gravel S=Sand	Location of Deposits	Address
Adelaide, Municipality of	S. and G.	Adelaide tp., lots 1 and 7, con. III, and 3, con. IV.	Arkona.
Aldborough, Township of	G.	Aldborough tp., lot A, con. VII.	Rodney.
Allan Bros	S. and G.	Stop 19, Kingston Rd.	Toronto, 60 Birchcliffe Ave.
Allan, Mrs. M	S.	Grantham tp., lot 7, con. II.	St. Catharines, R.R. No. 4.
Armstrong Supply Co., Ltd., The	S.	1143 York St., Hamilton.	Hamilton, 34 James St. N.
Ashton & Sons, E	S.	Scarborough tp., Victoria Park, W.	Toronto, 1354 Queen St. E.
Atkinson, Wm	S. and G.	Seymour tp., lot 12, con. VII.	Campbellford.
Burrows, John	S.	Widdifield tp.	North Bay.
Baxter, Jas	S.	Dereham tp., lot 16, con. X.	Brownsville.
Bellyou, Norman E	S. and G.	Murray tp., lot 6, con. I.	Trenton, R.R. No. 4.
Bennett, Sarah	S.	Scarlett Rd., York tp.	Toronto, 145 Caledonia Rd.
Benson & Patterson	S. and G.	Stamford tp., lots 17, 18	Stamford.
Blair & Son, James	S.	Fitzroy tp., lot 22, con. IV.	Arnprior.
Boyd Bros	G.	Osgoode tp., lot 27, con. IV.	Osgoode.
Brantford, Corporation of City of	S. and G.	Brantford tp.	Brantford, City Hall.
Brown & Sons, Wm	S. and G.	Smith tp., lot 19, con. III and lot 18, con. II.	Peterborough, Box 784.
Bourne & Son, John	S.	Scarboro tp.	Kingston Road.
Carroll Bros	S.	Humberstone tp., lots 3—9, con. I.	Buffalo, N.Y., 490 Ellicott Square.
Conlon, John J	S.	Pelham tp., lot 4, con. VIII.	St. Catharines, 31 Maple St.
Construction and Paving Co. of Ontario	S. and G.	Erin tp.	Toronto, 708 Confederation Life Bldg.
Collège du Sacré-Coeur	S.	Kingston Road.	Scarboro.
Elgin, County Highways	S. and G.	Yarmouth tp., lot 3, con. IV; Aldborough tp., lot C, con. VII; Southwold tp., lot 13, con. V.	St. Thomas, Court House
Ellins, Wesley	S.	Lot 16, con. C, Etobicoke tp.	West Toronto.
Empire Limestone Co	S.	Sherkston, Welland co.	Buffalo, N.Y., 19 Hudson St.

SAND AND GRAVEL OPERATORS, 1922—*Continued*

Name of Owner or Company	Material G=Gravel S=Sand	Location of Deposits	Address
Faulds, Morley	S. and G.	Southwold tp., lots 12 and 14, con. V.	Iona Station, R.R. No. 4.
Forbear Sand and Gravel Co	S.	Vaughan tp., lot 22, con. III.	Maple.
Foster, R.R	S. and G.	Ottawa, Gloucester tp.	Ottawa, 278 Echo Drive.
Frid Bros	S. and G.	Hamilton, Dundas Rd. and Macklin St.	Hamilton, Dundas Rd. and Macklin St.
Godson Contracting Co., Ltd	S. and G.	Brock tp., lot 12, con. IV.	Toronto, 113 Manning Chambers.
Gole, G	S.	Preston	Preston.
Guelph, City of	G.	Guelph	Guelph, City Hall.
Hamilton Sand and Gravel, Ltd	S. and G.	Burlington Heights	Hamilton, 110 Queen St. N.
Iroquois Sand and Gravel Co., Ltd.	S. and G.	Scarborough tp., lot 9, con. II.	Toronto, 1107 Royal Bank Bldg.
Johnston, G. F	S.	Westminster tp., lot 21, Con. V.	Wilton Grove, R.R. No. 2.
Johnston, Peter	S.	Manor Park	London, 51 Briscoe St.
Kent, County of	S.	Raleigh tp	Chatham.
Kilbourne & Son, Harvey	S.	Westminster tp., Wharncliffe Rd.	London, 9 Cove Road.
Kingston Sand and Gravel Co	S.	Kingston tp., lots 33-34, con. V.	Kingston, 179 Stuart St.
Larter, Chas	S. and G.	North Dumfries tp	Galt, 76 Chalmers St.
Lambton, County of	S.	Enniskillen tp., lot 9, con. XIII.	Sarnia.
Le Viness & Sons, A	S.	Stamford tp., lot 37	Stamford.
Malahide tp	G.	Malahide tp., lot 21, con. VI.	Aylmer.
Malloy, Wm. B	S. and G.	Ellice tp., lot 8, con. IV.	Sebringville, R.R. No. 1.
Maple Sand, Gravel and Brick Co.	S. and G.	Vaughan tp., lots 21-24 con. III.	Toronto, 454 King St. W.
McAllister, Wm	G.	Guelph tp., N. lot 3, div. E, con. I.	Guelph, 247 Woolwich St.
McLean & Son, A. B	G.	Parke tp	Sault Ste. Marie, 129 Spring St.
Middlesex, County of	S. and G.	Numerous places	London, County Bldgs.
Moyer, Lovelace Co., Ltd	S.	Pelham tp., lots 6 and 7, cons. VIII and IX.	St. Catharines.
Moore, John	G.	East Williams tp., lot 8, con. II.	Ailsa Craig.
Oakland Sand and Gravel Co	S. and G.	Oakland tp., con. III.	Niagara Falls.
Ollman Bros	S.	Hamilton, Macklin St.	Hamilton, Macklin St.
Ontario Highways Dept	S. and G.	Numerous pits	University and Dundas Sts., Toronto.
Paris Sand and Gravel Co	S. and G.	S. Dumfries tp., lot 34, con. 1.	Paris, R.R. No. 2.
Ponsford, A. E	S. and G.	Yarmouth tp., lot 1, con. VII.	St. Thomas, 605 Talbot St.
Porter, Thompson	S.	York tp., lots 28 and 29	Mt. Dennis, 866 Weston Road.
Quigley, B. C	S. and G.	Saltfleet tp., lot 29, con. III.	Hamilton.
Redden, Henry	S. and G.	Campbellford, Kent St.	Campbellford.
Rideau Canal Supply Co., Ltd	S.	Hogs Back, Gloucester tp.	Ottawa, Rideau Canal Basin.
Sand and Supplies, Ltd	S. and G.	Waterloo Co., near Ayr	Toronto, 54 University Ave.
Sarjeant Co., The	S. and G.	Barrie, James and Penetang Streets.	Barrie, Dunlop St.
Shannon, Hiram L	S. and G.	Richmond tp., lot 6, con. III.	Napanee, R.R. No. 5.
Shirk, Geo. M	S. and G.	Bridgeport	Bridgeport.

SAND AND GRAVEL OPERATORS, 1922—*Continued*

Name of Owner or Company	Material G=Gravel S=Sand	Location of Deposits	Address
Skinner, Robt	G.	Usborne tp., lot 11, con. V.	Exeter.
Sleeman, P	S. and G.	Hope tp., lot 9, con. II.	Port Hope.
Smith Estate (F. S. Scott)	S. and G.	N. Dumfries tp., lot 8, con. XII.	Galt.
Smith, Edward	S. and G.	Howard tp., lot 16, con. IX.	Ridgetown, R.R. No. 3.
Smith, McMillan & Fineout	S. and G.	McGregor tp.	Fort William, 12 Royal Bank Bldg.
Smythe, Ltd., C	S.	Etobicoke tp.	Toronto, 477 Runnymede Rd.
Stothart, James	S.	Smith tp., lot 17, con. II.	Peterborough, R.R. No. 4.
Stover, Elmer	S. and G.	Tillsonburg	Tillsonburg.
Thompson, George	S.	Widdifield tp.	North Bay.
Thompson, Peter	S. and G.	....	Ottawa, R.R. No. 1.
Townsend, Township of	G.	Townsend tp., con. V.	Waterford.
West Hawkesbury, Township of	S. and G.	W. Hawkesbury tp., lot 14, con. VI.	Vankleek Hill.
White & Co., Homer	G.	Hallowell tp., lot 22.	Picton.
Willox, Hervey	S.	Stamford tp., part lots 4 and 17.	Niagara Falls, 209 Bridge St.
Windsor Sand and Gravel Co., Ltd.,	S. and G.	Two miles west of Leamington.	Windsor, 57 Hall Ave.
Wright & Co	S.	Korah tp., sec. 13	Sault Ste. Marie, 960 Queen St.
Yack, Henry	S.	London tp., lot 12, con. II.	London.
Yarmouth, Township of	S.	Yarmouth tp., lot 8, con. V.	St. Thomas, Southern Loan Chambers.
York Sand & Gravel, Ltd	S. and G.	Gerrard St., Victoria Park Ave.	Toronto.

The following companies holding sand and gravel licenses from the Department of Mines carried on dredging operations during the period:—

SAND AND GRAVEL LICENSEES, 1922

Licensee	Location	Address
Cadwell Dredging Company	St. Clair river	Windsor.
International Sand & Gravel Company	St. Clair river	Detroit, Mich.
Northern Sand & Gravel Company	St. Clair river	Sarnia.
Chick Contracting Company	St. Clair river	Windsor.
National Sand & Material Company	Lake Erie	Welland.
Lake Erie Sand Company	Lake Erie	Sandusky, Ohio.
Homegardner Sand Company	Lake Erie	Sandusky, Ohio.
Cadwell Dredging Company	Lake Erie (S.E. shoal)	Windsor.
Cadwell Dredging Company	Lake Erie (old dummy)	Windsor.
Harbour Brick Company	Lake Ontario	Toronto.
P. Lyall & Sons Construction Company	Lake Ontario	Montreal, Que.
MacDonald, A. G	Lake Ontario (stone)	Bronte.
MacDonald, A. N	Lake Ontario (stone)	Bronte.
Pickard, L	Lake Ontario (stone)	Bronte.
A. B. McLean & Son	Lake Superior	Sault Ste. Marie.
Lapish & Small	Lake Superior	Sault Ste. Marie.
Smith, McMillan and Fineout	Lake Superior	Fort William.
Great Lakes Transportation Company	Thunder Bay	Fort William.
J. E. Carroll and T. E. Milburn (Niagara Sand Corporation)	Niagara river	Buffalo, N.Y.
Chatham Sand & Gravel Company	Thames river	Chatham.
C. & J. Hadley Company	Thames river	Chatham.
Ontario & Minnesota Power Company	Rainy lake	Fort Frances.

In all 528,193 cubic yards of gravel were excavated for which the Province received $83,453.71 in royalties. Removals were as follows: River St. Clair, 289,358 cubic yards; Lake Erie, 109,026; Lake Ontario, 90,685; Lake Superior, 21,629; Thames river, 12,379; and the balance (5,116 cubic yards) from Niagara river and Rainy lake.

Stone

As noted in Table I, the total output of stone of all grades was 2,317,265 tons valued at $2,969,926 during 1922, as against 2,716,080 tons worth $4,167,582 during the previous year.

The table which follows shows the valuation of the several kinds of stone marketed or used during the past five years:—

VALUE OF STONE PRODUCTION, 1918-1922

Year	Limestone	Sandstone	Trap	Granite	Marble	Total
	$	$	$	$	$	$
1918.............	820,985	145	24,744	23,334	....	869,238
1919.............	1,112,340	5,544	82,995	10,683	19,360	1,230,922
1920.............	3,786,263	10,502	92,630	55,277	300	3,944,972
1921.............	3,934,045	6,423	158,467	68,647	....	4,167,582
1922.............	2,547,485	9,454	167,630	245,357	....	2,969,926

The following were engaged in the stone quarrying industry in 1922:—

LIMESTONE OPERATORS, 1922

Name of Owner, Firm or Company	Location	Address
Belton, Peter..........................	Grantham tp.........	St. Catharines.
Bergin, Pat...........................	Napanee............	Napanee.
Bolender Bros.........................	Haliburton..........	Haliburton.
Britnell & Co., Ltd....................	Burnt River.........	Rear C.P.R. Yonge St. Sta., Toronto.
Brunner Mond Canada, Ltd............	Anderdon tp.........	Amherstburg.
Caldwell Bros.........................	Gloucester tp........	Limebank.
Canada Crushed Stone Corp., Ltd........	West Flamboro tp....	Dundas.
Carleton, County of....................	Osgoode, Gloucester, Nepean tps.	71½ Sparks St., Ottawa.
Cayuga Stone Company................	North Cayuga tp.....	21 Central Chambers, Ottawa.
Cook & Son, J. S......................	Amabel tp...........	Wiarton.
Crushed Stone, Ltd....................	Kirkfield............	47 Yonge St., Toronto.
Crystalline Milling Co., Ltd............	Herschel tp..........	120 Bay St., Toronto.
Farmer, Geo., & Sons..................	Osgoode tp..........	45 Bertrand Ave., Ottawa.
Farr, Mrs. L. G.......................	Bucke tp............	Haileybury.
Foster, R. R..........................	City View, Merivale Rd.	278 Echo Drive, Ottawa.
Gallagher Lime & Stone Co., Ltd.......	Barton tp...........	James St., Hamilton.
Gavard, L. H.........................	Gloucester tp........	12 Delorimer St., Hull.
Gosselin, Chas........................	Gloucester tp........	Quarries.
Gow, James..........................	Fergus.............	Fergus.
Hagersville Contracting Co., Ltd........	Walpole tp..........	Hagersville.
Hagersville Crushed Stone Co..........	Oneida tp...........	Hagersville.
Hagersville Quarries, Ltd..............	Walpole tp..........	4 Flora St., St. Thomas.
Haldimand County Good Roads System..	Rainham, Walpole tps.	Hagersville.
Hanover Cement & Stone Co............	Walkerton...........	157 Bay St., Toronto.
Halliday, Fred........................	Gloucester tp........	297 Booth St., Ottawa.
Hildreth, Chas........................	Barton tp...........	R.R. No. 4, Hamilton.
Innerkip, Corporation of...............	Innerkip............	Innerkip.
Kingston Penitentiary.................	Portsmouth.........	Portsmouth.

LIMESTONE OPERATORS—*Continued*

Name of Owner, Firm or Company	Location	Address
Kirby Co., Ltd., T. Sidney	Gloucester tp	213 Sussex St., Ottawa.
Lally Estate, M.	South Grimsby tp	Smithville.
Law Construction Co., Ltd., The	Bertie tp	107 Hillsdale Ave., Toronto.
Lincoln Road Dept., County of	North Grimsby tp	St. Catharines.
Longford Quarry Co., Ltd	Rama tp	Longford Mills.
Markus, Wm., Ltd	Pembroke tp	Pembroke.
Marshall, Jas.	Barton tp	Hamilton.
McNeely, D. R	Carleton Place	Carleton Place.
Mills, Jas	Napanee	Napanee.
Oliver Rogers Stone Co., Ltd	Owen Sound	841 Fourth Ave. E., Owen Sound.
Ontario Hydro-Electric Power Commission	Walkerton	Toronto.
Ontario Reformatory Industries	Guelph tp	Parliament Bldgs., Toronto.
Ontario Stone Corporation, Ltd	Uhthoff	611 Excelsior Life Bldg., Toronto.
Ottawa Improvement Commission	Ottawa	53 Queen St., Ottawa.
Perkins, Geo. A.	Owen Sound	830 6th Ave. W., Owen Sound.
Pickard, L.	Lake Ontario	Bronte.
Point Anne Quarries, Ltd	Thurlow tp	Foot of Jarvis St., Toronto.
Prescott, Town of	Wood St.	Prescott.
Public Highways, Dept. of	Various locations	Toronto.
Robertson, D., & Co	Nassagaweya tp	Milton.
Robillard, H., & Son	Gloucester tp	195 Nicholas St., Ottawa.
Roddy & Monk	Kingston	24 Elm St., Kingston.
Standard White Lime Co., Ltd	Beachville and Guelph	15 Douglas St., Guelph.
Thames Quarry Co., Ltd., The	St. Marys	St. Marys.
Walker Bros.	Stamford tp	Thorold.
Wallace, R., & Sons	Kingston	116 Patrick St., Kingston.
Wattam, Geo. H.	Amaranth tp	Shelburne.
Webber, John	Dunn tp	Dunnville.
Webster, Jas. S.	Galt	2 Augusta St., Galt.
Wehman, John	Kingston	251 Division St., Kingston
Wentworth, County of	Barton tp	Court House, Hamilton.
Wentworth Quarry Co., Ltd	Saltfleet tp	Vinemount.
Woodhouse Crushed Stone Co., Ltd	Woodhouse tp	Port Dover.

SANDSTONE OPERATORS, 1922

Name of Owner, Firm or Company	Location	Address
Rogers, F., & Co	Chinguacousay tp	1193 Queen St. W., Toronto.

TRAP OPERATORS, 1922

Name of Owner, Firm or Company	Location	Address
Bruce Mines Trap Rock Co., Ltd	Bruce Mines	Sault Ste. Marie, Mich.
Fort William, Corporation of	Rifle Range	Fort William, City Hall.
Mond Nickel Company, Ltd	Garson, Worthington and Levack mines	Coniston.
Ontario Rock Company, Ltd	Belmont and Methuen tps	Toronto, 410 Crown Office Bldg.

GRANITE OPERATORS, 1922

Name of Owner, Firm or Company	Location	Address
Abrams, J. M.	Pittsburgh tp.	Gananoque.
Brown, A. C.	Leeds tp., lot 9, con. IX	Lyndhurst.
Campbell and Lattimore	Findlay	C.P.R. Bldg., Toronto.
Fort William, Corporation of	Fort William	Fort William.
Gordon, D. J.	Leeds co.	Gananoque.
Horne, Wm.	Butler	Ashford Block, Winnipeg.
Mond Nickel Co., Ltd.	Drury and Levack tps.	Coniston.
Morrison Bros.	Wollaston tp., lot 24, con. V	Coe Hill.
Streets and O'Brien	Gananoque	47 Yonge St., Toronto.

Mining Divisions

Following are excerpts from comments by Mining Recorders on the subject of mining and prospecting activity in their respective Divisions:—

Sudbury.—Some claims were staked in new areas, namely, in the townships of Munster and Hess. There has been a revival of interest in prospecting in the vicinity of Wanapitei lake, more particularly in the townships of Scadding and Parkin.

Sault Ste. Marie.—The year was marked by much greater activity than in 1921, more especially in the Michipicoten and Goudreau areas. The business of the office showed a large increase over the preceding year.

Gowganda.—Several recent silver discoveries were made in the Miller Lake area. The Miller Lake O'Brien and Castle-Trethewey mines were active, as well as some smaller properties. Many mining leases have been renewed during the year.

Montreal River.—Considerable assessment work was performed in the townships of Cairo and Powell. The development of hydro-electric power at Indian Chutes is expected to benefit all properties of promise in the vicinity. Machinery was installed on the Thesaurus gold property in Baden township.

Timiskaming.—Activity was centred in South Lorrain as a result of the finding of high-grade silver ore on the Keeley and Frontier mines. The disastrous fire of October 4th wiped out the greater part of the town of Haileybury as well as devastating a large area in the Blanche River valley. The Recording Office was destroyed, but all important records were saved and moved to Cobalt town hall, where a temporary office was opened.

Larder Lake.—A revival of interest was manifested in the Larder Lake area as a result of encouraging assays secured by the Crown Reserve in McVittie township. Gold discoveries were reported from Ossian and Grenfell townships during the autumn. Business for the year was the largest in the history of the Division.

An index of activity in prospecting from year to year is furnished by the number of applications recorded for mining claims. The following tables give the record of the claims recorded since the Mines Act of 1906 became operative, the revenue received and remitted by the several Mining Recorders during the government fiscal year, and a summary of business transacted during the calendar year 1922:—

MINING CLAIMS RECORDED IN THE SEVERAL MINING DIVISIONS, 1907-1922

Mining Division	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
Timiskaming	7,860	1,650	1,343	1,021	922	516	1,326	215	Records incomplete.	156	269	184	244	329	159	328
Coleman	291	270	150	40	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....
Sudbury	456	(est) 254	1,859	1,131	2,309	776	483	237		464	262	168	673	267	319	701
Sault Ste. Marie	291	100	.....	181	119	137	127	23		44	135	199	90	90	216	541
Port Arthur	317	370	475	207	183	180	182	353		172	180	66	171	108	120	296
Kenora	.....	73	102	95	89	91	.....	25		45	32	48	31	25	53	168
Parry Sound	102	56	.....	26	15	5	.....	2		10	25	12	39	33	Closed	.....
Larder Lake	3,813	540	180	84	1,252	541	1,575	718		783	160	423	1,015	712	918	2,344
Montreal River	866	1,321	2,573	344	98	126	63	28		56	294	293	134	81	143	174
Gowganda	.....	.....	3,064	513	258	194	68	23		51	113	52	145	215	101	55
Porcupine	.....	.....	.....	2,150	3,756	538	496	240		401	236	48	136	192	273	760
Kowkash	.....	.....	.....	.....	.....	.....	.....	.....		160	135	2	9	21	3	148
Total	13,996	4,634	9,746	5,792	9,001	3,104	4,320	1,864	.....	2,342	1,841	1,495	2,687	2,073	2,305	5,515

STATEMENT OF MONEYS REMITTED BY MINING RECORDERS FOR THE FISCAL YEAR ENDING OCTOBER 31st, 1922

Mining Division	Name of Recorder	Address	Purchase Price	Forest Reserve Permits	Miner's Licenses	Recording Fees, etc.	Total
			$	$	$	$	$
Sudbury	Campbell, C. A.	Sudbury	2,636 36	550 00	3,576 00	5,396 25	12,158 61
Porcupine	Donaghue, W. A.	S. Porcupine	5,099 81	290 00	2,749 00	4,431 00	12,569 81
Larder Lake	Ginn, H. G.	Swastika	13,634 02	.....	7,195 00	18,217 15	39,046 17
Kenora	Holland, H. E.	Kenora	.....	.....	1,259 00	1,234 75	2,493 75
Timiskaming	McAulay, N. J.	Haileybury	164 38	100 00	5,653 00	3,081 50	8,998 88
Sault Ste. Marie	Miller, W. N.	Sault Ste. Marie	5,003 44	80 00	2,941 50	3,662 25	11,687 19
Port Arthur and Kowkash	Morgan, J. W.	Port Arthur	3,067 25	210 00	2,689 00	3,720 50	9,686 75
Gowganda and Montreal River	Morgan, M. R.	Elk Lake	1,339 83	490 00	1,303 00	2,519 50	5,652 33
		Total	30,945 09	1,720 00	27,365 50	42,262 90	102,293 49

SUMMARY OF BUSINESS TRANSACTED IN THE SEVERAL MINING DIVISIONS DURING CALENDAR YEAR 1922

Schedule	Sudbury	Porcupine	Larder Lake	Sault Ste. Marie	Port Arthur	Kowkash	Timiskaming and Coleman	Gowganda	Montreal River	Kenora	Total
1. No. of letters received during the year....	2,951	2,255	7,527	1,288	2,791	682	1,974	353	1,936	1,361	23,118
2. No. of letters written during the year.....	2,464	2,116	7,134	692	2,437	591	1,352	284	1,535	1,301	19,906
3. No. of Miner's Licenses issued...........	425	421	606	337	299	30	384	....	68	213	2,783
4. No. of Miner's Licenses renewed.........	318	234	527	243	214	22	779	33	158	49	2,577
5. No. of Mining Applications recorded.....	701	760	2,344	541	296	148	328	55	174	168	5,515
6. No. of Mining Applications cancelled.....	184	173	407	167	126	93	201	33	92	14	1,490
7. No. of Agreements, Transfers, etc., recorded	212	357	1,357	104	188	19	197	24	185	23	2,666
8. Amount received for Miner's Licenses, Permits, Recording Fees, etc.	$10,280 25	9,943 50	27,493 10	6,547 19	5,507 85	1,519 25	8,505 75	749 50	3,521 50	2,563 50	76,631 39
9. Amount received as Purchase Money or Rental..........................	$ 2,985 50	5,356 46	14,536 58	3,721 84	7,657 03	196 75	283 68	181 26	1,530 33	79 30	36,528 73
10. No. of Claims of which surveyors' plans were filed during the year...............	45	41	292	71	112	....	34	2	26	....	623
11. No. of disputes entered................	3	1	4	4	1	....	3	....	4	....	20
12. No. of disputed cases decided by Recorders.	....	....	....	....	....	....	....	....	....	....	....
13. No. of appeals to Mining Commissioner..	2	1	6	1	....	....	....	....	4	....	14
14. No. of extensions of time granted........	132	123	578	5	133	30	54	18	52	4	1,129
15. No. of Certificates of Record granted.....	60	73	227	20	96	2	26	8	54	....	566
16. No. of Certificates of Performance of Work granted..........................	64	72	171	34	90	2	9	7	34	6	489
17. No. of Claims for which papers were forwarded to the Department for issue of title.............................	55	55	150	33	29	2	6	7	37	....	374
18. No. of Forest Reserve Permits issued.....	60	30	....	....	13	8	16	8	47	....	182
19. No. of Substitute Miner's Licenses issued.	9	8	....	1	8	1	41	....	....	....	68

Mining Revenue

The revenue of the Department of Mines for the fiscal year ending October 31st, 1922, is given in detail hereunder:—

REVENUE FOR THE YEAR ENDING OCTOBER 31, 1922

Sales of Mining Land		$28,495 89
Rent—		
Mining Leases	$13,482 69	
Licenses of Occupation	6,784 74	
		20,267 43
Royalties		81,013 81
Fuel Investigation		7,614 57
Boring Permits		2,006 00
Sand and Gravel Royalty	$100,954 65	
Sand and Gravel Licenses	5,578 00	
		106,532 65
Miner's Licenses	$42,005 85	
Permits	1,770 00	
Recording Fees	43,518 70	
		87,294 55
Mining Tax Act—		
Acreage Tax	$34,759 77	
Profit Tax	160,994 41	
Gas Tax	16,742 22	
		212,496 40
Casual Fees	$3,873 06	
Patent Fees	190 00	
Timiskaming Testing Laboratories, fees	15,955 47	
Natural Gas Commissioner's Office, fees	1,593 50	
Draughtsmen, North Bay, fees	182 75	
Provincial Assay Office, fees	793 67	
Cable Testing Machine, fees	901 20	
		23,489 65
Refunds—		
Explorations and Investigations	$538 96	
Mining Recorders	185 00	
Contingencies	284-24	
		1,008 20
Total		$570,219 15

MINING LANDS SOLD AND LEASED IN YEAR ENDING OCTOBER 31, 1922[1]

District	Sales			Leases			Total		
	No.	Acres	Amount	No.	Acres	Amount	No.	Acres	Amount
			$			$			$
Timiskaming	217	8,601.06	18,265 67	232	9,107.61	2,302 20	449	17,708.67	20,567 87
Thunder Bay	29	1,276.60	2,946 50	15	598.90	598 90	44	1,875.50	3,545 40
Sudbury	14	687.75	1,795 63	46	1,795.69	1,313 62	60	2,463.44	3,109 25
Algoma	32	1,470.53	3,717 01	....	....	....	32	1,470.53	3,717 01
Kenora	10	824.00	100 00	....	....	....	10	824.00	100 00
Nipissing	....	....	....	11	528.95	103 31	11	528.95	103 31
Elsewhere	12	460.40	820 51	....	....	....	12	460.40	820 51
Total	314	13,320.34	27,645 32	304	12,011.15	4,318 03	618	25,331.49	31,963 35

[1]These figures do not agree with the first two items of the revenue statement above which records collections or moneys actually received during the fiscal year.

Under the Mining Tax Act, a graduated tax is levied on the net profits of mining companies in excess of $10,000 per annum. The basal rate is 3 per cent.

The following statement, prepared by G. R. Mickle, Mine Assessor, gives details of the Profit Tax for the fiscal year ending October 31st, 1922.

DETAILS OF PROFIT TAX

Gold—		
Hollinger Consolidated Gold Mines, Ltd	$110,986 63	
Dome Mines Company, Ltd	5,079 55	
McIntyre Porcupine Mines, Ltd	6,195 80	
Lake Shore Mines, Ltd	3,458 15	
Teck-Hughes Gold Mines, Ltd	683 73	
Wright-Hargreaves Mines, Ltd	1,090 92	
		127,494 78
Silver—		
Coniagas Mines, Ltd	$2,556 16	
La Rose Mines, Ltd	1,303 82	
Nipissing Mining Company, Ltd	29,639 65	
		33,499 63
Total		$160,994 41

Mining Companies Incorporated, Licensed, etc., 1913-1922

A synopsis of mining companies incorporated and licensed in Ontario during the past decade is given hereunder:—

Year	Incorporated		Licensed	
	Number	Capital	Number	Capital
		$		$
1913	119	78,000,000	12	21,735,000
1914	80	39,030,000	13	5,445,000
1915	59	42,005,000	2	10,200,000
1916	83	109,079,500	8	7,011,650
1917	100	117,183,000	7	7,202,000
1918	71	49,800,000	7	15,000,000
1919	147	223,530,000	10	9,554,197
1920	119	146,094,000	12	9,435,000
1921	67	105,715,000	6	1,030,000
1922	92	181,540,000	6	830,500

The lists which follow on pages 49-51 record for the year 1922 the companies incorporated, licensed, etc.:—

MINING COMPANIES INCORPORATED IN ONTARIO IN 1922

Name of Company	Head Office	Date of Incorporation	Capital
			$
Algonquin Mines, Ltd	Toronto	Aug. 14	2,000,000
Allard Platinum & Gold Mg. Co. of Ont., Ltd.	Toronto	Mar. 3	50,000
Alschbach Gold Mining Company, Ltd., The	Kenogami Lake	Sept. 9	2,500,000
American Matachewan Gold Mines, Ltd	Toronto	May 25	2,000,000
Anglo Porcupine Gold Mines, Ltd	Toronto	May 17	3,000,000
Anglo-Saxon Gold Mines, Ltd	Toronto	Oct. 13	3,000,000
Bancroft Mines Syndicate, Ltd	Toronto	June 5	250,000
Beatty Gold Mines, Ltd	Toronto	Aug. 11	2,000,000
Big Dyke Consolidated Gold Mines, Ltd	Toronto	May 12	10,000,000
Bison Gold, Limited	Toronto	Aug. 15	40,000
Blanche River Kirkland Gold Mines, Ltd	Toronto	Dec. 21	3,000,000
Border Mining Company, Ltd	Toronto	Feb. 6	40,000
Brant-Kirkland Gold Mines, Ltd	Toronto	Oct. 7	3,000,000
British-Colonial Gold Mines, Ltd	Toronto	Jan. 12	500,000
British Lorrain Mines, Ltd	Toronto	Nov. 17	1,000,000
Brookbank Gold Mining Company, Ltd	Toronto	May 26	1,000,000
Buffalo Tisdale Mines, Ltd	Toronto	Dec. 8	1,000,000
Cameron Porcupine Mines, Ltd., The	Timmins	Sept. 27	1,000,000
Canadel Gold, Ltd	Timmins	Nov. 10	100,000
Canadian Lorrain Silver Mines, Ltd	Haileybury	Apr. 18	2,000,000
Canadian Mining Syndicate, Ltd	Toronto	May 5	250,000
Canadian Prospecting Company, Ltd	Haileybury	Dec. 18	40,000
Castle-Trethewey Mines, Ltd	Toronto	Jan. 20	2,000,000
Champion Gold Mines, Ltd	Toronto	Oct. 11	500,000
Chippewa-Kirkland Mining Company, Ltd	Toronto	Sept. 14	2,000,000
Columbus Kirkland Gold Mg. Company, Ltd.	Toronto	Oct. 30	2,500,000
Consolidated West Dome Lake Mines, Ltd	Toronto	Aug. 4	5,000,000
Continental Mines, Ltd	Sudbury	Apr. 26	2,500,000
Copper Lake Mining Company, Ltd	Toronto	Feb. 17	500,000
Detroit-Goudreau Gold Development Co., Ltd.	Windsor	Jan. 11	2,500,000
Dufferin Coal Mining Company, Ltd	Toronto	June 28	500,000
Dunwich Oil Company, Ltd	Mimico	Sept. 28	100,000
Eureka Kirkland Gold Mines, Ltd	Cobalt	Sept. 20	500,000
Gauthier Mines, Ltd., The	London	July 25	100,000
Gold Island Mining Company, Ltd	Toronto	Oct. 18	5,000,000
Gold Range Mines, Ltd	Sault Ste. Marie	Mar. 6	3,000,000
Gordon Murray Gold Mines, Ltd	Toronto	May 29	2,500,000
Goudreau-Superior Mining Company, Ltd	Windsor	Jan. 31	1,500,000
Grenfell-Kirkland Gold Mines, Ltd	Toronto	Aug. 24	2,500,000
Grozell Kirkland Gold Mines, Ltd	Haileybury	Sept. 7	3,000,000
Harvey Kirkland Mines, Ltd	Toronto	May 12	5,000,000
Hayden Gold Mines, Ltd	Toronto	Jan. 24	5,000,000
Holding Consolidated Gold Mines, Ltd	Toronto	Oct. 3	5,000,000
Industrial Minerals Corp'n of Can., Ltd	Toronto	Jan. 26	150,000
Jarvis Gold Mines, Ltd	Toronto	May 8	50,000
Kirkland Excelsior Gold Mines, Ltd., The	New Liskeard	Aug. 8	3,000,000
Kirkland Federal Mines, Ltd	Toronto	June 1	2,500,000
Kirkland Gateway Gold Mines, Ltd	Toronto	June 7	2,000,000
Mammoth Porcupine Mines, Ltd	Toronto	Aug. 21	3,000,000
Matachewan Cairo Goldfields, Ltd	Toronto	Sept. 9	40,000
Matachewan Canadian Gold, Ltd	Toronto	May 13	5,000,000
Mawson, Syndicate, Ltd	Toronto	Oct. 14	50,000
McDermott Gold Mines, Ltd	Toronto	Nov. 9	3,000,000
McKenzie Porcupine Mines, Ltd	S. Porcupine	Sept. 11	3,000,000
McQuire-Robinson Radium & By-Products, Ltd.	Parry Sound	Jan. 18	1,000,000
Meco-Catharine Development Company, Ltd	Toronto	May 22	50,000
Menago Mining Company, Ltd., The	Sudbury	Mar. 22	200,000
Millions Lake Gold Mines, Ltd	Toronto	May 10	2,000,000
Montreal-Ontario Mines, Ltd	Kirkland Lake	Apr. 11	5,000,000
New York Porcupine Mines, Ltd	Toronto	June 8	2,500,000
Night Hawk Peninsular Mines, Ltd	Toronto	Mar. 24	5,000,000
Northern Canada Exploration & Development Corporation, Ltd	Toronto	Dec. 4	5,000,000
Northern Ontario Mg & Development Co., Ltd.	Sudbury	Aug. 30	250,000
Northern Resources, Ltd	Toronto	May 26	100,000

MINING COMPANIES INCORPORATED IN ONTARIO IN 1922—*Continued*

Name of Company	Head Office	Date of Incorporation	Capital
			$
Ontario Anthracite Mines, Ltd	Toronto	Mar. 2	500,000
Ontario-Lorrain Development Syndicate, Ltd	Toronto	July 20	1,000,000
Ostrom-Catharine Development Company, Ltd.	Toronto	Mar. 2	50,000
Ossian Mines, Ltd	Toronto	Dec. 1	200,000
Osweka Gold Mines, Ltd	Cobalt	Oct. 9	3,000,000
Pawnee-Kirkland Gold Mines, Ltd	Toronto	Apr. 18	3,000,000
Peace River Development Company, Ltd	Toronto	Mar. 18	3,000,000
Peace River Drilling Company, Ltd	Toronto	Mar. 8	1,500,000
Penn Kirkland Gold Mines, Ltd	Toronto	Oct. 12	2,500,000
Porcupine Creek Mines, Ltd	Toronto	June 5	3,000,000
Porcupine Grande Gold Mines, Ltd	Toronto	Aug. 15	5,000,000
Porcupine Producer, Ltd	Toronto	Oct. 26	2,000,000
Porter-Premier Gold Mines, Ltd	Toronto	Jan. 19	2,500,000
Providence Gold Mines, Ltd	Kirkland Lake	Jan. 26	2,000,000
Quill Mines, Ltd	Toronto	Aug. 26	500,000
Rainbow Mines, Ltd	Toronto	June 28	40,000
Shaw Porcupine Gold Mines, Ltd., The	Toronto	June 24	3,000,000
Shining Tree Consolidated Mines, Ltd	Toronto	Dec. 6	5,000,000
South Argo Gold Mines, Ltd	Toronto	May 18	2,000,000
Swastika Gold Mines, Ltd., The	Toronto	Nov. 8	2,000,000
Thomas Gold Mining Company, Ltd	Toronto	June 14	600,000
Trainmen Silver Mining Company, Ltd	Cobalt	Apr. 20	500,000
United Mineral Lands, Ltd	Toronto	Oct. 31	40,000
United Molybdenum Corporation, Ltd	Toronto	Jan. 16	750,000
Vickers Porcupine Mines, Ltd	Toronto	Nov. 20	1,500,000
Vipond Consolidated Mines, Ltd	Timmins	July 17	2,000,000
Wabigoon Soapstone Company, Limited	Toronto	Oct. 12	500,000
Wigwam Mining Company, Ltd., The	Elk Lake	June 1	2,000,000
Total—92			$181,540,000

MINING COMPANIES LICENSED IN 1922

Name of Company	Head Office for Ontario	Date of License	Capital for use in Ontario
Coniagas Alkali and Reduction Company, Limited	St. Catharines	Oct. 17	$400,000
E. J. Longyear Exploration Company	Sudbury	Nov. 8	30,000
North America Gold Corporation	Timmins	Nov. 8	300,000
Dryden Gold Corporation	Dryden	Sept. 26	50,000
Northern Area Development Company, Limited.	Ottawa	May 25	500
LICENSE IN MORTMAIN			
Jefferson Mines, Limited		Nov. 8	50,000
Total—6			$830,500

INCREASE OF CAPITAL STOCK IN 1922

Name of Company	Date	From	To
Beaumont Gold Mines, Limited	Sept. 28	$2,000,000	$3,000,000
Boston Creek Mining Company, Limited	June 17	2,000,000	4,000,000
Canadian Kirkland Gold Mining Company, Limited	Oct. 27	2,000,000	3,500,000
Canadian Non-Metallic Minerals, Limited	Feb. 18	40,000	100,000
Continental Mines, Limited	Sept. 13	2,500,000	3,500,000
Grace Mining Company, Limited, The	June 21	1,000,000	5,000,000
McEnaney Gold Mines, Limited, The	Oct. 23	3,000,000	4,000,000
Moffatt-Hall Gold Mines, Limited	May 23	3,000,000	5,000,000
Porcupine Crown Mines, Limited	Aug. 18	2,000,000	4,000,000

DECREASE OF CAPITAL STOCK IN 1922

Name of Company	Date	From	To
Dome Mines Company, Limited, The	Mar. 17	$5,000,000	$4,500,000
General Examining and Developing Company, Limited.	Dec. 8	800,000	500,000

CHANGE OF NAME IN 1922

From	To	Date
Burnand Gold Mines, Limited	Phosphate and Metals Mining, Limited	Apr. 1
Northern Ontario Gold Mines, Limited	McEnaney Gold Mines, Limited, The	Aug. 16
Silverado Extension, Limited	Pioneer Prospectors, Limited, The	Feb. 22
Swedish-Canadian Mines, Limited	British Canadian Mines, Limited	Dec. 7

MINING COMPANY CHARTERS SURRENDERED IN 1922

Name of Company	Date of Dissolution
Carveth Gold Mines, Limited	December 11
Central Operating Company, Limited	July 17
Hayden Gold Mines, Limited	November 27
Mikado Consolidated Gold Mines, Limited, The	February 27
Ontario Western Petroleum, Limited	December 11
South West Porcupine Syndicate, Limited	May 15

Provincial Assay Office

The Provincial Assayer, W. K. McNeill, reports as follows for the year 1922.

The Assay Office has been in operation without interruption during the entire year and the usual variety of work has been done with the assistance of T. E. Rothwell, Chemist and Assayer, and Robert Stewart, Laboratory Assistant.

The work during the year may be classified as follows:

FREE ASSAYS UNDER THE PROVISIONS OF THE MINING ACT OF ONTARIO

Mining Division	Samples Received for Free Assays
Kenora	35 for gold, 5 silver, 1 copper.
Fort Frances	21for gold, 1 silver, 2 copper, 4 nickel, 1 iron.
Kowkash	36 for gold.
Sault Ste. Marie	115 for gold, 11 silver, 1 copper, 2 iron.
Sudbury	92 for gold, 7 silver, 1 tin, 1 copper.
Timiskaming	30 for gold, 16 silver, 1 copper, 1 iron, 2 cobalt.
Montreal River	23 for gold, 3 silver, 1 copper.
Porcupine	99 for gold, 18 silver, 1 alumina, 1 silica.
Gowganda	11 for gold, 8 silver.
Port Arthur	56 for gold, 12 silver, 2 copper, 2 nickel, 2 tungsten, 2 molybdenum, 4 iron, 4 platinum, 1 tin.
Larder Lake	210 for gold, 13 silver, 3 copper, 3 nickel, 1 platinum, 1 iron, 1 tin.
Eastern Ontario	13 for gold, 6 silver, 1 platinum, 1 potash.

The following is a statement of the samples submitted by the general public for which the regulation fee was charged, and also those submitted by geologists and officers of the Department of Mines.

CUSTOMS ASSAYING AND GENERAL WORK

Gold, Silver and platinum..	680 samples.
Copper..................	9 samples.
Feldspar..................	9 samples; 2 of these for complete analysis.
Rocks..................	12 samples were submitted by geologists of the Department of Mines for complete analysis.
Radium..................	40 samples were submitted on which reports were issued. A number were radio-active.
Identification............	167 samples were received by mail and reports issued. A large number were brought directly to the Laboratory; of these no record was kept.
Miscellaneous............	55 samples of other minerals were tested. These included tin, tungsten, iron, zinc, lead, cobalt, bismuth, antimony, etc.

The schedule of charges for the Provincial Assay Office and Chemical Laboratory is as follows:

TARIFF OF FEES FOR ANALYSES AND ASSAYS

	Fee
1. *Assays:*	
Gold........................	$1 50
Silver........................	1 50
Gold and silver in one sample........................	2 50
Platinum minerals........................	5 00
Gold and platinum minerals in one sample........................	7 00
Separation of platinum minerals........................	Prices on application.
2. *Iron Ores:*	
Iron (metallic)........................	$1 50
Silica........................	1 50
Iron and insoluble residue........................	2 50
Ferrous oxide........................	2 00
Phosphorus........................	3 00
Sulphur........................	2 50
Iron, sulphur, phosphorus and insoluble........................	8 00
Manganese........................	3 00
Titanium........................	4 00
Complete analysis........................	Prices on application.
3. *Limestones, Dolomites, Marls, Clays, Shales:*	
Determination of:	
Insolubles........................	$1 50
Silica........................	1 50
Ferric iron........................	3 00
Ferrous iron........................	2 00
Alumina........................	3 00
Lime........................	2 00
Magnesia........................	2 50
Potash........................	5 00
Soda........................	5 00
Alkalies (on one sample)........................	6 00
Water (combined)........................	2 00
Moisture........................	1 00
Carbon dioxide........................	2 00
Sulphur........................	2 50
Phosphorus anhydrite........................	3 00
4. *Examination of Clay, Shale, or Cement Rock for Cement Manufacture:*	
Determination of:	
Silica, Iron oxide, Alumina, Lime, Magnesia, Sulphur, and Volatile matter........................	Prices on application.

5. *Coal, Coke, Peat, etc.:*

Determination of:

	Fee
Moisture	$1 00
Volatile combustible	1 50
Fixed carbon	1 50
Ash	1 50
Sulphur	2 50
Phosphorus	3 00
Caloric value (B.T.U.)	5 00
Ultimate analysis	Price on application.

6. *Mineral Waters* .... Price on application.

7. *Ores and Minerals:*

Determination of:

Alumina	$3 00
Antimony	4 00
Arsenic	4 00
Bismuth	4 00
Cadmium	4 00
Chromium	5 00
Cobalt	5 00
Nickel	5 00
Cobalt and nickel in same sample	6 00
Copper	2 00
Fluorite	4 00
Lead	3 00
Molybdenum	4 00
Manganese	3 00
Tin	4 00
Zinc	3 00

8. *Rocks, Complete Analysis* .... Price on application.

9. *Slags, Sand, etc* .... Price on application.

10. *Identification of Minerals and Rocks not Requiring Chemical Analysis* .... Free.

11. *Test for Radio-Activity* .... Free.

Any analytical work not specified in this list will be undertaken on application to the Provincial Assayer.

The pulp of each sample is retained for future reference.

Directions

Samples will be dealt with in the order of their arrival. In every instance specimens and samples should be accompanied by statement specifying the precise locality from which they were taken.

Crushed samples representing large quantities or samples less than five pounds weight may be sent by mail as third-class matter. Samples not exceeding eleven pounds in weight may be sent by parcel post. The name and address of sender should be written plainly on each parcel. Instructions, with money in payment of fees, should be contained in a separate letter. Samples may be sent by express, charges prepaid.

Sample bags addressed to this Laboratory for sending ore pulp by mail may be obtained free on application; also canvas bags for shipping.

Money in payment of fees, sent in by registered letter, post-office order, postal note, or express order, and made payable to the Provincial Assayer, must invariably accompany sample to ensure prompt return of certificate, as no examination is commenced until the regulation fee is paid.

Samples should be addressed as follows:

Provincial Assay Office,
5 Queen's Park,
TORONTO, ONT.

Timiskaming Testing Laboratories

Campbell & Deyell, Limited, carried on the business of ore sampling and assaying in the town of Cobalt for some years prior to May 5, 1919, when the Temiskaming and Northern Ontario Railway Commission purchased their plant and subsequently operated it. The property on which the plant is situated is held under lease from La Rose Mines, Limited. This lease was assigned to the Ontario Government as represented by the Minister of Mines by Order in Council dated July 5, 1921. The plant was transferred July 1, 1921. Since that date the Department of Mines has maintained at Cobalt, under the management of A. A. Cole, Mining Engineer of the T. & N. O. Railway, and Geo. Dickson, Superintendent, laboratories for sampling, assaying, and the purchase of small lots of gold ores.

Following is a financial report for the year, together with receipts for the last half of 1921.

FINANCIAL STATEMENT OF THE TIMISKAMING TESTING LABORATORIES

Month	Earnings 1922	Expenditures 1922	Operating		Receipts	
			Profit 1922	Loss 1922	1922*	1921
January	$1,131 95	$1,572 15	....	$440 20	$2,305 41	....
February	716 12	1,457 14	....	741 02	627 62	....
March	900 63	1,457 37	....	556 74	931 90	....
April	656 04	1,352 05	....	696 01	810 24	....
May	1,605 74	1,433 81	$171 93	....	736 59	....
June	1,295 70	1,395 56	....	99 86	1,447 77	....
July	1,320 31	1,251 88	68 43	....	759 59	$600 35
August	2,854 45	2,047 76	536 69	....	1,081 32	1,096 53
September	2,125 56	1,842 20	283 36	....	2,657 54	1,501 52
October	2,325 44	1,933 00	392 44	....	2,139 94	772 92
November	2,199 75	1,834 94	364 81	....	2,587 75	1,186 05
December	887 82	1,595 33	....	707 51	2,010 52	1,271 50
Total	$17,749 51	$19,173 19	....	$1,423 68	$18,096 19	$6,428 87

*In addition, from June to December, 1922, free assay coupons totalled $64.50.

The following is a brief statement of the work of the year:

Assaying.—Gold, 2,771 samples; silver, 3,718; silver bullion, 438; cobalt, 166; nickel, 11; miscellaneous, 44; total, 7,148 samples.

Silver ore and concentrates milled, sampled, assayed and bullion melted.—50 lots weighing 944 tons, and 141 bars of bullion melted.

Ore Testing.—This consisted of 20 amalgamation, 7 flotation, 6 concentration, 21 cyanide and 6 screen tests.

Shipment of cobalt residues.—Moisture determinations were made on 196 cars in addition to weighing and sampling. Silver and cobalt assays were made for 25 cars.

Gold ore purchased.—Four lots of gold ore, weighing in all 3,193 pounds, were purchased. These lots assayed $1.20 to $246.25 per ton, the gross payment after deducting charges being $121.38. The ore came from Painkiller lake, Matheson, Rickard township and Lightning river.

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Note—All place names refer to Ontario unless otherwise mentioned.

PROVINCE OF ONTARIO

DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES — THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-SECOND ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXII, PART II, 1923

Geology of Ontario—Manitoba Boundary

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO

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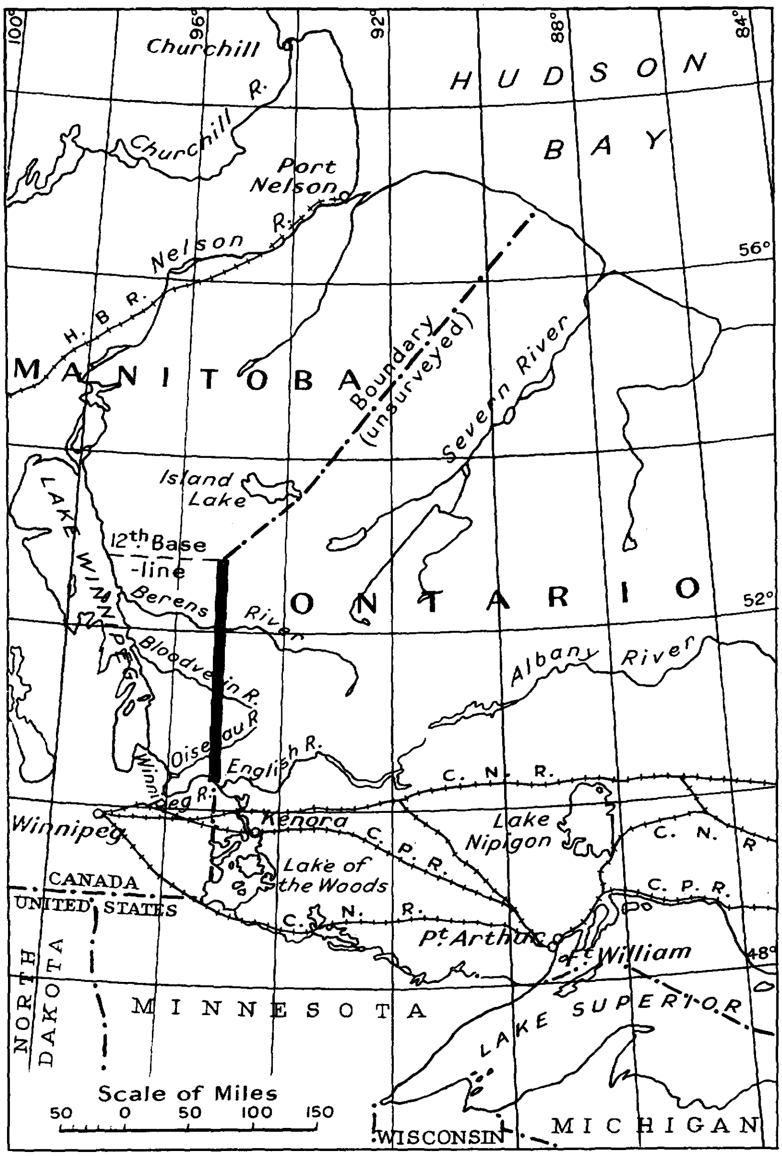
1923



Key map showing, in heavy full line, portion of Ontario-Manitoba boundary surveyed in 1921 and 1922.

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GEOLOGY OF ONTARIO—MANITOBA BOUNDARY

(From Winnipeg River to Bloodvein River, 1921)

By E. M. Burwash

Introductory

During the summer of 1921 the survey of the boundary between Ontario and Manitoba was extended northward from its intersection with the Winnipeg river. It had already been completed to that place from the point on the international boundary officially known as the "Northwest angle of the Lake of the Woods," a distance of 58 miles, 27.2 chains, as measured to a post located on the south shore of the main channel of the Winnipeg river, Fig. 1. The northward continuation of the boundary line was undertaken conjointly by the Topographical Surveys

Fig. 1.—Starting point of the survey, June, 1921. The Winnipeg river here is 15 chains wide, jackpine forest beyond with boundary line cut out 20 feet wide.

Branch of the Department of the Interior at Ottawa, and the Surveys Branch of the Department of Lands and Forests at Toronto. The actual work of the survey was carried out by J. W. Pierce, O. and D.L.S., of the Topographical Surveys Branch, Ottawa. The writer was attached to his party for the purpose of studying the geology along the boundary, as an appointee of the Ontario Department of Mines.

The part of the boundary surveyed during the past season lies on a meridian which is drawn from the international boundary to the northern limit of Township 44, Range 16, East of the Principal (Manitoba) Meridian.[1] From that point

[1] Usually contracted to "Tp. 44, R. 16, E.P.M."

the inter-provincial boundary continues on northeasterly bearings, first to the southeastern point of Island lake, and thence on a slightly more northerly course to a fixed point on the southwestern shore of Hudson's Bay in longitude 89°. The survey as carried out during the past summer involved the extension of the meridian line, which was cut out to a width of about twenty feet, located by long sights with a large transit, chained by improved methods, and marked at intervals of about one and a half miles by bronze plates cemented into the rock, their position being indicated by mounds of stone; while at intervals of about six miles concrete

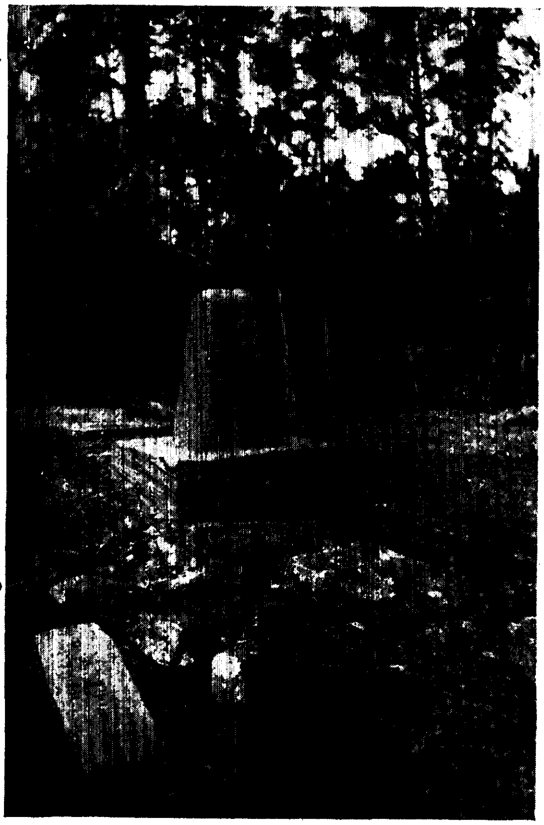

Fig. 2.—Concrete monuments were placed on prominent points along the Interprovincial boundary line at average distances of six miles. Brass plates on opposite sides bear the name and arms of the Province toward which they face, also the number of the monument. Bench-marks were placed in the summits of the monuments.

monuments were erected on prominent situations, Fig. 2. In addition, precise levels were run along the boundary, bench-marks established on each of the bronze plates already mentioned, and the topography of the country for a mile on each side of the line was mapped by transit and stadia. This furnished a valuable base for geological mapping, and, in addition, important lakes outside of the two-mile zone were mapped by the geological party by micrometer and compass so far as was practicable and consistent with the geological examination of the country along the line and the general progress of the survey.

Leaving Toronto May 25th a short time was spent in Winnipeg collecting equipment, and the writer with two student assistants proceeded by rail from Winnipeg to Lac du Bonnet on the Winnipeg river on the 30th. From this point we were transported by launch to the lowest portage on the Oiseau or Bird river, a stream which rises in the district of Patricia, Ontario, and flowing westward and somewhat southward, discharges into the northeastern bay of Lac du Bonnet. The lower course of this river lies along a band of rocks of the Wanipigow formation of E. S. Moore[1], a predominantly sedimentary series which overlies the Rice Lake or Keewatin volcanics in this region. Bordering the northern edge of the Wanipigow band, which probably represents a synclinal trough, there is a small strip of the lower Rice Lake volcanics, which extends westward several miles from Bird lake.

Along a granite contact on the northern edge of this strip of greenstones, some development work has been done on a deposit of copper-nickel ore, which occurs on a group of claims known as the Deacon-Devlin property. This property lies in the province of Manitoba about 12 miles from the Ontario boundary, but as the formation in which it occurs strikes in an eastern direction and may be found again on the Ontario side, it was thought best to make a brief examination of the workings and outcrops. For this purpose we remained at the company's camp for part of two days, and proceeded on the third of June by way of Bird lake and a route which leads in a southeasterly direction from the eastern end of it through a chain of lakes with connecting creeks and portages to the Winnipeg river. We reached that waterway on the 6th, and joined the boundary survey party whom we found encamped on a bay on the east side of the northward flowing reach which lies a little to the west of the inter-provincial boundary. From this point the geology of the country bordering the Winnipeg river, the first few miles of the boundary line and adjoining water-systems was examined. As the survey progressed the principal camp was moved successively to points in advance of the line on the principal water-routes which crossed it, and located as near as possible at their intersection. When necessary intermediate points on smaller lakes were also occupied, but this generally involved much labour in cutting portage-trails and packing heavy equipment and supplies over them, as compared with detours by way of the larger lakes and streams.

Where transverse chains of lakes or streams previously unsurveyed rendered such action advisable, the geological party worked with a light camp independently of the main party for as much as three or four days. At other times we occupied the same camp-sites as the survey and conformed our movements as far as possible to theirs.

In the course of the work, covering about three months, a considerable number of unmapped lakes were surveyed, and in some cases where good Indian or other previously-given names were not available, names were assigned to them. The remainder are indicated on the map by numbers.

The main rivers which were crossed all flow in a direction transverse to the line, and include the Winnipeg, the Oiseau, the Manigotagan, the Wanipigow and the Bloodvein. Possibly also the headwaters of the Black river (*See* under Water-powers) extend as far as the boundary and intervene between the Bird and Mani-

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E. S. Moore, "Region East of the South end of Lake Winnipeg, Geolog. Surv. Can. Summary Report, 1912, p. 262, *et seq.*

gotagan river basins. These rivers all run westerly into Lake Winnipeg. Hence the discovery of good canoe-routes from basin to basin at right angles to their courses, was not always easy, and involved the making of many and long portages. The survey ended for the season at 127 miles and 20 chains, slightly less than 69 miles from the starting point, but the geological work was not carried quite so far.[1]

The writer desires to express hearty acknowledgments of the ready and able manner in which his part of the work was facilitated by Mr. Pierce and the members of his staff. Though amply occupied with their own duties, they never failed in consideration for his wants, or in willingness to co-operate with him in any practicable way. To his student-assistants, H. C. Rickaby, of the University of Toronto, and C. S. Johnston, of Queen's University, thanks are also due. In addition to willingness and energy in the work assigned to them they each displayed a personal interest and initiative which rendered their services of unusual value. After the writer's withdrawal from the field they continued the geological part of the work alone for several weeks, Mr. Rickaby acting as geologist, and any materials in this report which deal with that part of the line which lies north of Garner lake are based entirely on their field-work.

GEOLOGY

A—.Physiography and Drainage Systems.

The Canadian Archean shield or belt has in general the form of a wide ridge of gentle slope enclosing the basin of Hudson Bay. The slopes of the ridge are usually steeper on the outward side, and very gradual on the inward toward the bay. Toward the bottom of the basin, along the western shores of the bay, the Archean rocks are overlaid by Paleozoic strata, which dip to the eastward beneath the waters of the bay, and project above its surface in Southampton, the Belchers and other islands. On its outer circumference the Archean belt is also bounded by Paleozoic strata. Their contact with the Archean lies at varying elevations, from below sea-level in the lower St. Lawrence region to about 1,000 feet in the neighbourhood of the Lake of the Woods, and declines from the last-mentioned locality to 750 feet or less along the eastern shore of Lake Winnipeg, which, roughly speaking, marks the contact for about 250 miles.

Between these Paleozoic boundaries the exposed surface of the Archean rocks rises for the most part to a considerable height, and its summit is the divide which separates the drainage-basins whose waters flow directly inward to Hudson Bay, or outward to the Atlantic, or to the St. Lawrence or Mackenzie rivers. There are, however, three passes across this encircling divide, two in the north and northeastern parts which lie below sea-level and contain the Hudson and Fury and Hecla straits, and one in the southwest, where, between the St. Lawrence and Mackenzie basins a wide depression crosses the divide and allows the Churchill and Nelson river systems to flow across the Archean belt at its narrowest place. These drain a considerable part of the western interior plain of the continent and also a large area of the adjacent outer slopes of the Archean belt, whose drainage flows westward into the interior plain, mainly by the Winnipeg and its tributary rivers, and is there received into the Nelson river system.

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[1] Positions on the boundary line are indicated throughout this report by their distance from the northwest angle of the Lake of the Woods measured in miles and chains. The starting point in 1921 was at 58 miles 27 chains.

A profile across the Archean belt along a line drawn from the southern part of Lake Winnipeg near the mouth of the Winnipeg river, northeastwardly to the shores of Hudson Bay at the mouth of the Winisk river, would exhibit a curve, convex upward, rising 600 feet within about 60 or 75 miles from Lake Winnipeg to a level upland, which gradually ascends another 100 feet to about 1400 feet elevation within the next 120 miles. From this summit diverge the headwaters of the Albany, the south branch of the Severn, the Berens, the Wenasaga and the Trout Lake rivers, streams which flow respectively east and northeast into Hudson Bay, northwest into Lake Winnipeg, and southwest into the English river. This highland area is, therefore, the most commanding in the district of Patricia. From it a spur extends northwest which separates the Lake Winnipeg from the Hudson Bay affluents, and ends near the salient northwestern angle of the Ontario-Manitoba boundary. Continuing the line of section northeastwardly from the dominant highland, we have a gradual descent whose profile, at first convex, becomes concave near Hudson bay, and has a total descent of 1,400 feet or more in 300 miles.

Superimposed upon these larger features there is a topography of low relief, generally not over two hundred feet and locally often much less, which is pre-Glacial in age, but has been quite largely modified by the action of the Pleistocene ice-cap. The effect of this agency has been to remove all the pre-Glacial residual rock-waste, and rock softened by weathering, leaving a hummocky surface of practically unweathered rocks. In this process the softer and the more deeply weathered rocks have naturally suffered most attrition, with the result that in many places the pre-Laurentian schists have been hollowed into lake basins. These are by no means absent in granite areas, however, where they have generally a more rounded form than in the schistose or gneissic rocks. Of the lake basins in general it is perhaps true that they represent the local deepening and widening of pre-existing valleys more often than excavations of previously plain or upland surfaces. Exceptions to this are probably the shallow basins of the muskegs and marshy lakes which often lie near or actually on the divides and in the last case drain into more than one river system.

Undoubtedly the minor streams at least had been adjusted to the courses of the bands of softer schists long before the Glacial epoch, and indeed before the Ordovician sea-advance, since the planation of the Archean surfaces seems to have been practically complete then, and much of the subsequent erosion has been expended on the removal of the Paleozoic strata and the re-exposure of the old Archean surface. Good examples of the adjustment of streams to the softer schistose belts are now to be seen in the valleys of the north branch of the Severn, the Oiseau and the Wanipigow rivers. The remnants of pre-Laurentian schist in which these and other valleys are cut, indicate by their strike the direction of the axes of folding of the mountain systems, which in Archean times occupied the region, and the gneisses which have generally been assigned to the Laurentian, but whose strike is usually parallel to that of the schist folds, are often to be considered as portions of the schist which have been injected with feldspathic and quartzose additions by the hydrothermal or pneumatolytic action of intruding granite masses. They are, however, much more resistant to erosion than the schists which have not been so injected, but not as resistant as the massive granites. Where the rivers flow over the more resistant rocks and follow courses parallel to those whose valley follow the schists, it may readily be inferred that their locus was originally determined by the presence of softer bands of infolded rocks which have now been removed. The streams meantime having previously incised their valleys into the harder rocks below, have maintained their position. The lower valleys of the Manigotagan and Berens rivers might be partially explained in this way, but throughout the region the disturbances of the drainage by the ice erosion, which has often cut across divides, and the establishment of new slopes by the post-Glacial uplift are also factors to which a large share in the determination of the present drainage system must be assigned.

Owing to the modification of the pre-Glacial topographical detail by the ice, the later stages of pre-Glacial erosional history are not clearly definable. This is more completely true owing to the smallness of the pre-Glacial relief. In some localities one is tempted, nevertheless, to discriminate between various parts of the surface, as for example, near the crossing of the Bird river, on the boundary, where the river and its tributaries occupy definitely-marked valleys incised from 80 to 100 feet below a gently undulating plain of glaciated granite which lies a few feet above and below an altitude of 1,200 feet. Rising above this are occasional monadnocks, notably the granite hill which lies between lakes Harris and Whitlock. The record here then is that of a peneplanation carried to a very complete condition, but with some residual heights, followed by a small uplift and

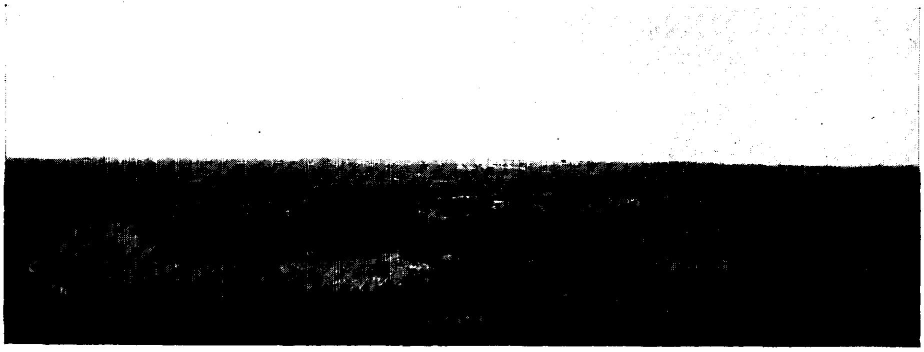


Fig. 3.—View along the boundary line from a hill, indicating the general flatness of skyline.

shallow trenching of the plain by the rivers. The sharpness of the river cuttings also suggests that on the granite, at least, the mantle of waste was not very thick prior to its removal by the ice.

The major river of this part of the Archean belt is the Winnipeg, which rises near the western end of Lake Superior and drains a basin of about 53,000 square miles, including practically all the southern slopes of the Archean highland between Lake Superior and Lake Winnipeg. Its valley, as was to be expected, is the deepest crossed by the boundary line in its course northward from Lake of the Woods, and the water-surface is approximately 984 feet above sea-level or 270 feet above Lake Winnipeg at the intersection. The line is here well down the southwestward slope of the Archean highland which rises from the prairie level, and as it is extended in a true north direction it might be expected to ascend this slope diagonally, while the distance between Lake Winnipeg and the boundary increases. The boundary passes over a series of flat-topped upland spurs and their intervening valleys in which the rivers descend westward to Lake Winnipeg, and crosses the Bird river and the Manigotagan, at elevations of 1,000 to 1,100 feet. The north branch of the Manigotagan, and the crossings of the Wanipigow and Bloodvein rivers are somewhat lower, though still over 1,000 feet, so that the slope of the highland is not maintained very far north, and in fact the minor divide which lies between these rivers and the Red Lake branch of the English river system to the east probably pitches downward from the Manigotagan crossing toward the Berens river, which crosses this divide and takes its rise, as already described, farther to the east at the great central highland of Patricia.

Viewed from any eminence the main slopes of the region are not visible, and the country as a whole has a remarkably level appearance and a very flat sky line throughout the whole distance surveyed in 1921, Fig. 3. This statement might properly be extended to the Archean region as a whole.

B.—Areal and Descriptive Geology

Winnipeg River Granite

At its intersection with the Winnipeg river, the boundary line traverses an area of massive red granite which was followed southward along the line from the main channel to the north shore of the bay leading southwestwardly to the mouth of the stream which discharges from Crow Duck lake. On the shore of this bay, a little west of the boundary, there is exposed an outcrop of coarse red granite porphyry with pinkish feldspar phenocrysts, which have their longer axes approximately parallel, smoky quartzes and dark biotite. Proceeding northward, the whole neighbourhood of the line is underlain by the same plutonic mass in various phases; the grain alternates between coarse and fine, and the structure pases from gneissoid to massive granular, through varying degrees of parallelism of the mineral constituents.

Microscopically examined, this granite reveals a mineral composition which was roughly estimated quantitatively from one section as follows:— Orthoclase 40 per cent., microcline 30 per cent., quartz 20 per cent., biotite 10 per cent., with perhaps a little hornblende and some dust-like ferrite inclusions in the quartzes which cause the "smoky" appearance observed by the unaided eye. In the section examined some secondary kaolin and sericite had resulted from a slight weathering of the feldspars, and a little epidote and brown iron ore were also noted. The same granite occupies the shores of the Winnipeg river southeastward from the boundary to the first chute, a distance of about three miles, and beyond. At the chute, which has a descent of about five feet, the jointing of the rock is such as to divide it into tabular slabs about a foot in thickness, and a ridge of these stratiform joint-blocks which dip up stream, forms the obstacle over which the river falls. The same granite also underlies the river to the west of the boundary for three miles as far as the northward bend, and thence northward to the southern part of Township 16, Range 17.

Inclusions or xenoliths of older rock are quite frequent in some parts of the red granite. Three types of these were noticed. The most frequent were fragments of a gray gneiss which weathers at about the same rate as the red granite, and others of dark mica-schist, which disintegrates much more rapidly, leaving pits in the surface of the enclosing granite. Less commonly inclusions of coarsely granular hornblendic rocks also occur, and some of the gray gneiss inclusions have themselves inclusions of mica-schist. The mica-schists on examination appear to be metasedimentary rocks, the gray gneiss is granodiorite or quartz-mica diorite, and the coarse hornblendic inclusions are probably recrystallized igneous rocks near granodiorite or more basic in composition, containing microcline, oligoclase-andesine and quartz, in addition to a very large percentage of automorphic hornblende.

Proceeding northward, the northern edge of the red granite is met with crossing the river and the boundary on a line with the northern shore of the bay which opens from the east side of the river in Section 10 of Township 16. It is here seen in intrusive contact with the gray granodiorite gneiss which furnishes the inclusions already noted; and also with lavas and schists which may have provided the other xenoliths, Fig. 4. These rocks undoubtedly formed the roof of the red-granite batholith, and as such extended farther south than their present margin.

Granodiorite Gneiss

On the west side of Winnipeg river the contact is somewhat farther south than on the east. The gray granodiorite is here seen to be intruded by felsitic

Fig. 4.—Complex on Winnipeg river composed of (A) Wanipigow schist; (B) older grey granodiorite gneiss; (C) red granite.

apophyses of the red granite, and both are traversed by red dikes of pegmatite near the contact. Microscopically, the gray gneiss is found to consist of a hypautomorphic granular mass of orthoclase, oligoclase, or a somewhat more basic plagioclase, microcline, quartz, biotite and hornblende with accessory zircon, apatite and magnetite. This rock varies in composition from granite to granodiorite and in some cases to quartz-mica diorite, according to the relative amounts of the various constituents present. It is itself intrusive in the Rice Lake volcanics and Wanipigow metasedimentary schists and gneisses which succeed it on the north at the westward bend of the Winnipeg river. From this point the Wanipigow formation extends northward as far as the north side of Ryerson lake.

Wanipigow Formation

This band of Wanipigow schist and gneiss is a southeastward extension of that which occupies the basin of the Oiseau (or Bird) river as far as the east end of Oiseau lake. Following the canoe-route thence it is found on the portage and stream which lead southeastward to Happy lake, along the north shore of that lake and on its south shores from its most southerly bay eastward nearly to the inlet from Summerhill lake, where the schist is penetrated by numerous sills of granite and passes into *lit par lit* and gneissoid transitional phases on that lake and on the portage from Summerhill to Ryerson lake. The northwest bay of Ryerson lake is bordered on the north by granite and on the south by a biotite gneiss. After leaving the north shore of Happy lake the band of schists crosses to Flanders lake, and is exposed on both sides of the long northwest arm of that lake and on the northeast side of the southern part. Thence it extends southeast and is found on both sides of Ryerson lake and on the islands in it. Crossing the Ontario boundary the Wanipigow formation extends eastward from Ryerson lake and is probably continuous as far as the south side of Burwash lake, beyond which it was not traced. Southward from Ryerson lake the Wanipigow extends, as already noted, to the bend of the Winnipeg river in sections 19, 20 and 21 of Township 16. Thence eastward a gneissoid belt intervenes between the recognized Wanipigow bordering Ryerson lake and the grey granodiorite gneiss to the south. In addition to the belt of metasedimentaries which extends southeast from Oiseau lake, another branch runs southeasterly to Little Trout lake and extends along the north side of it as far as the west end of Reynar lake, beyond which it is represented by large outliers and injected gneiss. From the north of Little Trout lake a band seemingly extends northwestward and was observed on the creek which discharges from Sucker lake. This belt follows the creek to the northern shore of Tulabi lake and forms the ridge over which the Bird river falls at the first two portages above Tulabi lake. At that point it apparently comes to an end. Thus the Wanipigow syncline which forms the bed of Bird river as far as Bird lake "fingers out" beyond that point, and one branch only extends a short distance across the Ontario boundary, so far as present researches show, although the country around the lakes east of Little Trout lake is composed of gneiss which is undoubtedly formed by granitic injection into these schists, and which has here and there areas which are practically identical in appearance with the main body of the formation, and may be considered as comparatively unaltered roof-pendants.

The rocks of the Wanipigow series as studied in this area represent sediments in a state of very advanced metamorphism. They appear to have been originally for the most part argillaceous. They fall under three classes:—

(1) *Gneisses,* in part garnetiferous, which are typically developed on the portage which leads southward from Oiseau lake to the creek draining Happy lake. These consist mainly of a mosaic of secondary quartz with a very subordinate amount of microcline, biotite in parallel leaves and some grains of epidote and magnetite. Scattered through the rock are garnets of much larger size than the other minerals, and containing inclusions of quartz and muscovite. Among the non-garnetiferous gneisses of this area are some in which the biotite occurs more abundantly in certain places, where it forms leafy aggregates, giving the gneiss a "spotted" appearance. The best examples of this were seen south of Ryerson lake and along the north shore of Little Trout lake. Throughout the

formation the biotite is frequently characterized by the presence of pleochroic halos.

(2) *Hornblende and biotite schists,* the former in some cases quite ferruginous through the presence of magnetite grains, but not sufficiently so to deserve the name of iron ore, which is applicable to somewhat similar rocks in the Lac Seul region, notably at Little Shallow lake. These schists consist essentially of interlocking secondary quartz-grains, with more or less biotite or hornblende in parallel arrangement. Small amounts of feldspar or kaolin are sometimes present, and as these increase in amount the rocks grade into gneisses. The schists in some cases consist almost entirely of quartz, but no case was observed in which primary quartz fragments could be distinguished, either with or without secondary enlargements.

(3) *Metamorphosed conglomerates.* These as found here are difficult to recognize as conglomerates in the field, apart from the weathering out of the pebbles on exposed surfaces. The matrix consists of a secondary quartz mosaic with a considerable amount of badly-decomposed orthoclase and hornblende in automorphic laths. There are some grains of plagioclase (albite or oligoclase-albite), a little pyrite in cubes, and apatite in grains. In some sections biotite and muscovite were also noted. The whole suggests an arkose subjected to much alteration, causing an increase in the percentage of quartz and re-crystallization of all the constituents. The pebbles examined proved to be schists of the kinds already described, and the rock as a whole is sometimes indistinguishable in the field from the Wanipigow gneisses. On the west side of Little Trout lake and along the stream between that and Sucker lake, conglomerates are also seen. In some cases the matrix of these is a spotted gneiss like that described above. In all cases the pebbles seem to have been separated originally in a fine grained siliceous and argillaceous matrix. The pebbles are of hornblende gneiss, quartz diorite gneiss, and biotite schist, and are here much more distinguishable by the eye than on Ryerson lake.

Rice Lake Formation

On the south side of Winnipeg river westward from its bend in sections 17 and 18 (northern part) and 19 and 20, of Township 16, Range 17, the shore was examined as far as the western boundary of the township, and was found to consist of what are undoubtedly rocks of the Rice Lake formation of Moore[1]. They are in order from lower to upper, schists, quartzites, ellipsoidal lavas and massive diorite. These occupy the south shore of the river most of the distance from the western boundary of the township to the bend of the river (Sections 20 and 21) where they cut across the river, forming an island and a slight rapid. They do not extend far on the other side and were not seen crossing the boundary which lies two miles farther east. On their southern side they are intruded by the grey granodiorite gneiss already referred to, and the river flowing along their northern margin covers the contact between the volcanics of the Rice Lake formation on its southern shore and the altered sediments of the Wanipigow which occupy its northern bank. The quartzite found here is of essential interest as it may indicate the source of the quartzite pebbles which in some cases occur, especially in the Lac Seul region farther east, in the conglomerates of the upper

[1]Moore, E. S., Geol. Surv. Can. Summary Report, 1912, pp. 263, 264.

schist series (here represented by the Wanipigow). Under the microscope it is seen to consist of irregular interlocking grains with few inclusions and these not in lines. There is no evidence of secondary enlargement, and the rock appears to be a completely re-crystallized quartzite. There is a little fine dusty material which shows opaque white by reflected light, possibly leucoxene from titaniferous magnetite, and in some parts the joint planes appear heavily coated with rust.

The pillow-lavas, Fig. 5, which occur near by are a fine grained mica-diorite or hornblende-mica gabbro, but probably the former. They are marked by parallelism of mineral constituents to flow as well as by the ellipsoidal structure. The massive lava which follows farther west is a typical diorite of a somewhat poikilitic texture, consisting of about 35 per cent. andesine, 60 per cent. hornblende in green laths, with accessory ilmenite and pyrite (?). The rock is very fresh. Macroscopically, it is a black fine-grained effusive, in general

Fig. 5.—Ellipsoidal lava, Rice Lake formation, Winnipeg river. Township 16, Range 17, East of Principal Meridian.

presenting a smooth massive appearance, but in some parts sheared and in others weathered to a pitted surface.

White Binary Granite and Pegmatite

These Rice lake lavas are intruded by dikes of coarse white pegmatite, Fig. 6, which exhibits a graphic structure in the feldspars and crystals of muscovite. This is seen further west to be a pegmatitic phase of a binary granite, quite different in its composition from either the red or the grey plutonics already noted. It consists of microcline, about 70 per cent., quartz 20 per cent., and intergrown biotite and muscovite. The accessories are garnet, much fractured, with quartz in the fissures and a little magnetite. Similar granite is to be seen at the west end of the main body of Ryerson lake, and at the outlet of Little Trout lake. So far as observed, it nowhere occupies a large area. On Ryerson lake the microclines show perthitic intergrowths of andesine, some graphic quartz intergrowths, and a little orthoclase. The white non-striated feldspar which gives its colour to the rock is microcline. This type of intrusion was not seen in the more northerly part of the survey. Like the other two plutonics, it is younger than the Wanipigow and Rice Lake formations. Its relations to the other plutonics were not determined here, but south of Wingiskoos lake it is intruded by a red granite. The Little Trout lake occurrence has roughly the composition: Microcline 60 per cent., orthoclase 10 per cent., oligoclase-albite 5 per cent., quartz 20 per cent., with small amounts of biotite and muscovite.

Following the boundary northward from Ryerson lake, one enters upon an area of granite which intervenes like a wedge between the two arms of the Oiseau lake band of the Wanipigow formation. Its apex extends northwest as far as Harris lake, where it forms a large hill, the most prominent topographical feature for many miles around. Widening toward the north and south as it

Fig. 6.—*Roche moutonnée* of Rice Lake lavas traversed by a white pegmatite dike, Winnipeg river.

extends eastward, this area includes both massive phases and gneissic borders. At the boundary its width is about four miles, and it embraces the small chain of lakes which lie east of Ryerson lake. The granite on these lakes is massive and generally red, but in some places there appear white areas which are possibly similar to the binary granites seen on the Winnipeg river and Ryerson lake. To the north the granitic area passes around the east end of the Little Trout lake schist band, and is continuous with the large area of gneiss which extends along the valley of the Bird river from Oiseau lake to beyond Snowshoe lake. It is a part of the large granitic area which occupies the shores of Lake Winnipeg from the mouth of the Winnipeg river northward beyond the Manigotagan river and includes the lower valleys of both rivers.

Between Ryerson lake and mileage 71 the granite is mainly massive and is a "binary" granite of the following composition, (roughly): Microcline, 45 per cent., orthoclase, 30 per cent., quartz, 20 per cent., biotite and muscovite, five per cent. It is probable, therefore, that the dikes and other small bodies of white binary pegmatitic granite seen within this area and to the south of it represent its later pneumatolytic phases. To the northward, approaching lake No. 10, the granite passes into gneiss, owing to the large amount of included schists and gneisses of the Wanipigow formation which occur in it. So abundant is this material that it forms in fact far the largest part of the rock, and is evidently in its original position as to dip and strike, though permeated by the granite and altered from grey schists and gneisses to gneisses of a more or less pinkish colour by the re-crystallization of kaolin and other feldspathic materials into pink orthoclase, with additions hydrothermally introduced. This is, therefore, rather a part of the contact metamorphic aureole of the batholith than the batholith itself, and answers well to the term "injection gneiss." It is cut in all directions with small felsitic or aplitic dikes of the granite, and in places with the white binary pegmatite already described. Some pink pegmatite was also observed in the southern part of the area between lake No. 7 and Huston lake which consisted of pink feldspar with lesser amounts of quartz and black tourmaline in unusually large proportion. There are also red pegmatite dikes in the area north of Shinewater lake.

On the east side of the main body of Little Trout lake the reddish granites enclose a small area of grey granodiorite gneiss, which consists of oligoclase, orthoclase, microcline, quartz, hornblende and biotite, with a little zircon. The gneissoid structure here is due to parallelism of mineral constituents caused by flowage, and not to included schists. The relation of this mass to the surrounding red granite was not observed. It agrees very well with the older plutonics of the Winnipeg river, and like them is found in immediate proximity with the still older Wanipigow schists.

On the lakes which extend northeasterly from Little Trout lake, the rocks observed were all gneisses of the injection type, with occasional small areas of Wanipigow schists or gneisses less or not at all affected by the granitic intrusion. The gneisses vary somewhat in composition, the feldspars being sometimes chiefly oligoclase, but mainly microcline and orthoclase. A primary gneiss with schist inclusions at the west end of Wilson lake is composed of microcline, orthoclase, andesine, quartz (largely micropegmatitic), brown biotite and muscovite. Along the line northward from Little Trout lake to Snowshoe lake very similar rocks occur, and the rocks examined on the north shore of Snowshoe lake, on the route northward to Wingiskoos lake and on the line as far north as Octopus lake, are with a few small exceptions gneisses of the same sort. At Octopus lake they give way again to a large area of Wanipigow metasedimentaries, which form part of the great belt of the Wanipigow formation lying along the valleys of the lower Wanipigow and upper Manigotagan rivers. In many parts of the intervening area it is difficult to decide whether the granite gneiss or comparatively unaltered included schists form the major part of the rock. For instance, the band of Wanipigow schists which is shown on Moore's map[1] extending west from the south side of Fishing lake to the south end of Wingiskus lake has been omitted on the map accompanying this report, since on examining the portages from Bird river to the south end of Wingiskus lake the rocks were found to be either granite or injected gneiss composed largely of granite sills and dikes, and therefore rather to be classed

[1]See footnote, p. 10.

with the batholithic gneisses of the surrounding region.[1] Immediately to the south of Snowshoe lake the inclusions in the gneiss have the composition of quartz-mica diorite, so that the pre-granite formation represented in the gneiss here is probably the Rice Lake rather than the Wanipigow.[2] Epidote veins several inches wide occur here also, traversing a pegmatite dike; besides granular epidote they include a little quartz, microcline and ferrite. About two miles south of Snowshoe lake an area of grey porphyritic gneiss has the composition of monzonite (microcline, andesine, hornblende and biotite). The phenocrysts are microcline, and the rock contains numerous inclusions of the older schists. This corresponds perhaps to the older grano-diorite plutonics of the Winnipeg river, and its relations to the red gneisses here are similar, as it occurs in them as included fragments. A magma of this composition might account for the epidote veins already described, but these are younger than the red pegmatite in which they occur.

Northward from Snowshoe lake the schist inclusions become somewhat larger and less altered, and schist areas of considerable extent were seen around lake No. 25, Johnston lake and the southeast bay of Octopus lake. Along the shores of Snowshoe lake practically the same gneissic rocks are found, and on the portage from Alga lake to Wingiskus lake a white, binary gneiss was seen like that to the south, but without plagioclase. The muscovite is in aggregates which appear sheaf-like under the microscope. This white gneiss is older than the red granite, as shown here by their contact relations. On the small lake near "mileage 84" an ordinary biotite gneiss was found in contrast to the binary granites which occupy most of the adjoining country.

Near the northern edge of this gneissic area a muscovite-tourmaline gneiss occurs at the east end of lake 29, due possibly to the injection of pegmatitic materials into the Wanipigow schists, but the outcrop is not large enough to observe its field relations.

The southern boundary of the Wanipigow formation is reached at Octopus lake, and extends thence east and west across the line. Its westerly course was not traced, but its location on Wingiskus lake permits of an approximate tracing of it to the eastward of the line for a few miles. A fairly complete section of the Wanipigow was seen along the line between Octopus lake (85 miles 60 chains) and 92 miles 50 chains, which lies a little east of Island lake, a width of nearly seven miles.

Commencing at the contact on the eighty-sixth mile, the area underlain by the Wanipigow rocks is at first low-lying and occupied by what appear to be micaceous schists. Farther on these give way to more compact, fine-grained rocks almost glassy in appearance, with conchoidal fractures, which rise into a ridge of some height at 86 miles 27 chains. Microscopically examined, these rocks are found to consist of secondary quartz mosaic with a considerable amount of kaolin-like material, some biotite and chlorite derived from biotite. Disthene inclusions appear in some of the quartzes, also grains of apatite, magnetite and pyrite. In other cases numerous very small micas and green hornblendes are disseminated through the quartz mosaic, and occasional fragments of andesine occur, which show strain shadows. The rocks are therefore probably in part crushed volcanics of andesitic affinities, and in part more siliceous metasedimentaries. It is possible therefore that the southern edge of the pre-granite

[1]A narrow strip of schist along the south side of Alga lake may represent the uninjected Wanipigow schists.

[2]Compare also gneiss at west end of Wilson lake.

belt here should be assigned to the Rice Lake formation, especially as the rocks examined on the southeast part of Rickaby lake and the adjacent parts of Wingiskoos lake are of the same type and have been indicated as Rice Lake on the map. (*See also* Fig. 7.)

On the other hand, they may represent detrital material derived from Rice Lake rocks in Wanipigow time, which have not been subjected to much weathering or transportation before their deposition, but since their induration have undergone dynamic metamorphism.

These rocks continue to near the end of the eighty-eighth mile, when they give way to a sheared conglomerate, the matrix of which consists of fractured quartz fragments and sericitized orthoclase crystals with some plagioclases, all exhibiting strain shadows and imbedded in a finer mass of sericite, quartz and probably feldspar, in which is developed a good deal of pyrite in crystalline aggregates. In this matrix are pebbles of phyllite or very fine grey schist,

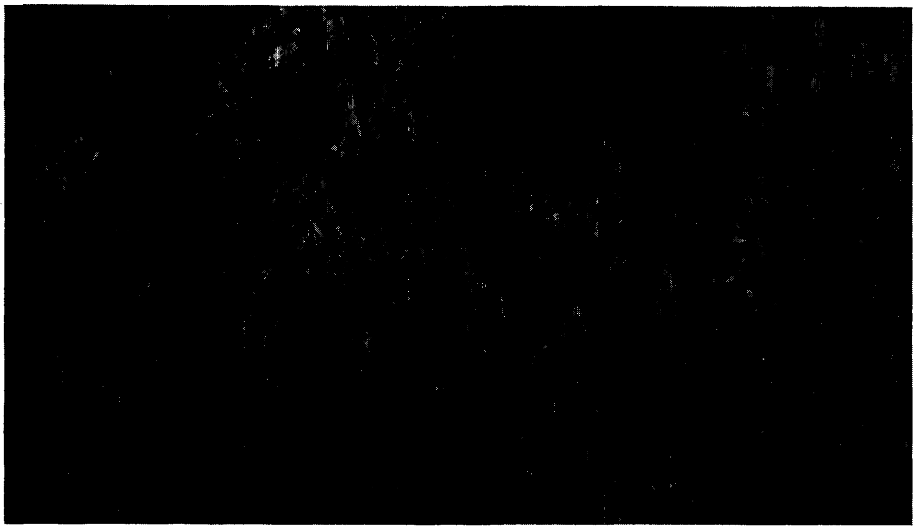


Fig. 7.—Wanipigow conglomerate, a little to the west of mileage 91 and north of the Manigotagan river.

probably representing slates, and of granite and chert. The cherts are mainly angular, the granites well rounded or sub-angular, and the phyllites squeezed into more or less elongated, lenticular shapes. The rock might be described as a greywacké conglomerate.

To the north of the large meandering stream which discharges from Wingiskoos lake and crosses the boundary at 88 miles 20 chains, the colour of the rock changes from a dark grey to a light greenish grey, and it is characterized by a much more marked lamination. At lake 39 the rock has a more massive structure and an amygdaloidal appearance due to small rounded masses of calcite, which weather out leaving a pitted surface. These on examination prove to be cataclastics composed of crystals of andesine which exhibit strain shadows and possibly other feldspars much altered, and often rounded by rolling, enclosed in a matrix of quartz and smaller feldspar fragments, in which are parallel leaves of biotite, brown in the centre but often altered to chlorite and iron ore round the edges. In cracks in the shattered feldspars there is some calcite. There is also in one section some titaniferous iron ore with leucoxene as an alteration product and a little chlorite. The rock may well be a crushed andesite porphyry. At another point on the south shore of Lake 38, somewhat east of the line, there is an ophitic diorite or diabase, consisting of optically continuous areas of hornblende (perhaps after augite) with laths of feldspar traversing it in various directions. Much of the hornblende is chloritized. Rutile is also present in branching prisms. This rock corresponds to the Rice Lake formation, and it would appear that the belt here consists of a double syncline of Wanipigow rocks with an intervening anticline along which the underlying Rice Lake is exposed, or possibly the Rice Lake rocks extend from the eastern part of lake 38 to the southern margin of the pre-granite area. In this locality there is a considerable number of small quartz veins which in general contain a good deal of pyrite and chalcopyrite, with iron rust, but no gold is visible and samples submitted to assay failed to reveal the presence of any values in precious metals.

To the north of lake 39 conglomerate appears again and extends to the Manigotagan river flat which is covered with silt to the north of the river. A little west of the line there is a belt some 300 feet in width of a coarse conglomerate, Fig. 7, which has boulders up to eight inches in diameter, and angular and subangular pebbles. The boulders include a greenish grey gneissoid rock. In the middle of the band a streak of graphitic schist occurs and to the south of (below) this the pebbles are mainly of angular chert. The pebbles and boulders are imbedded in a grey matrix, and are as a rule not in contact but separated by some distance. As the whole presents at present a rounded *roche-moutonnée* surface, samples of the pebbles were not secured. On the line the conglomerate is exposed at the north side of the river flat at 91 miles 20 chains, where it is associated with graphitic schists in the lower part. There are lenticular pebbles of cherty silica, and the matrix consists of a secondary quartz mosaic partially crushed and the cracks filled with kaolin, epidote and iron ore with pyrite cubes here and there. To the north the rocks appear to be sheared argillaceous grits, and at the mound near mileage 91.65 there is a phyllite consisting of parallel micas with intervening kaolinized material with fine streaks and lenses of interlocking quartzes and plagioclases.

At 92 miles 51 chains a granite area is reached. The rock as examined here is approximately 65 per cent. microcline and orthoclase with a little oligoclase, about 25 per cent. quartz and the rest biotite in fine leaves clustered in aggregates. This granite in part seems to have undergone some shearing, and in such places contains muscovite. It has inclusions which are apparently of a gneissoid quartz-mica diorite.

Rice Lake Rocks

To the west of this granite area Rice Lake rocks succeed to the Wanipigow gneisses and conglomerates, and are exposed along the east side of the northeast bay of Island lake, where the rocks as examined seem to represent sheared mica-andesite. On the portage from the north end of this bay to Garner lake, a section of the Rice Lake is exposed which includes similar rocks to that just mentioned, together with sheared quartz porphyries and gneiss, with biotite schist and hornblende schist whose original condition in itself is more obscure, but which are probably derivatives from the other rocks mentioned.

At 92 miles 12 chains the Rice Lake formation crosses the line in a narrow belt that underlies the basin of lake 48. It is here represented by a biotite gneiss composed of a large percentage of parallel biotite, the intervals of which are filled with small quartzes and feldspars with epidote in grains or short prisms, perhaps due to alteration of hornblende and a little chlorite, a rock probably produced by dynamic metamorphism of a dioritic or andesitic original. On the south shore of the lake the rock is quartz diorite without mica. Throughout this Rice Lake area occasional dikes of granite occur, and quartz veins are fairly numerous. At the south end of the portage from Island lake to Garner lake there is an exposure of grey clastic rock, which has a matrix of fine secondary quartz with larger crystals of andesine embedded in it, and parallel biotite and hornblende between the feldspars—apparently a sheared diorite—in which are fragmental inclusions of biotite granite, containing some oligoclase in addition to orthoclase and microcline, and hornblende schist with a considerable amount of magnetite in grains. The inclusions are so common as to give the rock at first sight an agglomeratic appearance.

From the north shore of lake 48 a hornblende-biotite gneiss again appears on the line and extends a little to the west of it, but micaceous schists of the Rice Lake formation are encountered again before reaching the south shores of Garner lake.

The western end of Garner lake is entirely occupied by Rice Lake rocks, and the south shore is all of that formation until the point just west of the boundary is reached, when a reddish gneiss is exposed, succeeded again by Rice Lake rocks at the southeastern corner of the lake. The eastern end, however, is of granite, which includes an area of grey gneissoid granodiorite. The principal type is a reddish hornblende-biotite granite gneiss. On the northeast bay of the lake a narrow belt of Rice Lake rocks appears, a specimen from which has the composition of diorite gneiss, and a narrow band of granite reaches the north shore of the lake on the peninsula just west of this bay. Owing probably to absorption of basic material, it is here a hornblende syenite gneiss. The remainder of the north shore westward is composed of Rice Lake rocks.

The contact between the granite and the Rice Lake formation extends north by west from the northeast part of Garner lake, but the line was not traced and is therefore conjectural as shown on the map, from the point where it leaves Garner lake until it is found on the route to Wallace lake, at a point on the portage from Moore (or Partridge) lake about 390 paces north from Moore lake. Here the Rice Lake rocks give way to a gray plutonic granodiorite gneiss or monzonite gneiss, which no doubt corresponds in its relations to that seen on the Winnipeg river and at several intervening points. The rock consists essentially of green hornblende, orthoclase, andesine or oligoclase-andesine, and some lenses of quartz-mosaic, probably secondary and due to shearing action. In part, the rock is in a cataclastic condition. This rock gives way again to a sericite gneiss or schist on the portage from Wallace lake to the first small lake on the route south from Wallace lake. The tongue of monzonite which here projects westward splits the Rice Lake formation into two arms, very much as the granite area north of Ryerson lake, divides the Wanipigow belt of the lower Bird river. The northern side of the plutonic runs from the portage south of Wallace lake to the southern bay of Siderock (or Whitefish) lake, and thence eastward along the Wanipigow river to a point about 20 chains west of the west end of lake 76. From this place the contact turns northerly and returns to the west a short distance north of Siderock and Wallace lakes. The rocks of the Rice Lake area in this locality, so far as studied during the summer of 1921, are very similar to those already described farther south, including hornblendic schists and gneisses.

Granite Area from Garner Lake to Carroll Lake

From Garner lake northward as far as the line was surveyed in 1921, the boundary lies over granitic rocks. These form a complex in themselves of (1) red granites, mostly hornblende biotite granite, or biotite granite with a little plagioclase in addition to orthoclase and microcline, but rendered more basic in places by assimilated dioritic inclusions, and (2) grey gneisses which have the composition of granodiorite or diorite. Commencing just north of Garner lake, hornblende-biotite and biotite granites occur. The latter is grey in colour and cataclastic in structure. Much of the gneissic rock in the southern part of the area bears the same relation to the Rice Lake formation that the gneisses of the Bird river valley bear to the Wanipigow. They are in reality a part of the contact zone including the metamorphic aureole of the batholithic intrusions, some parts of which have suffered injection and others more complete assimilation in the granite. It is certain that these more basic rocks, higher in iron, lime and magnesium, would fuse more readily than the more silicic and aluminous metasediments, and the gneissic structures formed would therefore appear more as if due to fusion and flowage than to *lit-par-lit* types of injection. Hence it is difficult to distinguish the grey gneisses which occur here due to absorption of dioritic rocks by granite, from a possibly older plutonic granodiorite such as the grey granitoid gneiss on Winnipeg river appears to be. The distinction has to be made largely on the basis of field observations, and these the writer was not able to make for the area in question as he had to leave the field after proceeding as far as Garner lake. In the map which is attached certain areas marked with crosses indicate granodiorite gneisses, while those marked with "v"s refer to the red granite of the region which is normally a biotite-granite or hornblende-biotite granite. Even the latter of these two phases might be due to assimilation of hornblende schists which are not uncommon in the Rice Lake formation, and only field relationships could throw light on the point. In some areas on the map the somewhat involved mixtures or transition phases from one type of rock to the other have been indicated by placing the different symbols in alternate rows.

Passing northward along the route from Siderock lake to O-Buck-O-Win lake, the Rice Lake rocks are crossed in about half a mile on the first portage and give way to gray gneisses which contain very little plagioclase, but are in general hornblende gneisses with a considerable amount of microcline in addition to some orthoclase and micropegmatite. The hornblende is in exceptionally large amounts, and often is much the larger part of the rock. A subordinate amount of biotite is present in some places . There are a few grains of magnetite and pyrite included in the hornblende. On the portage which ends at O-Buck-O-Win lake some phases containing andesine, labradorite and titanite occur, apparently due to absorption of dioritic and gabbroic types of rock from the Rice Lake series. This belt of grey rock belongs probably to the outer assimilation zone of the red granite batholith, and does not represent an older granodiorite. It passes by degrees into the red granites of O-Buck-O-Win and Carroll lakes, where the types are similar to those already described for this area, namely, biotite gneiss, hornblende-biotite gneiss, hornblende gneiss, and massive granular phases which are chiefly biotite granite and in some places hornblende-biotite granite. Typical sections of the granite itself from Miles 116 and 117 (between Carroll and O-Buck-O-Win lakes) have the composition orthoclase, microcline, micropegmatite, quartz and biotite, with accessory apatite and magnetite. The gneissoid condition generally brings with it in addition a greater or less amount of plagioclase, hornblende and epidote, with an increase in the amount of magnetite due to inclusions of it in the hornblende. Among inclusions in the granite of this area, hornblende schist is common, corresponding to its frequent occurrence among the Rice Lake rocks of the vicinity. There were no instances noted here of metasedimentary inclusions, which would indicate that the batholithic intrusion had not cut its way through the lower Rice Lake formation before its congelation.

Economic Minerals

The economic mineral resources of the region as revealed in the season's work are in brief:—

(1) Granite suitable for structural purposes, on the Winnipeg river.

(2) Copper ores of the Bird river.

(3) Gold-bearing quartz of the region between Garner lake and Siderock lake.

(1) Granite

The red biotite granite of Winnipeg river at the inter-provincial boundary and on both sides of it for some distance, Fig. 11, covers a considerable area adjacent to the river. As already noted, it can be found in even-grained massive phases with joints a convenient distance apart, and has a very good appearance. Some such localities are available immediately adjacent to the river, and the stone could be transported by water downstream at least as far as Lamprey Falls, about half way to Point du Bois, the nearest railway station, which is 23 miles distant by river and about 15 or 16 in a straight line.

The red granite seems to exfoliate a little so that exposed corners have apparently been rounded since the retreat of the ice, but this is possibly due to fires, and if not it is a process too slow to be a detriment to building stone. It may indicate, however, that the rock is not very well adapted for resisting the action of fire as compared with other granites. The smoky and blue quartzes add a purplish touch to the colour, which might give a very fine effect in buildings.

The grey granodiorite gneiss is also massive enough for building purposes, but probably masses of it free from inclusions and large enough for quarrying might not be as easily found.

Other granites further north are largely gneissic owing to great amounts of included Wanipigow or Rice Lake rocks, and are as described, largely transitional contact phases between schist and granite. In general, therefore, they lack the massiveness and uniformity which is desirable for building-stone.

(2) Copper Ores

If not useful otherwise, these more northerly granite bodies seem to have exerted more influence on the mineralization of the older rocks than have those in the immediate vicinity of Winnipeg river. The copper ores which are being developed on the Deacon-Devlin property just west of Oiseau lake lie in a fractured zone of Rice Lake hornblende-diabase immediately adjacent to an intrusive granite contact and extending parallel to it for about half a mile. The contact itself has been traced from the northwest bay of Oiseau lake westward for about eight miles, according to one of the local prospectors. Apophyses of granite extending into the Rice Lake rocks and inclusions of the latter in the granite demonstrate the fact that the granite is the younger of the two. In one place the fracture zone or zone of faulting was seen extending across the brecciated contact belt, and it is, therefore, of an age subsequent to the solidification of both rocks. The mineralization has taken place along slickensided surfaces and in open parallel cracks which are filled with chalcopyrite, pyrrhotite and magnetite, with a little pyrite and bornite. There are also irregular zones of coarse amphibolite rock with a little muscovite and much disseminated sulphides, which appear to be the result of recrystallization and partial replacement of parts of the country rock. The rock itself is a dark basic material, in the main too fine grained for determination by the eye, but under the microscope it is seen to be a hornblende-diabase, or a diabase in which the augite has been altered to hornblende by the granite intrusion. The structure is diabasic and the feldspar labradorite. In other parts of the rock the most basic feldspar seems to be andesine, and the rock is therefore a poikilitic diorite corresponding to that seen on the Winnipeg river in the Rice Lake formation, and the diabasic part may be simply a lime-rich phase of extrusion from a dioritic magma.

The mineralized part, as stated, is traversed by many slickensided parallel fractures along which the mineralization extends, and the rock has also accessory magnetite, accompanied by sulphides which may be original constituents, since amphibolitic bodies under the microscope reveal a mass of coarse fibrous hornblende with a large amount of pyrite or pyrrhotite and a less amount of chalcopyrite. The sulphides are in part at least younger than the hornblende, which is also considerably chloritized. Sulphides are intruded along the cleavages in the hornblende crystals. Muscovite is also present interwoven with the hornblende. The ferromagnesian mineral of the surrounding rock, which may originally have been augite, and if so had already been altered to hornblende by the granitic intrusion, has been re-crystallized, or largely so. The feldspar has been entirely removed in solution and, combined with potash from invading granitic secretions, had its silica and alumina re-crystallized in the form of muscovite. The lime of the feldspars, and that released by chloritization of hornblende, has probably acted as the precipitant of the metallic sulphides and perhaps oxides, and has been later removed in solution.

The deposition of the ores seems, therefore, to have been due to heated solutions from the granite, which were excreted as one of the last stages of the batholithic intrusion after the outer shell of the intrusive mass had hardened along the contact, and following some zonal fracturing which took place subsequent to this solidification of the outer shell of the batholith. The granite itself is part of the binary granite area, which is seen on the inter-provincial boundary north of Ryerson lake. As examined near the Deacon-Devlin property, it consists of orthoclase with oligoclase-andesine in microperthitic intergrowth, biotite, muscovite and quartz, the last in unusually large amounts, with accessory magnetite. This would account well for the potassic and siliceous solutions, and in part for the iron. But as chalcopyrite occurs as an accessory in the diabase, it seems probable that the sulphides may have been partly derived from parts of the diabase assimilated by the granite, and that the deposits here represent a concentration of the accessories from a very considerable amount of the basic rock. These would enter into solution in the granite magma, but would only be precipitated on re-entering the basic rock where lime occurs in considerable proportions.

The largest body of ore seen was at the west end of the deposit where a fissure eighteen inches wide is filled with compact metallic sulphides. The ore is a mixture of pyrrhotite and chalcopyrite, with some quartz and ferromagnesian silicates. It is traversed at intervals by parallel cracks containing quartz veinlets of later origin than the ore, which indicates that the faulting or shearing action continued throughout the process of deposition, though perhaps intermittently, and after the sulphides had been deposited granitic end products continued to be supplied to the newly-formed fissures.

Specimen sampling only of the deposits was made, and consequently nothing can be said as to the value of the property. An assay of the ore indicates the presence of 10.66 per cent. of copper and the absence of gold and nickel. The failure of nickel to appear in the assay may be due to the absence of pyrrhotite in the specimen assayed, but this is improbable, as there was little gangue in the specimen, and the copper produced would account for a chalcopyrite content of less than one-third of the weight of the sample.

(3) Gold Quartz of the Garner Lake—Wallace Lake Area

Between the 92nd and 111th miles the boundary passes along the eastern edge of the gold-bearing area within the Province of Manitoba, which is known as the Rice Lake gold-field. None of the claims staked so far were found to lie on the Ontario side of the boundary, although the Bee claim (No. 155805) on the south shore of Garner lake lies within a few yards of the line. As stated by E. S. Moore,[1] "the Rice Lake rocks contain more of the large quartz veins than the Wanipigow, probably for two reasons, viz., the Rice Lake suffered extensive diastrophism before the Wanipigow formations were laid down and were therefore more fractured; and the Rice Lake being buried deeper than the Wanipigow at the time of the granite intrusion, was more highly silicified." The present writer was not able to find field evidence of the first of these two possible reasons, either in greater metamorphism, or in angular relationships of the two formations, although the latter may exist. On the contrary, the basic Rice Lake effusives are often still in a massive condition without schistosity, and not much re-crystallized, and the fracturing which they have undergone, to which the veins are attributable, is at least in one case, that of the Deacon-Devlin property, contemporary with or subsequent to the post-Wanipigow granitic intrusions, as has been shown, and, therefore, subsequent to the shearing action which has produced cataclastic conditions in the Rice Lake formation in some regions and schistosity in others. The massive condition is in itself favourable to such transverse fracturing under shearing stress, and the more commonly gneissoid and schistose structure of the Wanipigow may have permitted slipping along already established planes of weakness during the movements accompanying the intrusion of the granite, rather than the production of new fissures. A number of veins were noticed in the Wanipigow formation south of the Manigotagan river, but all proved to be barren, as indeed were most of the quartz samples taken from the Rice Lake formation itself, except those obtained from the Tinney claims a little west of Beresford (or Bulldog) lake, and one from the Sturgeon claim on the south side of Garner lake.

[1]See footnote, p. 10.

At the Tinney claims the country rock is apparently greenstone and derived schists. A narrow dike of granite rock runs parallel to the lake from the Edna claim (150414) to the south side of the Nora (154145), a distance of three-quarters of a mile or slightly less. The rocks along this intrusion show much fracturing and many stringers of quartz. Some of the quartz-bodies are of considerable extent and several of them show native gold. According to the claim owners, the granite and greenstone along the contact assay fairly well in many parts. An assay of quartz from the Tinney No. 1 claim, which contained visible gold, gave a return of $114.40 per ton, but a sample from a quartz body twenty-five feet long and three feet wide on the Tinney No. 2, which ran approximately parallel to the strike of the rocks, yielded only 40 cents per ton.

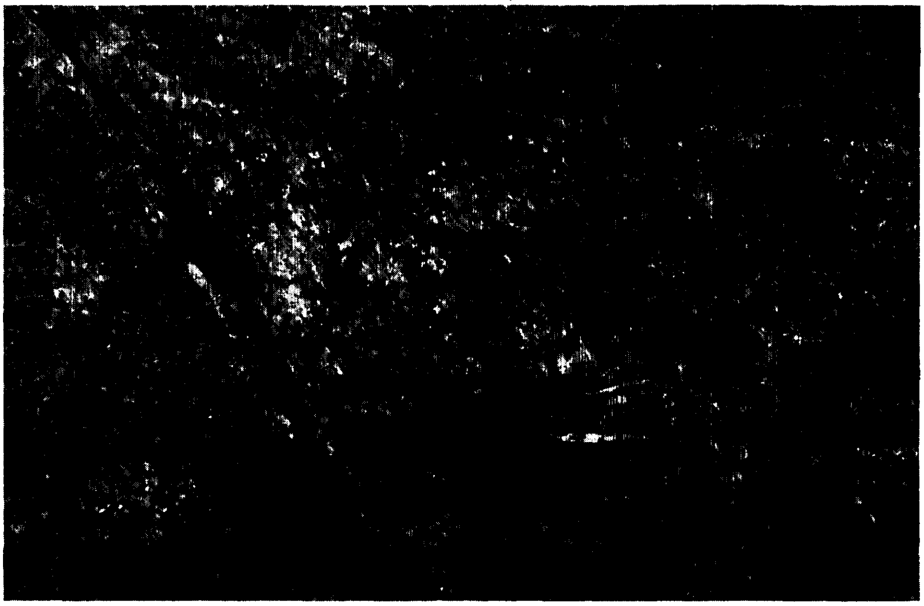


Fig. 8.—Glaciated surface of Wanipigow schist on portage between Wingiskus and Bee lakes. Sticks are lying in slightly divergent glacial grooves. The spotted effect is due to lichens.

On the Sturgeon claim (155803), which lies on the east side near the north end of the portage from Island lake to Garner lake, there is a gash vein in the schists which has a strike of about S.75°E. astronomic. It is exposed for about 20 feet and has a width of about two feet. The only visible ore mineral is iron pyrites, but the ore assays $6.40 a ton in gold.

The veins seen in the Wanipigow formation were gash veins parallel to the strike of the gneiss, and while they showed some mineralization in the form of pyrite, which is also found widely disseminated through the greywacké and conglomerate, they were found to contain no gold.

The presence of gold then is not determined by the size or character of veins, so far as the observations of this survey would indicate, nor apparently by the presence of other mineralization, but by the character of the country-rock. On the Sturgeon claim this is a hornblende schist composed mainly of green hornblende fibres in parallel arrangement with iron oxide also in bands.

The intervening quartz mosaic occupies a comparatively small part of the rock. Much of the hornblende is chloritized and there is also some derived epidote. The rock appears to be an altered trap, probably diabase. The nearest granite to both of these gold-bearing veins is the biotite-hornblende granite, which first appears on the boundary north of the Manigotagan river above 92 miles 50 chains. The difference between this and other granites along the boundary from the Winnipeg river northward, consists in the slightly greater basicity, indicated by the presence of hornblende in addition to biotite. A little oligoclase also is present. But it would appear that the determining factor in the deposition of gold and copper ores in the region is rather to be seen in the basic, and especially the calcareous character of the wall-rocks, than in the mere presence of metallic ingredients in the granitic secretions.

Glacial Observations

The whole of the area which was gone over during the season exhibited abundant evidence of intense glaciation, Fig. 8. Rounded surfaces, especially on the northern and eastern sides of hills, striated wherever the surface had not been removed by the scaling due to forest fires, or as in the case of some granites, by exfoliation or other forms of weathering; numerous lakes occupying undrained rock basins, and erratic boulders, all testified to the movement of ice over the country from a northeasterly direction. Very little morainic material occurs either as ridges or till sheets, but in many cases sandy plains occupy the valleys between the rounded hills, and in some few valleys a deposit of grey, stratified silt is found. These are respectively littoral and off-shore deposits of Lake Agassiz, and as such represent englacial materials worked over by the wave action of the lake, and deposited according to their coarser or finer character in shallower or deeper parts of the bays, on the eastern margin of the lake. Since the country which the line traverses stands at 1,000 to 1,200 feet above sea-level the shore line must have moved down the slope from the boundary toward Lake Winnipeg owing to the recession of the waters during the last stages of retreat of the ice barrier which retained them on the north.

The sand plains on the higher parts of the country may possibly be in some intsances outwash aprons or valley trains, but are more probably the result of the working over of till by wave action along shore lines, and the deposition of the sand in shallow bays as before stated. The area of level sand plain which lies along the northeast shore of Snowshoe lake would agree with this last conception, both as regards its appearance and its location in the valley of the Bird river, which would be occupied by a bay of the lake. The lower reaches of the river have cut a valley of some depth through deposits of clay or silt, which is seen in a succession of terraces on each side. This deposit is undoubtedly to be assigned to deposition in the deeper waters of the lake; and similar deposits occur in the valley of the Manigotagan river, where it crosses the boundary and on the shores of O-Buck-O-Win lake on the Bloodvein river.

The directions of the glacial striations which were observed during the summer are given in the subjoined table. They vary from S.45°W. to S.71°W., a difference of 26°.

Table of Glacial Striae

(Astronomic Bearing W. of S.)

1.	Winnipeg river, S. shore West boundary Tp. 16, Range 17	50°
2.	Same locality, North shore	64°
3.	South end of island, Sec. 16, Tp. 16, Range 17, E. P. M.	50°
4.	Foot of falls on Winnipeg river 3 miles S.E. of the intersection of the line	53°
5.	East side of large island below the falls	55°
6.	North shore of bay 1 ½ miles S. of Winnipeg river	57°
7.	West side Winnipeg R. at N. line of Tp. 15, Range 17	48°
8.	Bay of Ryerson lake on S.W. ¼ Sec. 34, Tp. 16, Range 17	55°
9.	Ryerson lake, S. shore N.W. bay (N.E. ¼ Sec. 33)	53°
10.	" " " " point on S.E. ¼ Sec. 34	65 ½°
11.	" " " " Ontario-Manitoba boundary line	61 ½°
12.	South shore of West bay of Lake Wilson	70°
13.	West shore of central southerly bay of Little Trout L.	45°
14.	Small bay on west side of Sucker lake	58°
15.	On creek from Sucker L. to Tulabi L. near first portage below Sucker L.	59°
16.	Snowshoe lake near second interesection of boundary line	50°
17.	200 yards North of Alga lake on route from Bird river to Wingiskoos lake	57°
18.	Point on N. shore of Snowshoe lake about 1 ½ miles east of Ontario-Manitoba boundary	62°
19.	Northeast part of small lake just N. of Snowshoe lake on the line (Lake 25)	58 ½°
20.	¼ mile West of the boundary about 86 miles 50 chains	71°
21.	Southwest bay of Flanders lake	55°
22.	North shore of Northwest bay of Flanders lake	57°
23.	On the boundary 8 chains N. of the first lake South of the Manigotagan river (Lake 39)	63°
24.	Second lake South of the Manigotagan river, (Lake 38) small island near West end. (1) Stoss side	64°
	(2) Lee side	71°
25.	Island lake, point on west side of N.E. bay ¼ mile S. of the portage to Garner lake (1) Stoss side	45 ½°
	(2) Lee side	61°
26.	Boundary Line at 92 miles 20 chains	62°
27.	West end of lake on 96th mile (Lake 48)	62 ½°
28.		54°
29.	Readings on O-Buck-O-Win lake	56°
30.		62°

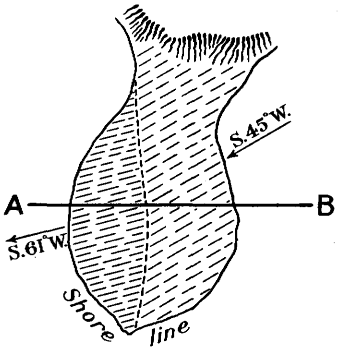
The glaciation of the region has been most extensively studied by J. B. Tyrrell[1] who has examined a large part of western Patricia from Hudson Bay southward to the upper waters of the English river, and also the eastern shore of Lake Winnipeg and the valleys of Nelson and Hayes rivers. He has found in some localities as many as three distinct sets of striations, and from his observations it appears that the region has been affected by at least as many ice sheets. Those which may have affected the region are:—(1) Labradorean, which had its centre of accumulation on the east side of Hudson Bay, and extended as far west as the line of the Hayes river; (2) Preceding the Labradorean was the Patrician ice sheet, whose centre of accumulation lay south of Hudson Bay, and about 125 miles north of the Albany river, in the longitude of Lake Nipigon; (3) Preceding this was an older ice sheet whose centre is not determined, but which may have been an earlier advance of the Labradorean; this axected especially the northern part of Patricia; (4) The Keewatin ice sheet, whose gathering ground lay to the west of Hudson Bay, extended southward and westward, and probably affected the western margin of the regions more or less at times. During the field work along the boundary in 1921 there were no striations noted which could be assigned to the Keewatin glacier. On the other hand, it is probable and in some places appears quite certain that first

[1]J. B. Tyrrell, "The Patrician Glacier South of Hudson Bay, Compte-Rendu, 12th Inter. Geological Congress, pp. 523-534; Ont. Bureau Mines, Vol. XXII, 1912, Pt. 1.

the Patrician glacier, and afterwards the Labradorean ice sheet passed over the region examined. In general, ice radiating in straight lines from the centre of dispersion of the Patrician glacier would cross what is now the intersection of the Ontario-Manitoba boundary and the Winnipeg river in a direction about S.56°W., and would cross the boundary at the farthest north point reached in 1921, about seventy miles north of the Winnipeg river intersection in an average direction of about S.67°W. At intervening points on the boundary one would expect bearings of striæ averaging between these two extremes. The striæ of the Labradorean ice sheet, on the other hand, might be expected to follow a more southerly course, say from S.55°W. to S.45°W., for the whole region. It is, of course, necessary to allow for local deflections of the ice movement due to topographic obstructions near the thin edge of the retreating ice, and for variations due to lateral movements at the sides of lobes of the ice sheet at its margin before or during its final recession. But as will be seen on referring to the extremes of the observed readings as given above, the observations during the season agree very well with the results to be expected from Tyrrell's description of the Patrician glacier, and allowing for the variations indicated above, all the striæ, so far as their direction is concerned, might be assigned to ice from this source alone.

But if both the Labradorean and Patrician glaciers are here represented, this section of the boundary coincides with segments of the periphery of the two sheets where the direction of movement in each case was so nearly identical that any of the observed sets of striæ might conceivably have resulted from the action of either ice sheet. Local conditions of occurrence are, therefore, important in determining whether one or two distinct glaciations are represented, and the conditions which presented themselves in the field, and appear to have evidential value for the occurrence of two rather than one glaciation are, (1) wide divergence between sets of striæ very close together, and (2) topographic location of the two sets of striæ of such a nature that one might necessarily or readily be supposed to have been exposed during the first glaciation, but sheltered during the second, either by a drift covering or by being on a lee surface in a depression where the ice either did not impinge or was practically stagnant, owing to the difference in direction of movement as compared with the first glaciation. It will be seen that the last case would be more common where the difference in direction of the ice-movement was increased up to 90°, in which case narrow depressions, which would be striated longitudinally by the first glaciation, might be filled with stagnant ice and remain unaffected by the transverse movement of the abrading englacial material during the second glaciation. In order to warrant any great degree of certainty when the divergence between the two striations is small, both the conditions of close proximity and different attitude of the glaciated surfaces would be required.

The observed cases which appeared to meet these conditions were of two different kinds, viz.: (1) The channel of the Winnipeg river at the western boundary of Tp. 16, R. 17, is a well incised, pre-glacial valley cut in the rock, and bearing S.80°W. The stream here is from twenty to thirty-five chains wide. The north slope would be a lee side for any ice moving southwesterly, and here the striæ run S.64°W. On the south side *per contra,* which would be a "stoss" surface, the reading is 50°. If the valley had any effect on the direction of the ice crossing it, it would be to throw it somewhat more westerly, but this would be more probable the more closely the ice coincided in direction with the valley, and less probable the greater the angle of crossing. The bearing of south fifty degrees west is much less than one would expect for the Patricia glacier, whose undiverted flow here would be about eight degrees more westerly. It is, therefore, altogether probable that the striations on the south side represent the later Labradorean ice sheet, which have here impinged on the south wall of the valley without diversion, obliterating the earlier records of the Patrician glacier. On the northern bank, the reading of sixty-four degrees is more westerly than the Patrician ice movement would be expected to be by about eight degrees, a factor which could be accounted for by the local effect of the valley diverting the ice flow westward, while the preservation of the striæ on this side is accounted for by the southward slope of the surface. If both records are of one time, we would have to suppose that the ice in crossing the river diagonally has been diverted fourteen degrees in the opposite direction to what would normally be expected. It seems tolerably clear, therefore, that the striæ of the north, bank (S.64°W.), represent the older Patrician glacier, while those of the south bank, (S.50°W.), represent the later Labradorean ice-advance.



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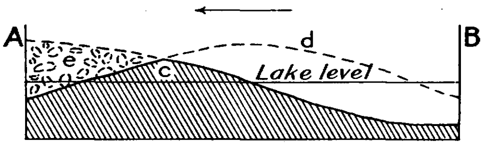

2.

ROCK EXPOSURE, ISLAND LAKE, EXHIBITING TRACES OF TWO DISTINCT GLACIATIONS.

1.—Plan of glaciated outcrop with two facets meeting at an angle, and bearing striæ of different horizontal directions.

2.—Vertical section of the same along line AB.

(c) The rock remaining at present (hatched).

(d) Hypothetical outline of *roche moutonnée* formed by first glaciation.

(e) Probable till or other drift of the first glaciation which served as a protection to the lee side of the *roche moutonnée* while the stoss side was being worn away by the ice of the second glaciation. This unsolidified material has since been removed by the wave-action of the lake.

Arrows in each case indicate directions of ice-movement.

(2) In two other localities, not far apart, the evidence is of a somewhat different nature. The localities are (*a*) a small island (marked X) at the west end of Lake thirty-eight, ninetieth mile, and (*b*) a point on the northeast bay of Island lake (*See* No. 25, Table of Glacial Striæ.) to the west of mileage 96. In both places a low, well-glaciated rock occurs, whose surface, instead of having the usual rounded whaleback or *roche moutonnée* form, consists of two distinct facets inclined to each other and meeting at a sharp angle like the ridge-line of a roof. In each case one facet is facing the advance of the ice, the other inclines away from it. In each case, too, the striæ on the stoss side are several degrees different in direction from those on the lee side.

and the two sets of striæ form an angle with one another at the ridge which separates the two facets. It can hardly be doubted that the striations in the stoss side represent a later glaciation which has worn away the stoss side of a *roche moutonnée* formed by an earlier glaciation, leaving a part of the lee side perhaps protected by frozen drift of the earlier glaciation. At Lake thirty-eight the difference in direction is seven degrees (stoss side sixty-four degrees, lee side seventy-one degrees) and on Island lake fifteen and one-half degrees (stoss side forty-five and one-half degrees, lee side sixty-one degrees). In each case the stoss side corresponds with the more southerly direction of the later Labradorean glaciation, and the lee side with the more westerly direction of the earlier Patrician glaciation, as was to have been expected. At Lake thirty-nine both ice streams have, for some local reason, been diverted considerably more to the west than would normally be the case, but on Island lake they correspond ex-

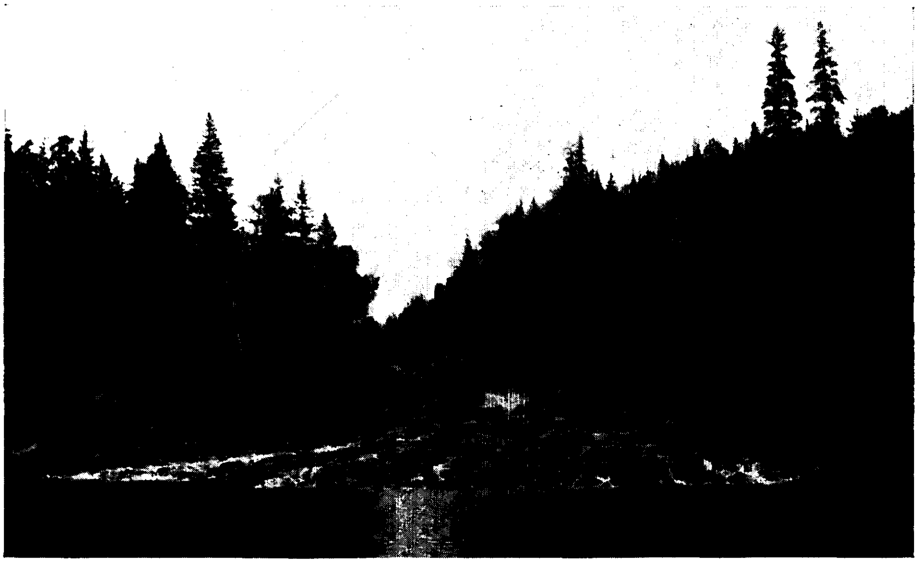

Fig. 9.—Post-Pleistocene boulder-cone, which has resulted from the cutting of a dam of till at the outlet of Tulabi lake on Bird river and deposition of the boulders at the foot of the fall. (August 24, 1921).

tremely well with the general movement in each case for that locality. The annexed figure illustrates the nature of these exposures by a diagrammatic plan and section drawn to represent the Island lake occurrence.

On the basis of these observed facts the writer inclines decidedly to the opinion that both the Patrician and Labradorean glaciations have left distinguishable records along this section of the boundary. At some points, post-Glacial erosion has resulted in the lowering of lake beds by the removal of drift dams. A good example of this is to be seen at the outlet of Tulabi lake, Fig. 9.

Historical Summary

The succession of events indicated by the petrography and interformational relations of the rocks described above may be briefly set forth as follows:—

Earliest Epoch One of Igneous Activity

The earliest record is that of a very ancient period of vulcanism with both subaerial and submarine extrusion successively in the same localities, as illustrated on the Winnipeg river by the succession of quartzite, poikilitic diorite, and andesitic pillow-lava. This area, which lies along the southern edge of the Oiseau river belt of the Wanipigow formation, represents the lower rocks of the southern limits of a synclinal trough, whose northern limit is bordered by the diabase and diorite of the copper-bearing area at the west end of Oiseau lake. These two igneous areas correspond to each other structurally on opposite sides of the fold and are also much alike lithologically, except that diabase, which occurs in the Bird Lake area, was not observed in the Winnipeg river exposures. The Rice Lake[1] rocks of the northern area on the lower Manigotagan and Upper Wanipigow rivers hold the same relation to the Wanipigow series, but occupy much more extensive areas, both in length and width on both sides of the overlying metasedimentaries. Both formations have been involved equally in the folding, which resulted in these structures, and any angular unconformity between the two formations due to pre-Wanipigow folding of the Rice Lake series, which may exist, is now difficult to determine.

The rocks of this formation throughout the field are largely andesitic, but diabase and rhyolite also occur.

Period of Coarse Sedimentation

Following the period of predominant vulcanism, there was an epoch of coarse sedimentation, in which conglomerate with an argillaceous matrix, and poorly sorted finer beds, mainly argillaceous, but in part siliceous and occasionally partly calcareous, were deposited. These are now represented by gneisses, greywackés, arkoses and biotite and hornblende schists. The matrix of the conglomerate is often of a gneiss or greywacké, and where the pebbles were of slaty materials they are now indistinguishable by the eye on fresh fractured surfaces, although they may stand out in relief on weathered faces and are often distinguished under the microscope by their slight differences of composition, texture and grain. The history indicated here is probably that of some uplift, followed by widespread erosion of the older materials, including granites which are not now to be seen in the region, and the widespread deposition of conglomerate and finer but ill-sorted detritus over the surface. The same conditions have been observed in the Wenasaga river, Birch lake and Red lake fields from fifty to one hundred miles farther east.[2] The source of the pebbles in the conglomerates is somewhat obscure. They include:—

(1) Pebbles referable without any doubt to the volcanics of the Rice Lake series.

(2) Granitic pebbles whose source seems to be uncertain, and not accounted for within the immediately adjacent territory. In the regions farther east and south, however, there was undeniably a considerable folding immediately after the Keewatin, which is correlated by Moore with the Rice Lake, and in connection with or following this orogenic movement there were extensive granite intrusions, which with their attendant gneisses have been known under the name

[1]Formation name given by E. S. Moore to the older volcanic series in this field.

[2]*See* Burwash, E. M., A Geographical Reconnaissance into Patricia, 29th Report, Ont. Dept. of Mines, 1920, Pt. 1, pp. 169, 175; also Burwash, E. M., The Pre-Cambrian of Western Patricia, Jour. Geol., Vol. XXX, No. 5, July-Aug., 1922, pp. 393 *et seq.*

Laurentian. Here there seems to have been no such intrusion at that time, and the folding seen elsewhere was probably represented only by gentle uplift, sufficient to subject the region to considerable erosion. The mountains of adjacent regions may well have supplied to the lowlands here the granite pebbles and the other ill-sorted detritus, characteristic of glacial or torrential deposition. The granite pebbles, moreover, are often well rounded and suggest a somewhat distant origin, while the matrix is often composed of large and small angular quartz grains imbedded in finer arenaceous matter or grains of unaltered feldspar.

(3) Quartz pebbles, also generally well rounded, for which the Keewatin (Rice lake) may nevertheless account, as in the case of the quartzites seen interbedded with lavas on the Winnipeg river. These are especially characteristic of the conglomerates from Slate lake on the Wenasaga river, and thence westward.

(4) Chert fragments, often quite angular, derived from rocks of the iron formation, none of which so far as yet known, occurs in the Rice Lake formation of this vicinity. It is not uncommon in other localities in the Keewatin, however, and may have been derived from part of the formations nearby, but since completely removed by erosion. Pillow lavas, as observed by Moore, are much less abundant in the Rice Lake than in the Keewatin elsewhere, and it is probable, as deduced by Leith and others, that the iron formation deposits were due to the aqueous solutions released from submarine extrusions, the iron and silica of which solutions were thrown down upon the sea-bottom in the form of a banded precipitate of alternating colloidal silica and the iron silicate, greenalite. The latter has since been leached to the oxide. It is probable, therefore, that iron formation was originally present in the Rice Lake series at no great distance from the present boundaries, since pillow lavas, although uncommon, are found in some parts of the field.

While no striated pebbles or other indubitable evidences of a glacial origin were found in the Wanipigow conglomerates, they present one or two characteristics which are not irreconcilable with such a theory, viz.: (1) No evidences of bedding were observed in them, or parallelism of the pebbles, except where extreme shearing of the rock would account for the parallelism, (2) in so far as observed, the larger fragments, which are rounded, angular and subangular in proximity to each other, are seldom in contact, but generally somewhat separated in the matrix, which would not be the case where stream-deposited boulders or talus blocks have their interstices afterwards washed full of finer materials, Fig. 7.

Stage of Deformative Movements

Succeeding the Wanipigow sedimentation, which may have been largely subaerial and littoral, there was a period of folding which resulted in a great degree of regimal metamorphism reducing the mixed arenaceous and argillaceous materials to the condition of schist or gneiss, and the extrusives likewise in many parts to schists or cataclastic greywacké or gneiss.

Granitic Intrusions

Following the deformation there were probably two stages of granitic intrusion, the older the more basic and the later acidic. The two plutonics are clearly of different ages in some parts of the region, as on the Winnipeg river, where angular fragments of the older granodiorite can be seen included in the later granitite. In other places, as observed by Moore, there are intermediate phases to be seen in various parts of the field, but on the other hand, these could be accounted for by the assimilating of Rice Lake andesite rocks in the margins of the red granite intrusions, such as has undoubtedly taken place in some places, or by the assimilation of the earlier plutonic by the later. On the Winnipeg river the grey granodiorite is seen to be intrusive in the Rice Lake schists, and is intruded by the granitite. It is, therefore, younger than the schists, but older than the granitite. There are the usual pegmatites, red in colour, attributable to the red granitite, and traversing it and the adjoining rocks. Their composition is usually reddish orthoclase about eighty per cent., smoky quartz, biotite in crystals up to two inches in diameter, apatite prisms about one-quarter inch in diameter, and tourmaline. The red biotite granite, granitite, of the Winnipeg river is replaced further north by a reddish binary granite in which muscovite is commonly present along with the biotite, and in the area to the north of the second pre-granite belt, from Island lake to Carroll lake, hornblende is generally present with the biotite. Microcline as well as orthoclase is common to all. The whitish binary granite and pegmatite seen on Winnipeg river, Little Trout lake Ryerson lake, and elsewhere, may be a pegmatitic phase of the red binary granite, in which red orthoclase is entirely replaced by white microcline. In one case, however, on the portage from Alga lake to Wingiskoos lake, a body of this white granite was found cut by a dike of red granite, which would place it as possibly intermediate in age between the grey granodiorite gneiss and the red granite were all red granites of equal age. As the red granites themselves differ in composition, it is possible they may be different in age, but it is more probable that they are comagmatic differentiation phases.

Besides the purely massive aspects, the granite has produced a great variety of composite rocks by its action on the intruded formations. In the localities where the pre-granite rocks were schistose or already gneissic, it has by penetration of its end products along the planes of schistosity, depositing feldspar and quartz, produced wide areas of gneiss, especially in the case of the more siliceous Wanipigow series. In other cases the action has been rather an assimilation by stoping and fusion, and to this the more massive basic effusive rocks seem to be especially subject.

Finally, the quartz deposited in fissures of the older rocks by the excreted solutions of the granite has formed veins in both Wanipigow and Rice Lake rocks. The gold-bearing veins are largely confined to the Rice Lake greenstone areas, probably for reasons already discussed, namely, that the precipitation of the metals from solution required the presence of basic reagents which were absent in the predominantly silico-aluminous measures of the Wanipigow.

Erosional Phases

The subsequent history indicated in this region is largely erosional. There is evidence that the Archean rocks were reduced to a planated surface, not greatly different from the present, before Paleozoic time, and that Paleozoic strata were deposited on this surface over large areas which are now again uncovered. The surface laid bare again since Paleozoic time was undoubtedly enlarged by the action of the Pleistocene ice caps, which also removed all regolith and partly decomposed rock from the Archean surface, and affected its topography in ways already discussed in the section on physiography. Whether the three erosion cycles of which remains were thought to be detected, were pre-Glacial merely, or also pre-Ordovician, is a problem which would require some further analysis.

In the following table the outlines of the geological history are condensed:—

9. *Recent*—Removal of some drift by wave and stream action. *See* Fig. 9. Deposition of stratified clays and boulder cones, weathering of micaceous rocks.

8. *Pleistocene*—Removal of regolith and overlying rock; deposition of till sheets, outwash sands, morainic ridges, etc.

7. *Mesozoic and Paleozoic*—Deposition, at least in some localities, of strata since removed.

6. *Pre-Ordovician*—Planation of Archean rocks.

5. *Post-Wanipigow*— (1) Folding and regional metamorphism. (2) Granitic intrusions.

4 *Wanipigow*[1]—Deposition of conglomerates, greywackés and arkoses from materials partly travelled, but mainly local and ill-sorted, by agency of mountain torrents or glaciation.[2]

3. *Laurentian*—(?)

2. *Pre-Laurentian*—Uplift (?)

1. *Keewatin*—Extrusion of traps, andesites and rhyolites, partly under water, partly on land, with periods of sea-advance or recession marked by sands.

Waterpower

The streams crossed by the part of the boundary line surveyed in 1921, all flow westward and fall into Lake Winnipeg, with an average descent from the boundary to the lake of over 300 feet, as shown in detail by the following table:—

River	Altitude at boundary	Fall to Lake Winnipeg[3]
	ft.	ft.
Main stream, Winnipeg river	984	270
Manigotagan river	1015 (Garner L.)	301
Wanipigow river	1071	357
Bloodvein river	1062 (Carroll L.)	348
		Fall to Lake du Bonnet[3]
Bird river	1073	246

The characteristics of the rivers of the Archean Shield which affect their value as sources of waterpower are determined by two physiographic factors:—(1) The "quilted" type of topography which prevails, consisting, on a large view, of flat-topped uplands with rounded slopes extending down into the main depressions, such as that occupied by Lake Winnipeg, or the slope to Hudson bay, a characteristic which also appears in the lesser uplands which lie between the smaller streams, such as the English river and others, (2) The effects of glaciation in providing numerous lake basins on the uplands and elsewhere, and the youthfulness of the drainage system which was established after the retreat

[1]The rocks classed by Dr. Burwash as Wanipigow appear to correspond to the Timiskaming series of the eastern part of Northern Ontario.—W. G. M.

[2]This period may cover part of the time included under 2 and 3.

[3]Lake Winnipeg has an altitude of 714 feet and Lac du Bonnet, an expansion of the Winnipeg river in Manitoba, is 827 feet above sea level.

of the ice. The result of these conditions is that the rivers on the uplands take their rise in groups of lakes which drain one into another by short streams, often by single falls or rapids each descending over the lip of its rock-basin at its lowest point into another whose outlet lies lower still. Except in some few cases where the basin was dammed by drift, Fig. 8, no lowering of these outlets by erosion has yet occurred. Such streams are therefore at their headwaters in reality branching chains of lakes, which wind in all directions, so that the water frequently flows in a direction opposite to that in which its final destination lies. The lakes are often of large area, and afford excellent opportunities for storage of flood-water by the construction of dams at their outlets. As the gradually augmenting streams approach the steeper slopes leading to the larger depressions, they may still, to a considerable extent, maintain the character of lake reaches connected by waterfalls, or may descend as a series of rapids through valleys or canyons of pre-Glacial age. The typical profiles of such rivers are therefore convex upward, with great possibility of storage in their upper reaches, and a concentration of their waterpower in large units in their lower courses where the streams have practically reached their maximum volume. This steep descent is sometimes followed by a slight concavity of profile on nearing the mouth, where the stream may be navigable for a few miles without canalization.

These general considerations apply quite fully to the streams crossed by the Ontario-Manitoba boundary line in its course northward from Lake of the Woods, with the result that while the storage basins and much of the drainage area of these rivers lies either near the boundary, upon it, or eastward in the Province of Ontario, the more important of their available power sites lie to the westward in the Province of Manitoba, on the steeper slopes toward Lake Winnipeg.

Peat bogs, which are common in the uplands, undoubtedly afford some natural regulation to the flow of the rivers by retarding the rapid escape of storm-water or melted snow. The lakes have a less efficient action in this respect and probably allow of more rapid evaporation. The intervening hills, on the other hand, being practically solid unweathered rock with smooth glaciated surfaces, discharge their waters very rapidly into the valleys, though even here the growth of mosses acts to some extent as a check. The amount of evaporation here is probably not large, owing to the rapid run-off, and the percentage of water which finds its way below the surface or remains long in the cracks of the rocks is probably small, as evidenced by the fact that springs of any size are very seldom seen. The maintenance of forests in these upland areas is no doubt important in reducing both the rapidity of run-off and the amount of evaporation.

Winnipeg River System

Surveys of the Winnipeg river have been made by the Dominion Water Power Branch, Department of the Interior, and accurate information is therefore available regarding that stream[1] and its principal tributary, the English river. As is well known, its falls from Point du Bois down have been, or are being brought into service for supplying electric power to the city of Winnipeg, while its upper power sites are in use at Kenora, and farther east at Fort

[1]See Water Resources Papers Nos. 3 and 7, Dept. of the Interior; also Denis and Challies, Waterpowers of Manitoba, Saskatchewan and Alberta, Commission of Conservation Reports, 1916.

Frances. The total power which is available on the section of the Winnipeg river from the boundary to Lake Winnipeg is estimated at 249,300 shaft horse power, using the unregulated minimum flow of the river, and this might be increased by proper storage dams and regulation of flow to about 418,500, allowing for 75 per cent. efficiency in the plant. On the Ontario side, between the boundary and Lake of the Woods, there is a fall of 77 feet. Of this 20 feet head is concentrated at the Kenora and Keewatin power sites[1], and 44 feet additional is available at White Dog rapids, a few miles east of the boundary, with a minimum available horsepower of 26,800 at 80 per cent. efficiency. The English river, which enters the Winnipeg below the White Dog rapids, but on the Ontario side of the boundary, has a drainage area of 22,000 square miles and a total descent from Lac Seul to the boundary of 169 feet, of which 80 feet is concentrated in one fall near the mouth of the river at the outlet of Atikwa lake. The power available here, on the basis of 80 per cent. machine efficiency, and minimum flow, is probably 40,000 shaft horse power. There is a further descent of about four to six feet in the Winnipeg river a few miles east of the Manitoba boundary. This fall is divided into a number of separate chutes by islands in the stream. The theoretical minimum horse power obtainable here would be 5,800 at 80 per cent. efficiency.

North of the English river and east of the inter-provincial boundary, there is an unexplored area where no topographic mapping has been done which would yield information as to the limits of the drainage basins of the rivers which cross the boundary flowing westward to Lake Winnipeg. The extent of their upper waters is therefore unknown, but they are enclosed on the east within an irregular space which is limited by Red lake and its tributary waters and the line of the White river, which lie about 40 miles east of the boundary, and by the Berens river which is about 120 miles north of the English river and roughly parallel to it. The southern half of this area, or at least the western part of it, appears to be mainly occupied by the upper drainage basins of the Bird river and of the south branch of the Bloodvein river. The Manigotagan appears to be quite near its head-waters at the boundary, and the Wanipigow extends only across the line as a small canoeable stream which drains a number of small lakes, the most easterly of which reaches a distance of about three and a half miles into the district of Patricia.

Among the minor tributaries of the Winnipeg river is the Bird river, which rises in the district of Patricia, crosses the boundary about 20 miles north of the Winnipeg river and flows west-southwest into Lac du Bonnet. It has an elevation of 1073 feet at Snowshoe lake, where the boundary crosses it, and its fall from there to Lac du Bonnet is 246 feet. Although it was not followed to its headwaters, the total basin was estimated at nearly 400 square miles, which would yield about 9 horsepower per foot of head in the lower reaches of the river as a minimum. The best power sites observed on this stream were at the two portages just above Tulabi lake[2], and the two falls at the outlet of Snowshoe lake and the narrow lake just below it, Fig. 10. There is probably a total head of 100 feet in these four sites which might yield a minimum of 500 horsepower, or more if storage basins were developed. This would be convenient for local

[1]See Denis, Electric Generation and Distribution in Canada, Commission of Conservation, 1918.

[2]See G. S. C. Sum. Rep. 1912, map, p. 262.

use should the mines of this river prove workable. At the same time it must be considered that a comparatively short transmission line would furnish power from the much larger and more economic sources on the Winnipeg river, a few miles to the south. The Bird river flows in a well marked valley without lake expansions for about 15 miles above its mouth, receiving one tributary on the south. In this portion of the river there are seven rapids, the first of which is situated about 5 miles from the mouth, and no doubt small plants could be installed to make use of much of their power. Above this reach is Bird lake, about 5 miles long, the first of a succession of lakes extending to the headwaters of the river, of which Snowshoe, Fishing and Eagle lakes are the largest. These lie on the Ontario side of the boundary, except a small part of the west end of Snowshoe lake. Above Eagle lake there are two branches which have not been followed to their sources, and of these that which enters from the north seems to be the more important.

Fig. 10.—Falls on Oiseau (Bird) river, low water stage, a short distance west of the boundary. The descent is about 20 feet. (August 24, 1921.)

Octopus Lake and Connections

Proceeding northward the boundary passes out of the Bird river basin on the southerly part of the 85th mile, and this is also the northerly limit of the Winnipeg river drainage area on the line of the boundary. Following this is a small lake of elongated form leading northwest, which drains into Octopus lake. This and Johnston lake, a short distance to the east of it, are typical "height of land" lakes, extremely irregular in shape, full of islands, for the most part shallow and surrounded by country of very low relief. Such lakes often drain in more than one direction, but that is not the case here. The waters of Octopus lake and the small lakes along the line just north of it flow to the westward, while Johnston lake drains into Wingiskus lake, which lies about a mile and a half farther east. The outlet of Wingiskus lake, however, flows westward, crossing the boundary at about 88 miles 20 chains. To the north of this are three other lakes numbered 37, 38 and 39. Lake No. 37 flows eastward through Rickaby lake into Wingiskus lake and 38 and 39 flow westward. In these lakes and their outlets we have the headwaters of another drainage system, whose basin is about 6½ miles wide where crossed by the line. It is not certain whether these are the headwaters of Black river, which enters Lake Winnipeg just north of Traverse bay, or whether they belong to the stream which enters the east side of Happy lake, which in turns drains to Muskrat or Manigotagan lake. The altitude of Octopus lake is 1,142 feet, and that of Lake 37 is 1,134 feet. They are therefore respectively 428 and 420 feet above Lake Winnipeg, and Wingiskoos lake is probably about 1,100 or more feet in elevation, or roughly 400 feet above Lake Winnipeg. Their heights above Muskrat lake would be:—

Octopus lake	207 feet.	
Lake 37	199 "	
Wingiskus lake	190 "	(roughly)

This drainage basin does not extend to the eastward of Wingiskoos lake, which has an area of about 2½ square miles. The hills in this neighborhood have a maximum elevation on the line of 1,222 feet; the local relief is therefore not much over 120 feet, and near Octopus lake about 80 feet. Another characteristic height-of-land feature is the extensive muskeg which lies parallel to the west side of Wingiskus lake.

Manigotagan Basin

The Manigotagan river has been surveyed from its mouth as far as Long lake by the Manitoba Hydrometric Survey[1] and gaugings were taken of its discharge near the mouth during parts of 1913, 1914 and 1915. The drainage area was estimated at 375 square miles, which should afford a minimum mean flow of 94 second feet at .25 second feet per square mile. There are six practicable power sites below Muskrat lake, with a total head of 223 feet and an estimated horsepower of 608 at minimum flow or 3,034 with regulated flow. The group of lakes half way down the course of the river, of which Muskrat lake is the largest, afford ample storage facilities to secure the required uniform distribution of the flow throughout the year implied in the term "regulation." Above Long lake the river divides into two branches. The northerly branch again divides. One of its branches coming from the east drains Garner lake, which lies on the boundary, and a few small lakes to the east of it, and the other carries the waters of Beresford and Moore lakes, which lie to the north, toward Wallace lake, and probably a number of small lakes easterly to the boundary. The main southerly branch leads in a southeasterly course in line with the main trend of the river, and drains Island, Slate and Bee lakes and another lake east of Bee lake[2].

Its headwaters, therefore, extend about eight miles east of the boundary line and lie just to the east of Wingiskoos lake. The area of the drainage basin above Long lake is about 210 square miles. If, as seems probable, the waters of Wingiskus lake and the lakes west of it flow into Muskrat lake, the area of the basin thus drained above Happy lake is about 90 or 100 square miles. The estimate of the Manitoba Hydrometric Survey of 375 square miles for the entire drainage basin of the river above Wood Fall would therefore appear to be rather too conservative. No possible power-sites of much potential horsepower were observed in the region travelled near tbe boundary, but such con-

[1]See Denis and Challies, Waterpowers of Manitoba, Saskatchewan and Alberta; Commission of Conservation, 1916, p. 83.

[2]For a map showing the headwaters of the rivers from the Winnipeg river southerly, see Geo. Surv. Can. Sum. Report, 1912, p. 262.

centrations of power as may be possible on the Manigotagan above Long lake and especially on the Beresford and Garner lake branches, which have a total fall to Long lake of only 25 feet, might prove to be of value owing to the proximity of the mining claims of the Rice Lake gold field. But if the mining development here should assume large proportions no doubt the power of the lower part of the river would be utilized.

Wanipigow River and Bloodvein River

The Wanipigow or Hole river rises a very short distance east of the boundary and follows a course nearly parallel to the Manigotagan river and from five to ten miles north of it. It has not been surveyed by the Manitoba Hydrometric Survey, but in general it may be stated that it appears to resemble the others already studied in having its headwaters in a group of lakes, of which Wallace lake and Whitefish or Siderock lake are the most important and have a combined area of about 4 square miles. The area of Wanipigow lake on the lower part of the river is about the same, and the Rice lake-Clearwater lake group at the head of the south branch might also afford some storage. The total descent of the river from the boundary to Lake Winnipeg is 357 feet, but the distribution of this along its course is not available at present, and the possible power concentration cannot be calculated. The total drainage area of this river, above the junction of the English brook, is about 600 square miles, which should afford a minimum of 13 horsepower per foot of head at sites near the mouth of the river.

A few miles north of the Wanipigow river intersection, the boundary line reaches O-Buck-O-Win lake. The greater part of this lake lies on the Manitoba side of the boundary and its most southerly bay is about a mile to the west of the 113th mile. Its total length from north to south is about six and a half miles, with a maximum width of about one and a half miles. From near the middle of the east shore a bay extends three and a half miles to the southeast, and crosses the Ontario line. The outlet of the lake is on the northerly part of this bay and flows about half a mile across the line into Carroll lake. This lake lies almost directly north and south along the boundary for ten and a quarter miles. Both lakes are of the typical upland type, very irregular in outline, with long bays and many islands. From the west side of Carroll lake the southeasterly branch of the Bloodvein river flows in a northwesterly direction. The elevation of the river at the boundary and of the lake itself is 1,062 feet. O-Buck-O-Win lake is 3 feet higher. Allowing for islands these two lakes have a probable area of five or six square miles, but little is known of the area which is tributary to them. The Bloodvein river, where it enters the east side of Carroll lake, is estimated to be about 70 per cent. of its volume at the outlet and comes from a southeasterly direction. Its headwaters are said[1] to extend to the height of land beyond which the streams flow to the English river. The outlet of Carroll lake, which was observed in September, is described as "a large flow of water," but was not seen by the writer. The descent from the boundary to Lake Winnipeg is 348 feet, of which about 200 feet appears to be above the main forks of the river at Kowtunigan lake. The total drainage area of this river is estimated by the Commission of Conservation at 3000 square miles but the data for an exact determination are still wanting. The boundary survey for the season of 1921 ended a short distance north of Carroll lake.

[1] See Denis and Challies, *op. cit.*, p. 86, *et seq.*

Soil

The country adjacent to that part of the boundary which was surveyed during the season of 1921, offers little in the way of inducements to the agriculturalist. Lying as it does near the height of land which separates the streams that flow westward to Lake Winnipeg from others which flow to the east and south to join the English river and its tributaries, the elevation varies from about 1,000 to 1,225 feet or more, and the surface consists very largely of low, rounded hills and ridges of smoothly glaciated rock, swept bare of soil by the action of the Keewatin and Patrician glaciers. Such unconsolidated materials as remain are found in the valleys and along the margins of lakes for the most part, but occupy only small areas.

Along the Winnipeg river the country consists principally of rounded hills of granite, but a few re-entrants of the main valley and small tributary valleys are floored with silt, which produces a heavy growth of wild hay, and these flats, which are often flooded at high water, furnish favourable feeding grounds for red deer (*Odocoileus Virginianus borealis*). An area of level land with soil of apparently good quality lies along the northern shore of the bay into which Crow Duck lake discharges, and which is crossed by the boundary line a mile and a half to the south of the main channel of the Winnipeg river. The width of this strip of soil where the line crosses it is about half a mile.

To the north of the Winnipeg river there are a few narrow valleys between the granite hills, which are floored with clay or slit which supports a growth of large poplar. These are confined, however, to Township 16, immediately north of the Winnipeg river, and beyond Ryerson lake which lies near the northern boundary of this township, but few such spots were seen. From Ryerson lake to Snowshoe lake on the Bird river there is a succession of granite hills with occasional muskeg, but no soil.

Below Bird lake in Manitoba, there is a deposit of clay extending for several miles up the Bird river valley from its mouth at Lac du Bonnet, constituting an eastward extension of the Lake Agassiz deposits which cover the prairies farther west[1]. It has been sculptured into a series of terraces on each side by the river during the recession of the lake, and these are now occupied as farms by Lettish settlers who came there some years ago from Brazil, whither they had previously migrated from the Baltic provinces of Russia. The clay, however, does not extend far above the first portages and is not seen to the east of Bird lake, but there is a deposit of till on the portage between Bird and Tulabi lakes and some soil on the portages as far as Snowshoe lake, but only in scattered areas of small extent. On the north side of Snowshoe lake, on the Ontario side of the boundary, there are extensive sand flats which may represent inshore deposits of the glacial lake or glacial outwash, probably the former. To the north toward Manigotagan river a few patches of till are found in valleys and on ridges. In the valley of the Manigotagan river above and below the point where the line crosses it, there is an exposure of grey stratified silt, exposed in banks which rise about fifteen feet above the river in places, but this occurs only as a very narrow band, hardly more than one or two hundred yards wide in most of its course, as seen between Bee and Slate lakes. It is probable also that in the country between Slate, Island and Garner lakes, there are considerable areas of soil, much broken by protruding hills of rock.

[1]See also under "Glacial Observations."

On the portage from Garner lake to the northeast arm of Island lake, the lower parts of the country and the hill-sides are covered with till which is absent only on the hill-tops, and appears to be overlain by alluvium in the swales along a creek and in other places by muskeg. The short portage leading from the Manigotagan river to Island lake is also largely covered by soil.

Farther north there is an area of presumably sandy soil which is crossed by the line from 112 miles 40 chains to the south shore of O-Buck-O-Win lake, and is wooded with large banksian pine.

Timber Resources

Of the portion of the boundary surveyed in 1921, only the southern end lies within the habitat of the red and white pine (*Pinus resinosa* and *Pinus strobus*). These were found growing on the shores of the bay which extends southward from the Winnipeg river and leads to Crow Duck lake. The line intersects the north shore of this bay about a mile and a half south of the main

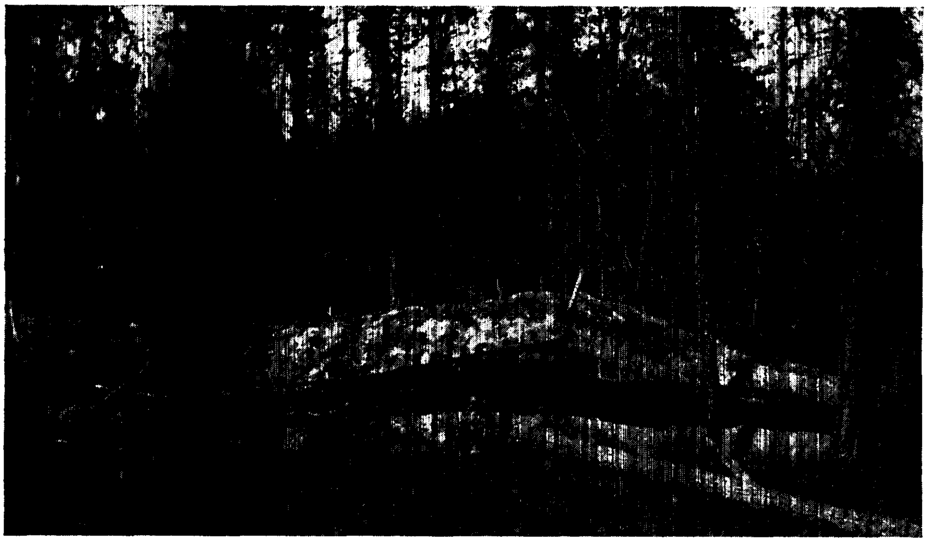

Fig. 11.—Sparse jackpine forest on summit of granite hill near Winnipeg river. The arched slabs of granite are apparently due to ice movement.

channel of the Winnipeg river, and at this point, red and white pine and bur oak (*Quercus macrocarpa*) were observed growing. None of these were noticed north of the valley of the Winnipeg river, except the oak which was also observed in the valley of the Manigotagan river where it crosses the line. On the flats, bordering streams, the elm (*Ulmus Americana*) was noticed as far north as the Manigotagan valley, where some sumach (*Rhus typhina*) was also seen. Mountain ash (*Pyrus Americana*) and white cedar (*Thuja occidentalis*), which occur in the region north of Lac Seul were not seen on the Ontario-Manitoba boundary, but would probably be found by careful searching. The balsam poplar or balm of Gilead (*Poplus balsamifera*) occurs where there is exceptionally good clay land and was seen in some abundance, especially in the lower valley of the Bird river, but owing to scarcity of soil is not common farther north. Willows of small size were everywhere found fringing rivers and lakes. They appear to be of two distinct varieties, but the species are undeterminable except in spring. The alder (*Alnus incana*) was less common in such localities, but occurs especially in the sheltered "swales" among the hills. Of the more important trees of the region, as judged by the areas which they cover, the jackpine, aspen and black and white spruce hold the chief places. Throughout the region traversed the jackpine (*Pinus Banksiana*) covers by far the largest area, probably more than half of the total. It occupies not only all the dry sand plains, but also the bare rounded hills of granite, Fig. 11. Its heaviest growth is usually on sandy soil, where it may reach a diameter of about two feet and a height of sixty feet, but on the exposed hill-tops the stand is more open and the trees are seldom over a foot in diameter and are short and gnarled, Fig. 11. The aspen or common poplar (*Populus tremuloides*) is probably the second tree in numbers and is found chiefly in valleys, along lake margins or the lower slopes of hills, where some soil of fair quality exists, Fig. 12. In some such localities,

Fig. 12.—Poplar bush on shore of Bee lake, Manigotagan river, two miles east of the boundary. A hunter's cache is on the scaffold.

as for example, the valleys of the Winnipeg and Bird rivers, it reaches a very large and dense growth, sometimes two feet in diameter and 70 or 80 feet high, and as usual in such localities it is often mixed to some extent with the balsam poplar along rivers, and in dryer and more stony localities with a few silver birch (*Betula alta* var *papyrifera*), some of which attain a fair size. The areas covered by spruce along this section of the boundary are comparatively small, and are limited in the case of black spruce (*Picea mariana*) to some open stands on muskegs and in the case of white spruce (*Picea Canadensis*) to some areas in valleys and along rivers where the spruce is mixed with poplar. Tamarack (*Laryx laricina*) of fair size and in good condition was noticed in the Bird river valley, and a few individuals at other points.

The bird cherry (*Prunus pennsylvanica*) is also found commonly in dry locations along the edges of open glades or the banks of lakes and rivers. Dwarf juniper (*Juniperus communis*) was noted near the Winnipeg river, as were wild gooseberry and raspberry bushes. The usual blueberries were in abundant fruitage on burned areas near the Bird river during the latter part of July. Among the flowers noticed in June was a very handsome pink species of *Cypripedium* or moccasin flower.

Forested and Burned Areas

Near the intersection of the boundary and the Winnipeg river the country is finely wooded with large trees, mainly jackpine on the hills with some poplar and spruce along the valleys. This is also true of the country northward as far as Shinewater lake, and of the lower valley of the Bird river, until Bird lake is reached. The north side of this lake is burned over and the burnt area extends thence eastwardly. At the boundary line its width is about 9½ miles or more, from Shinewater lake northerly to Snowshoe lake on the Bird river. This river has burnt country on both sides at intervals all the way from Snowshoe lake to Bird lake, but on the boundary line the river marks the northerly limit of the brulé; thence northerly the line crosses a succession of hills wooded with jackpine, which is for the most part not as large as that near the Winnipeg river, but a few intervening valleys are wooded mainly with poplar, which in some places reaches large dimensions, notably in the river valleys and on the shores of Garner and O-Buck-O-Win lakes. Some muskegs occur, but these are not in the main extensive. The largest seen was that which lies to the west of Wingiskoos lake and bears a sparse growth of small black spruce.

Fish

The waters crossed by the boundary line or which lie near it are entirely tributary to Hudson bay and belong to the Nelson river system. The principal fish in these waters are the sturgeon (*Acipenser rubicundus*), pike (*Lucius lucius*), pickerel (*Stizostedion vitrium*), whitefish (*Coregonius clupeiformis*), goldeye (*Hiodon alosoides*), lake trout (*Cristoniover namaycush*), and perch (*Perca flavescens*). Suckers (*Catostomus catostomus*) and tullabees (*Argyrosomus tullabee*) are also found. All of these occur in the Winnipeg river or its lake expansions. Those caught by our party near the boundary line crossing included sturgeon, pike, pickerel and perch. Pike and pickerel were by far the most readily caught in June, and the pike was the commonest fish in all the waters. Trout were also found in Little Trout lake, which drains into Bird river, an affluent of the Winnipeg. As no nets were used, it is not possible to state whether whitefish were present in any of the streams or not, but these commonly retire to the deeper lakes except at spawning time. Mud turtles of large size were seen in the Winnipeg river waters.

Game, Animals and Birds

In the valley of the Winnipeg river where grassy meadows occur, red deer are very plentiful, but they were not seen in such numbers north of the Bird river. Moose (*Alces Americanus*) occur quite abundantly in the whole region traversed, Fig. 13, and woodland caribou (*Rangifer caribou*) were also seen at several points. Here as elsewhere these three varieties of deer form an interesting oecolological group, each occupying a distinctive place in relation to the available food supply. The red deer live mainly on grass, the caribou on moss and the moose on spruce twigs and water plants. They are therefore complementary rather than competitive in the life scheme of the region. In accordance with the same principle the moose, whose food is the most abundant, are larger and on the whole the most numerous and widely spread in the coniferous forest region. The red deer are the smallest of the three, more southern in range, and more abundant only where grass-grown meadows occur, and the caribou, while larger than the red deer, are the least numerous of the three in the southern parts, but more abundant in the north, where grasses give way to mosses.

Ruffled grouse (*Bonassa umbellus*) were constantly met with throughout the season, but spruce partridge (*Canachites canadensis canace*) were rare or absent, and prairie chicken (*Tympanuchus Americanus*) were not seen. Wild ducks of several sorts were rearing broods on almost every lake or quiet reach of river.

Fig. 13.—Moose feeding on water weeds, Elbow lake, Bird river. (August, 1921.)

The blue heron (*Ardea herodias*) was occasionally met with, and the loon (*Gavia immer*) was common everywhere and was seen nesting on the Winnipeg river in June. Gulls (*Larus argentatus?*) and terns (probably *Sterna hirundo*) also nest commonly on rocky islets in many of the lakes. Wild geese (probably *Branta canadensis*) were seen collecting in flocks in August on the lakes where wild rice abounds, especially Slate lake on the Manigotagan river.

Fur Bearing Animals

Surprisingly few of these were met with during the season, for the reason, apparently, that they had been hunted to extermination a few years ago. Hunters' trails several years old were seen everywhere and beaver work, both houses, dams and cuttings of a corresponding age, but there was no evidence of recent activity by beavers (*Castor fiber* var *canadensis*) except a small showing on one lake, where a few fresh cut sticks were found, Fig. 14. No bear (*Ursus americanus*) and not more than one mink (*Putorius vison*) were met with by the writer during three months in the field. The reason for this may be traceable to the existence of the Rice Lake gold field immediately west of the boundary, which has brought a large number of prospectors into the country, who in many cases may spend the winter in trapping; or possibly the Indian trappers who originally occupied the region, finding their hunting grounds trespassed upon, have hunted them out and moved off to other localities. As to the methods which had been used in the extermination of the beaver, their lodges with the roofs broken in bore witness. Some traps were found set, apparently for muskrats (*Fiber zibethicus*), but these appeared to be abandoned, and none of the animals themselves were seen. No traces were found of fur-bearing animals other than those mentioned, but occasional porcupines were encountered.

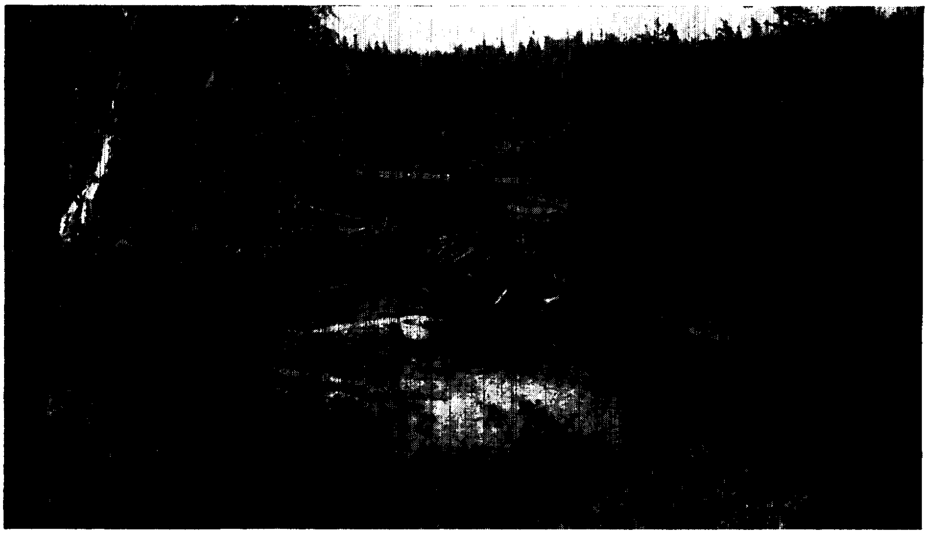

Fig. 14.—Beaver dam at eastern inlet of Little Trout lake.

Climate

Following the procedure adopted by the writer in the field season of 1919 on the survey of the Sixth (Ontario) Meridian and the region which lies to the north and northwest of Lac Seul, a record of the daily maximum and minimum temperatures was kept with a Sixe's thermometer, and in addition notes on wind, rain and cloudiness were made with fair regularity. The results are appended in tabular form below. The monthly means for the field season follow:

	Max.	Min.	Mean.
June (1st, 2nd, 8th & 10th omitted)	92°F.	29°	67.25°
July (10th & 23rd omitted)	91.5°	52°	69.29°
August (20th omitted)	87°	33.5°	59.47°
September	81°	31.5°	53.76°
October 1st. to 4th.	62°	31°	43.50°
June, July, August & September	92°	29°	63.73°

The frost recorded in June occurred on the 3rd and 4th, and no further frost was encountered until Sept. 16th, when the temperature fell to 31.5°. The mean temperatures above given, being taken as an average of the daily maximum and minimum are from one half to one degree too high, but making the fullest allowance for this, the mean summer temperature of the region is well above that required for successful grain-growing. Owing to several failures of the thermometer indicators and consequent lack of a number of records, the results cannot be regarded as of very much scientific value. Full records were kept on 120 days, and partial records for five days more, altogether 125 days, from June 3rd to October 5th. Of these days rain fell on 68, or about 54.4 per cent. Although no rain-gauge was used it is clear that the region, which is virtually a ridge lying to the east of Lake Winnipeg and at 350 to 500 feet greater elevation, has a considerably greater precipitation than the lower prairies to the west. Of the 68 rainy days thunder accompanied the rain on 18; of these, 6 were in June, 7 in July, 3 in August and 2 in September. These numbers when compared with the mean temperatures for these months give fairly comparable curves, *See* diagram. The frequency of thunderstorms increases almost in proportion to the mean temperature, which apparently proves that the storms owe their origin to the usual cause in flat countries, namely, the frictional electricity due to the separation of electrical charges when a heated stratum of air on the surface of the earth pours upward through an opening in the cooler strata above. The observations, which might show a greater coincidence between the effect and the cause if extended over a number of seasons, appear to indicate also that for this region a minimum of such atmospheric disturbances is reached when the mean temperature falls to between 45° and 50°.

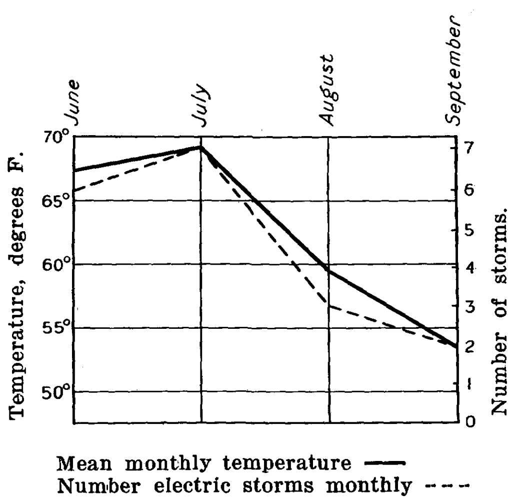

Diagram showing relation of temperature to frequency of thunderstorms, June-Sept., 1921.

DIRECTION	NUMBER	PER CENT.
N.	2	1.96
N. W.	18	17.65
W.	20	19.61
S. W.	25	24.51
S.	5	4.90
S. E.	15	14.71
E.	11	10.78
N. E.	6	5.88
Total	102	100.00
Total Westerly	63	61.76
Total Easterly	32	31.37

Recorded Winds

These observations were taken in a narrow belt of country extending along the Ontario-Manitoba boundary from the Winnipeg river for about 60 miles due north. They represent, in a general way, the climatic conditions of that part of the meridian, but are not wholly applicable to any precise locality.

Meteorological

Date 1921		Locality
June	3	Deacon-Devlin mine to Portage S. from W. end of Bird Lake
"	4	Portage S of Bird Lake to Lake in N.E. part of Tp. 16, Range 17, E.P.M
"	5	On portage on S. shore of Lake in N.E. part of Tp. 16, Range 17, E.P.M
"	6	Camp on Lake as above to Winnipeg River near Ontario Manitoba line
"	7	Camp on Winnipeg River, about 3 miles N. by W. of Ontario-Manitoba line
"	8	" " " " " " " " "
"	9	" " " " " " " " "
"	10	" " " " " " " " "
"	11	" " " " " " " " "
"	12	" " " " " " " " "
"	13	" " " " " " " " "
"	14	" " " " " " " " "
"	15	" " " " " " " " "
"	16	" " " " " " " " "
"	17	" " " " " " " " "
"	18	" " " " " " " " "
"	19	Camp on N.E. shore of Lake in N.E. part of Tp. 16, Range 17, E.P.M
"	20	" " " " " " " "
"	21	" " " " " " " "
"	22	" " " " " " " "
"	23	" " " " " " " "
"	24	" " " " " " " "
"	25	" " " " " " " "
"	26	" " " " " " " "
"	27	" " " " " " " "
"	28	" " " " " " " "
"	29	" " " " " " " "
"	30	" " " " " " " "
July	1	" " " " " " " "
"	2	" " " " " " " "
"	3	" " " " " " " "
"	4	" " " " " " " "
"	5	Lake in N.E. corner of Tp. 16, Range 17, E.P.M (East of Principal Meridian)
"	6	*En* route to camp on Little Trout Lake
"	7	Camp on Little Trout Lake
"	8	" " "
"	9	" " "
"	10	" " "
"	11	Camp on Lake Reynar
"	12	" " "
"	13	" " "
"	14	Lake Reynar to Little Trout Lake
"	15	Moving Little Trout Lake to 2 mile portage above Tulabi Lake
"	16	Second Portage above Tulabi Lake (Bird River) to Snowshoe Lake
"	17	Camp at outlet of Snowshoe Lake, Bird River
"	18	Snowshoe Lake to Sucker Lake
"	19	Camp at Sucker Lake
"	20	Sucker Lake to second portage above Tulabi Lake
"	21	Second portage above Tulabi Lake to Snowshoe Lake
"	22	Camp at Snowshoe Lake
"	23	" " "
"	24	" " "
"	25	" " "
"	26	" " "
"	27	Snowshoe Lake to East end of same
"	28	Camp on East end of Snowshoe Lake
"	29	" " " "
"	30	East end Showshoe Lake to small lake to North of Snowshoe Lake
"	31	Camp on small Lake on line North of Snowshoe Lake
August	1	" " " " " "
"	2	" " " " " "
"	3	Portage North to small lake West of 86th mile

Report

Temperature (Degrees F.)		Wind		Sky, Rain, etc.
Minimum	Maximum	Direction	Velocity	
29	60	N.W.	Breeze	Clear; calm evening.
29.5	68	W.	"	Fair.
38	68	S.W. by S.	Gentle	Warm, cloudy morning with rain at night.
50	69	E.	....	
47.5	84	....	....	Fair.
....	70	....	....	Fair to cloudy.
59	83	S.E.	Gentle to violent	Clearing morning, thunderstorms later.
....	81	S.W.	Calm to strong	Rain in afternoon.
53	76	S.W.	Breeze	Clear to rain.
59	75	W. by S.	Strong	Clearing.
58.5	82.5	S.W.	Gentle breeze	Fair, a few cirrhus clouds.
51	82.5	S.E.	Strong afternoon	Showers in forenoon, but clearing later.
62.5	88	E.	" "	Rain in evening.
69.5	84.5	....	....	Rain in morning; afternoon thunderstorms.
68	68	....	....	Rain all night and this morning.
62.5	76	W.	Breeze	Cloudy.
60	82	....	Calm	Fair.
62	87	E.	Slight to fresh	Fair.
63	76	S.W.	Strong	Thunderstorms in afternoon.
63	72	N.W.	"	Rain to clearing, evening calm.
56	74	N.E.	....	Rain, clear afternoon.
57	68.5	....	....	Clear, clouds in afternoon.
58	77	S.W.	....	Showers, clearing later.
61	81	S.W.	Gentle	Cloudy with showers clearing later.
61	85	S.E.-S.W.	....	Clear and fine.
60	90	S.	Gentle	Thunderstorms last night—very hot.
67.5	78	....	....	Cloudy and thunderstorms, clearing later.
65	92	S.	....	Thunderstorms last night—heat oppresive.
78	91.5	S.W.	....	Bright to thunderstorms.
69	82	S.E.	....	Rain last night, thunderstorms all day.
65	74.5	S.W.	Strong	Clearing morning, rain again in afternoon.
59	73	S.W.	Fresh	Clear all day.
60	70	S.W.	Strong	Cloudy, clearing.
54	80	....	Calm	Clear and still all day.
61	81	....	Calm	Clear to rain in afternoon
63	84	W.	Slight	Clear morning, showers in afternoon.
59	83	S.E.	Breeze to storm	Cloudy, clearing; thunderstorms later.
....	81	S.W.	....	
59	67	....	Calm	Rain until afternoon.
53	73	E.	....	Cloudy, rain about noon, clearing later.
60.5	77.5	E. to W.	Slight	Cloudy, clearing later.
62.5	88	W.-N.W.	Breeze	Cloudy morning, clearing later.
54	88	....	Calm	Clear and fine.
54	80	....	Calm morning	Thunderstorms in afternoon.
60	77	....	" "	Thunderstorms and rain all night.
58	81.5	W.	....	Clearing morning, showers in afternoon.
57	79.5	S.E.	Calm, morning & even.	Clear.
60	87	W.	Slight	Clear sky.
59	84	E. to S.E.	Calm to strong	Clear morning with rain at night.
71	80	N.W.	Strong, decreasing	Clearing, calm evening.
....	84	N.W.	Strong in morning	Evening clear and calm.
56	75	N.W.	Fresh	" " "
53	77	....	Calm	Clear sky.
59.5	66.5	E.	....	Cloudy, showers.
61	79.5	N.E.-N.W.	Calm evening	Cloudy to clear.
53	83	W. to S.E.	Breeze	Thunderstorms in afternoon and all night.
60	85.5	N.W.-W.	Strong	Thunderstorms in evening; rain at night.
57	77	N.W.	....	Clearing, calm evening.
52	68.5	N.E.	....	Clear morning, cloudy later.
42	68	N.E.	Slight	Clear to cloudy.
42	71	N.W.-E.	Slight	Cloudy.
42	80.5	S.E.	Breeze	Calm, morning and evening.

Meteorological

Date 1921		Locality.
August	4	Camp on small lake West of mile 86...
"	5	" " " "
"	6	Camp on small lake West of 85 miles, 60 ch.
"	7	" " " " "
"	8	" " " " "
"	9	" " " " "
"	10	85 miles 60 chains to Wingiskoos Lake.
"	11	Wingiskoos Lake to camp on Manigotagan River (Mile. 92).
"	12	Camp on Manigotagan River, ¼ mile west of 92 miles 15 chains.
"	13	" " " " " " "
"	14	" " " " " " "
"	15	" " " " " " "
"	16	" " " " " " "
"	17	" " " " " " "
"	18	" " " " " " "
"	19	Manigotagan River camp to N.E. bay of Island Lake.
"	20	N.E. bay of Island Lake to N.E. bay of Garner Lake.
"	21	Camp at N. end of N.E. bay of Garner Lake.
"	22	" " " " "
"	23	" " " " "
"	24	" " " " "
"	25	" " " " "
"	26	" " " " "
"	27	" " " " "
"	28	" " " " "
"	29	" " " " "
"	30	" " " " "
"	31	" " " " "
September	1	" " " " "
"	2	" " " " "
"	3	Garner Lake Camp to West end.
"	4	Garner Lake to Bulldog Lake.
"	5	Bulldog Lake to small lake N. of Partridge Lake.
"	6	Small lakes between Partridge and Wallace Lakes.
"	7	Wallace Lake to small lake W. of 110th mile of the boundary.
"	8	Small lake west of boundary, 110th mile.
"	9	" " " " "
"	10	" " " " "
"	11	" " " " "
"	12	" " " " "
"	13	" " " " "
"	14	" " " " "
"	15	Small lake west of boundary, 110th mile.
"	16	" " " " "
"	17	" " " " "
"	18	" " " " "
"	19	Siderock Lake to O-Buck-O-Win Lake.
"	20	O-Buck-O-Win Lake.
"	21	" "
"	22	" "
"	23	" "
"	24	" "
"	25	" "
"	26	" "
"	27	" "
"	28	" "
"	29	Carroll Lake.
"	30	" "
October	1	Carroll Lake to Siderock Lake.
"	2	Siderock (Whitefish) Lake to Bulldog Lake.
"	3	Bulldog Lake to Island Lake.
"	4	Island Lake to Snowshoe Lake.
"	5	Snowshoe Lake.

Report—*Continued.*

Temperature (Degrees F.)		Wind		Sky, Clouds, Rain, etc.
Minimum	Maximum	Direction	Velocity	
60	80	....	Calm, clear morning..	Thunderstorms in afternoon, rainy night.
60.5	66	W.	....	Cloudy, thunderstorms, rainy night.
45.5	55	N.W.	....	Mist and rain.
45	66.5	N.W.	....	Clearing, evening clear and calm.
40	74	S. by E.	....	Clear.
56	68.5	E. to N. E	....	Cloudy morning, clearing later.
56	70.5	E.	Breeze.............	Clear morning, rain at night.
55	73.5	S.W.	Fresh..............	Clear, some cumulus clouds.
42	69	N.	....	Cloudy, showers in afternoon.
39.5	68.5	W.	Calm morning.......	Clear morning, showers later.
33.5	67.5	S.W.	Gentle.............	Clear.
44	75	W.-S.W.	Fresh in afternoon...	Clear.
50	62	S.E.	....	Cloudy, showers.
54	67	W.	Calm evening........	Clearing, afternoon fine.
37	64	....	Calm...............	Clear morn. & even.—showers during day.
50.5	63.5	N.	Strong.............	Rainy morning, clearing in the afternoon.
39.5	....	....	Calm...............	Cloudy.
39.5	71	W.	....	Clear.
57	68	....	....	Clear & cloudy, alternately frequent showers
51	68	....	Calm...............	Clear.
45	73	S.W.	Light..............	Cloudy.
52	72	S.	....	Cloudy, thunderstorms..
64	81	....	....	Morning, misty & cloudy; p.m., clear, calm.
61	77	S.W.	Light..............	Clear.
46	72	....	....	Morning, heavy rain; evening, clear, calm.
55	74	N.W.	Strong.............	Clear.
38	62	S.E.	Light..............	Morning, frosty in valleys, clear.
49	87	S.	....	Clear, a few light clouds.
68	81	S.	....	Thundershowers during preceding night.
52	68	W.-N.W.	....	Clear.
51	74	....	....	Cloudy, slight showers.
64	70	....	....	Cloudy, heavy rain in afternoon.
51	68	W.	....	Clear to showery in afternoon.
46	60	N.W.	....	Clear.
40	70	N.W.	....	"
44	68	E.	....	Clear morning, cloudy afternoon.
53	61	N.E.	....	Cloudy, occasional rain.
53	57	E.	....	Rain.
43	49	W.	....	Cloudy, occasional rain.
41	51	W.	....	Fair to misty with light rain.
42	51	E.	....	Cloudy, light showers.
47	56	W.	....	Partly fair, occasional showers.
35	61	W.	....	Clear and fine.
31.5	54	....	....	Fine morning, heavy rain at night.
41	56	....	....	Rainy morning, clearing afternoon.
34	64	W.	....	Clear.
46	59	....	....	Cloudy, rain in afternoon and night.
51	64	....	....	Partly fair, slight rainfall in afternoon.
56	64	N.W.	....	Rain all day.
49	59	N.W.	....	Rain, clear afternoon.
43	58	S.E.	....	Cloudy to clear, thunderstorms at night.
51	58	W.	....	Partly fair, showers morning and afternoon
35	64	S. to S.E.	....	Clear.
46	64	S.E.	....	Fair to cloudy.
46	66	W.	....	Clear, showery in afternoon.
44	64	S.W.	....	Clear morning, showers in afternoon.
41	49	S.W.	....	Partly clear, showers.
37	51	S.W.	....	Cloudy, showers in afternoon.
33	56	S.W.	....	Partly clear, some showers.
33	48	....	....	" " "
31	54	S.W.	....	Clear.
31	62	S.W.	....	"
35	....	....	....	"

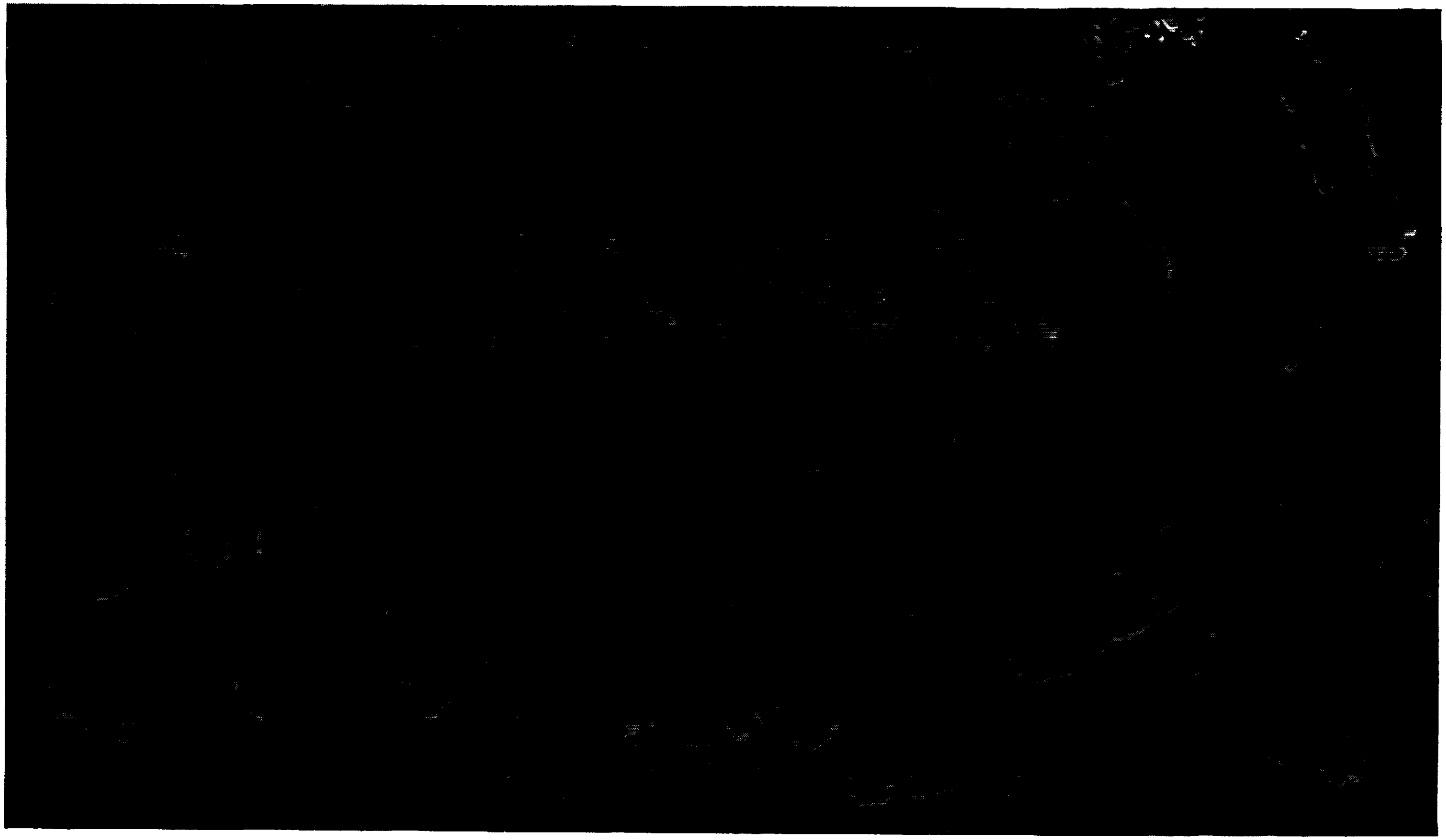

Fig. 15.—AEROPLANE PHOTO, ONTARIO—MANITOBA BOUNDARY LINE

OFFICIAL PHOTOGRAPH BY THE AIR BOARD OF CANADA OF AREA NORTH OF GARNER LAKE, SCALE 1 INCH=7 CHAINS.

Surface is broken by innumerable lakes. Uplands are mostly bare rock sparsely covered with small Jack Pine. About one-half of the surface consists of spruce swamp and muskeg. South side of Lake No. 70 crosses line at 107 miles, 22.94 chains.

GEOLOGY OF ONTARIO—MANITOBA BOUNDARY
(From Bloodvein River to Twelfth Base Line, 1922)

By H. C. Rickaby

Introductory

The following report contains a summary of the results of an exploration undertaken during the summer of 1922 for the Ontario Department of Mines along the boundary line (longitude 95° .09′ .06″ west of Greenwich), between the Provinces of Ontario and Manitoba. It describes a continuation of the work of the previous year under E. M. Burwash. As in 1921, the work was carried on in conjunction with that of the Topographical Survey party under J. W. Pierce, O.L.S. and D.L.S., to whom the writer wishes to express his appreciation for his co-operation in the field and in preparing the accompanying base maps.

The writer was assisted in the field by J. C. Macgillivray, of Kingston, who rendered valuable service throughout the season. Included in the work of Mr.

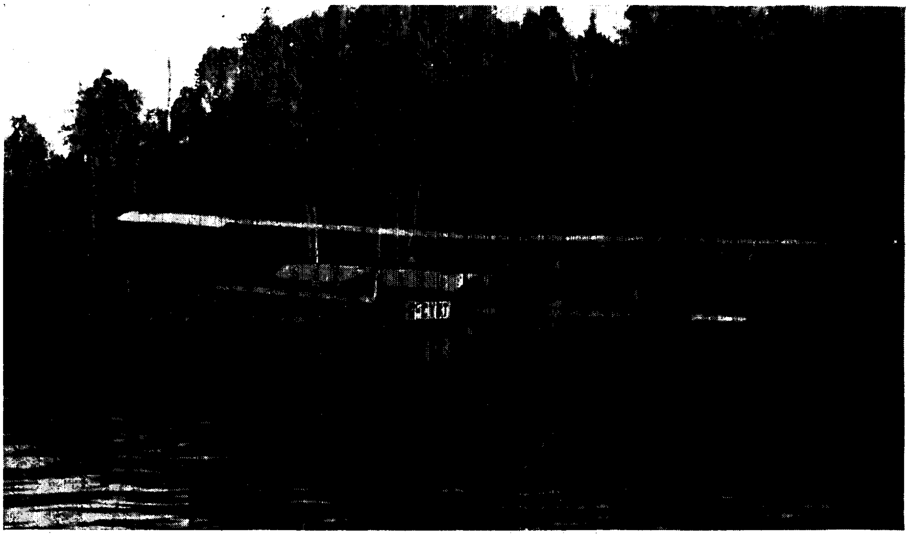

Fig. 16.—Dominion Government hydroplane brings mail from Victoria Beach on Lake Winnipeg to Boundary Survey Party on Wooden lake, July 4th, 1922.

Pierce's party was an accurate survey of all bodies of water within one mile on either side of the boundary line, and this we endeavored to extend as far as possible by means of micrometer and track surveys of rivers crossed, particularly those which might be of use as routes.

The writer is also indebted to the officers in charge of the Hudson Bay Co. posts at the mouth of the Bloodvein river, and Berens river, and on Family lake for their hospitality, and to Major Hobbs of the Air Board of Canada, with station at Victoria Beach on the shore of Lake Winnipeg, for assistance in leaving the field by hydroplane at the end of the season.

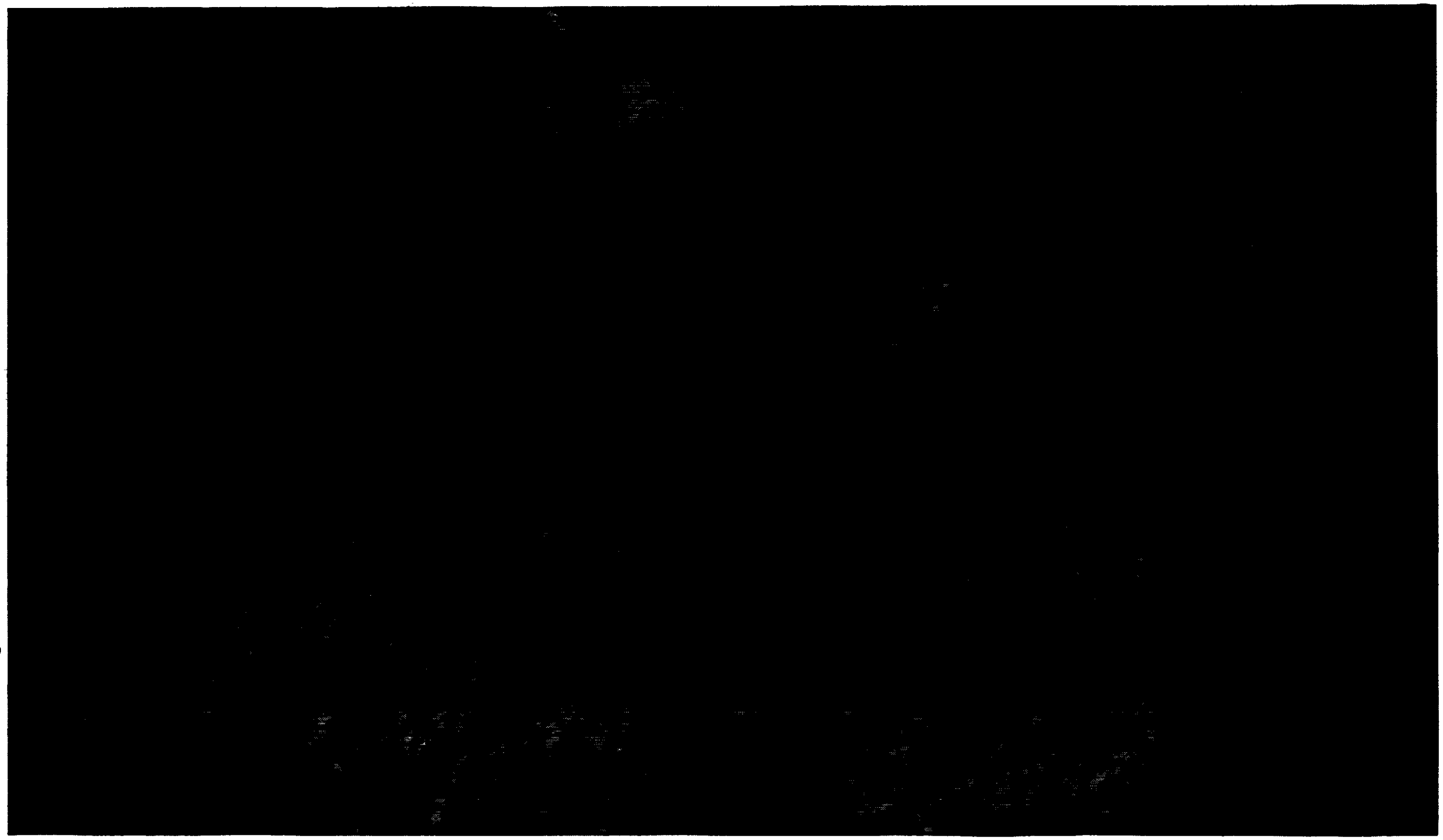

Fig. 17.—AEROPLANE PHOTO, ONTARIO—MANITOBA BOUNDARY LINE.

Official Photograph by the Air Board of Canada Showing Headwaters of Wanipigow River, Scale 1 inch=7 Chains
Rock surface is sparsely covered with small jack pine, muskegs and swamps intervening. Position of stone monument No. 121 at 109 miles 25.8275 chains on summit overlooking river is indicated by X. The river is about 40 feet in width.

The region explored lies along the boundary line between the two Provinces from Carroll lake (lat. 51° 10' approx.) north to the point where it deflects to the northeast, a distance of about 120 miles. It includes parts of the upper basins of three rivers flowing in a north-westerly direction into Lake Winnipeg, namely, the Bloodvein, Berens and Poplar.

The work of the previous season ceased on Carroll lake, which is on the south tributary of the Bloodvein, and it was deemed advisable to use this river as a route to our first camp on its main branch, although information as to the nature of its upper waters was rather meagre. Accompanied by one of the surveyors we left Winnipeg on May 27th, the rest of the survey party having preceded us by one week. From Selkirk we travelled by steamer up Lake Winnipeg to Little Bullhead, which is on the west side of the narrows, and here we hired a row boat to take us across to the mouth of the Bloodvein.

Owing to the uncertainty of the route and the risks of canoe navigation at high water, we were obliged to hire guides to take us up the river. With two canoes and two Indians we left the Hudson Bay Company post on May 30th. Our route lay up the main branch of the river as far as the mouth of the inlet from Sasaginnigak lake, thence up this inlet to the lake. We were told by the Indians that the Bloodvein for some distance above this inlet is full of rapids, and owing to the difficulty of navigation is not used as a route by the trappers. This portion of the journey occupied two days, during which time we made thirty portages. These were made to get over the waterfalls and rapids which occur quite regularly, but they are all short, not over ten chains in length, while the current of the river in the intervening stretches is seldom so strong as to make paddling difficult.

Crossing Sasaginnigak lake to its southeast corner, we travelled up an inlet in a general southeast direction for about five miles, including two portages of one chain and twenty chains, to a large lake. From here there is a choice of two routes back to the river. The one used by the surveyors follows a south arm of the lake and crosses the height of land by a portage of one hundred chains back to the river again. The other route, which we followed, goes up a southeast arm of the large lake, thence via the inlet in a southeast direction across a string of small lakes connected by portages, coming back into the Bloodvein again on the lower end of Stonefort lake. This route has twelve short portages. From Stonefort lake another half day's paddle brought us to Burntwoodhills lake, where camp was located, and which we reached on June 3rd, exactly four days from time of leaving the mouth.

Physiography and Drainage System

All the area crossed lies on the west slope of the divide, the drainage being toward Lake Winnipeg. The boundary line crosses the main branches of the three large rivers at the following elevations—the Bloodvein 1057 ft. (Burntwoodhills lake), the Berens 1023 ft. (Eagle lake), and the Poplar at 1028 ft. (below Palsen lake). Generally speaking, the topography throughout is of low relief, not over 200 feet, and all the country seen has the usual level appearance characteristic of the Archean, as a whole. The alleys between the ridges of granite and gneiss are occupied largely by muskeg and lakes. Since most of the latter, as well as the streams within one mile on either side of the line, were traversed by the survey party, a glance at the maps will give an accurate idea of the proportion of water to land which characterizes the country. In moving along the line, the camp equipment and supplies were transported entirely by canoe, and in only two cases was it necessary to go more than seven miles from the boundary. In the routes used there were only three portages which exceeded one mile in length.

Bloodvein River Basin

The boundary line crossed three large branches of the Bloodvein river, the south branch at Carroll lake, the central at Burntwoodhills lake, and the north at Long Pine lake. Burntwoodhills lake is about four miles long in an east and west direction, with two narrow arms each about four miles in length and stretching straight north and south. The steep shores rise to a height of 75 feet in places, and it evidently derives its name from the fact that several of the surrounding hills have been burned over. From the eastern entrance of its chief

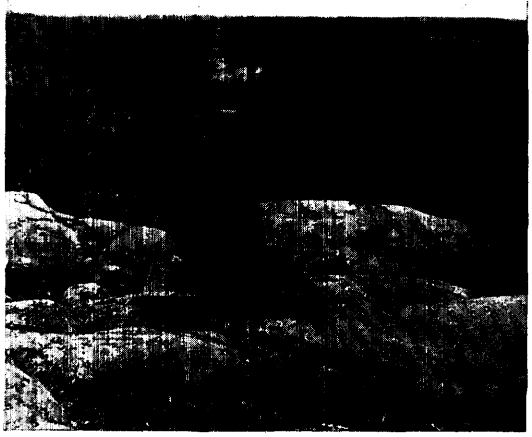

Fig. 18.—Boundary line monument in foreground, 217 miles north of Lake of the Woods. Note the even sky line, characteristic of the pre-Cambrian peneplain.

inlet, a track survey was made for about 15 miles up the river. A two-mile stretch of river brings us to another lake which is reached by one of two channels each with a six-foot fall. This lake has several arms with large islands, and moderately steep shores up to 60 feet in height. The river which enters the southeast arm of this lake takes a very winding course between low banks with considerable clay soil on which there grows some fine specimens of spruce and poplar. A three-mile paddle brings us to Barclay lake, which extends in a northeasterly direction for about four miles. It has an average width of about three-quarters of a mile, with steep shores up to 100 feet in height. The chief inlet is from the south.

From the camp on Burntwoodhills lake a trip was made south via the south arm and the route shown as far as Carroll lake. This lake is about eight miles long in a north and south direction, with many arms and islands, and with no large stretch of open water. Its shores are for the most part steep, rising in places to a height of 100 feet. The chief inlet comes in from the east side between narrow, steep banks with three falls in a distance of two miles. The country to the east appears to be very rough and the rock all massive granite.

Travelling north from Burntwoodhills lake, the next large body of water crossed was Long Pine lake, which was reached by a series of lakes and creeks with connecting portages, one of which was approximately one and three-quarters miles long. This lake which is about seven miles long, with an average width of less than half a mile, lies in a narrow valley with its steep shores rising in places to over 100 feet in height. It is evidently the headwaters of the north branch of the Bloodvein, and drains into Sasaginnigak lake.

Berens River Basin

From Long Pine lake there is a very good canoe route right through to Family lake, via Bear creek and Dogskin river. A string of four small lakes connected by four short portages brings us to Bear lake. The inlet to this lake comes in at its north end and a track survey was made up as far as its headwaters, a group of lakes about eight miles east. Below Bear lake the creek averages from one to three chains in width down to Wooden lake, with six short portages in this distance. A short stretch of river connects Wooden lake with Dogskin lake, which is a fairly open sheet of water about five miles long with moderately steep shores. The river runs out of the north end and takes a winding course through two more small lakes to Whiteye lake. There are five short portages in this distance to avoid rapids. Below the last-named lake the river takes an almost straight course N. 20° W. to Family lake with no rapids and an average width of about 8 chains.

Eagle lake, our next camping place, and the route leading to it via Douglas lake have already been described by A. P. Low.[1] About one and a half miles above the entrance of the south channel of the Berens river a large tributary comes in from the south through a narrow opening between high, rocky banks. A track survey was made up this river for about eighteen miles in a direction approximately S. 15° E. as far as Herod lake. It is a series of lake-like expansions connected by rapids or waterfalls. The portages across these are all short and well cut out and it appears to be a much used route. Later on we were told that it is used by the Indians as a short-cut to Pekangikum and also to the headwaters of the Bloodvein river. Herod lake is about 4 miles long in a north and south direction, with fairly steep shores and has an elevation of approximately 1,095 feet. Above it is another small lake with two tributaries coming in from the east, but the portages could not be located and the route was not followed any farther.

Our next main camp was on Fisher lake on the boundary line 12 miles north of Eagle lake. This was reached by making use of the Deer lake route described by Mr. Low. Going north from the east end of this lake, we crossed a 27-chain portage, then four more small lakes with small portages connecting them. Leaving the north side of the fourth small lake, we crossed the height of land and three small pot-hole or kettle lakes, to a narrow creek flowing west. About half a mile down this creek there is a 39-chain portage which leads to the southeast corner of Big Jackfish lake. This part of the Deer lake route described by Mr. Low, is still used by the Indians when travelling light or at low

[1]Geol. Surv. Canada, Ann. Report, Vol. II, 1886, pt. F.

water, but for freighting supplies for the Hudson Bay Company, another route leading from the extreme north end of Fishing lake is used. The two routes join at the portage leading into Big Jackfish lake, and from here north the portages are in excellent shape right through to Deer lake.

Poplar River Basin

From Fisher lake we moved via the Deer lake route to Saskatoon lake on the south branch of the Poplar river. The outlet from this lake is a large one, as it drains the country for about 20 miles to the east and northeast. It takes a winding course in a general northwest direction to Chicken Hawk lake, where the boundary line is again crossed. A micrometer survey was carried down this branch of the Poplar river for about eight miles west of the line. There is not much indication of travel, but as far as seen it is an excellent canoe route with the usual short portages to avoid the rapids and falls. From Red Willow lake there is a route for light canoe travel leading slightly west of south in a straight course through to the north end of Fishing lake.

Three miles north of Chicken Hawk lake, the line crosses an east arm of Flying Squirrel lake, which is about four miles long in a north and south direction. The outlet from it flows west for four miles and then, according to information obtained from the Indians, in a northwest direction emptying into the main branch of the Poplar river.

Other Lakes of Poplar River Basin

Crooked lake is a narrow, sinuous lake, only part of which was explored. The shores vary in steepness, rising in places precipitously to a height of 50 feet. The southeast end shows considerable brulé, but there is some good, green timber, chiefly pine and spruce, on the north and south shores. The outlet from the northwest arm has a large volume of water flowing out through a narrow cleft in the rock, and dropping 12 feet over a series of rapids.

Mackay lake, nearly all of which is in Ontario, is crossed by the line at mile 223½. It is a fairly open sheet, about four miles long, with remarkably clear water. The south shore is high and precipitous, but the north shore, where the rock is largely greenstone, is low and rises gently with some good-sized spruce, pine and birch. The water drains west by a good-sized stream.

Palsen River Basin

The boundary line crosses a large branch of the Poplar river at mile 227¾. Travelling up this branch about 3 miles, you come to Palsen lake, a large body of water, stretching in a general northwest direction. A track survey was made for about eight miles of its length. There appeared to be much more water stretching off to the east and southeast with large islands. The shores of the lake are all low and covered with brulé. It is evidently much travelled by the natives, as there are many cuttings and other signs of camping grounds.

According to information obtained from Indians, there is a good route to Deer lake from Lake Winnipeg via the Poplar river. The writer and his assistant made an attempt to find this route from the west end of Deer lake where a large river enters, but owing to limited time, without success. It would seem, however, that if all of the Poplar river is as easy for canoe travel as the portions crossed in its upper waters, such a route would be better than the present one via the Berens river.

Geology

With the exception of one small area in the vicinity of Mackay lake, all the rocks seen during the summer consisted of granites and gneisses. They range in colour from light grey to red, some of the more basic types being dark grey or greenish. In composition, they vary from typical granites, in which orthoclase and microcline predominate, to granodiorite in which plagioclase is the chief feldspar. Most of the granite shows a certain degree of parallelism in the arrangement of the minerals, and the division into granites and gneisses depends upon the degree to which this foliation is developed. The gneiss, which is of the ortho-gneiss variety, shows a strike varying from 25° to 45° east of south.

Quartz, which is prevalent in all these varieties, makes up from 25 to 40

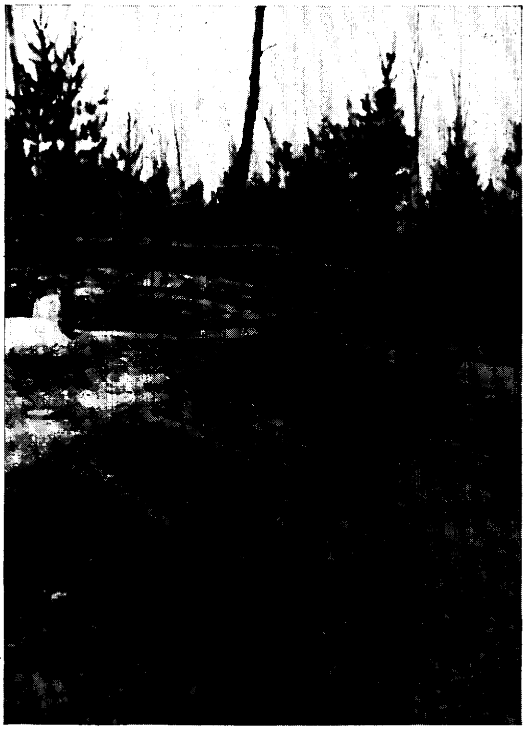

Fig. 19.—Inclusion of greenstone in granite, north end of Bear lake.

per cent. of the rock constituents, and the feldspars from 35 to 60 per cent. Where plagioclase predominates it is of the oligoclase variety. Biotite is present in nearly every case, and along with hornblende and a few accessories, makes up from 5 to 15 per cent.

Throughout the area these granites and gneisses are intruded by a later red granite pegmatite. Small inclusions of dark hornblende rocks and altered greenstones were noted in a few localities.

Keewatin

Between miles 224 and 225, the line crosses several small, lens-shaped bodies of hornblende schists, varying in length up to 400 feet. They lie in a general east and west direction, and the strike of the schistosity is parallel to the axes of the bodies. No more of this greenstone was seen west of the line, but from the west end of Mackay lake, extending to the east into Ontario is a large body of similar rock. The south shore of the lake is granite, but the north shore and the islands of the lake are composed of these basic volcanics. The contact with the granite is very irregular, and the greenstone is intruded in many places by the acid rocks. Isolated patches of these schists are to be seen for about two miles north from the main body. In this area it was noticed that the compass needle shows small deflections of 2° or more, due probably to local attraction.

Soil and Climate

Very little soil of a cultivable quality was noted during the season, and only for the most part in small patches along the river valleys. The most notable stretch is situated on the main branch of the Bloodvein river, east of the boun-

Fig. 20.—Pot hole in granite at south end of Dogskin lake.

dary line. The outlet from Barclay lake to the next large lake below takes a winding course between clay banks. The soil, which is evidently of glacial origin, stretches back on either side for at least one-quarter of a mile, and is thickly-wooded with a fine growth of spruce, tamarack and poplar.

The weather was quite pleasant throughout the season, and the climate is suitable for the growing of vegetables. Good crops of potatoes were to be seen at the Hudson Bay Company post on Family lake, and at the Indian Reserve on the north end of Fishing lake.

Glacial Observations

Throughout the area covered there is to be seen considerable evidence of glaciation in the rounded surfaces of the rocks and the lakes or muskegs occupying undrained rock basins. There is, however, comparatively little morainic material with the exception of erratics and occasional small sand plains. A good example of glacial pot-hole was observed at the south end of Dogskin lake about 20 feet above the level of the water on an eastern slope of the granite. It was about 3½ feet in diameter and 5 feet in depth.

Distinct striæ are everywhere abundant; the following is a list of bearings taken:

RECORD OF GLACIAL STRIAE

1.	Long Pine lake, south shore	S. 59° W.
2.	Bear lake, north end	S. 63½° W.
3.	Bear creek (headwaters)	S. 62° W.
4.	Dogskin lake, south end	S. 60° W.
5.	Dogskin lake, north end	S. 64° W.
6.	Dogskin lake, east shore	S. 64° W.
7.	Herod lake, south end	S. 77° W.
8.	Packman lake, west shore	S. 74° W.
9.	Orono lake, north shore	S. 67° W.
10.	Fishing lake, north shore	S. 64° W.
11.	Saskatoon lake, northwest bay	S. 67° W.
12.	Flying Squirrel lake, north bay	S. 67° W.
13.	Lake No. 71 (Mile 218)	S. 67° W.
14.	Crooked lake	S. 57° W.
15.	Mackay lake, west end	S. 58° W.

Forests

The forests consist almost entirely of Banksian pine, white and black spruce, balsam, tamarack, poplar and birch, the first-named being much the most common. The pine is limited largely to dry and sandy ground, and seldom attains a diameter greater than 12 inches. Spruce, tamarack, balsam and poplar are confined to the valleys of streams and lakes and to the borders of the muskeg, where in places they reach a diameter of 15 inches or more.

The Bloodvein river and its tributaries are for the most part fairly well timbered with all the above varieties. No large area of brulé is to be seen along the route up this river with the exception of the country to the east and north of Sasaginnigak lake. The shores of this lake and the surrounding country have been largely burned over some years ago. From Stonefort lake up the main branch to Barclay lake, the most easterly point reached, the country is well covered with pine, spruce, etc., with only small areas of brulé, and shows some of the best timber seen during the season. The same remarks may be applied to the country along the line and the routes shown from Carroll lake north as far as the south shore of Long Pine lake.

The north shore of the last-named lake is the beginning of a large stretch of old brulé, which extends north along the line as far as Eagle lake. It is to be seen along the route from Long Pine lake to Wooden lake, and down the Dogskin river almost to Family lake. Its eastern limit would appear to be reached in the group of small lakes at the headwaters of Bear creek, which runs into Wooden lake. Farther north it extended eastward beyond Herod lake on the Pickerel river. All of this area is covered with a thick growth of young pine and spruce at least 15 years old. The old timber, which occupies less than five per cent. of the area, is limited to small strips near the lakes.

From Eagle lake north as far as Chicken Hawk lake on the south branch of the Poplar river, spruce and balsam are to be seen in groves of varying sizes with Banksian pine covering most of the higher ground. Brulé areas of various sizes and ages are quite common, especially along the Deer lake route.

Going north from Chicken Hawk lake we pass again into country covered for the most part by second-growth pine and spruce of varying age. This continues as far as Mackay lake, on the shores of which, as well as on Crooked lake and Perreault lake, some good stands of pine and spruce are reported. Passing north from the last-named to the end of the line at mile 238 and in the vicinity of Palsen lake, the country is practically all new brulé with none of the old trees left standing.

Fish and Game

Whitefish are said to be obtainable in most of the lakes in the area covered. Pike and pickerel are very plentiful, while lake trout were caught in some of the lakes of the upper waters of the Poplar river.

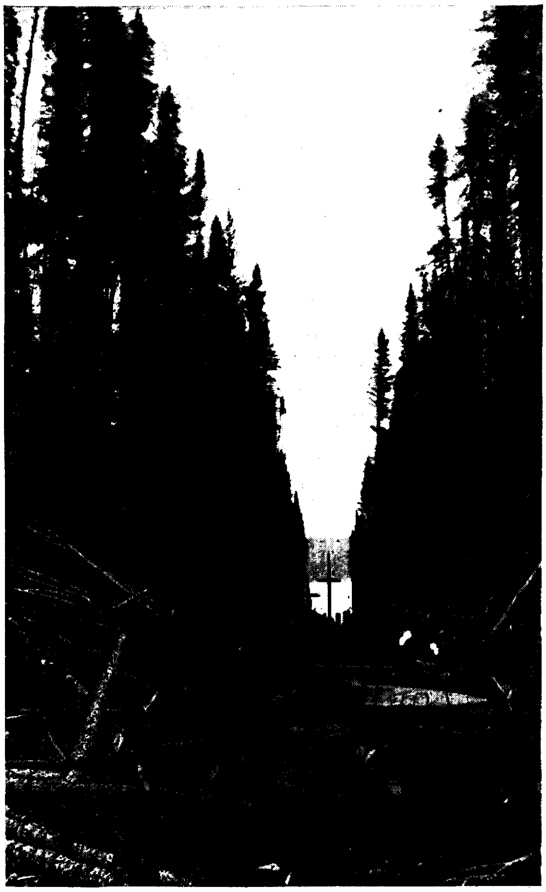

Fig. 21.—Good stand of banksian pine on boundary line south of Fisher lake.

Moose appeared to be fairly plentiful throughout the district, especially along the Bloodvein and Poplar rivers. Caribou were occasionally seen all along the line, but red deer were very rare north of the Bloodvein.

Of the fur-bearing animals, there were seen numbers of black bear, beaver, otter, marten, mink and muskrat. The beaver appears to be pretty well trapped out, except in the upper waters of the Poplar river, where many recent dams and beaver houses were noted. The Indians seem to be able to obtain all the above varieties in considerable number.

Waterpowers

The report on the water powers of Manitoba, Saskatchewan and Alberta, published in 1916, by the Conservation Commission of Canada, includes information then available on the waterpowers of the three most important rivers draining this territory, viz., the Bloodvein, Berens and Poplar, with estimates as to size of basins, etc. The upper parts of these basins are well provided with reservoirs in the form of lakes and muskegs, which should maintain a considerable volume in the driest season.

An estimate of 3,000 square miles for the basin of the Bloodvein would appear to be approximately correct. The drop in elevation from the boundary line to Lake Winnipeg is about 345 feet, and the nature of the descent is much the same throughout its course, as far as seen. Rapids and falls occur with frequency and many of these are of sufficient height and so situated as to be available for waterpower. The south branch flowing out of Carroll lake has already attained volume, as has also the main branch which was followed up as far east as Barclay lake.

Fig. 22.—Rapids on Pickerel river below Herod lake.

The fall of the Berens river from Eagle lake to Winnipeg lake is 313 feet. No further information can be added to that already obtained, except with respect to the Pickerel river, which joins the Berens from the southeast just above Eagle lake. This river which has a large volume was followed up as far as Herod lake, the elevation of which is approximately 1,095 feet. In this stretch of the river there are six rapids or falls, two of which have a drop of 14 feet each.

The last forty miles of the boundary line crosses country which is entirely in the upper basin of the Poplar river. The difference in elevation between the waters crossed and that of Lake Winnipeg ranges from 320 to 345 feet. The nature of the descent appeared to be similar to that of the two large rivers to the south, the river consisting largely of lakes or level stretches of water connected by rapids or falls. The estimated area of the drainage basin, given by the aforementioned report, is 1,950 square miles, but it would appear, from the latest information, that the actual size is considerably greater, and should be placed at 2,400 square miles, at least.

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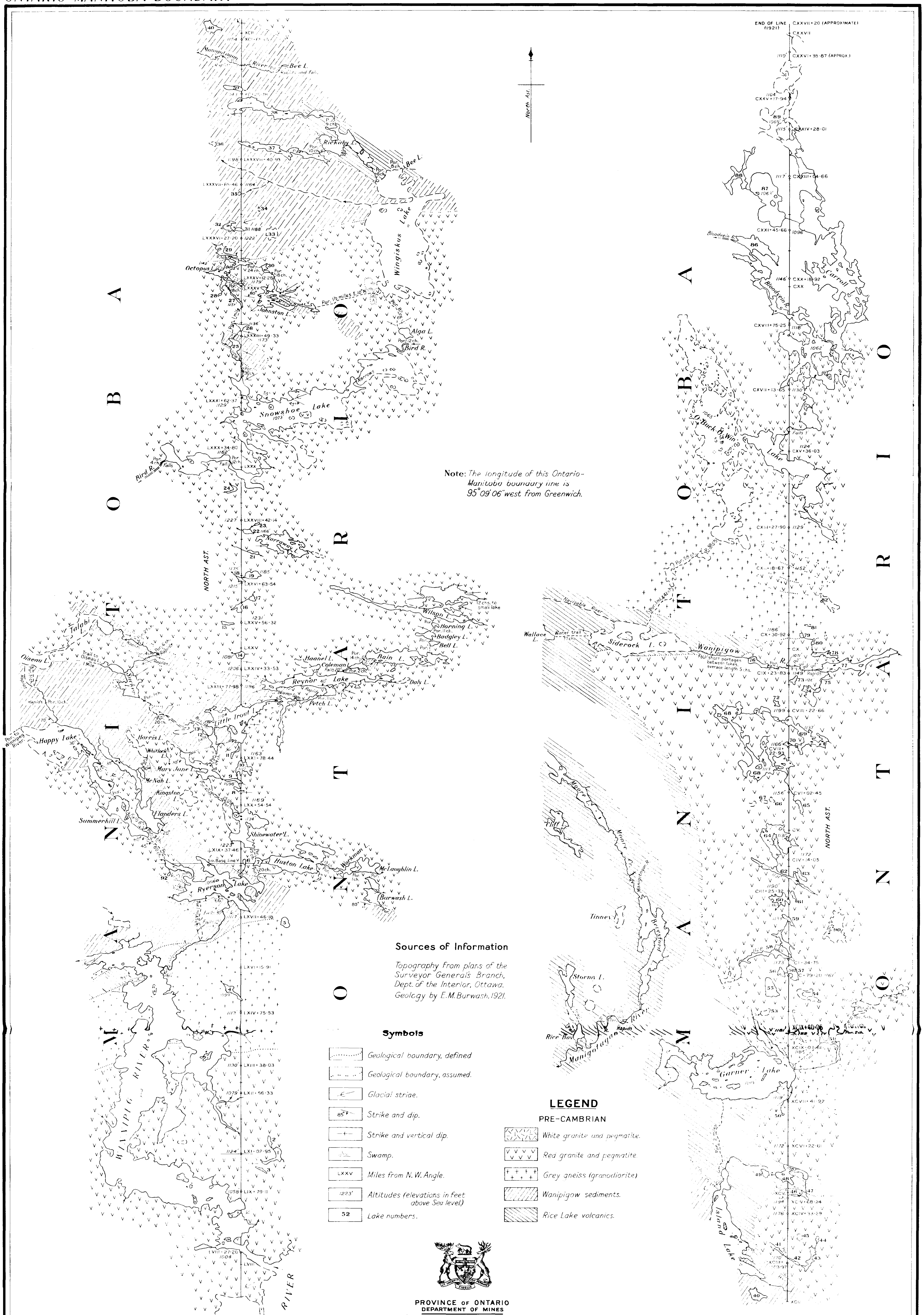
Map Nº 32a.
ONTARIO-MANITOBA BOUNDARY



Hon. H. Mills, *Minister of Mines.* Willet G. Miller, *Provincial Geologist.*

Map Nº 32a.

PART OF THE

ONTARIO-MANITOBA BOUNDARY,

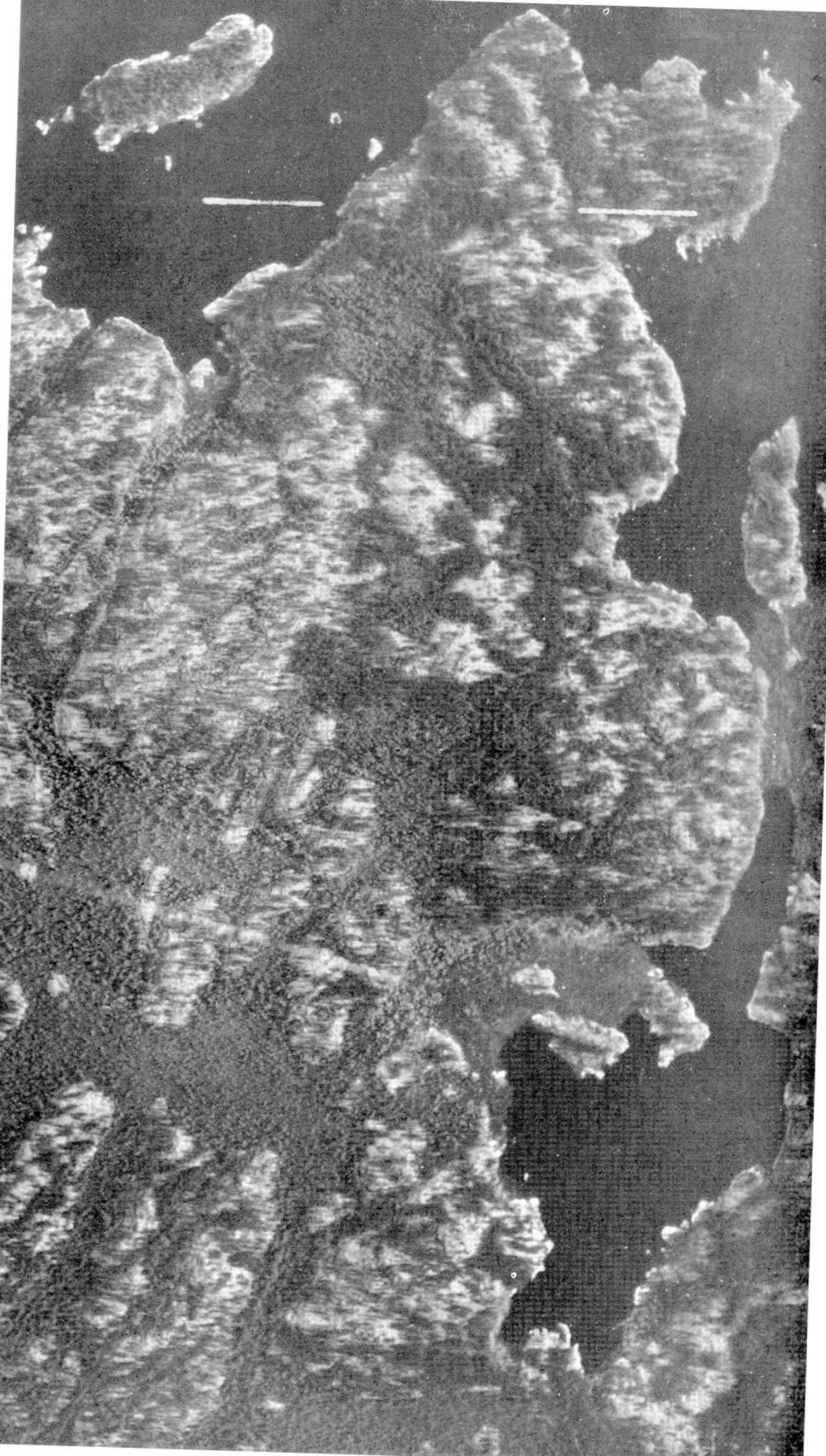
FROM WINNIPEG RIVER, NORTH TO BLOODVEIN RIVER.

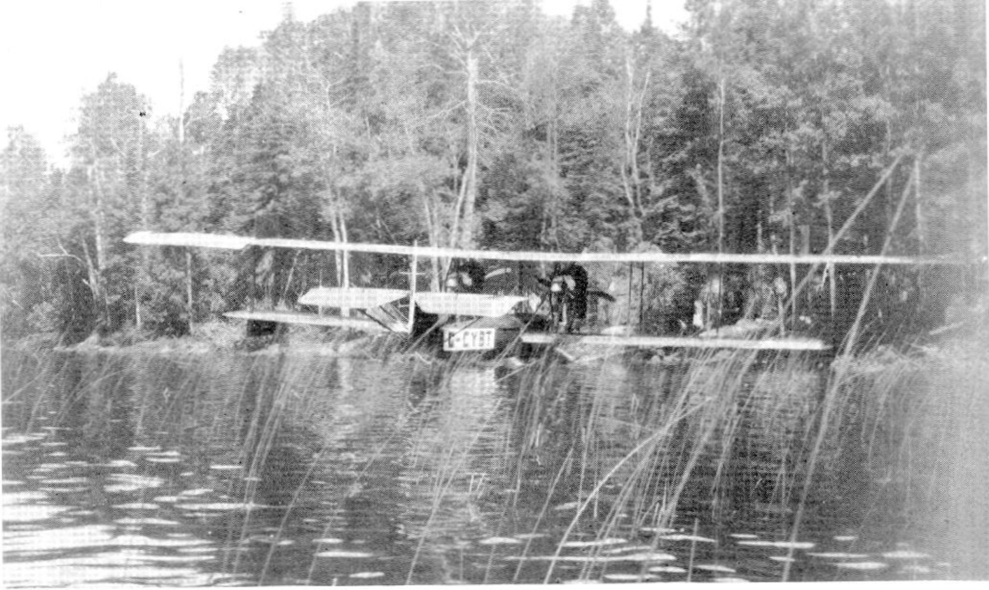
To accompany report by E.M. Burwash in Volume XXXII, Part 2, Ontario Department of Mines Report 1923.

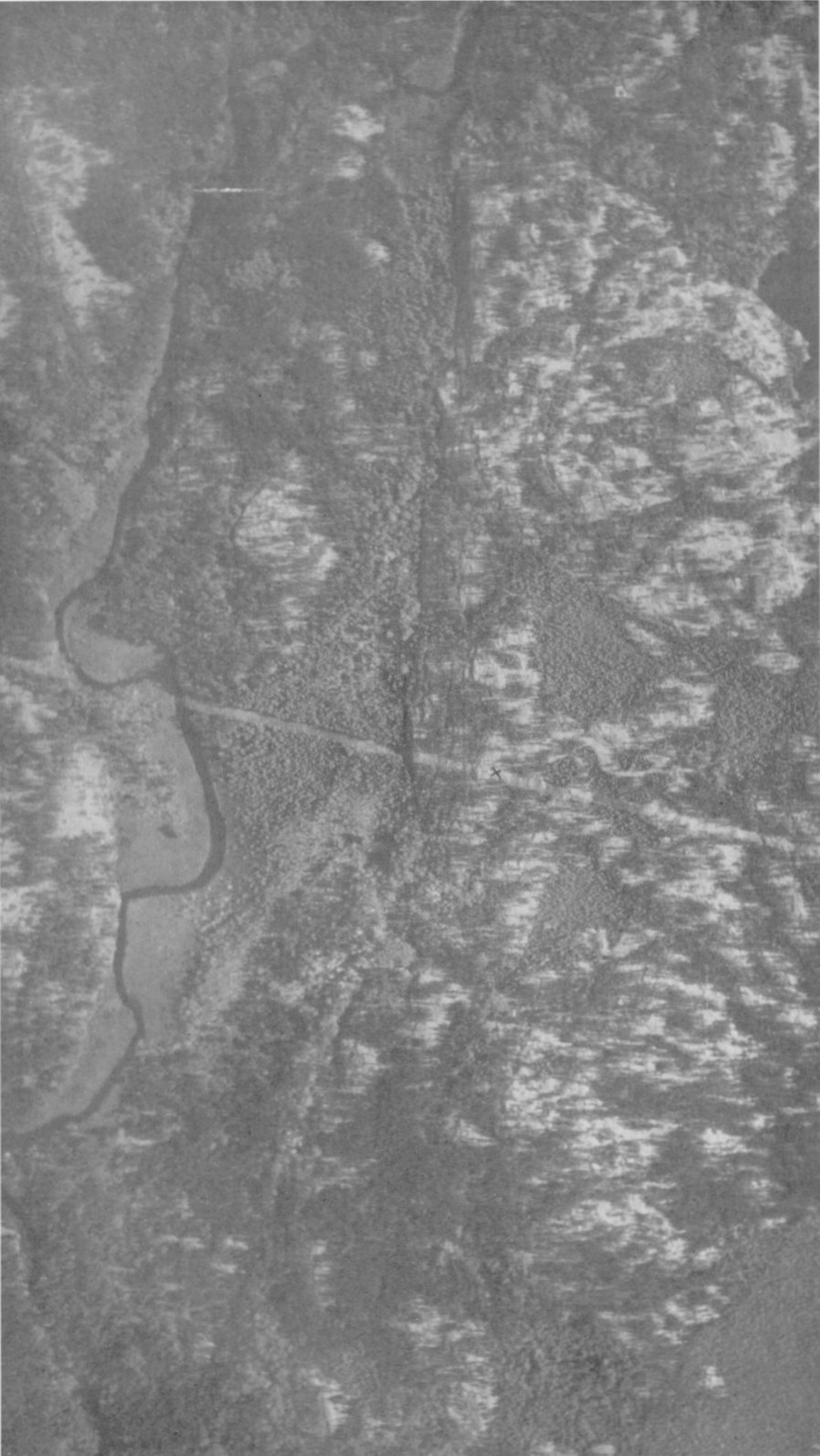
Scale: 1/126,720 or 2 Miles to 1 Inch.

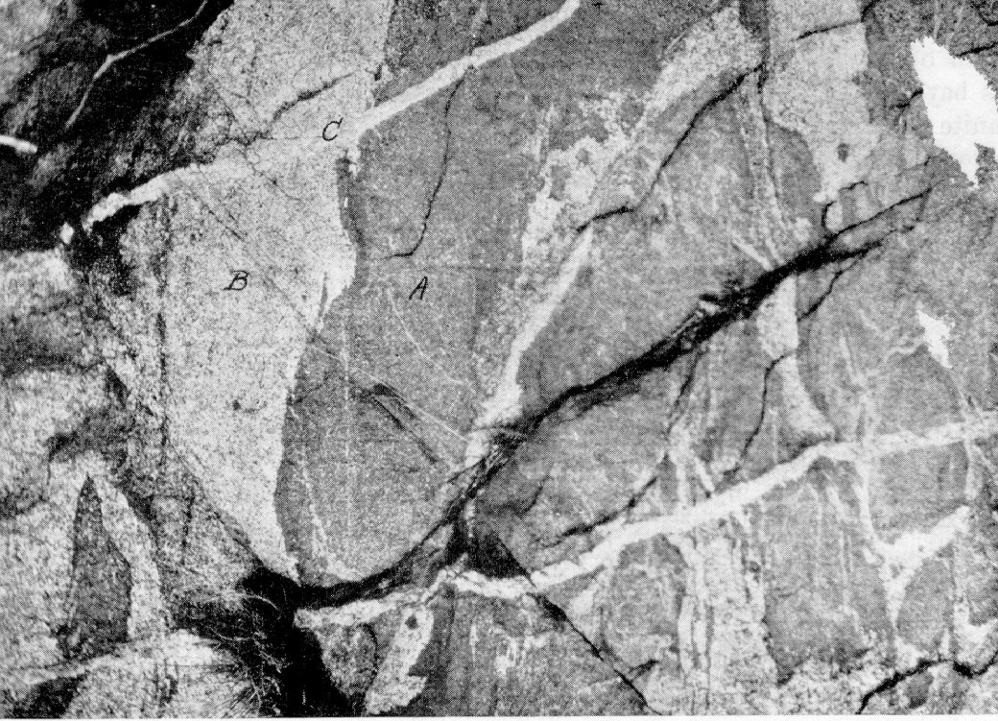
Miles 2 1 0 2 4 6 Miles


MANITOBA
ONTARIO
Note: The longitude of this Ontario-Manitoba boundary line is 95°09'06" west from Greenwich.
Branch of Bloodvein River Flowing to Sasaginnigak Lake.
These two streams connect lower down.
LEGEND
PRE-CAMBRIAN
Granites and massive gneissic rocks.
Foliated granites and gneisses.
Hornblende schists, greenstones.
Symbols
Geological boundary, defined.
Geological boundary, assumed.
Glacial striae.
Strike
Miles from N.W. Angle.
Altitudes (elevations in feet above Sea level)
Lake numbers.
Standard posts and concrete monuments.
Track surveys.
Sources of Information
Topography from plans of the Surveyor General's Branch, Dept. of the Interior, Ottawa.
Geology by H.C. Rickaby, 1922.
To Berens River
Family Lake
Douglas Lake
Moar Lake
Bloodvein River
PROVINCE OF ONTARIO
DEPARTMENT OF MINES
Hon. H. Mills, Minister of Mines. Willet G. Miller, Provincial Geologist.
Map Nº 32 b.
PART OF THE
ONTARIO-MANITOBA BOUNDARY,
FROM BLOODVEIN RIVER NORTH TO ANGLE AT 12TH BAS: LINE
To accomp?ny report by H.C. Rickaby in Volume XXXII, Part 2, Ontario Department of Mines Repor, 1923.
Scale: 1/126,720 or 2 Miles to 1 Inch.
Miles 2 1 0 2 4 6 Miles





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PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. CHARLES McCREA, *Minister of Mines* THOS. W. GIBSON, *Deputy Minister*

THIRTY-SECOND ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXII, PART III, 1923

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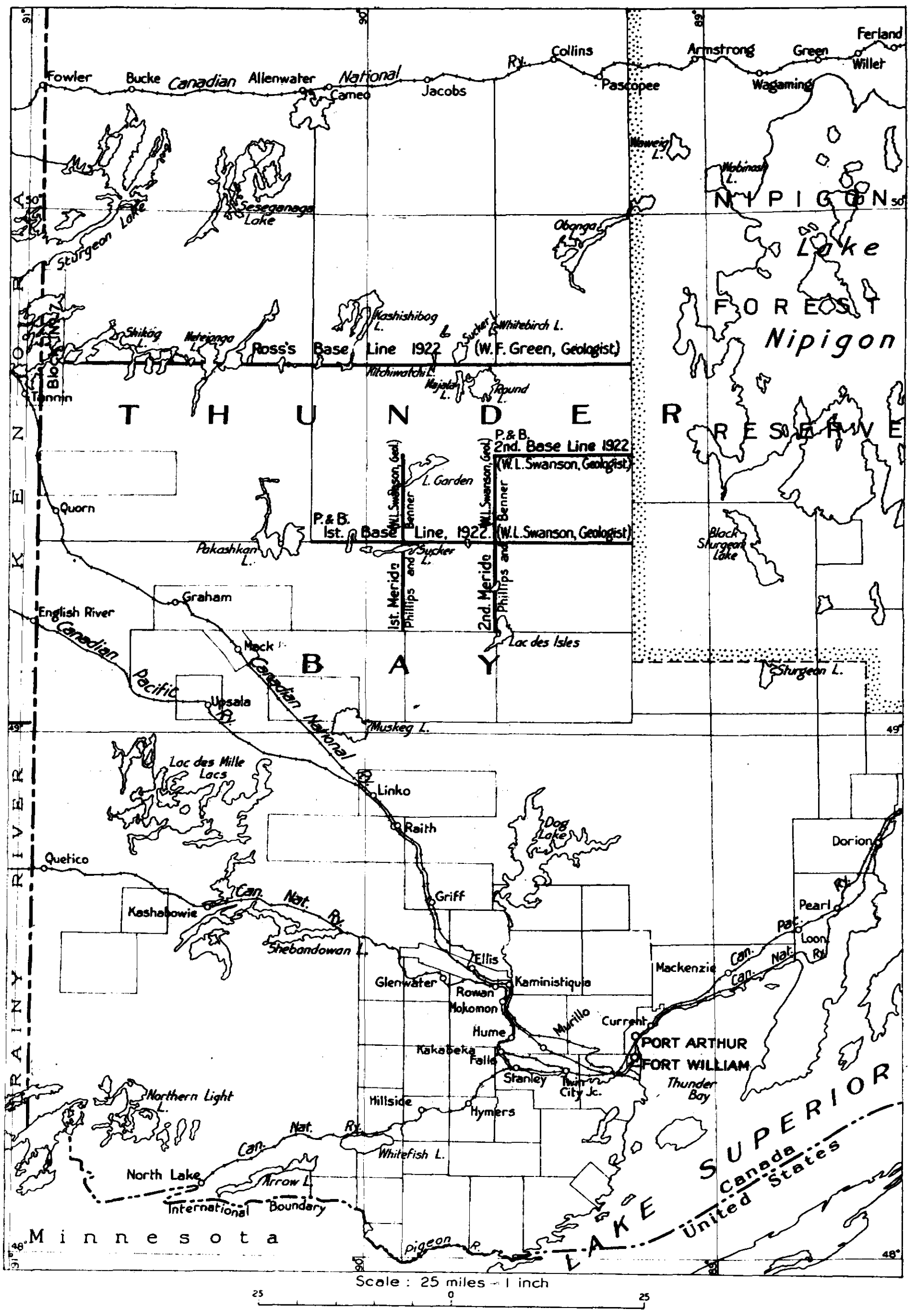
(In pocket inside back cover)



Key map showing location of base and meridian lines covered by the reports of W. F. Green and W. L. Swanson, which follow.

GEOLOGY OF BASE LINE RUNNING WEST FROM NEAR MILE 19, WESTERN BOUNDARY OF THE NIPIGON FOREST RESERVE

By W. F. Green

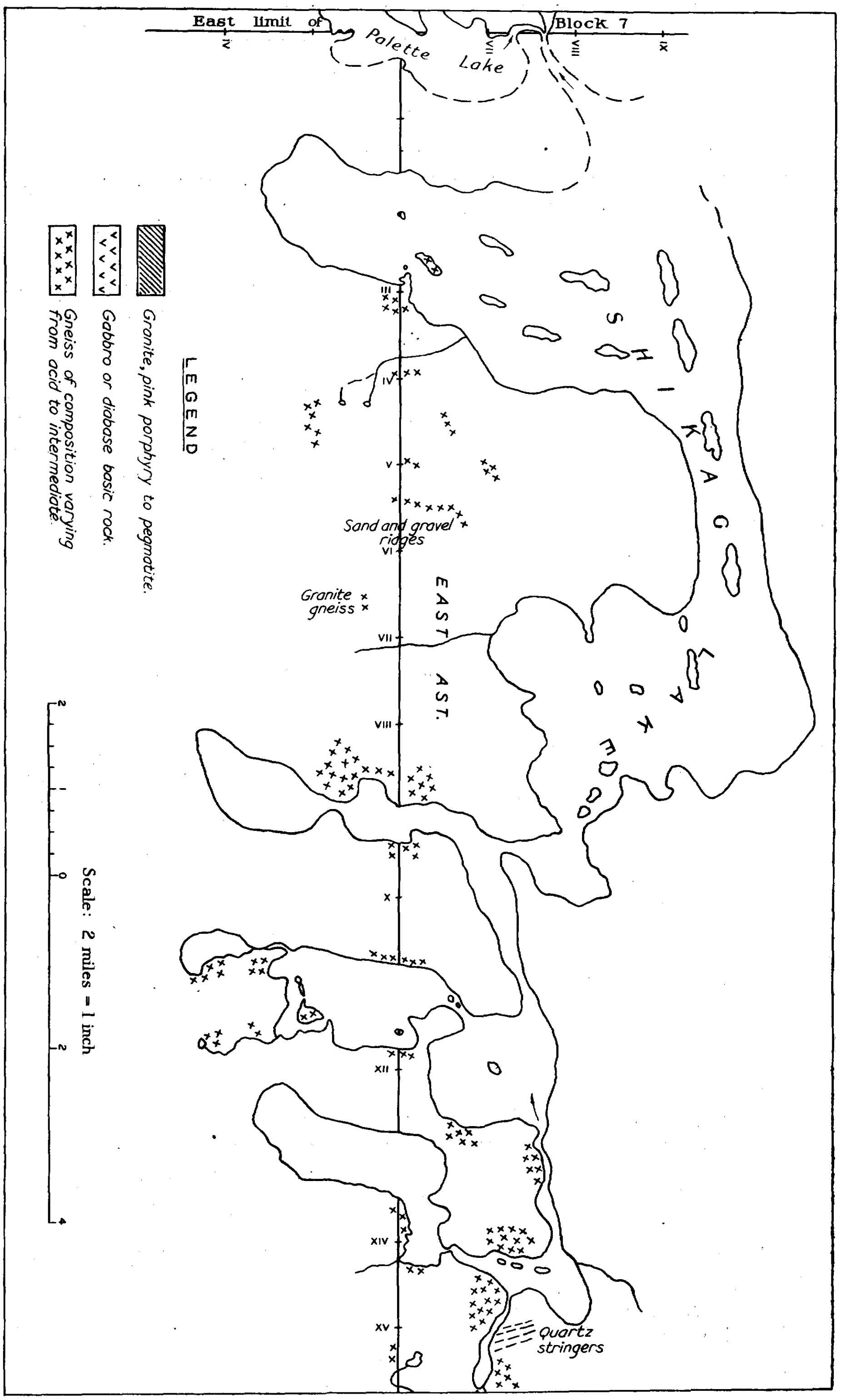
Following instructions received from the Deputy Minister of Mines the writer left Toronto and joined the survey party of Messrs. Lang and Ross on June 1st, 1922, at Fort William. From there the party proceeded by rail to Tannin station on the Superior branch of the National Transcontinental railway. Here canoes were obtained to take the party and supplies to Shekak lake. From near the southwest bay of this lake, the base line started from the eastern boundary of Block 7 and continued due east to the western boundary of the Nipigon Forest Reserve, a distance of nearly 75 miles.

The line was divided into three sections: First, from Block 7 due east 33 miles to a meridian run last year by Lang and Ross; second, a continuation of the line due east 24 miles, from which point another meridian was run due north to the main line of the National Transcontinental railway; third, a continuation of the line some 18 miles farther to the western boundary of the Nipigon Forest Reserve. The base line was tied in to the western boundary at a point 25 chains south of the 19th mile post.

Topography

In general the line for the first 33 miles is through a country that is very much broken up by lakes, both large and small. The larger lakes are very irregular in outline, usually having a number of deep bays. The streams, especially those joining the smaller lakes, are rough and carry little water. The portages are mostly from lake to lake, the fall from one lake to the next being taken up by the rapids in the stream. The country is rolling, consisting of low ridges of gravel and boulders with some exposures of granite or granite gneiss. These exposures are in the form of escarpments of only a few feet in height somewhere along the side of the ridge, or occasionally a flat outcrop overlain with a thin coating of moss. At no point is the relief of the country great, and the slopes are not steep. Even though this condition prevails the swamp area is not the predominant feature. As the end of the first section was neared the relief became greater, the ridges rising more abruptly showing cliffs of 30 feet in height. The character of the rock had changed also from the granite gneiss to coarse gabbro or diabase.

In the second section the rough character which started about mile 32 of the first section, continued for the first couple of miles. It then changed again to the same character of relief as appeared in the beginning, a succession of low ridges of sand gravel and boulders with swamp areas. At mile 20 in the second section, however, the difference in relief began to be more noticeable, and from this point to the end of this section and also through the third section to the boundary of the reserve, the differences in elevation are more marked. From the swamps to the tops of the ridges the change in elevation is as much as two hundred feet. Few lakes are encountered along the line, and the streams, usually in deep ravines, are small and turbulent showing good fall. The escarpments, accompanied by a talus slope, are much higher and of greater extent, often fifty feet. The descent from these coarse-grained rock exposures in many cases is quite steep and gradually changes to a more gentle slope nearer the swamps.



Sheet No. 1.—Ross's Base Line, 1922, Thunder Bay District.

Soil

The soil over the first two sections is for the most part sand and gravel with boulders interspersed. The covering over the rocks varies in thickness from a few inches in some of the lower areas to several feet, especially on some of the ridges. In the third section there is more clay, and in the Gull river vicinity the soil is a clay or sand loam. The country is too rugged and rough for agriculture, except possibly the lower valley of the Gull river.

Timber

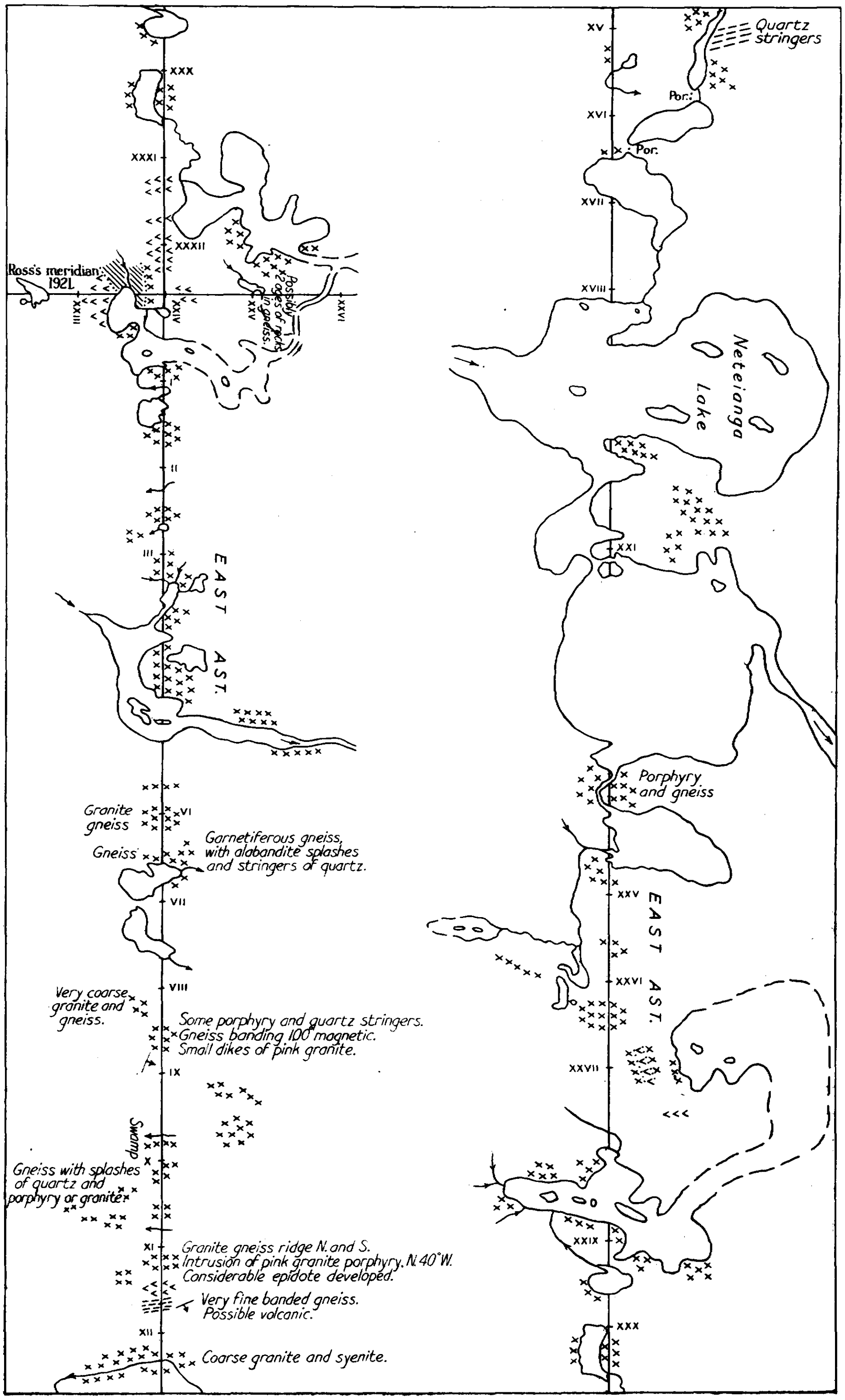
The timber along nearly the whole of the line is green. A little, along the first fifteen miles or so, is brulé. Some of it is old and some of as recent date as the present year, the fire being in progress while the line was cut. Also about five miles of the last section is brulé of one or two years' standing. Aside from these two areas the timber is green. In the swamps spruce trees from four to eight inches in diameter suitable for pulpwood, were found while on the ridges the size of these increased until trees of eighteen inches to two feet were found. Areas of jackpine or banksian pine suitable for lumber or ties were seen. A quantity of poplar and birch suitable for lumber would be available if means of transportation were at hand.

Geology

In the first two sections the predominant rock is the granite gneiss. The structure varies from coarse to fine banded, and the composition varies from granite to the intermediate types of rock syenite and diorite. In many cases the banding and also the grain of the rock is so coarse, that over a small outcrop the rock would appear to be massive. From near mile 30, section one, to near mile 3, section two, the character of the rock outcrops is changed and massive gabbro ridges appear. From mile 20 eastward in section two, gabbro ridges appear with the gneiss, and in the third section when the high ground is reached, the tops of the ridges are coarse gabbro, while in the lower lying ground gneiss occurs. These ridges all run in a northerly and southerly direction, but in the western portion of the line the direction is somewhat to the northeast, while as the Gull river is approached the trend is practically north and south.

Section One.—In this section the rocks are all medium to coarse grained, and of a general grey colour. In composition they are granite gneisses, and in some cases, for instance opposite mile 14 along the lake shore to the north of the line, the rock is massive syenite in appearance. On the shore of the small lake to the north of mile 15, there is an interesting rock exposure, though not very large. Here the rock has been intruded by a porphyry, and stringers and irregular masses of quartz are found interbanded with the rock. An examination of the exposure showed no mineralization. A zone a few feet wide and about 100 feet long showed some movement, but the stresses causing the shearing were not sufficient to develop a schist. Since the forest was burning at the time it is probable that there is now a much larger exposure of rock in this vicinity, and it might be worth while to find if this were only a local condition, or whether it extended over a large area and showed mineralization at some point.

Nothing more than the gneiss was noted until on a trip north from mile 27 a dike of diabase only a few feet wide was found with a general northeast and southwest trend. Again about mile 31 the line crossed a series of gabbro



Sheet No. 2.—Ross's Base Line, 1922, Thunder Bay District.

ridges. The rock is coarse-grained and massive and occurs with escarpments of nearly 30 feet. The ridges are not continuous but are offset somewhat with deep ravines between. This condition continues along the line to the meridian at the end of the first section.

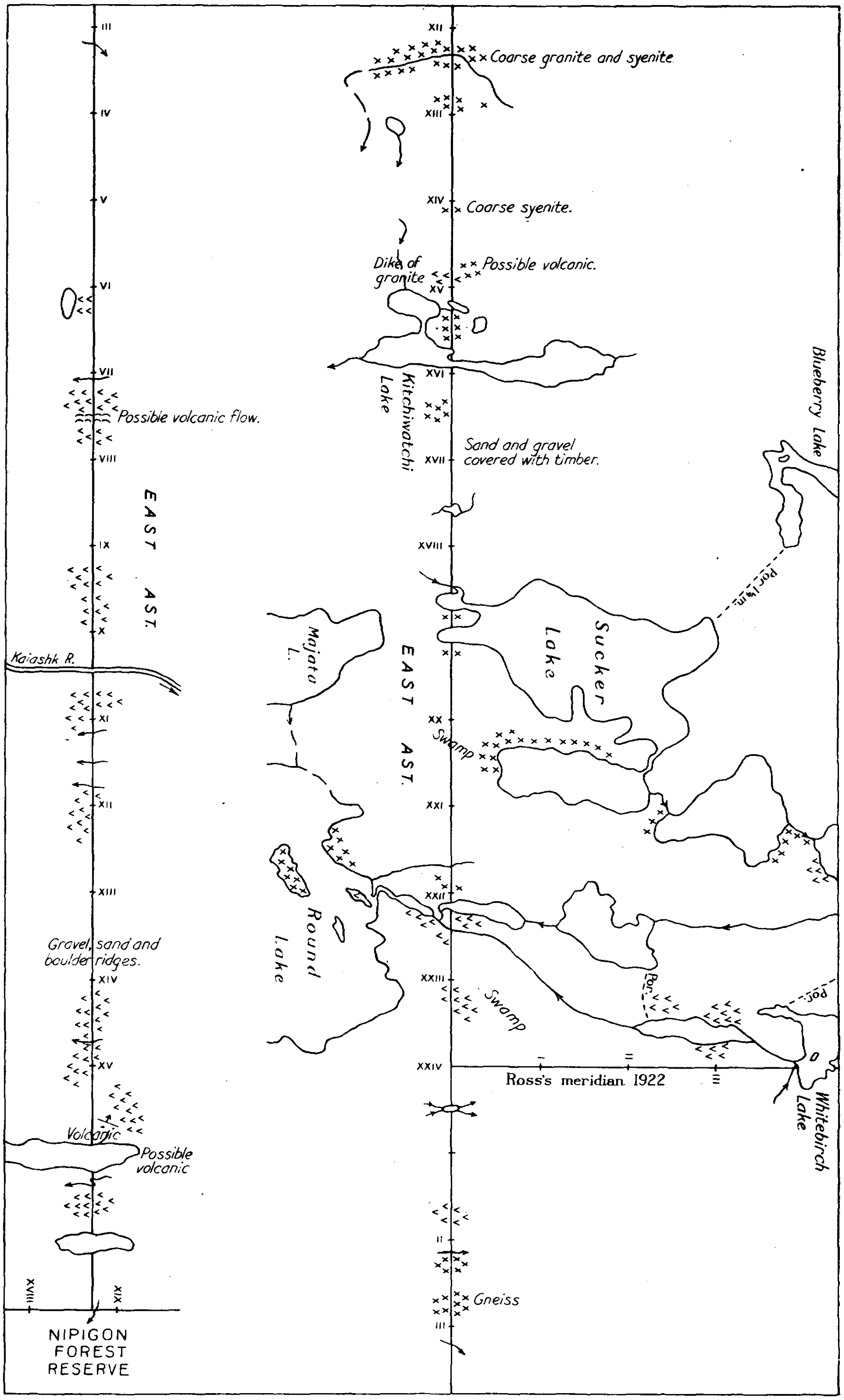
A different condition prevails north of the line. From the northeast bay of the lake just north of mile 31 plus 40 chains, the outlet of the lake is over a low outcrop of gneiss. The banding is almost east and west. There seem to be two sets of bands, one of the grey gneiss and with it another of light-coloured granite. They appear to be of different age. Exact conditions and relations could not be determined on this outcrop.

On the meridian line at a point a few yards south of where the base line crosses, is the edge of a grey gneiss outcrop. This continues south along the meridian for nearly a quarter of a mile. The banding is nearly east and west. About fifty yards north of the lake crossed by the meridian, a change of rock occurs. Pink granite with a structure varying from porphyritic to pegmatitic is exposed, and forms the north shore of the small lake. The pegmatitic phase shows feldspar crystals of 2 to 3 inches in diameter, also coarse quartz masses, and crystals of slightly altered muscovite broken and not very large. On the south side of the lake is a hill of coarse-grained gabbro. A contact was looked for and found at the west end of the lake. Here the granite seems to come up through the basic rock. Small masses of the gabbro are surrounded by the granite. The grain of the rock is coarse right up to the contact. A small dike of the granite was found in the gabbro in an almost horizontal position and extending for several yards along the outcrop. From a study of conditions here it would seem that the granite is later in age than either the gabbro or gneiss as it intrudes both. It appears to be a large batholith coming up under the basic rock and also breaking through the gneiss. No contact of the gneiss with the gabbro was found.

Section Two.—The first mile or so of this section is the same as the last of the first section, namely, rough with outcrops of coarse-grained rock. The character of the rock then changes and the outcrops are low. The exposures are mostly grey gneiss. Along with this, however, is a fresher looking rock, pink in colour and similar in appearance to the pink granite seen at the meridian. The structure of this pink-coloured rock is more porphyritic, and at mile 6-7 near the small lake, this condition is marked, distinct crystals of quartz showing in a finer groundmass. Here also are considerable irregular masses of quartz and considerable development of garnets. This area seems to be overlain by only a thin covering of moss and soil. The same gneiss with varying phases continues to mile 19 on Sucker lake.

From this point a trip was made up a chain of lakes to the north, thence over a long portage in an easterly direction to another chain of lakes, and down this chain to the foot of the lake which empties into a very rough river. From the foot of this lake a portage of about a mile to the west brought us into still another chain of lakes, and we continued the trip down these lakes until we reached Round lake. From this lake we returned north to where the line crossed this water route and joined the survey party just east of mile 22.

Going north from Sucker lake the outcrops are not very high and consist mostly of gneiss or massive granite. On the third lake to the north a large ridge of diabase was found along the east side of the lake, while on the west side low outcrops of gneiss occur. On an island near the narrows of the lake an intermediate phase seems to be developed and it has the appearance of a diorite or greenstone. Studied under the microscope in thin section it is seen



Sheet No. 3.—Ross's Base Line, 1922, Thunder Bay District.

to be an intermediate type of rock. Over the long portage to the east and south along the shore of the lake the granite again occurs in small areas from which the drift has been removed. On the shores and at the foot of the lake from which the portage to the west is made, ridges of diabase again appear. Just below where the line crosses the lake, near mile 22, there is another large outcrop of basic rock; and again on some of the islands at the north end of Round lake the same rock occurs. Also a large exposure of basic rock in the form of a ridge with a northeasterly trend occurs near mile 23.

Section Three.—In this section the differences in elevation are very marked. The ridges are large and extensive. The foot of the ridges has usually a gentle slope which becomes more steeply inclined toward the top, in places showing escarpments with small talus slopes, of 50 feet or more in height. These slopes have a good covering of soil and a splendid growth of timber. The outcrops are mostly very coarse-grained gabbro. At mile 15 plus 70 chains on the line, another rather interesting phase occurs. A small outcrop here weathers to a very light-coloured surface, almost white. It has somewhat the appearance of limestone. Studied under the microscope in thin section it is found to consist of outlines of feldspar crystals which have been highly altered to carbonate. It might represent a contact phase with a very impure limestone or a highly altered phase of igneous rock containing feldspars high in lime. Following the outcrops to the north and east the rock seems to be igneous rather than sedimentary. To the north and west about 100 yards is an escarpment of coarse-grained basic rock. As the intervening area is drift covered the relation of these two rocks was not obtained. From this point to the end of the line the covering of drift is thick with only here and there a small outcrop of coarse-grained basic rock.

Summary

The rocks examined fall into three groups: the greyish-coloured gneiss with its various phases which occur in low-lying ridges; the coarse-grained gabbro which occurs usually in high ridges and seems to overlie the gneiss, though actual contact was not observed; and a fresh pink coloured granite with different structures which intrudes the other two types. No zones of mineralization were found, though irregular masses and stringers of quartz were seen on the lake north of mile 15 in the first section and near mile 6-7 in the second section where it is accompanied by porphyry. If this area is burned or the timber removed so that the rocks become exposed it might be well to spend some time to determine the relation and extent of the porphyry, the pink granite, and the two phases of the gneiss; also to see if any zones of mineralization can be discovered near mile 15 of section one, near mile 6-7 of section two, and mile 15-16 of section three.

All along the line for the greater part of the distance the country is covered with good timber, some suitable for pulp and some for lumber, if transportation were such as to make it available.

The country is too rugged and rough for agriculture, except possibly the lower portion of the Gull River valley.

Should no zones of mineralization be discovered, probably the best use to be made of this area would be to keep it covered with forest and utilize the timber.

GEOLOGY OF CERTAIN BASE AND MERIDIAN LINES WEST OF LAKE NIPIGON

By W. L. Swanson

The following report is a description of the geological work done during the summer of 1922 in connection with the survey of certain base and meridian lines in an area southwest of Lake Nipigon. The Department of Lands and Forests had assigned to Messrs. Phillips and Benner, O.L.S., Port Arthur, the task of surveying these lines, and the writer acting under instructions from the Department of Mines, Toronto, was attached to their party in the capacity of geologist. He was directed to note the geology along the lines, paying particular attention to any rocks or formations he might encounter favourable for the occurrence of ores or non-metallic minerals.

Mack Lake to Cedar Lake

The writer arrived at Port Arthur on the morning of June 7th, and joined the survey party which was already aboard the C.N.R. train bound for Sioux Lookout station. Shortly after noon we arrived at Mack station, where we detrained. Thence we followed a fairly good road for about two miles until we arrived at a lake, named by the Indians White Beaver lake. There the canoes which we had with us were brought into service. We followed the long direction of this lake for about two miles until we reached a portage, 44 chains in length, connecting White Beaver lake with a smaller lake, named Long lake. Having crossed this portage, the party encamped for the night. Resuming our journey on the morning of the next day we crossed Long lake, and came to a narrow, tortuous creek which we followed for about a mile until it entered a small, narrow lake about one mile in length. Following the long direction of this lake we came to a portage, 12 chains in length, which brought us to Sand Hill lake. After an hour's paddling we arrived at a portage, 6 chains in length, which crossed a hill 100 feet or more in height. The Indians informed me that this was Mountain portage. At the northern end of this portage is a small lake, 4 chains in width, which brought us to another portage, 14 chains in length. Having crossed this portage we arrived at a small lake, Clearwater lake, on the shore of which we encamped for the night. Next day we crossed Clearwater lake, a distance of about one mile, and came to a portage 16 chains in length connecting Clearwater lake with a considerably larger lake, named Shell lake. This latter lake is shown on published maps of this region. We followed this lake in a north and northwest direction for about five miles until we arrived at a portage, 24 chains in length. We crossed this portage and arrived at Cedar (Pakashkan) lake where we encamped for the night. Next day we paddled in a northerly direction on Cedar lake for about five miles, and then went through the woods in a southeast direction for 21 chains and came to the line surveyed westward in 1921 by K. G. Ross. Three chains east of where this line was met is mile post 35. We followed this line eastward to mile post 34 which is a corner post. We encamped there for the night as that corner post was to be the starting point for our survey.

The direction of the route which we followed from Mack station to Cedar lake was mainly north and northeast. En route but few rock exposures were noted until Cedar lake was reached. Numerous rock exposures were seen on the islands and along the shores of this lake, but no opportunity was obtained of examining them, with the exception of those showing at the place where we disembarked previous to proceeding inland to Ross's line. The rock examined is a biotite gneiss. One outcrop has a strike of N. 50° E. and a dip about 60° N.W.

On the morning of June 12th, the party under direction of E. P. A. Phillips began the survey of the first 12 miles of line in a due east direction. Between the starting point and the 6-mile post, exposures of biotite gneiss are abundant. At 2 miles 44 chains is a deep gully, and the western bank of this gully is composed of a biotite-gneiss cliff about 75 feet in height. The strike of the exposure is about N. 20° E. and the dip is about 45° W. Some of this gneiss is richly quartzitic. The quartz is mostly of the clear variety, but some rose quartz was seen. Stringers of quartz were observed at intervals. This gneiss exposure extends north of the line for 5 chains, where it disappears under drift. To the south of the line the exposure is continuous for 8 chains, and then is visible at intervals for 7 chains more until it gives way to the drift.

Small exposures of gneiss were seen on the shore of the lake, south of 2 miles 50 chains. These exposures differ from those described above in having a great deal of hornblende instead of biotite. Hornblende gneiss was also found occurring with biotite gneiss at 2 miles 68 chains. This exposure is fine-grained in texture.

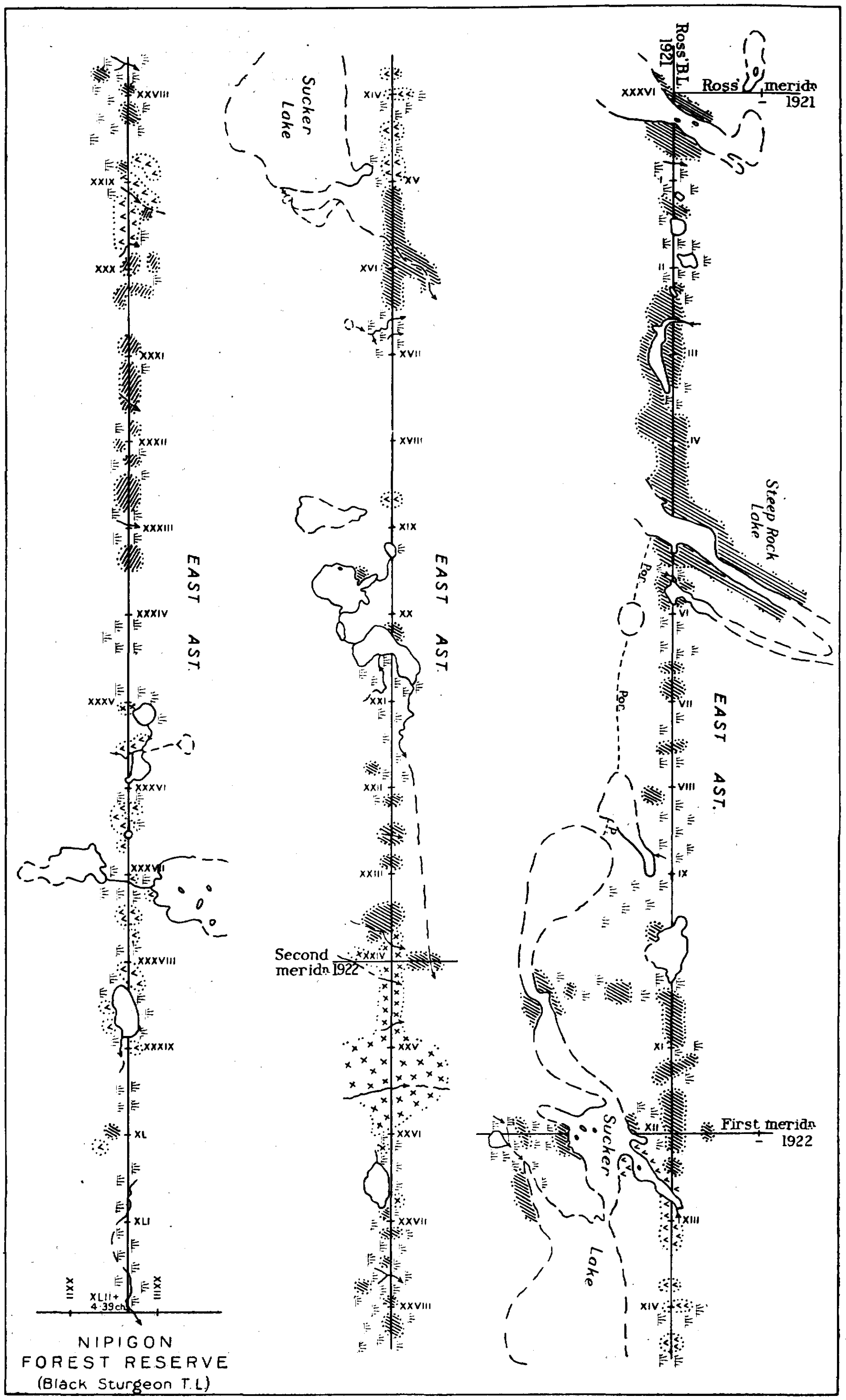
Biotite gneiss found at 3 miles 18 chains is coarsely crystalline, and contains large and abundant mica flakes. At 15 chains south of 3 miles 56 chains is a small outcrop of biotite gneiss or biotite granite gneiss, rather granitic in texture, and containing large crystals of feldspar. At 4 miles 28 chains a small outcrop of biotite gneiss was found. It is distinctly gneissoid and strikes due north and has a dip of 75° E. A few stringers of quartz were observed in it. At 5 miles 19 chains on the eastern shore of Steep Rock Shore lake is an exposure of biotite gneiss with small patches of biotite granite. Some portions of the granite contain a chloritic mica and are pegmatitic in texture, while in contrast other portions are fine-grained. Reddish orthoclase is abundant. The strike of the gneiss is about N. 35° E. and the dip 75° S.E.

Steep Rock Shore Lake

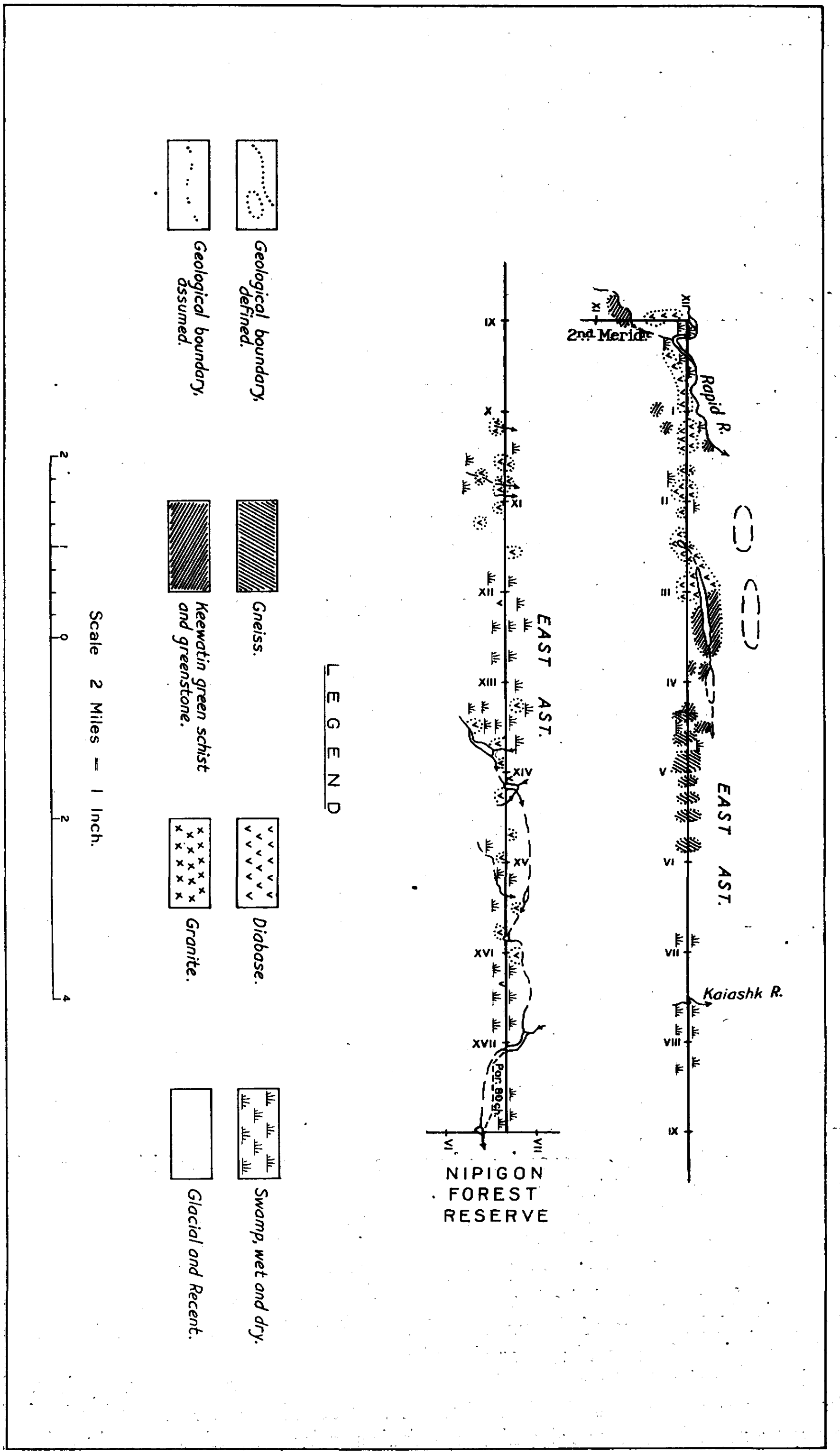
Steep Rock Shore lake was followed north of the line for about 4 miles. Its shores are formed of biotite gneiss and are quite steep, attaining a height of 70 feet or more in places. Thus, the lake well deserves its Indian name. At about 20 chains north of the line, the rock is quite gneissoid and the dip is about 75° E.

Between the 6-mile and the 12-mile posts, rock exposures are few in number, except between the 10-mile and 12-mile posts. At 7 miles 38 chains is a small outcrop of hornblende granite gneiss. A thin section made from a specimen of this rock shows green hornblende to be present in rather large crystals. Quartz is abundant in small, somewhat rounded grains. Plagioclase is more abundant than orthoclase, and both show partial kaolinization. A few small crystals of apatite were observed and also an alteration product, the identity of which was not determined.

The outcrops of biotite gneiss in the vicinity of 11 miles 20 chains all seem to have a strike of N. 40° W. to N. 30° W. Patches and veins of granite are numerous, and a few veins of clear quartz were observed. The gneiss is mostly of the biotite variety, although exposures of hornblende gneiss, fine and coarse



Sheet No. 1.—Phillips' and Benner's First Base Line, 1922, Thunder Bay District.



Sheet No. 2.—Phillips' and Benner's Second Base Line, 1922, Thunder Bay District.

grained in texture, were seen. Biotite gneiss extends fairly well exposed from 11 miles 40 chains to 11 miles 57 chains. At 11 miles 78 chains, there is biotite-hornblende granite gneiss, a thin section from which showed biotite to be abundant in the form of large flakes. The pleochroism of the biotite ranges from straw-yellow to dark brown. Green hornblende crystals are fairly abundant. A few scales of muscovite are present. Quartz is abundant as large grains. Orthoclase and plagioclase crystals are about equal in number and are partially kaolinized. Several rounded grains of apatite were seen. A small amount of epidote is also present.

Having completed the survey of the first 12 miles of line, we began the survey of another 12 miles in direction due north from the 12-mile post. Small exposures of biotite gneiss and occasionally biotite-hornblende gneiss or hornblende gneiss were seen frequently between the 12-mile post and the lake at 3 miles 19 chains. Outcrops of biotite gneiss are frequent on both shores of the lake. The strike of the gneiss exposures between the corner post and the lake is on the average about due east and west.

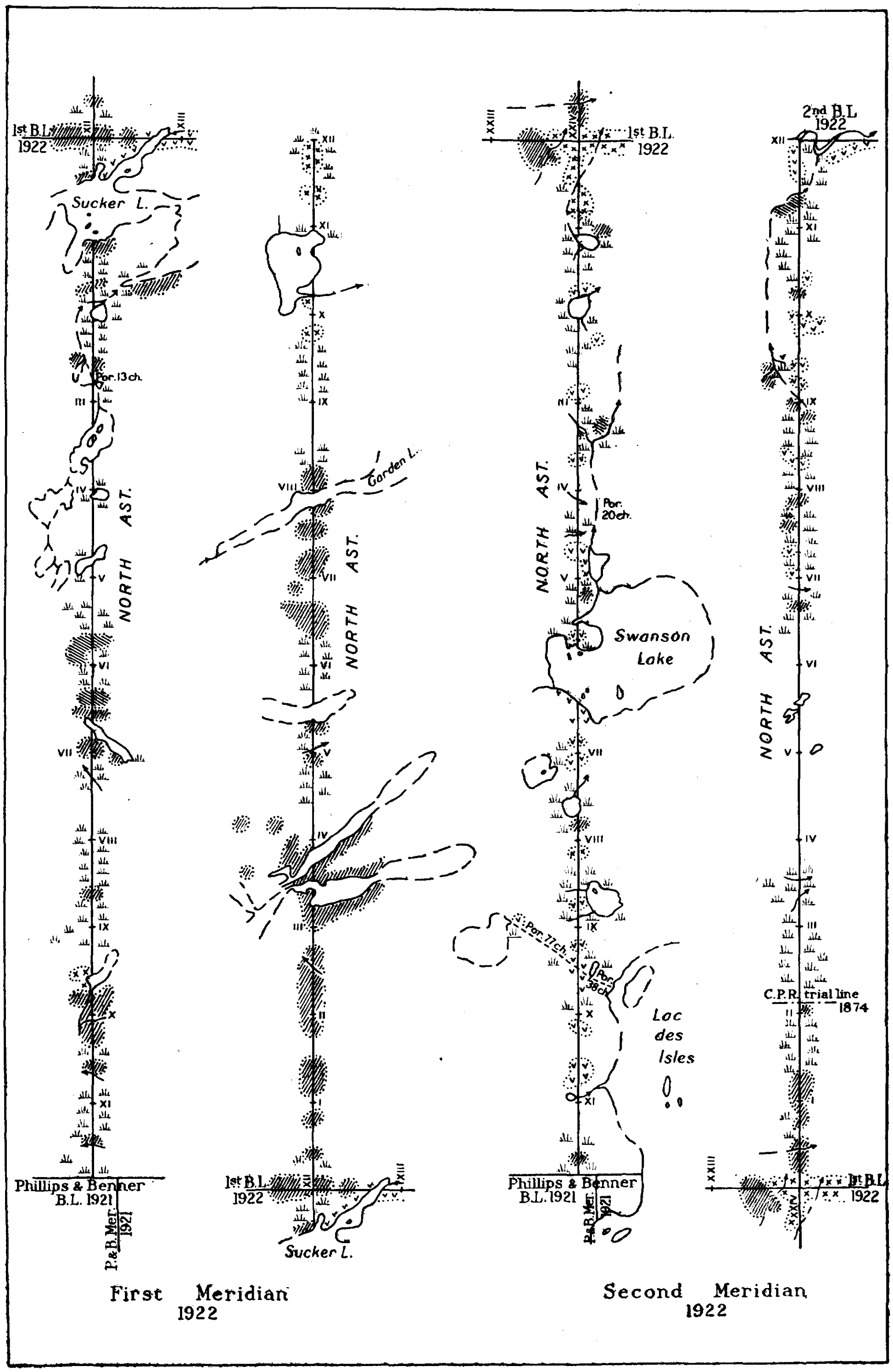
From the 4-mile post to 9 miles 62 chains, the rock is mainly biotite gneiss, occasionally hornblende gneiss. The exposures are small in size, and some are rather schistose. At 9 miles 62 chains is what appeared to be schistose biotite gneiss. Examination of a thin section proved the rock to be a muscovite granite. It is very fine-grained and greatly altered. The feldspar is much kaolinized and the other minerals present are indistinct. Muscovite is abundant as small shreds and scales. A few much altered shreds of biotite are present, also a large amount of a pale greenish mineral, probably chlorite.

The exposure, described immediately above, is evidently near the contact between the great gneiss area which had been traversed and an area of biotite granite, which is represented by a few small exposures found near the line at 10 miles 15 chains and more abundantly between the 11-mile and 12-mile posts. The granite occurring in these exposures is evidently younger than the biotite gneiss, which had hitherto been the prevailing type of rock. The crystals of the minerals forming the granite are large. Biotite is prominent, and the appearance of the granite suggests that it had probably intruded the gneiss at a period subsequent to the formation of the latter rock. However, the granite is evidently, like the gneiss, a Laurentian rock.

Gneiss and Keewatin South of Sucker Lake

Having returned to the corner post, we began the survey of 12 miles of line due south from that point. Biotite gneiss occurs on the south shore of Sucker lake, and small exposures of biotite gneiss at intervals between the lake shore and the 2-mile post. From there to 5 miles 53 chains, rock exposures are very few, the country showing a succession of spruce swamps and low hills covered for the most part with small birch and poplar. Near 5 miles 53 chains, small exposures of schistose Keewatin occur and these continue to near the 6-mile post. Keewatin again appears at 6 miles 30 chains, and at 6 miles 37 chains, biotite gneiss. The contact between the gneiss and the Keewatin could not be found, being covered by drift. The strike of the Keewatin is, on the average, about S. 75° E. and the dip 85° S. The strike of the gneiss is N. 45° E. and the dip 85° S.E. The rock is dark green in colour, and rather slaty in structure.

Between the 7-mile post and 9 miles 43 chains, exposures are very few. Some biotite gneiss occurs near 8 miles 45 chains. West of the line at 9 miles 43 chains is an exposure of biotite granite about 4 chains in length, salmon-red in colour, and



Sheet No. 3.—Phillips' and Benner's First and Second Meridians, 1922, Thunder Bay District.

rather coarsely crystallized. It is on the side of a hill sloping towards a lake, and the granite evidently extends east, west, and north from the exposure, although this could not be verified on account of the covering of drift. Immediately to the west of the western bay of the lake, are two small exposures of this red granite.

South of the lake is an area containing numerous small exposures of biotite granite gneiss. Some of these contain irregular patches of red granite. The gneiss is coarsely crystallized, and includes here and there small stringers of quartz of a width of two to six inches. The gneiss, where well exposed, is nearly white in colour. From 10 miles 20 chains to where the line met J. K. Benner's surveyed line of 1921, exposures of biotite gneiss are few and widely separated.

Returning to the corner post, we resumed the survey of the base line. Small exposures of biotite gneiss were found frequently between the 12-mile post and 12 miles 38 chains. At 12 miles 42 chains is a small outcrop of diabase. Between 12 miles 38 chains and 12 miles 42 chains is a swamp extending some distance north and south of the line. The contact between the diabase and the gneiss evidently follows the long direction of the swamp. The contact itself was not found.

At 12 miles 54.5 chains is the western shore of a deep bay of Sucker lake. This shore is formed by a vertical diabase cliff, 30 to 40 feet in height. The diabase is exposed to view for almost the full length of the bay. At the mouth of the bay diabase was found on both shores, but two small islands in the bay are of biotite gneiss. About ten chains west of this bay, biotite gneiss occurs on the shore of Sucker lake. Evidently the line of contact between the diabase and gneiss in this area is very irregular.

A thin section made from diabase occurring at 12 miles 63 chains, shows plagioclase to be present in moderately large crystals, much kaolinized, also augite, rather grey in colour, in large and small crystals. A large amount of limonite-like material, probably an alteration product from magnetite, was observed. Magnetite, in fairly large irregular grains, is moderately abundant. The minerals in this section are rather clouded by the alteration product mentioned above.

From the eastern shore of the deep bay of Sucker lake to 15 miles 2 chains, the rock seen is diabase. Between 13 miles 25 chains and 14 miles 30 chains exposures are very few in number and are widely separated. At 15 miles 15 chains is a biotite granite gneiss. The contact between this and the diabase was not found, being covered by swamp.

From 15 miles 15 chains to 16 miles 40 chains are numerous exposures of biotite gneiss. The gneiss is somewhat porphyritic in appearance, and shows in places an augen structure. At 16 miles 17 chains, a small stringer of dark, finely schistose rock was observed in the gneiss, and occasionally small patches of red granite. These exposures occur in a "pot hole" area, numerous small knolls and rounded hollows being a characteristic feature.

From 16 miles 40 chains to 18 miles 50 chains, no rock was seen. At 17 miles 20 chains, open brulé begins and continues to 18 miles 50 chains, where second-growth jackpine and birch are found. Between 18 miles 50 chains and 18 miles 55 chains are three small exposures of diabase. No more rock was visible on or near the line until the shore of a lake was met at 20 miles 20 chains, where biotite-hornblende granite gneiss occurs, extending along the shore for about ten chains. At about 30 chains south of 19 miles 45 chains, biotite granite gneiss forms a narrow point projecting into a small lake.

From where the line met the east shore of a lake at 20 miles 36.5 chains to the 22-mile post, no exposures occur, but between the 22-mile post and 23 miles 54 chains, there are a few small outcroppings of biotite gneiss and biotite-hornblende granite gneiss. These were most numerous in the vicinity of 23 miles 40 chains. At 22 miles 70 chains occurs an exposure of the last-named rock with an intermingling of dark-coloured and light-coloured areas. The dark-coloured silicates are prominent in the dark areas, and the light-coloured silicates in the light-coloured areas.

At 23 miles 56 chains, there is a showing of hornblende-biotite granite, followed by numerous exposures of granite as far as the 26-mile post. Some of the granite is of the biotite-hornblende variety, but the prevailing type is that in which the hornblende predominates. Most of the granite occurs in ridges having a north or northeast direction. The colour varies from nearly white to salmon-red, and dark-coloured silicates are abundant. On the whole, the granite is coarsely crystallized and in places it is somewhat gneissoid. Between the 25-mile and 26-mile post much granite was encountered, and from the top of the hill bordering the deep valley at 26 miles 37 chains, ridges, presumably of this rock, were seen to extend northward for about five miles and southward for about three miles.

From 27 miles to 28 miles 70 chains, exposures are few in number and widely separated; they are of biotite granite and biotite-hornblende granite gneiss. From 28 miles 72 chains to 29 miles 58 chains, diabase outcrops are numerous along and north of the line. A thin section was made from rock obtained one chain north of 28 miles 72 chains, proving it to be olivine diabase. The section shows splendidly the typical ophitic structure. The plagioclase occurs as large lath-like crystals, and the spaces between the feldspar crystals are well filled by augite. A few crystals of apatite were observed. Hematite is present in small amount, and magnetite in the form of large grains is relatively abundant.

At a short distance south of 28 miles 73 chains, there is a small exposure of biotite-granite gneiss. A thin section shows quartz, in the form of small grains, to be only moderately abundant. There is more orthoclase than plagioclase, and both feldspars show much kaolinization. Biotite in moderate amount, much altered, and some chloritic material were observed, also numerous small grains of magnetite. The minerals in the section were indistinct and much altered.

Keewatin North of the Line

At 14 chains north of 29 miles 27 chains is a small exposure of Keewatin rock. A thin section shows it to be either hornblende or chlorite schist. A large amount of green material, some of which showed pleochroism, is seen in the section. This material is evidently hornblende or chlorite, but the original crystals have been so much altered that it was difficult to identify it. Graphite, in the form of large flakes and minute grains, was abundant.

From 29 miles 70 chains to 33 miles 35 chains, small exposures of Keewatin rocks are fairly numerous. Some of these show but little schistosity. They are mainly olive-green in colour, and some contain small amounts of calcite. In some the rock is evidently an amphibolite or a closely related variety. The strike of the exposure appears to be, on the average, about N. 75° E., and the dip is nearly vertical. One showed several square feet of clear quartz at one place; the quartz probably extends for some distance, but as the surface is mostly of drift, the extension could not be followed. Grains of pyrite occur freely in the rock.

From 33 miles 35 chains to the 35-mile post, no rock was seen, but a few small outcroppings of hornblende granite are found near the latter. At 35 miles 32 chains is the summit of a hill about 210 feet in height, at the foot of which diabase occurs and extends about twenty chains northwest of the line. Evidently the hill itself is of diabase. The rock where seen between 35 miles 47 chains and the 39-mile post is diabase, but exposures are few in number and widely separated. Some of them are of the olivine-diabase variety, but usually the rock does not contain much olivine.

From the 39-mile post to where the line met Benner's surveyed line of 1918, no rock was visible. However, some hornblende granite gneiss occurs twelve chains south of the 40-mile post, and a small exposure of olivine diabase twenty chains south of 40 miles 9 chains.

Granite, Gneiss, and Keewatin

When the party had returned to the 24-mile post, the survey of a line due south was begun. For the first mile, exposures of hornblende-biotite granite are numerous. In some biotite appeared to be more abundant than hornblende. The granite varies from light-coloured to salmon-red. A small extent of biotite granite gneiss occurs near the small lake at 1 mile 4 chains.

Between the 1-mile and 5-mile posts what little rock can be seen is diabase, with the exception of some Keewatin schist found east of the line at 3 miles 30 chains. The diabase at 1 mile 57 chains is considerably weathered. It is of a resinous-green colour and contains numerous small flakes of biotite. Immediately east of the line at 3 miles 28 chains is a small exposure of Keewatin schist. A patch of quartz was observed in the schist, and small fragments of the schist are included in the quartz, giving it a brecciated appearance. The strike of the schist is N. 10° W. and the dip about 85° W. At 15 chains east of 3 miles 32 chains, a larger area of schist occurs in a cliff varying from 20 to 30 feet in height, and extending northward for a distance of eight chains, where it disappears beneath a poplar knoll. The rock has a dark green colour, and contains numerous patches and stringers of granite. Some of the latter are typically granitic, while others are fine-grained and resemble sandstone. They vary in width up to two inches or more. The schist area includes a few patches of barren quartz. The average strike is about S. 75° E. and the dip varies from 60° N. to nearly horizontal.

At 4 miles 36 chains, there is a low ridge which is evidently a glacial moraine. The long direction is N. 70° E. and the steepest part faces towards the south. The ridge contains an abundance of gravel and numerous boulders of biotite granite, hornblende granite, diabase, and Keewatin schist.

Between the 5-mile post and Benner's surveyed line of 1921, exposures are few and are widely separated. A small outcrop of biotite granite gneiss occurs 8 chains east of 5 miles 18 chains. The strike of the gneiss is about N. 30° E. and the dip about 80° E. It is surrounded by swamp, and the nearest rock is diabase, distant about ten chains. Small exposures of hornblende-biotite granite gneiss occur at 7 miles 64 chains, and one of muscovite granite gneiss near 11 miles 50 chains. A thin section of the muscovite granite shows much quartz and orthoclase, the latter considerably kaolinized. Large crystals of plagioclase are moderately abundant. A few crystals of microcline were observed and numerous small shreds and scales of muscovite, together with several grains of epidote and a few well-formed crystals of apatite. An undetermined, yellowish alteration product is present in considerable quantity.

The remaining exposures between the 5-mile post and Benner's survey line are of diabase and gneiss, the former being more abundant. Where the line meets the south shore of Swanson lake is a diabase cliff, thirty to forty feet in height. West of the line, the diabase is exposed continuously for eight chains, and at intervals for twenty-two chains before it finally disappears under drift. This rock is considerably fractured by vertical and horizontal fissures, forming large, irregular blocks of various sizes. The colour is dark green.

At 9 miles 36 chains, the line crosses an old portage which, when followed eastward for thirty-eight chains, terminated at Lac des Isles. The portage extends westward from the line for seventy-seven chains to the shore of a small lake. This portage was well blazed and had evidently been much travelled. Trappers' trails had been seen occasionally during the summer, but this was the first real portage encountered since leaving Cedar lake over two months previously.

At the 10-mile post, a marked variation of the compass-needle was noted. As a rule the direction in which the needle pointed made an angle of 2.5° with the direction of the line, but at the 10-mile post this angle increased to 6°. The variation was probably due to diabase, containing considerable magnetite, occurring in the immediate vicinity. No diabase exposure was found near the post, with the exception of one at 10 miles 6 chains, and this, apparently, contained no magnetite.

Immediately east of 10 miles 48 chains is a diabase cliff about 50 feet in height. The diabase is exposed for a distance of about two chains in a northerly direction. This cliff is, probably, about 250 feet above Lac des Isles, which was visible about 40 chains distant. At 10 miles 64 chains is another diabase cliff exposure, about thirty feet in height, which extends northeast from the line for a distance of two chains, and westward from the line for three chains. It is about 300 feet above Lac des Isles, and provides a splendid view of this lake. The diabase in these cliff exposures is coarsely crystallized.

Granite, Diabase, Keewatin

Having returned again to the 24-mile post we began the survey of a line due north from there. Small exposures of biotite-hornblende granite are numerous for the first eleven chains, followed by like areas of biotite granite gneiss and biotite-hornblende granite gneiss. These continue rather abundantly to 1 mile 28 chains.

From 1 mile 28 chains to 6 miles 40 chains, no rock was found, with the exception of a small patch of biotite granite gneiss lying immediately east of the line at 2 miles 1 chain, and varying from pink to red to nearly white in colour. It is slightly gneissoid in places and rather granitic in others.

From 1 mile 28 chains to 3 miles 50 chains are large areas of spruce swamp. In one of these was seen what is probably the C.P.R. trial line of 1874. Its direction is almost due east and west, and it crossed our line at 2 miles 10 chains. Several tree stumps, still showing the marks of the axe, were found in the swamp. The direction of the line, as determined by aligning these stumps over a distance of 20 chains, is N. 86° W. (magnetic). Two trees show typical line blazes.

From 3 miles 50 chains to 6 miles 50 chains is an area of land bearing the largest trees that were seen during the summer. The varieties are jackpine, spruce, birch, poplar, and balsam. Many of these trees are two feet in diameter, and the butt of one spruce felled by axemen, showed 96 annual growth rings, and of another 115. The area is quite hilly, and might be described as a "pot hole" area, because of the numerous deep, rounded hollows between the hills, and of the lakes, which show neither outlets nor inlets.

Between 6 miles 50 chains and the 12-mile post, rock exposures are widely separated and few. They are of biotite granite gneiss, hornblende granite gneiss, Keewatin schist, and diabase, the last named being the most abundant. At 7 miles 51 chains, there is a small outcrop of hornblende granite gneiss. In places the gneiss is somewhat porphyritic in texture, showing large crystals of quartz and feldspar. As a rule, however, it is fine grained. The colour of the gneiss varies from nearly white to salmon-red. A few small patches of clear quartz were seen in it. There is evidently some chloritic material in the rock, which occurs as scattered patches or tiny veinlets. The structure is only slightly gneissoid. The strike of the exposures of gneiss is, on the average, N. 60° E. and the dip is nearly vertical.

Diabase occurs at 8 miles 21 chains, varying from quite fine-grained to rather coarse. It appears to contain some olivine and a small amount of magnetite, also a little biotite.

In the vicinity of 11 miles 20 chains are numerous small exposures of Keewatin schist. The average strike of these is N. 70° E. and the dip is 80° S. The rock is somewhat slaty, and can be cleaved into rather thin slabs. It is dark green in colour, and contains chloritic and micaceous material, also in places small grains of pyrite. A thin section made from the rock at 11 miles 25 chains shows it to be a hornblende schist. The section showed the minerals to be indistinct and much altered, and it was traversed by a small stringer of quartz. Some calcareous material was present, and a few grains of zoisite and epidote.

At 11 miles 64 chains, resinous-green diabase formed a cliff, at a distance of one to three chains east of the line, and exposed northward for a distance of about eight chains. The cliff varies from ten to fifty feet in height. In places the diabase is much fractured into large, irregular blocks. A deep talus of diabase boulders and blocks extends to a distance of about two chains from the cliff. Part of this talus is underlain by small diabase ledges projecting from the main exposure.

Keewatin Schist and Diabase

Having arrived at the 12-mile post, the survey of the line due east was begun. Between the 12-mile and 4-mile posts, rock abounds, and the largest exposures seen during the summer occur in this area. They are of Keewatin schist and diabase. At 56 chains east of the 12-mile post, there is a diabase cliff which extends southwest from the line for twenty-five chains before it disappears under drift. It is also exposed northeast of the line for a distance of seven chains. It varies from ten feet to over seventy feet in height, and in places is nearly perpendicular. At certain parts of the cliff, the diabase is much fractured into large blocks and slabs. The rock is of medium texture, dark resinous-green in colour, and contains a small amount of magnetite. This ridge is evidently a continuation of the diabase ridge, noted as running mainly east of the line at the 10-mile post on the second 12 miles north of the base line.

At twenty-one chains north of 1 mile 30 chains, Keewatin schist outcrops about 2 square chains in area. The strike is N. 30° E. and the dip about 75° N. At nineteen chains south of the 1-mile post there is a small exposure. A thin section made shows the rock to be evidently a hornblende schist, although the mineral thought to be hornblende is so much altered as to render definite recognition difficult. Numerous tiny grains of quartz and graphite occur in the section.

At 2 miles 46 chains is a diabase cliff-exposure, twenty to forty feet in height. It extends south of the line for ten chains, and north of the line for fifteen chains in direction N. 60° E. It then changes its direction to almost due east, and forms the southern shore of a long, narrow lake. Another such cliff begins about four chains north of the line, distant from the former about four chains. The two cliffs follow the same direction and form a narrow gorge, with rock walls ranging from twenty to one hundred feet in height, leading down to the long, narrow lake. The southern wall of the gorge becomes gradually higher as it follows the lake eastward, and in places attains a height of three hundred feet or more, bordering the lake. The northern cliff on the other hand gradually diminishes in height as it proceeds to the east, until finally it is almost hidden by drift. Near the western end of the lake are great heaps of diabase blocks which have weathered out from the cliff and accumulated at its base. At thirty-six chains from the western end of the lake, the diabase ends abruptly against Keewatin schist. The actual contact is obscured by drift, and for the most part the schist itself is also covered. Small exposures, however, occur on both sides of the lake and beyond it. The strike is evidently about N. 80° E. and the dip about 30° N. The exposures appear to be much disturbed and show great variation of dip and strike.

The diabase has a dark resinous-green colour and a medium texture, and contains a small amount of magnetite. The Keewatin rock varies from slightly to decidedly schistose, and in colour from dark to light. Small stringers of quartz, varying from less than an inch to six inches or more in width, are fairly numerous. The schist shows, in places, considerable micaceous material and also a small amount of scaly, chloritic matter. It is evident that much mineralization has taken place near the contact. In numerous places the schist has a slickenside appearance. A thin section made from near the contact shows the rock to be a biotite schist. The biotite is for the most part much altered, but a few irregular crystals, showing good cleavage and distinct pleochroism, were observed. The ground-mass of the section appears to be composed of tiny grains of quartz with here and there a few larger ones. A very few shreds of muscovite are present, but small grains of magnetite are rather abundant.

Between the 4-mile and 6-mile posts, the biotite granite gneiss prevails, although Keewatin rocks are frequently to be seen north of 4 miles 40 chains. As a rule the exposures of biotite granite gneiss have a strike of N. 70° E. and a dip of 70° S.

Between the 6-mile and 10-mile posts, no rocks were visible. The area is one of rolling country with a relatively small proportion of swamp. The trees are jackpine, spruce, birch, poplar, and balsam, not exceeding twelve inches in diameter, with the exception of a few large spruce, about thirty inches in diameter, near the 10-mile post.

Between the 10-mile post and where the line meets Phillips' line of 1920, rock exposures are as a rule small, and few in number. They are all of diabase. Some of the diabase is quite coarsely crystallized, but most of it is of medium texture, and it generally contains grains of magnetite rather abundantly. In places it is of the olivine variety.

A thin section from the diabase at 12 miles 10 chains, shows large crystals of plagioclase and a few crystals of microcline. The feldspar exhibited only a slight degree of kaolinization. Augite is present as large, irregular crystals, and there was a distinct micrographic intergrowth of feldspar and quartz. Magnetite and hematite are rather abundant, the former as large, irregular grains. A few small crystals of apatite were observed.

The diabase found at 13 miles 60 chains, shows in thin section plagioclase and augite as very large crystals. The feldspar has undergone only slight kaolinization. Magnetite in the form of very large grains is abundant. The minerals in the section are greatly discoloured by alteration products of the magnetite.

A thin section from the diabase at 14 miles 17 chains, shows good, idiomorphic crystals of plagioclase, and much augite of a grey-green colour, with twin crystals of the latter. Large grains of magnetite are numerous, and the section is streaked by alteration products of the magnetite. One part of the section showed a micrographic intergrowth of quartz and feldspar. A little quartz was observed in other parts of the section, and many needle-like crystals of well-preserved apatite.

The diabase described, which shows a micrographic intergrowth of quartz and feldspar, may be named quartz diabase. The quartz is evidently original, in part at least, as is shown by its intergrowth with the feldspar. The rock from which these sections were made is so coarse as to approach in appearance a gabbro.

Having completed the survey of the allotted mileage by the afternoon of September 19th, we made preparations for our return journey to Port Arthur. We proceeded via a well-marked and well-cleared portage 80 chains in length, to the place where Phillips' line of 1920 crossed the river flowing into Kabitotikwia lake. This was our place of embarkation, and is twenty chains south of where we completed the survey. The water in the river was very low, and in numerous places the canoes had to be lightened of the weight of all occupants in order to float down stream. There are no less than twelve portages between our starting point and Kabitotikwia lake. These portages vary from two to twenty chains in length, with a combined length of 105 chains. Having crossed Kabitotikwia lake we proceeded down the river of the same name. En route we crossed four portages, having a combined length of twenty-seven chains, before we arrived at the one leading from a large bend in the river to Chiefs bay. This last-mentioned portage is 140 chains in length.

Crossing Chiefs bay and Black Sturgeon bay in our frail craft, a portage of forty-nine chains in length led us south from Black Sturgeon bay to a small lake. Another portage, twenty-four chains in length, took us from this lake to Black Sturgeon lake. Leaving the southern end of Black Sturgeon lake, we proceeded southeast down the river flowing into Nonwatin lake. Shortly after leaving Black Sturgeon lake we crossed a portage, one chain in length, to avoid a rapids at the head of a small lake formed by the widening of the river. A short distance below that point there is another portage, thirteen chains in length, leading to another wide part of the river. Below this the water was very shallow, and the canoes, lightened of the weight of their occupants, were floated most of the distance thence to Nonwatin lake. Before arriving at Nonwatin lake a portage leading from the river to the lake was found. It is seventy-one chains in length, and at about thirty chains from the river the portage crosses McDougall's survey line.

Between Nonwatin lake and Eskwanonwatin lake is a portage, ten chains in length; between Eskwanonwatin lake and the mouth of Sucker creek are three portages, twenty-one chains, thirteen chains, and nine chains in length, respectively. Between Sucker creek and where the C.P.R. crosses the Black Sturgeon river, near Coughlin, are six portages, the lengths of which are thirteen, ten, three, ten, eight, and fifteen chains, respectively.

The return journey to Coughlin occupied five and one-half days, and we travelled from daylight to dusk during each day. If the water had been at high-water instead of low-water level we should probably have saved at least a day. With regard to the portage between Kabitotikwia river and the railroad, it is noteworthy that they are well marked by blazes and fire rangers' signs.

Notes on Rocks of the Area

With regard to the geology of the region traversed by the lines surveyed during the summer, some general observations can be made. West of the second meridian is a great area of comparatively flat land, a large part of which bears a deep covering of drift. Rock, where exposed, consists for the most part of well-foliated biotite-granite gneisses with interbanded belts of hornblende gneisses. The strike of the foliation planes of these gneisses preserves a generally uniform direction of ten to twenty degrees north of east, with, however, numerous local variations. The dip of the gneisses is, almost without exception, at high angles. Exposures of diabase, Keewatin schist, and biotite granite are also found in this area, but not nearly so abundantly as those of the gneiss. The gneisses and granites are quite probably of Laurentian age, although some of the non-gneissoid granite may be Algoman.

Along and east of the second meridian surveyed during the summer, the country is much rougher than that described above. High hills and deep valleys are numerous, and large areas of swamp are not so frequent. The predominating rock exposures are of diabase. The other rocks found in this region are of Keewatin schist, biotite and hornblende gneiss, and hornblende granite.

The Laurentian or possibly Algoman formation is represented in this area by very large hornblende granite and biotite granite batholiths occurring in the vicinity of mile posts 25 and 26. The Laurentian is also represented by gneissoid granites and gneisses in various places in the main area.

The Keewatin rocks are various types of schists and eruptives, formed chiefly from basic materials. Hornblende or chlorite is commonly abundant in the various rock types. Biotite schist was found associated with Keewatin schist in one locality.

The predominating rock in the area is diabase. It is without doubt the youngest rock of any of those mentioned above, and is probably of Keweenawan age. It occurs in the form of huge intrusive sheets and dikes. Evidently the diabase sheets overlie unconformably the rocks representing the earlier formations. Some of these sheets or sills show gradation from a fine-textured portion near the margin to a coarser central part. These central parts approach a gabbro in aspect.

Economic Notes

Considering the region from an economic point of view, it is the opinion of the writer that, while minerals may yet be discovered there in paying quantities, the sections passed over during the summer do not show many indications of such occurrences. The predominance of Laurentian gneiss and of diabase of later age, neither of which appeared promising as an ore-carrier, does not offer much encouragement to the prospector. Also the paucity in number and size of the rock exposures in the region, due to the prevalence of large areas of swamp and drift, militates against its being good prospecting ground.

The areas which the writer would recommend for prospecting for metals are as follows:—

(a) The vicinity of the lake occurring between the 10-mile and 11-mile posts on the first twelve miles surveyed north of the base line.

(b) The granite area in the vicinity of mile posts 25 and 26 on the base line. This area extends a considerable distance north and south of the line, and somewhere in the area a contact of the granite with the Keewatin schist, which occurs farther east, might be found.

(c) The area of Keewatin rock in the vicinity of mile post 31 on the base line.
(d) The area of diabase and Keewatin rock in the vicinity of mile posts 3 and 4 on the last eighteen-mile line. Exposures are large and numerous along the lake and river drainage system north of the line.

Although the region traversed during the summer does not on the whole appear very promising for prospecting purposes, it presents a manifest source of wealth in its immense amount of standing forest suitable for pulpwood. Also the area described above, which contains the large jackpine, spruce, and poplar trees, offers promise of being suitable for agriculture. This area should also in the future prove to be a source of valuable timber. On the whole, however, it may be said that, on account of its distance from a railroad or from Lake Nipigon, it will be many years before the region is utilized for any other purpose than as a trapping-ground.

At present, game such as moose, wolves, beaver, fisher, bear, and deer are rather plentiful, but the presence of an occasional trapper's cabin in the region, shows that toll is being steadily taken of these wild animals. No human inhabitant was seen during the summer by the main survey party, but our freighters reported having met two resident trappers, and occasional winter camps gave evidence of the presence of at least a few other trappers during the winter months.

Acknowledgments

In conclusion, the writer wishes to acknowledge the kindly hospitality shown him by E. P. A. Phillips, which made enjoyable what might otherwise have proved to be an irksome task. The writer also desires to acknowledge his indebtedness to officials of the Department of Mines, Toronto, who gave him advice and suggestions in connection with the preparation of the above report.

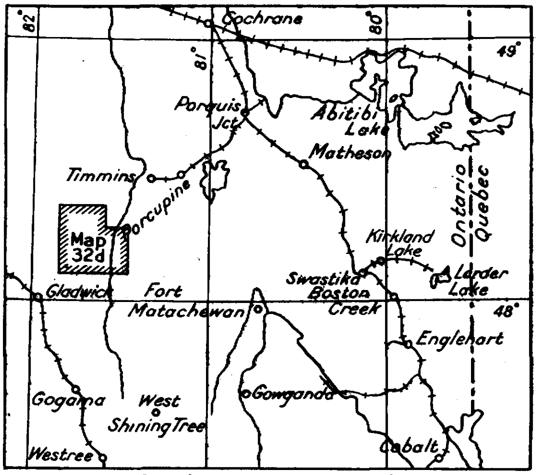
KENOGAMISSI LAKE AREA

Including Townships of Denton and Keefer

By E. W. Todd

Introduction

The Kenogamissi Lake area, comprising the townships of McKeown, Doyle, Reynolds, Childerhose, Hillary, and Pharand, is situated in the District of Timiskaming due southwest of the Porcupine gold area (see Key map). Bordering townships to the west and south lie in the District of Sudbury. Contiguous to the north is the Cripple Creek area.



Scale, 50 Miles = 1 Inch

Key map showing position of Kenogamissi Lake area.

It was considered that the geology of the area might prove interesting because of its position with reference to the Porcupine gold belt. From there, the Timiskaming sediments have been traced by A. G. Burrows[1] into the townships of Thorneloe and Bristol. These lie northeast of the Kenogamissi Lake area. The possibility existed that the rock relationships of the Porcupine area might be continued in a southwesterly direction. Upon examination, however, as will appear from the present report, it turned out that the greater part of the territory is underlain by granite and gneiss. Comparatively small areas only of older rocks were found.

Apart from the plans of the township surveys, little definite information in regard to the character of the territory was available. No reports on the geology have been published.

Work was started in the Kenogamissi Lake area on June 2nd, 1922, and finished about the end of August. The remainder of the season was spent in the townships of Keefer and Denton. These adjoin Hillary and Reynolds to the

[1]Ont. Dept. Mines, Vol. XXI, pt. 1.

north and form part of the Cripple Creek gold area of which a partial survey was made by W. R. Rogers and E. L. Bruce in 1911.[1] They described the geology as seen along the principal water routes. In 1910, A. G. Burrows mapped the rocks exposed on a group of claims in Denton township.[2] Sufficient additional traverses were made in these two townships to determine the probable extent of the several formations. The results of this work are included in this report and the maps which accompany it.

Acknowledgments

The writer is indebted particularly to the officials and men of the Northern Canada Power Company for the handling and care of the supplies used by the party during the season. Several long canoe trips, each involving one and one-half miles of portage, were saved by the party by the kind action of the Company in transporting provisions from Timmins to Wawaitin falls, a distance of eighteen miles.

Able and loyal assistance was rendered during the field season by C. F. Cockshutt, G. A. Murray, W. T. Robson, and A. R. Trayes.

The chemical analyses and assays referred to in this report were made by W. K. McNeill and T. E. Rothwell, of the Provincial Assay Office. Geological maps were prepared by P. A. Jackson. The writer wishes to thank the staff of the Department of Mines for useful suggestions in connection with the preparation of this report and the map which accompanies it.

Access

From the T. & N. O. railway at Timmins, Ontario, the Mattagami river gives access to the eastern townships. The distance by water to the northern limit of McKeown township is about twenty-two miles. The western part of the area is reached by following certain tributaries of the same river. These routes are described later under the heading of Canoe Routes.

Topography

In a general way the country presents the appearance of a great rolling plain, broken at intervals by shallow, narrow valleys. The direction of these valleys is north and south, and they are remarkable for their uniformly straight outline. There are five such valleys crossing the territory and each one forms the course of a stream or series of lakes. The approximate elevation is 1,000 feet above sea level. The maximum relief is about 350 feet.

In the townships of Pharand, Hillary, and Keefer, lakes are very plentiful. One traverse of three miles in Hillary disclosed ten lakes which varied in length from 5 to 60 chains. They lie in glacial deposits, and many of them are typical kettle ponds. In the remaining townships there are few lakes apart from the main waterways. Much swamp exists throughout the whole of the eight townships examined.

Accompanying Map

The map shows a micrometer compass survey of the principal canoe routes; for Keefer and Denton, the map of Rogers and Bruce was used; and in addition a chain of lakes extending south from Star lake is correctly shown. Elevations of

[1]Ont. Dept. Mines, Vol. XXI, pt. 1.
[2]Ont. Dept. Mines, Vol. XX, pt. 2, p. 19.

lakes were determined by level and aneroid barometer, while heights of hills were for the most part estimated. For the Chesterfield[1] chain of lakes, the elevations are based on the T. & N. O. railway figure for Kenogamissi lake. The elevation of Pharand lake is only approximate, as the levels were carried by water from Denton township.

The exploration traverses overland are indicated by heavy dotted lines. The rock outcrops seen along these courses and bordering the waterways are shown in darker colour. The probable extent of the different formations is indicated in lighter tint.

Canoe Routes

Kenogamissi Lake[2]

This lake, an expansion of the Mattagami river, intersects the townships of McKeown and Doyle, dividing them into almost equal parts. Its shore line is remarkably uniform. Although the lake has a maximum width of less than one-third of a mile in Doyle, an unobstructed view of about six miles of water may be obtained. The lower part of the lake, in McKeown township, is bordered by very low spruce flats, and presents a particularly desolate appearance owing to the fringe of drowned timber along the shores. At one place the flooded land extends back a distance of one mile. The average width of the drowned area, however, is about five chains. This condition holds for about three miles. Proceeding southward, the low ground is replaced by ridges of granite which extend unbroken to the southern limits of the area and beyond. Occasional low cliffs show at the water's edge, but for the most part, a narrow belt of dead timber forms the shore line. The bordering ridges range in height from 50 to 100 feet, and form an absolute barrier to the drainage of the country behind. As a result much swamp exists. There are no creeks of greater width than two feet entering the lake for a distance of nine miles from the south boundary of Doyle.

The lake is famous for its fish. Pike and pickerel are very plentiful, the drowned land providing a particularly suitable habitat for this type of fish.

Chesterfield Creek

The Chesterfield creek rises near the south boundary of Doyle township and flows north through McKeown to empty into Kenogamissi lake in Thorneloe township. As a result of the damming of the water at Wawaitin falls, it is flooded back from its mouth for a distance of about three miles. It was formerly used by people travelling up the Grassy river, a portage being made across from Chesterfield creek. Since the raising of the water level, this route had been abandoned. However, at the present time it may be travelled, especially in high-water seasons.

The first portage encountered along the creek is found one-half mile south of the north boundary of McKeown. This portage is well cut out, as it has been used by prospectors travelling to a body of Keewatin rocks situated farther up-stream. Beyond this portage the creek is navigable for about three-fourths of a mile. Then after crossing a very poor portage, Flag lake is entered. This little lake is surrounded by pink biotite granite. On the left bank at the foot of the lake, a small outcrop of Keewatin schist is found. Similar rock is exposed on the portage below. From Flag ~~lake two miles of winding creek, flanked by~~

[1]Formerly called Caribou Back.

[2]W. A. Parks, Ont. Bur. Mines, Vol. IX, pp. 127-128.

low granite ridges, leads to lower Chesterfield lake. A short portage gives access to upper Chesterfield lake which lies in Doyle township. Low cliffs of grey granite gneiss form the west shore of this lake; the other side is fringed with granite boulders.

From upper Chesterfield lake to the source of the chain, the creek is sinuous and is blocked by many beaver dams. The source is a pond about 10 chains in diameter. A rough portage over a low divide of morainic material leads to Trayes lake. This lake is the headwaters of another stream which flows south and east into the Grassy river. The country hereabout is all burned over, and evidences of glaciation are abundant. The portage south from Trayes lake is very rough and hard to follow. It leads to lower Michegama lake, which is the largest lake seen on this route. It extends for two miles or more beyond the south boundary of Doyle township.

From lower Michegama lake there is a route westward to Kenogamissi lake. It is called "Red Pine portage" by Indian trappers, because of the existence of a striking grove of red pine trees which mark the end of the portage at Kenogamissi lake.

Beaver are plentiful along Chesterfield creek. In fact, were it not for the work done by this animal in damming back the water, it would be impossible to travel on the creek connecting the lakes along the route.

Redsucker River[1]

The lower portage into this river from Kenogamissi lake in McKeown township is now used in preference to the one starting from Joe Moore's cabins. The raising of the dam at Wawaitin falls, with the consequent rise in water level, has reduced the length of this portage by forty chains. To enter it presents some difficulties, as about one-half mile of drowned land must be traversed. A narrow channel marked only by a fire-ranger's sign is kept clear of timber. This passage frequently becomes blocked with logs. The portage itself is an excellent one, crossing level sandy land for its entire length, a distance of 90 chains.

Redsucker river possesses many short rapids, twenty-three of which are encountered in passing through the townships of Denton, Reynolds, and Childerhose. They range in length from 2 to 20 chains, and the greatest fall is 6 feet. The majority of them are navigable either way except at times of high water. It is then more feasible to use portages when travelling up stream.

The river is flanked by prominent sand hills which effectually block the drainage of the country. No outcrops of rock are visible along its course until the middle of Childerhose township is reached, where the sand hills give place to ridges of pink granite. Two navigable streams join the river near the southern limit of Childerhose. One of these, entering from the west, is the outlet of Pharand lake[2].

The water in Redsucker river is noticeably colder than that of other streams and lakes in the area. This condition is due to the many small springs which are found seeping out at the base of the sand hills along the banks.

Speckled trout are found in this river. This variety of fish is not known to exist in the other waters of the area.

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[1]Also known as Tatachikapika. The lower part of this river is described by Rogers and Bruce, Ont. Dept. Mines, Vol. XXI, pt. 1, p. 266.

[2]Also known as Great Pike lake.

Pharand Lake

Pharand lake may be entered by canoe from a point on Redsucker river about a mile north of the south boundary of Childerhose township. A stream about twice as large as Cripple creek connects the lake with the river. The lower end of this stream is in level sandy country, and its course is tortuous. Above the first portage Keewatin rocks are well exposed on the right bank for some distance. The stream follows the line of contact between the older rocks and pink porphyritic granite, which is exposed at intervals along the left bank. Many short rapids and falls are encountered. The longest of these makes necessary a portage of 11 chains. In all there are thirteen of them. The portages, however, are in fairly good condition, despite the fact that this route has been travelled only by trappers.

Pharand lake is not shown on most of the existing maps. It is situated in Pharand township and, excepting Kenogamissi, is the largest lake in the area. It is remarkable for its length of shore line. Possessing many deep bays with heavily wooded shores and numerous islands also timbered, it presents a pleasing contrast to the other lakes of the area. Its shores consist chiefly of sandy ridges. Occasional outcrops of slightly gneissic granite are exposed beneath the sand at the water's edge. Near the outlet small outcrops of Keewatin schist occur. From the extreme western end a portage gives access to Allen lake. North of this lake is found the eastern extremity of a belt of Keewatin rocks, which extends westward to the edge of the area and beyond into Kenogaming township.

Otter Lake Chain

To reach the western part of the area, the Cripple creek must be followed to Star lake. This route is described by Rogers and Bruce in their report on the Cripple Creek area. Portages along this creek are kept clear by fire-rangers. There are eight portages in times of low water. The majority of the rapids, however, can be navigated in high-water seasons.

From the southern extremity of Star lake, a trail leads through rough brulé to Ellery lake. South and west of this lake bare granite hills rise to a height of 100 feet or more. The long portage into Warren lake is very poorly marked, and passes over rolling morainic deposits which have been thoroughly cleaned off by fire. Although there is a shorter trail connecting Ellery lake with Raft lake, it is not generally used as a portage because of the high hills which intervene. From Warren lake, Keefer[1] and Raft lakes may be reached easily, although no portages are marked. Recent fires have swept the country in this vicinity free of obstructions, so that a canoe can be packed between these lakes without serious difficulty. Between Warren and Raft lakes Keewatin rocks of both volcanic and sedimentary origin are exposed.

Keefer lake is the most attractive one of the chain. Its southern half has escaped the fire. A number of red pine bluffs stand out on its shores which consist almost entirely of glacial sand and gravel. But one outcrop of rock, consisting of granite, is exposed on its entire shore line.

The Keefer lake chain drains into the Kamiskotia river, not into Star lake as shown on existing maps.

Opishingquaquaya Lake[2]

This lake is most easily reached from Star lake by travelling north into the township of Whitesides, and following a route west from Dana lake to the Kamis-

[1] Also known as Otter lake.
[2] W. A. Parks, Ont. Bur. Mines, Vol. IX, p. 130.

kotia river.[1] Portages along this route are excellent, being for the most part over level sandy ground. In Keefer township the river expands into the lake, the shores of which are made up of low, sandy hills. Occasionally a small outcrop of granite is seen. In Hillary township the rock outcrops become more plentiful. Most of them consist of massive pink and gray syenite. At the head of the lake a narrow band of Keewatin schistose rocks is exposed. To the west at this point, there are prominent hills of ellipsoidal greenstone on which the rock has been bared by forest fires. About midway on the portage above the lake, granite is again found exposed.

Existing maps show a portage from the river, some distance above Opishingquaquaya lake, leading into Robson[2] lake. At the present time this portage does not exist, as forest fires have destroyed the old trail.

Beaver lake is a small body of stagnant water surrounded for the most part by spruce and cedar swamp. There is no rock exposed on this lake.

Forests

The usual types of trees are found. Spruce, balsam, birch, and poplar grow over the greater part of the area. A considerable quantity of large cedar is found in McKeown township between Kenogamissi lake and Chesterfield creek. Much of it is unsound at the butt, however. The finest timber is found along Redsucker river for a distance of about three-fourths of a mile inland. It is banksian or jackpine, ranging up to two feet in diameter. Throughout Pharand township, jackpine is found on the ridges. This township is practically untouched by fire. Hillary, Keefer, and Denton originally contained much red and white pine, but have been burned over recently. Small patches have escaped the fire, one of which is seen west of Keefer lake just south of the line in Hillary township. This stand of red pine covers an area of about one half of a square mile. Other smaller groves are found on this lake.

Geology

The rocks of the area are all pre-Cambrian, and may be grouped as follows:—

KEWEENAWAN(?)	Narrow diabase dikes.
LAURENTIAN[3]	Biotite gneiss, massive biotite granite, hornblende granite, syenite, quartz porphyry, granite porphyry.
KEEWATIN[4]	Slate, tuff, iron formation. Greatly altered basic and acid lavas.

The greater part of the area is underlain by granite. The rocks in the townships of Doyle and Reynolds consist entirely of this type, with the exception of occasional dikes of later diabase. A band of Keewatin schists approximating three and a half miles in length and averaging one mile in width is located in McKeown. This body of rocks appears to be exposed in considerable volume for some distance to the east in Fripp township. Another body of these rocks occupies an area of about six square miles in Pharand and Childerhose. Other smaller bodies are found in Hillary and Pharand. A considerable part of Keefer and Denton is underlain by Keewatin rocks, but apart from the west side of Denton, outcrops are not plentiful.

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[1]See Cripple Creek Area map, Ont. Dept. Mines, Vol. XXI, pt. 1.

[2]Also known as Beaver lake.

[3]Some of the fresh-appearing granite may be of Algoman age.

[4]Some of the sediments may belong to the Timiskaming series.

Geological investigation in the area is handicapped by the prevalence of drift and swamps. Green bush with a very dense undergrowth covers most of Kenogamissi area, and the rocks are usually covered by a thick bed of moss or by a thin layer of sand.

Keewatin

McKeown Township.—At a point on the east side of Kenogamissi lake, 150 chains south of the north boundary, is situated the only exposure of rock belonging to the Keewatin to be found on the lake. This rock consists of a greyish green chlorite schist carrying considerable carbonate. The strike is due east and west, and the dip is vertical. In a vein of quartz, lying between schist and granite porphyry, the following minerals were observed: galena, sphalerite, stibnite, and much pyrite. A sample taken from this vein assayed for gold and silver did not show their presence.

East from the lake at this point occasional low moss-covered outcrops of similar rocks are found. At a point 43 chains east and 12 chains north there is a small knob of diabase cut by granite dikes. An outcrop of rusty carbonate schist, carrying much pyrite and enclosing many narrow quartz veins, is found 117 chains east of the outcrop on the lake. A sample of this material carried no gold.

East from the north end of Flag lake, a prospector's trail leads to the east line of McKeown; about one-half square mile of rock is exposed in this neighbourhood. It consists of dark-coloured schists with occasional bands of a more acid type. These are intruded by two kinds of granite dikes. One variety weathers pink, is much fractured, and carries many stringers of light green epidote. The other weathers white, and shows phenocrysts of quartz. Many small quartz stringers cut both the schists and porphyry. They are as a rule parallel to the strike of the schist. In this locality a number of abandoned mining claims were found. On one of these, at a point 25 chains northwest from the IV-mile post on the line, a trench had been made along a vein enclosed in chlorite schist. At one end of the trench a pit had been sunk about 6 feet. Th vein material consists of quartz and calcite carrying galena, sphalerite, pyr and chalcopyrite. The schist is heavily impregnated with pyrite. The tc width of galena amounts to about 10 inches. A promising looking samr this material was found, on being assayed, to carry no gold or silver.

West of Alice lake, a distance of 15 chains, an outcrop of fine-grair loidal lava is exposed. The surface of this rock is pitted, the am filled with calcite. On the west shore of Alice lake there is a smal of well-banded slaty rocks. They are pre-granite in age, and are found at Wawaitin falls where they have been classedas Timiskami

Childerhose and Pharand.—On Pharand creek in Childerh a ridge of fine-grained altered basalt, showing ellipsoidal stru along the right bank for a distance of one and a half miles. At forms a steep ridge 100 feet in height. Barren quartz in narrow abundant. On the creek, ten chains east of the boundary line, an light-coloured rock is exposed which is probably a much altered rhyolit of this rock is found west of the line.

In proximity to Deacon lake, rocks of the Keewatin group are considerable volume. They are, for the most part, highly metamorpho of basic or intermediate composition. A prominent hill of altered occurs 30 chains west of the middle of Deacon lake. Many dikes of g porphyry cut the older rocks. Some highly schistose porphyritic acid ro occurring in narrow dikes, are also cut by the granite porphyry.

At the foot of Pharand lake the schists are almost cut off by the granite. They appear again to the west on Robin lake in small outcrops showing at the water's edge beneath the overburden of sand. It is probable that this band of rocks connects under the drift with the body found north of Allen lake.

Between the north end of Gordon lake and the west line of Pharand, a somewhat different type of rock is found. It is coarse-grained in appearance and fairly massive. This rock looks much fresher than the other Keewatin rocks in the vicinity. It is, however, older than the granite. In thin section it is found to consist almost wholly of secondary hornblende and is probably altered pyroxenite. It is exposed in considerable volume to the west in Kenogaming township.

Beginning thirty chains south of the IV-mile post on the west line of Pharand township, an outcrop of ellipsoidal rock of intermediate composition is exposed for a distance of ten chains. It contains narrow dikes of fine-grained rock which in thin section shows phenocrysts of quartz in a ground mass consisting chiefly of quartz, orthoclase, and plagioclase. Torsion cracks are filled with pyritous quartz. A sample on being assayed carried no gold.

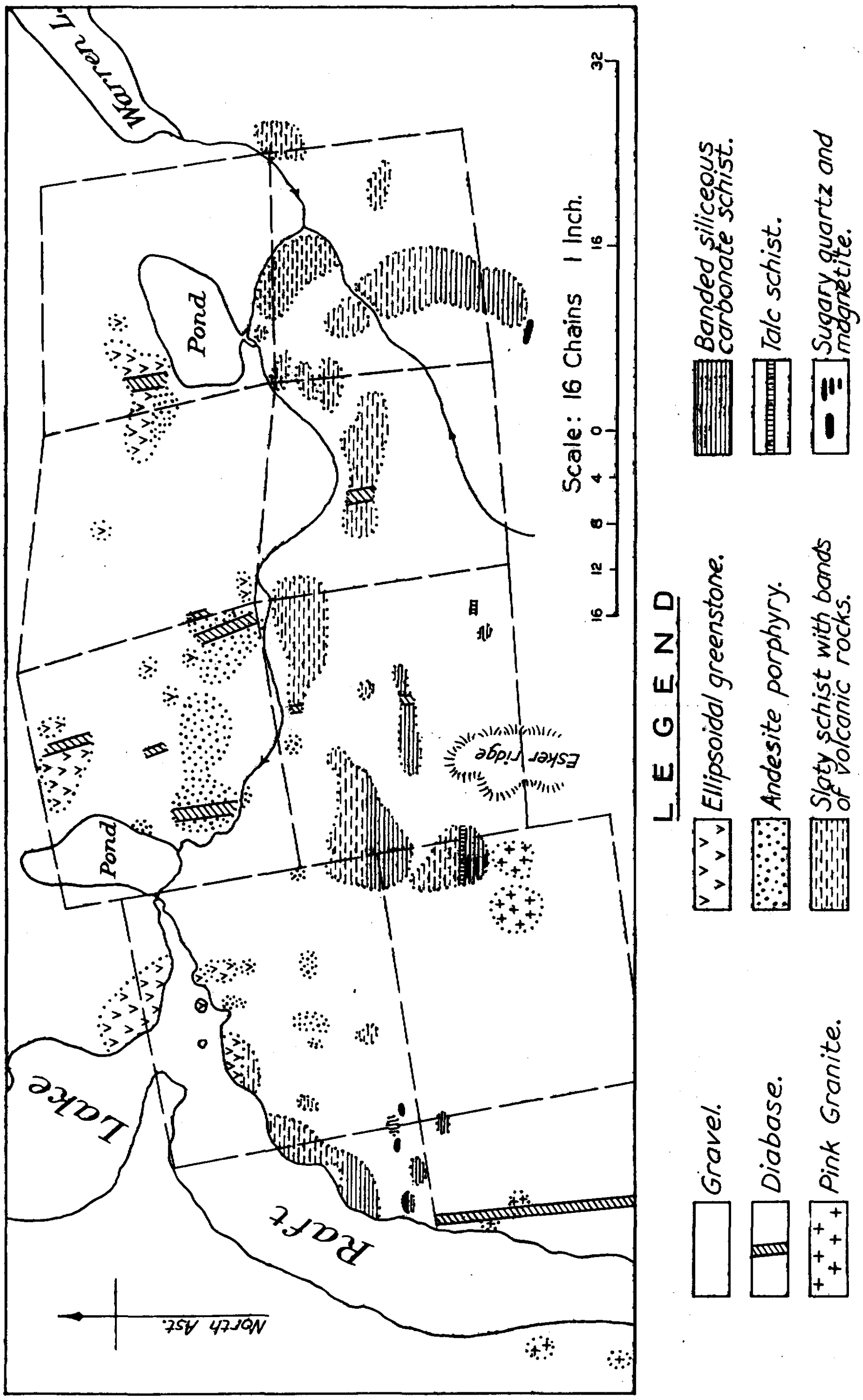
Directly east of the IV-mile post, a distance of twelve chains, there is exposed at the base of a low drift hill, an outcrop of stratified tuff. It is made up of alternate bands of light and dark material, is very fine-grained, and contains occasional squeezed fragments of more resistant rock.

Hillary.—At the foot of Opishingquaquaya lake a narrow band of rusty schists extends into the township for three-fourths of a mile. A number of quartz veins, lenticular in outline, occur, and pyrite is abundant in the schist. A sample taken from one of the largest veins, which had a maximum width of two feet, contained no gold.

Following the discoveries in the vicinity of Porcupine, considerable staking was done in Hillary. The claims have since been abandoned. Many of them are on granite and syenite, in which veins are found frequently in this locality.

Keefer and Denton.—The Keewatin rocks in Denton township are all dark colour, and as a rule are more massive than the smaller bodies found in the townships. Granite dikes are not so plentiful. An outcrop, worthy of mention, is exposed near the north end of the 67-chain portage on Cripple 's of sedimentary origin, showing in thin section the structure of a e. It is similar in appearance to the slate found in the Timiskaming eloe township and may belong to this group. This, however, firmed.

township in the vicinity of Raft lake, a number of claims were the summer of 1922. A plan showing the actual exposure of rock is reproduced on the following page.



Map of small portion of Keefer township showing rock outcrops on Warren, Ellery, and McCoomb claims staked in 1922. Claim lines are approximate.

North from the granite to the creek joining Raft and Warren lakes, there is found a complex group of rocks which in a general way has the appearance of sediments. For a distance of 10 chains from the edge of the granite, the rocks consist of very fine-grained siliceous material highly impregnated with carbonates. The surface presents a decidedly banded appearance, having weathered in remarkably uniform grooves which run parallel to the granite's edge. Near the granite contact there are a number of narrow rusty bands of iron formation. This rock is made up of sugary quartz and magnetite. North of the iron formation a narrow well-defined band of talc schist is found. It is of evident volcanic origin and is now composed largely of talc, quartz, and carbonates.

Ten chains north from the granite, the banded rock passes into a highly schistose phase, which is exceedingly fine-grained and cleaves like slate. It also contains a large amount of calcite. Interbanded with it are a number of bodies of true volcanic derivation.

Lying principally north of the creek, there is a belt of more massive rock, which consists of abundant phenocrysts of white feldspar set in a fine, green ground mass. This rock weathers to a light grey colour. Microscopically, it is composed of kaolinized plagioclase in a glassy ground mass, containing also shreds of biotite, some calcite, chlorite, and magnetite; there also are some minute quartz crystals in stringers. The rock is a somewhat altered andesite porphyry. A sample of this material, on analysis by W. K. McNeill and T. E. Rothwell, Provincial Assay Office, gave the following results:—

Silica	56.88 per cent	Magnesia	3.40 per cent
Alumina	17.09 " "	Soda	4.04 " "
Ferrous oxide	4.97 " "	Potash	0.67 " "
Ferric oxide	2.38 " "	Carbon dioxide	0.98 " "
Lime	7.26 " "	Water (combined)	2.51 " "

Along its southern edge this rock is felsitic, and in places passes into banded chert. North of the andesite body, rocks of more basic appearance are exposed which show ellipsoidal structure. They are somewhat more massive than the other rocks described.

An occasional narrow dike of granite porphyry cuts the schists, and diabase dikes cut all the rocks in a complex manner.

The Keewatin rocks are rich in quartz, which occurs mostly in veins filling torsion cracks. Considerable pyrite shows in the veins and in the schist surrounding them.

It appears that in this locality volcanic ash material was being sorted and laid down under water while at the same time volcanoes were intermittently depositing lava flows. The whole complex is now tilted on edge.

On Sly lake, two small outcrops of massive felsitic rock are exposed. In thin section it is similar to the andesite at Raft lake, but the phenocrysts are not apparent in a hand specimen. The same rock was found again one mile west of Sly lake.

Laurentian

Granite.—In the eastern part of Doyle township a gneissic granite is exposed in considerable volume, being much in evidence on the Michegama lakes. The strike is about north and south. The gneissic structure is well developed, and in places the rock is much contorted. It is intruded by occasional dikes of fresh pink granite which may be of Algoman age.

The gneissic type of rock is confined to this part of the area. The granites and syenites in other parts are comparatively fresh in appearance and for the

Fissure vein in basic Keewatin rock, cut off by diabase dike, east of Raft lake, Keefer township.

Pink granite dikes cutting grey biotite gneiss, Doyle township, west shore Upper Michegama lake.

most part quite massive. The biotite variety is most common. A notable exception in this regard is found on Lost Dog creek in Hillary township. The granite here consists of large crystals of quartz and orthoclase with an abundance of hornblende. The rock has a rusty, decomposed appearance due to the alteration of the hornblende.

Along Pharand creek, the granite is unusual because of the high colour of the feldspar. The orthoclase is bright red, giving the rock a striking appearance.

All the granites are cut by dikes of Keweenawan(?) diabase.

Syenite.—Occasional small bosses of massive syenite occur in all the townships. A considerable mass of pink quartz syenite is found in Hillary township along the west shore of Opishingquaquaya lake. It is made up almost entirely of pink feldspar crystals reaching one inch in length. It would make a fine ornamental stone.

Granite Porphyry.—The Keewatin rocks are everywhere intruded by acid offshoots from the granite which vary in colour from red to grey. The width ranges from less than one inch to 20 feet. In places they cut across the schistosity of the older rocks, but as a rule are parallel to it.

Keweenawan(?).—Vertical dikes of diabase cut all the other rocks in the area. They are remarkably consistent in strike, which is north and south in direction. In places they occur quite close together, as in the vicinity of Raft lake. The dikes vary in width from one foot to three chains. The rock is usually fine to medium grained, but subordinate amounts of very coarse types occur. On Kenogamissi lake there are two such dikes showing, in which the plagioclase crystals reach a length of 1½ inches. This type of diabase is more subject to the influence of weathering, and generally has a rusty, decomposed appearance.

Pleistocene and Recent

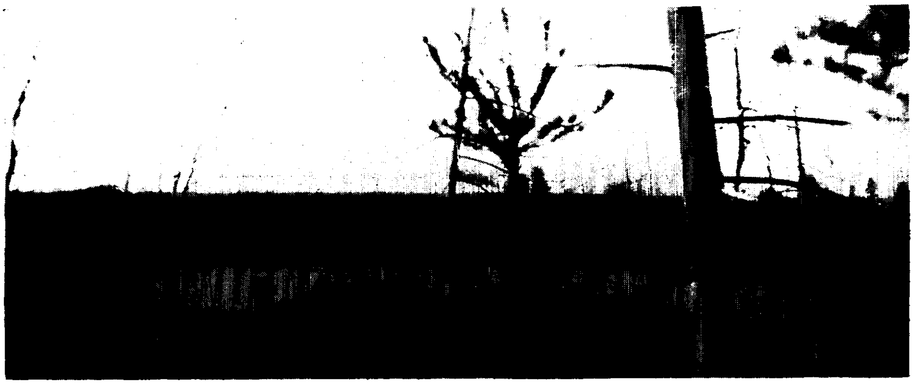
Sand, gravel, and swamp cover most of the eight townships. The lack of development of the drainage has resulted in the formation of much swamp back from the waterways. In places the mantle of moss is underlain by peat beds, but in general deposits of sand and boulders lie close to the surface.

Some splendid examples of morainic deposits are found in Reynolds, Hillary, and Keefer townships. A prominent esker ridge, consisting of coarse sand and gravel, extends along the western side of Keefer lake. This ridge, broken by the lake, may be followed south in Hillary for three miles. Another such deposit is found east of Redsucker river near the north boundary of Reynolds. This latter ridge reaches a height of sixty feet in places. It has very steep sides, and measures about fifteen feet across the top.

The central part of Hillary township, which is not coloured on the map, is covered with extensive kame deposits. Kettle ponds and dry kettle holes are plentiful.

A part of Pharand township, lying north of Pharand lake, is covered with a deposit of water-washed sand, probably an old lake deposit. Similar material is found in many other parts of the area.

The origin of the deposits of stoneless sand, which form the hills along Redsucker river, is connected evidently with the river itself. They may be regarded as having been formed in early post-glacial times by the repeated flooding of the river banks during high-water seasons. The finer parts of the deposit left filling the old rock valley by the glacier were picked up by the swiftly-flowing water of the river and were, in part, deposited on its banks when the water subsided. This process, repeated many times, resulted in the formation of sand ridges parallel to the river. The finest materials were laid down in outwash plains extending back some distance from the river. Heavier parts of the glacial deposit, consisting of boulders, now form the bed of the stream. The constant erosion of the river bottom to lower levels results in the sand hills appearing much higher on the side next the river. Their present broken appearance is due to the work of ordinary erosion agents, which has proceeded ever since the river ceased to overflow its banks.



Many kettle ponds, such as that shown above, are found in Hillary township in morainic deposits. About 20 square miles of the township is burnt over and has the appearance of the background in this illustration.

Economic Possibilities

Gold is known to exist on the Gordon and Carlton claims in Denton township. It has been found in veins in both the Keewatin and granite rocks. It is said that native gold has been seen in the vicinity of Raft lake in Keefer township. Reports state that gold occurs also in Whitesides, Carscallen, Bristol, Thorneloe, and Fripp townships, all of which lie close to this area.

Although none of the samples taken from the surface during the geological investigation of the area carried values, it still appears that the bodies of Keewatin rocks shown on the map are worthy of some prospecting. Quartz, occurring in two kinds of veins, is abundant in these rocks. In one case it fills fissures showing in well-defined veins. Examples of this occurrence are seen on Raft lake in Keefer township. The other type of vein occupies torsion cracks. These veins are usually limited to a few feet in length and a few inches in width. In places they occur in numbers close together. Such a condition exists south of the IV-mile post near the west line of Pharand township. This form of quartz vein is common in Pharand and McKeown. Throughout the area, both types of veins carry sulphides. In McKeown township galena, sphalerite, pyrite, and chalcopyrite are found. In other townships pyrite appears to be the principal sulphide.

From an agricultural standpoint the territory offers no attractions. The soil is unsuitable for crop-raising.

Considerable good timber is found in the Kenogamissi area in all the townships excepting Hillary, over the greater part of which the forests have been destroyed by recent fires. A large part of Denton and Keefer townships also has been burned over.

INDEX, PART III

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. CHAS. MCCREA, *Minister.* THOS. W. GIBSON, *Deputy Minister.*

THIRTY-SECOND ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXII, PART IV, 1923

Kirkland Lake Gold Area

By A. G. BURROWS AND PERCY E. HOPKINS

(Revised Edition)

Lebel and Gauthier Townships

By PERCY E. HOPKINS

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

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Kirkland Lake Gold Area

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GEOLOGICALLY COLOURED MAP

(In pocket at back of report)

PREFACE [1]

The following report on the Kirkland Lake gold area will be found to be one of the most interesting and important descriptions of a Canadian mining area that have been published for some years, at least. The authors, A. G. Burrows and P. E. Hopkins, of the geological staff of the Ontario Department of Mines, have had wide experience in the pre-Cambrian gold and silver areas of the province.

The Kirkland Lake area can be classed as Ontario's fourth most important metal-producing area, being preceded, in order of seniority, by Sudbury, Cobalt, and Porcupine. The development of the area was retarded during the period of the Great War, systematic work having been begun only about a year previous to the outbreak of the conflict.

Exploration in the Kirkland Lake area has shown that there are three principal zones of mineralization or, to use a more definite term, of metallization. The main or central zone extends in a northeast-southwest direction along the southern expansion of Kirkland lake for a distance of over two and a quarter miles; the southern zone is distant about three-quarters of a mile from the main zone, and the northern about two miles. The gold production up to the present has come from the central zone.

According to the authors, the central zone shows a major fracturing along which are situated the principal mines. This fracturing crosses all the rocks in the zone, including feldspar porphyry, syenite, lamprophyre, and conglomerate. In addition to the major fracture, there are branch or minor fractures now represented by branch veins or lodes.

The fracture zone, where examined, usually contains several fault planes which often form the boundaries of ore bodies. The fault planes along which the ore deposits have been formed dip to the south, generally at angles of 80° to 85°. At several mines development has been carried on with regard to two prominent fault planes, called footwall and hanging-wall planes. These planes are from a few feet to 40 feet or more apart, ore occurring sometimes over the whole width or, as is more common, near one wall or the other, depending on subsidiary slip or fault planes. Ore has also been found beyond the recognizable fault planes or so-called vein boundaries. Mineral-bearing solutions with accompanying vapours have filled fissures and more or less replaced the rock in the fracture zone. The quantity of vein quartz in the ore deposits is relatively small as compared with the mineralized porphyry or other rocks that make up the ore bodies.

The minerals in the ore bodies, other than the primary constituents of the rocks, are quartz of two or more ages, calcite, ankerite, sericite, chlorite, iron pyrites, copper pyrites, small quantities of galena and zinc blende, molybdenite, graphite, and barite. The ore minerals are native gold with the tellurides, calaverite, petzite, and hessite. Other tellurides are altaite, coloradoite, and tetradymite.

The authors say that the gold deposits at Kirkland lake in their mineral constituents resemble those of the Sierra Nevada, California, and that it is probable that they were not formed at as high temperatures as those of Porcupine, Ont. Granite, syenite, and porphyry in the Kirkland Lake area are believed to represent different facies of one magma. While the gold-bearing deposits were formed subsequent to the intrusion of the porphyry, they are believed to be genetically connected with this rock.—W.G.M.

[1] This preface by the late Provincial Geologist, Dr. W. G. Miller, was prepared for the second report issued in 1920.

KIRKLAND LAKE GOLD AREA

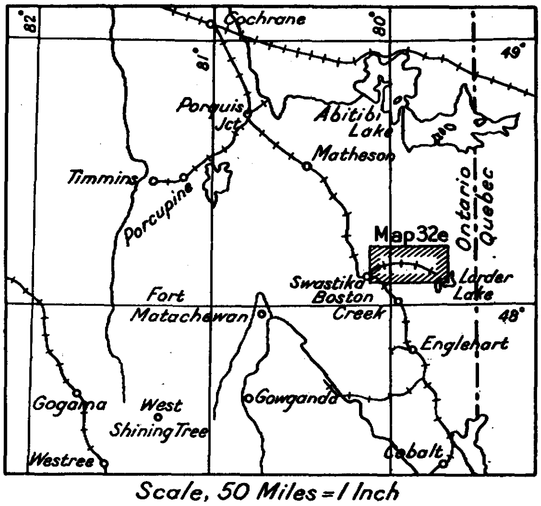
By
A. G. Burrows and P. E. Hopkins

(Revised Edition)

INTRODUCTION

The first report on the Kirkland Lake gold area was published as Part II of the Twenty-Third Report of the Ontario Bureau of Mines, 1914. The area covered by that report and the accompanying map embraced the townships of Teck, Lebel, Gauthier, Otto, Boston, and McElroy, an area of about 210 square miles, and dealt principally with the Tough-Oakes mine, the chief property at that time.

Owing to the important developments that have since taken place, a detailed examination was made of the geology and ore deposits in the vicinity of Kirkland



Key plan showing position of the Kirkland-Larder gold area, map No. 32e, district of Timiskaming.

lake during a part of the summer of 1919. The report was accompanied by a geologically coloured map, No. 29g, scale 600 feet to the inch, embracing twelve square miles in the vicinity of the productive area, and by map No. 29h (insert) showing the geology and veins of the central ore zone.

The geology shown on map No. 29g, now out of print, has been reproduced on a smaller scale on map No. 32e of the Kirkland-Larder area which accompanies the present revised report.

The topographical mapping, chiefly with plane table and telescopic alidade, was done by W. R. Rogers and P. A. Jackson, assisted by G. A. L. Gibson, E. Howell, J. Kirkconnell, and Geo. Tyrrell. Contours at vertical intervals of ten feet are shown on those parts of the map-area which were then cleared of trees. Sea-level datum was adopted, using bench marks of the Temiskaming and Northern Ontario railway.

Areal and economic geological work was done during a part of 1919 by the writers, ably assisted by A. W. Carlyle and K. B. Heisey. The chief difficulties in mapping consisted in outlining the extremely small outcrops caused by the frequent changes in rock types. As some of the mines were filled with water at the time of their visit in 1919, the writers returned in the spring of 1920 and continued the underground examination. Two weeks were spent in the field in October, 1924. It is hoped that the maps and report will be of assistance in further development of the area.

The writers are indebted to the mining men of the camp for their assistance and hospitality.

Assays and analyses were made by W. K. McNeill and T. E. Rothwell, Provincial Assay Office.

Location

Kirkland lake, latitude 48° 9′ north and longitude 80° 3′ west, through which pass the ore bodies to be described in this report, is situated in Teck township, Larder Lake mining division, district of Timiskaming. Kirkland lake lies four miles northeast of Swastika, a village on the Temiskaming and Northern Ontario railway, sixty-three miles north of Cobalt and 392 miles north of Toronto by rail. An excellent macadam road has been constructed from Swastika to the various mines. The camp has local and long distance telephone connection, and there is a good stage service between Kirkland Lake and Swastika. A branch line of the T. & N. O. Railway from Swastika to Larder Lake, passing near several mines and prospects in the Kirkland Lake area, was opened November 10, 1924.

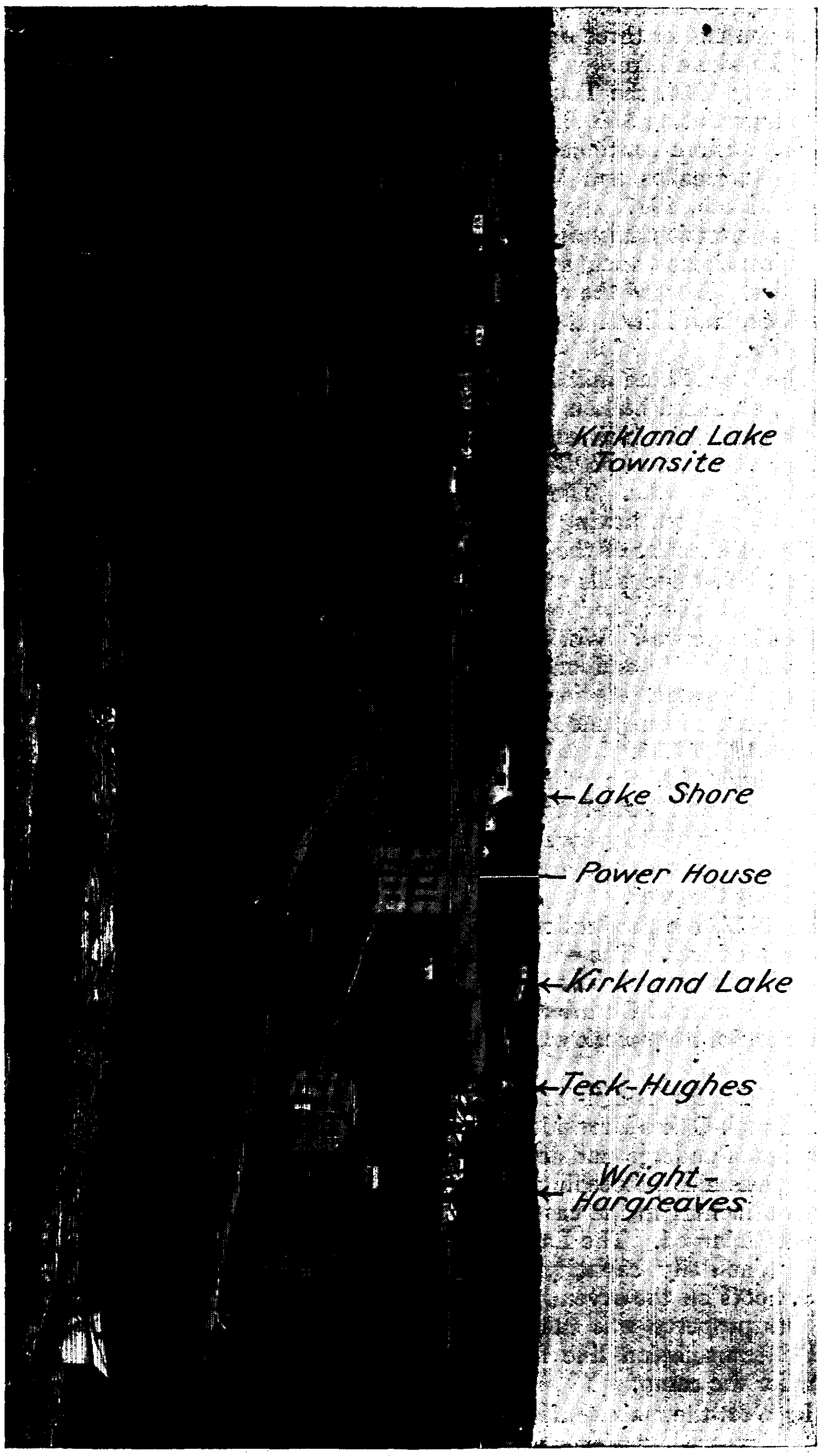
History

At the time of the gold rush into Larder Lake in 1906 and during the boom days of Cobalt, many claims were staked for gold around Swastika and northeasterly to the lake now known as Kirkland lake.

Some assessment work was done on many of the claims, but most of them were allowed to revert to the Crown. The Swastika property continued to be worked and by 1911 had produced some gold. In the same year gold was discovered in several veins on adjoining claims, which were developed by the Lucky Cross Mining Company. The encouragement received by these two mining companies, together with the success being obtained at Porcupine, led to renewed interest in the older area. The first gold discovery in the vicinity of Kirkland lake was made in the autumn of 1911 by W. H. Wright on claim No. T.C. 709 (L. 1,830), now a portion of the Wright-Hargreaves mine. The gold occurred in quartz veinlets traversing reddish feldspar porphyry. By the end of the year most of the ground had been restaked. In January, 1912, gold-bearing veins were found in the porphyry and conglomerate on the Tough-Oakes claims, three-quarters of a mile northeast of Kirkland lake. Little interest was taken in the area during that year. However, the development of the No. 2 vein of the Tough-Oakes and shipments of high-grade gold ore from that property created great interest during 1913. Much surface trenching was done, which resulted in the finding of a number of promising veins on the following properties: Burnside, Robbins (Sylvanite), Wright-Hargreaves, Oakes (Lake Shore), Teck-Hughes, Wettlaufer (Orr), Wood-McKane (Kirkland Lake), and Hunton.

By midsummer, 1914, hydro-electric power from Charlton was available for the Tough-Oakes. Underground work was carried on at the Oakes (Lake Shore) and Teck-Hughes.

In 1915, the Tough-Oakes operated a cyanide mill with a capacity of 125 tons per day. The Oakes, now incorporated as the Lake Shore, continued to



View looking west from a hill on the road from Tough-Oakes Burnside mine to Kirkland Lake.

develop ore in the No. 1 vein. Considerable prospecting was also done during the year on two or three properties at Goodfish lake, two and a half miles northeast of Kirkland lake.

During 1916, the Tough-Oakes worked continuously, employing some 300 men and producing $700,000 in gold. A mill was also built on the Teck-Hughes. The Lake Shore continued to develop ore, and work was commenced on the Wright-Hargreaves and Wood-McKane (Kirkland Lake).

In March, 1917, the Northern Ontario Light and Power Company completed an electric transmission line to the camp from Cobalt, a distance of sixty-five miles; hence, with ample power, active mining was begun on numerous properties. Toward the close of the year mills were in course of erection on the Lake Shore and Kirkland Lake, and at the latter the shaft had reached a depth of 700 feet.

The Lake Shore mill commenced operating in March, 1919, and up to end of 1924, produced bullion valued at $3,796,292. The finding of the main No. 2 deposit under the lake early in 1918 was of great importance, since it led to vigorous exploration on the extension of the main fracture to the east and to the west of the lake. The Tough-Oakes mill closed in the midsummer of 1918, the developed ore having been exhausted. Other properties also closed temporarily on account of the high cost of supplies and labour.

In 1919, three mills were operating, namely: Kirkland Lake, Lake Shore, and Teck-Hughes; and others were being constructed on the Burnside and Wright-Hargreaves. Work was also resumed on the Ontario Kirkland, now Montreal Ontario, and on the Tough-Oakes, the latter having amalgamated with the Burnside. Owing to the miners' strike, which caused all mining operations to cease from June 12 to October 22, 1919, the year's production was low, namely $489,207.30.

During 1920, the mines were running smoothly and the Kirkland Lake, Lake Shore, and Teck-Hughes together produced $1,038,393.

The Wright-Hargreaves new mill was completed and began production in May, 1921. The other three mines continued producing at about the same rate throughout the year.

In 1922, the production was $2,162,548, the Wright-Hargreaves being the leading producer. The mill of the Kirkland Lake Proprietary, formerly the Tough-Oakes, was reopened for a time. The new mill of the Ontario Kirkland, now the Montreal Ontario, also produced a small amount of bullion. Much surface exploratory work was done on the Continental, to the east of the Tough-Oakes.

In 1923, the Tough-Oakes and Burnside mines were consolidated under the name Tough-Oakes Burnside. The mill closed in January to allow an energetic campaign of underground development to be carried out during the year. Shaft-sinking was also proceeding to the 1,000-foot level on the adjoining Sylvanite. The Continental to the east also commenced sinking. The Wright-Hargreaves mill was enlarged. The Lake Shore also commenced enlarging its mill from 60 to 300 tons daily capacity. The Teck-Hughes encountered numerous high-grade shoots on the seventh level which increased its production to $1,137,523. The Orr property was taken over by the Teck-Hughes. The building of a parallel transmission line from Cobalt should assure complete and constant power for the camp.

In 1924, the main shaft of the Kirkland Lake mine was carried to the 1,600-foot level where lateral work will be done; while the Teck-Hughes started a main four-compartment shaft which was down 700 feet by the end of the year. The

Lake Shore mine increased its drilling to 300 tons per day and located high-grade ore on the 800- and 1,000-foot levels. The Wright-Hargreaves encountered No. 1 vein on the 1,000-foot level where long shoots of high-grade ore were opened up. The mill capacity was enlarged to 400 tons per day. The Tough-Oakes Burnside mill was reopened in September.

Kirkland Lake is second in importance among Ontario's gold camps and is rapidly developing. Four mines have workings on the 1,000-foot levels, while the two western properties have lateral workings at 1,100 feet.

Topography

The Kirkland Lake area is situated a few miles south of the divide between the Hudson Bay and River St. Lawrence waters. A contoured topographical map has been made of the cleared portions of the map-area, the contours being shown at vertical intervals of ten feet. Kirkland lake has an elevation of 1,038 feet above sea-level, and no hill apparently rises more than 100 feet above that level. Rock outcrops over most of the area. The small proportion of drift is usually sand, thinly distributed. The mineral deposits are frequently found in the lower parts of the area, since the fractured zones and adjoining altered rocks are more easily eroded than are those that are less fractured and less altered. The porphyry apparently weathers down more easily than the other rocks.

Previous Work

The east boundary line of Teck township was surveyed in 1907 by J. J. Newman, O.L.S. This line passed near Kirkland lake, which was named after Miss W. Kirkland, of the Surveys Branch, Department of Lands and Forests. In 1911, E. L. Bruce,[1] while examining the gold deposits at Swastika, mapped to within one mile of Kirkland lake. During parts of 1913 and 1914, the writers made their first report[2] on the area. Descriptions and articles have from time to time appeared in mining journals and transactions of mining societies. The writers are R. E. Hore, Charles Spearman, J. B. Tyrrell, G. C. Bateman, and others.

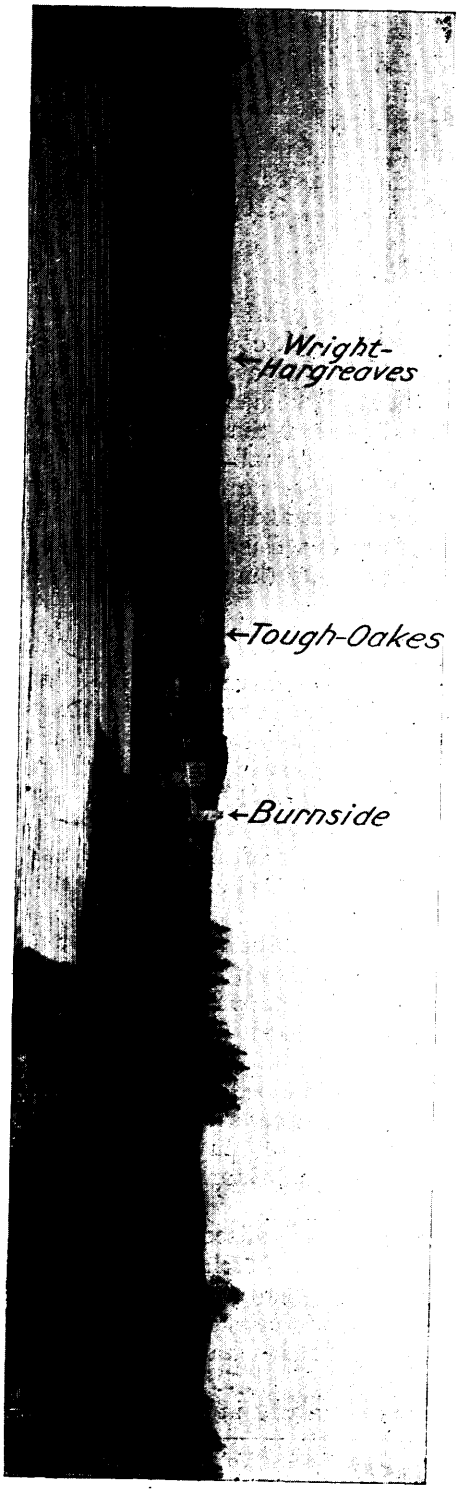
The map, No. 29g, accompanying the second edition of this report, represented only a limited part of the area ordinarily known as the Kirkland Lake gold area, which was geologically mapped in a general way and shown on map No. 23a, 1913, Ontario Bureau of Mines. The present map, No. 32e, is on a larger scale and shows in greater detail the geology in the vicinity of Kirkland lake, where a number of properties have been developed into producing mines. It will serve as a guide for further exploration in a larger area, for similar associations of rock extend for several miles to the southwest in Teck township, also northeast and east of Kirkland lake through Lebel and Gauthier townships, where gold has already been found in a number of veins.

The Kirkland Lake area is part of a large mineralized region that extends roughly from Matachewan in the southwest to Larder lake and beyond into Quebec province to the east. In places the older gold-bearing rocks are covered by deposits of newer formations, conglomerate, greywacké, and slate of the Cobalt series that have not been removed by erosion and consequently cover possible gold deposits.

The character of the gold deposits varies greatly in different parts of the

[1]E. L. Bruce, The Swastika Gold Area, Ont. Bur. Mines, Vol. XXI, 1912, pp. 256-265.
[2]A. G. Burrows and P. E. Hopkins, The Kirkland Lake and Swastika Gold Areas, Ont. Bur. Mines, Vol. XXIII, pt. II, 1912, pp. 1-39.

View showing location of mines at the southwest end of Kirkland lake.



East end of Kirkland lake showing location of mines.

larger area, but all occurrences are believed to be associated with the acid intrusive rocks of a granite, syenite, and porphyry character that frequently outcrop in various parts of the area.

Hydro-Electric Power

In April, 1914, in the early stage of development of the area, the Tough-Oakes mine received a small quantity of power from the Charlton hydro-electric plant, twenty-six miles to the south. The power is transmitted on a three-phase transmission line at 33,000 voltage and stepped down at the mine sub-station to 2,200.

Following upon further development, the Northern Ontario Light and Power Company bought the Charlton plant and extended their transmission line from the sub-station at Cobalt, a distance of sixty-five miles. When the power from Cobalt was turned on in March, 1917, sufficient was available for the whole Kirkland camp.

A large sub-station was built on the Sylvanite property at the terminus of the transmission line. The voltage is stepped down from 44,400 volts to 2,200, and the power lines run from this station to the several mines.

The larger motors are operated on 2,200 volts, and transformer stations are located at the different mines, where the voltage is again stepped down to 550 volts for motors and 110 volts for lighting.[1]

GENERAL GEOLOGY

The compact rocks are pre-Cambrian, classified according to the following table, the oldest being placed at the bottom and the others in the order of their relative ages.

Table of Rocks in Kirkland Lake Gold Area

PLEISTOCENE	
Glacial and Recent	Sand, gravel, and swamp.
PRE-CAMBRIAN	
Keweenawan (?)	Quartz diabase and olivine diabase.
Post-Timiskaming Intrusives (Algoman?)	Red and grey feldspar porphyry with subordinate amounts of hornblende syenite and felsite occurring as dikes and stocks. Red hornblende syenite. Black mica lamprophyre grading into or cut by red hornblende syenite, the latter being felsitic or porphyritic in places.[2] Serpentine. Hornblende and biotite granite and gneiss, syenite, granite porphyry, feldspar porphyry, felsite, pegmatite, and hornblendite.
Timiskamian	Schistose conglomerate greywacké and quartzite containing some carbonate schist. Rusty carbonate.
Keewatin	Pillow lava, altered diabase, green schists, rusty carbonate, and iron formation.

[1]Fuller particulars are given in A. R. Webster's report on "Hydro-Electric Development for Gold and Silver Mines of Northern Ontario," Ont. Dept. Mines, Vol. XXXIII, 1925, pt. 7.

[2]These three groups of rocks are differentiation fácies from the same magma.

Historical Geology

The Keewatin, which is the dominant rock in the region, occupies only a small portion along the north and southeast sides of the map-area. These rocks are chiefly basalt and diabase, volcanic rocks which have flowed out under the sea, with subordinate amounts of iron formation, rusty carbonate, and other rocks. Lying unconformably on these rocks and interfolded with them is a band of Timiskamian sediments which occupies most of the accompanying map-sheet. These fragmental rocks are two miles in width and extend to the southwest and to the northeast for several miles. After the deposition of the sediments, extensive folding and metamorphism took place. Later the sediments were cut by a number of intrusives, namely: granite, syenite, serpentine and related lamprophyre, syenite, and feldspar porphyry. The gold deposits are genetically connected with the porphyry. All the rocks including the ore bodies have been intruded by diabase dikes of Keweenawan or Matachewan age. These pre-Cambrian rocks may have been covered by Paleozoic rocks, but no erosion remnants are to be seen at present. The glaciers which passed over the whole region have scraped away any decomposed rock from the surface and carried it southward, leaving the rocks and mineral deposits exposed as we find them. In places the rocks are still covered by a thin mantle of glacial sand and gravel.

Keewatin

The Keewatin rocks have the widest distribution in the area, but only portions of them occur in the north and southeast parts of the map-area. They consist largely of ellipsoidal, amygdaloidal, and spherulitic lavas with alternating flows and dike-like masses of diabase, together with some rusty carbonate and narrow bands of iron formation. The greenstone type is usually massive and green in colour, but a schistose area occurs in the northeastern part of the map-sheet along the Keewatin-Timiskamian contact. These rocks are so altered that it is difficult to classify them distinctly.

In the fresher samples of fine-grained greenstone, a basaltic texture can be observed showing rods of plagioclase set in a groundmass of pyroxene or hornblende, which is generally altered to chlorite. The chemical composition of typical Keewatin rocks from the northern part of the township is shown below:—

	No. 1	No. 2
	per cent.	per cent.
Silica	48.70	53.90
Alumina	15.21	19.67
Ferrous oxide	8.35	10.21
Ferric oxide	4.28	0.71
Lime	11.11	8.30
Magnesia	3.76	0.72
Soda	3.23	2.78
Potash	0.59	0.58
Carbon dioxide	2.25	0.86
Water	0.65	1.80
Manganous oxide	....	0.32

No. 1.—Ellipsoidal greenstone (basalt) 15 chains west of mile post III, north line of Teck township.

No. 2.—Amygdaloidal greenstone (basalt), Amikougami lake, 15 chains north of mile post III, north line of Teck township. This rock also shows an ellipsoidal structure.

Ellipsoidal greenstone, Amikougami lake, which lies to the northwest of Kirkland lake.

Unconformity between conglomerate of the Timiskaming series and Keewatin diabase, claim L. 1,824, Kirkland lake.

Diabase, occurring as dikes and broad masses, intrudes the fine-grained greenstone at many places. This rock is generally less fresh-looking than the Nipissing diabase of Cobalt, but occasionally it is mistaken for this much younger basic rock. It is often light green in colour and coarse in grain like gabbro, while the original constituents are usually altered to secondary minerals. There is a large volume of this rock around Amikougami lake and throughout the Keewatin areas in the north part of Teck and Lebel.

The rock is pre-Timiskaming in age, since an unconformity was observed on mining claim L. 1,824 on the south shore of the northwest bay of Kirkland lake. Fragments of the diabase were found as pebbles in the Timiskaming conglomerate that rests on the diabase.

Numerous narrow rusty carbonate bands occur throughout various parts of the Keewatin.

A pronounced band of ferruginous carbonate cut by numerous quartz stringers extends for a few miles in length across the southern part of the area. These rocks may be equivalent to the Grenville series, but they are closely associated with the Timiskaming series and are so classed.

A few narrow iron formation bands consisting of black slate, chert, and magnetite occur with the Keewatin in the southeast part of the area.

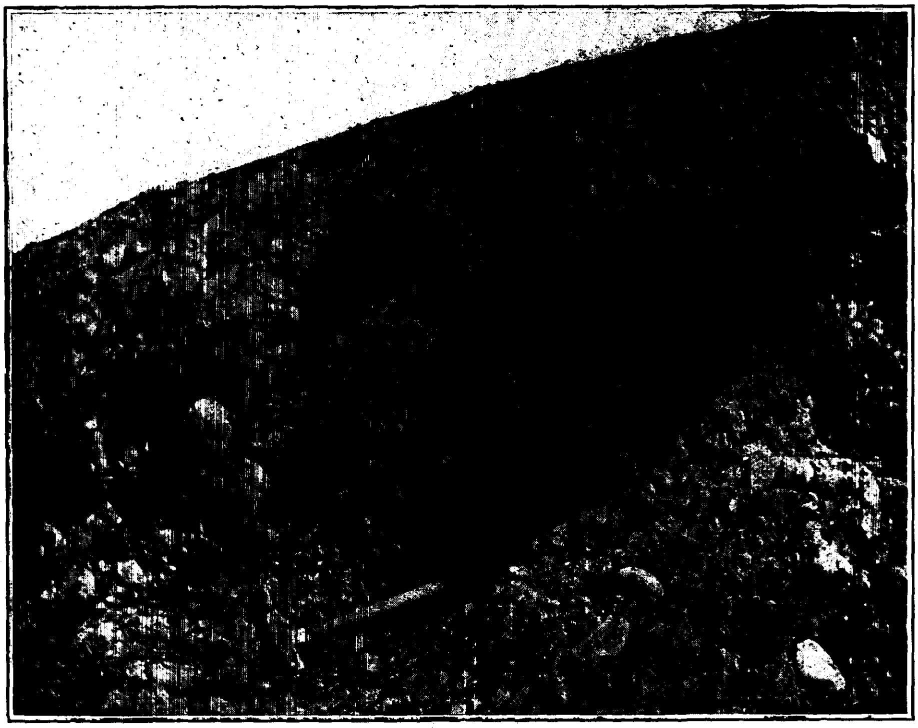
Timiskaming Series

In the central part of the area, there is a broad syncline of sedimentary rocks extending in a general northeast and southwest direction with an average width of about two miles. These rocks are bounded on the north side by highly altered Keewatin greenstone and related rocks and on the south side by intrusive rocks, syenite, granite, etc., in the area shown on the accompanying map. Farther southwest the boundary rocks along the south side are Keewatin lavas, as seen near Swastika. In this series of rocks, there are recognized various bands of conglomerate, slate, greywacké, and quartzite, all in a highly inclined attitude, usually dipping to the south. These have been greatly altered to schist with a cleavable structure developed across the bedding planes of the sediment. Some of the bedding and schist strikes and dips are marked on the map. The marginal bands of sedimentary material are more highly altered than those nearer the centre of the series.

To the north of the northeast bay of Kirkland lake, on claim L. 2,322, to the west of the wagon road, the northerly edge of the sedimentary rocks can be observed. Here both the greenstone (pillow lava) and the fine-grained sedimentary rock are extremely schistose, and the contact is obscure. There are some included fragments in the fine-grained material near the contact. A few feet farther south are bands of extremely fine-grained glossy schists of varied colour, yellowish to blackish, while a few hundred feet farther south along the road there is a striking conglomerate carrying numerous rounded fragments of older rocks and numbers of conspicuous jasper pebbles from an old jasper iron formation. The contact previously described dips steeply to the south, but the evidence here is not sufficient to indicate an erosional unconformity. On mining claim L. 1,824 (H.S. 1,199) on the south shore of the northwest bay of Kirkland lake, there are fragments of diabase included in a conglomerate that lies on an old diabase of the Keewatin; and in an isolated outcrop of conglomerate on claim L. 2,796, in the northwest part of Lebel township, fragments of basalt are numerous. The basalt is the principal Keewatin rock on which the conglomerate was deposited. No contacts with the Keewatin have been observed along the south boundary of the sedimentary series. In the first report on "The Kirkland

Lake and Swastika Gold Areas," it was suggested that the sedimentary series may occur as a syncline in the Keewatin, in which the rocks were folded into their present highly inclined attitude, the edges of the strata now being exposed at the surface. Owing to the numerous intrusions of porphyry, syenite, and lamprophyre throughout the sediments, it would be difficult to work out a sequence of the bands of conglomerate and other rocks in cross-section.

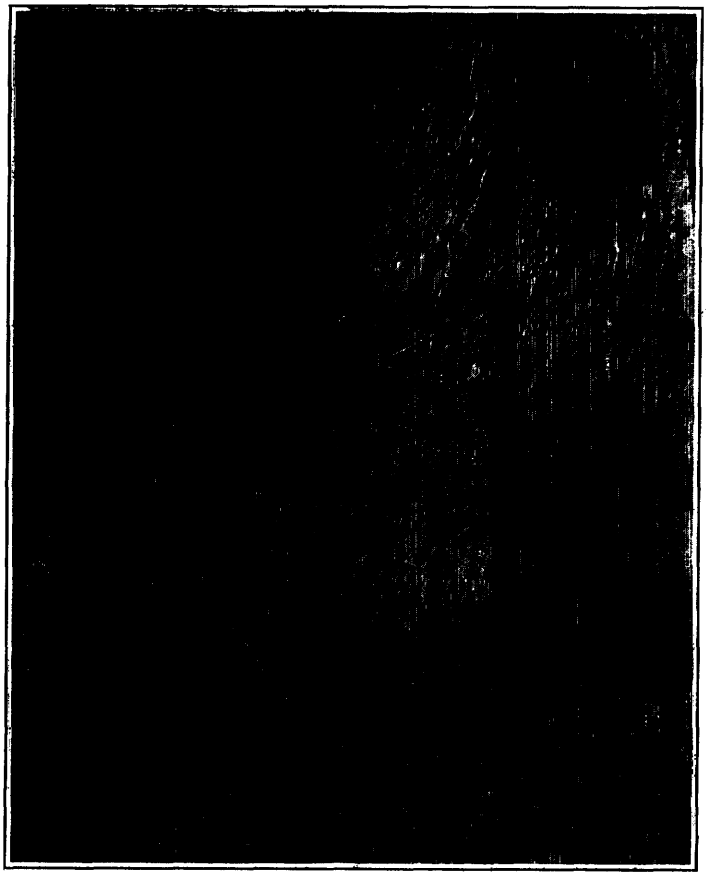
These rocks appear to have suffered more alteration than the Keewatin greenstone, but owing to the more open structure of the sedimentary rocks and the chance for replacement with carbonate, the alteration could easily be greater in the younger rock.



Conglomerate of the Timiskaming series, half a mile north of Gull lake, Lebel township.

The sediments are mainly conglomerate in which pebbles of various kinds are generally numerous, while in section the conglomerate alternates with narrow bands of greywacké and other fine-grained sediments. As previously stated, the marginal sediments have been entirely altered, and much of this rock is simply fine-grained glossy schists. Some of the conglomerate bands have been compressed into schists as shown to the northeast of O'Connell lake. At other places where the pebbles are of hard porphyry, chert, and other material, the matrix has been rendered schistose and the pebbles are readily separated from it. A conglomerate of this character occurs to the north of Gull lake on L. 2,452.

There is a great variety of pebbles in the conglomerate, including various greenstones, diabase, porphyries, felsite, an occasional granite, and numerous fragments of iron formation. Some of the fragments of iron formation are of a bright red jasper, which gives the rock a very striking appearance. There are also pebbles of quartz with pyrite from a series of veins older than the Kirkland Lake gold-bearing veins. One of these mineralized quartz pebbles was assayed and found to contain no gold. A microscopical examination was made of greywacké from the vicinity of the Tough-Oakes mine, south of No. 3 vein, near the Teck-Lebel line. The greywacké is composed of angular fragments of quartz, orthoclase, plagioclase, chlorite, and other minerals, with considerable carbonate scattered through it. The rock is quite readily recognized as of sedimentary origin. The impregnation of the rocks by much carbonate or sericite aids in distinguishing them from greywacké of the Cobalt series.



Conglomerate of the Timiskaming series, which has been rendered highly schistose, north of O'Connell lake, Lebel township.

Like the Keewatin, the Timiskaming series has been impregnated with carbonate solutions. A rock which has been altered to ferruginous carbonate outcrops about nine chains north of O'Connell lake. Because of the high percentage of carbonate in these rocks, they are generally rusty-weathering, owing to the oxidation of the iron in the carbonate to ferric oxide. Generally, the sediments in fresh specimens are grey, but where the material has been exposed for a few years on dumps, it becomes oxidized and rusty in appearance.

In the southerly part of the sediments, there is a band of carbonate rock traceable at intervals for several miles, which has been differentiated on the map.

It is not definitely known whether the rock belongs to the Keewatin or Timiskaming. The rock is cut by numerous irregular veinlets of white quartz and resembles the carbonate or ankerite bands frequently observed in the Porcupine and Larder Lake areas. Some of the material mineralized with iron pyrites and copper pyrites was found to yield traces and up to $2 of gold to the ton.

Post-Timiskaming Intrusives (Algoman?)

There are several igneous rocks, namely: granite, syenite, hornblendite, feldspar porphyry, and serpentine, which are found in the southerly part of the accompanying detailed map-sheet but whose relationship to the Timiskaming series is not definitely known, since they were not observed in contact with the sedimentary rocks. Since most of them are fresh and massive and the sediments are greatly altered, it is considered that the igneous rocks are the younger. Some of the felsitic and porphyritic rocks on the Highland Kirkland (T. 16,554 and 16,555), on claim L. 2,034 south of Gull lake, on the Queen Lebel property and elsewhere resemble the trachyte at Larder lake which was stated by H. C. Cooke to belong to the Timiskaming period.

A number of intrusives, including lamprophyre, syenite, and feldspar porphyry, also occur throughout the conglomerate and associated rocks of the Timiskaming series, and their relationship is therefore clearly recognized. These intrusives occur in the central part of the area, either as broad stock-like masses or narrow dikes in the sedimentary rocks. The surface outcrops usually have their longer axes in a northeast-southwest direction.

It is quite likely that all these igneous rocks belong to the same era, being different facies of a plutonic rock which underlies the whole area. The syenite and granite are exposed by deep erosion.

Granite, Serpentine, Etc., South of Kirkland Lake

These rocks consist of aplite, felsite, syenite, feldspar porphyry, granite porphyry, granite and gneiss, pegmatite, hornblendite, lamprophyre, and serpentine, all of which are closely intermingled and grouped together, since they are difficult to separate. These rocks occur in the southern part of the area separating the Keewatin on the south and the Timiskaming on the north. They clearly intrude the Keewatin and apparently cut the rusty carbonate, which may be of Timiskaming or Keewatin age. The acid rocks are pink, grey, or light green in colour, while the basic ones are dark green. The rocks vary in texture from quite fine-grained aplite to coarse-grained hornblendite with crystals two inches across.

Granites.—These are usually of the mica type, although hornblende granites were seen. Occasionally large feldspar phenocrysts are present. The dark-coloured types may be due to the assimilation of some of the adjacent rocks.

Feldspar Porphyry.—A grey feldspar porphyry, to the east of Murdock creek, from claim T. 15,752 has been described by E. L. Bruce as follows:—

The feldspar phenocrysts show distinctly on the surface. Under the microscope the rock is distinctly porphyritic. The phenocrysts are plagioclase feldspar near the albite end, set in a groundmass of quartz, feldspar, and hornblende. Considerable alteration has taken place, producing chlorite, sericite, kaolin, carbonates, and epidote. Magnetite and chalcopyrite are present. The phenocrysts make up a large part of the rock, the areas of groundmass being narrow.

An analysis of this rock gave: silica, 60.71; alumina, 14.87; ferric oxide, 3.26; ferrous oxide, 3.60; magnesia, 3.52; lime, 3.29; potash, 2.52; soda, 4.40; carbon dioxide, 1.68; water, 2.35.

This calculates to a norm consisting of: quartz, 17.34; orthoclase, 11.10; albite, 37.16; anorthite, 1.67; magnetite, 1.20; chlorite, 12.93; kaolin, 4.82; sericite, 3.14; hornblende, 7.70.

This shows the acidic nature of the feldspar. The large quantity of chlorite present explains the rather high percentage of water in the analysis.

Hornblendite.—The large massive hornblendite outcrop near the second mile post on the east boundary of Teck township probably represents a basic segregation from the granite rocks. In places the hornblende crystals are two inches across. Other minerals present are biotite, magnetite, apatite, titanite, and epidote.

Serpentine.—Narrow dikes of serpentine were found cutting the above rocks. Three of these typical fine-grained dikes have been indicated on the map.

Intrusive Rocks near Kirkland Lake

There is a close association of lamprophyre, syenite, and feldspar porphyry in different outcrops in the vicinity of Kirkland lake and extending southwesterly and northeasterly from this locality. This relationship does not appear to be fortuitous, but is evidently the result of a number of intrusions from the same parent magma. In many parts of the area, it is possible to trace a dark-coloured lamprophyric rock into a red syenitic type with intermediate hybrid varieties, suggesting magmatic differentiation. Again, it is possible to see the red syenite distinctly cutting the lamprophyre, either in broad masses or in narrow dikes, only a few inches in width. Both these rocks are intruded by a reddish or greyish rock showing d stinct phenocrysts of feldspar, to which the name feldspar porphyry has been applied. In underground examination it is frequently difficult to distinguish the red feldspar porphyry from the red syenite. From observation in the field it is possible to state that the basic lamprophyre type is the oldest and the feldspar porphyry the youngest of the intrusions, i.e., the rocks have been intruded in the order of decreasing basicity from one general

Lamprophyre dike with narrow dikelets of red syenite, northwest of the Tough-Oakes Burnside mine.

magma. These various types are all well exposed on the northwest part of the Orr claim (L. 16,626), now Teck-Hughes, to the southwest of Kirkland lake. They are of great economic importance, since the gold deposits of Kirkland lake are believed to be genetically connected with these intrusions and to have been formed subsequently to the intrusion of the more acid variety, the feldspar porphyry.

Lamprophyre.—This is normally a black to dark grey rock frequently showing phenocrysts of ferromagnesian mineral, which may be augite, hornblende, or mica; occasionally two of these minerals show in the same specimen. The common lamprophyre is of the "vogesite" type, while "minette" has been recognized at the Lake Shore mine and elsewhere. The rock usually has a rough surface in weathered outcrops, due to unequal weathering of its constituents. Occasionally it has a pitted surface, due to the leaching of the ferromagnesian phenocrysts. Again it is often traversed by numerous dikelets of red syenite, only an inch to a few inches in width. These dikelets resist weathering better than the basic lamprophyre and stand out as ribs, usually in a direction parallel to the long axes of the outcrop. These small dikes have resulted from a filling of cracks by the more acid material of the residual magma.

Analyses of augite lamprophyres are given in the following table:—

	No. 1	No. 2	No. 3	No. 4
	per cent.	per cent.	per cent.	per cent.
Silica	48.50	52.29	47.44	47.20
Alumina	22.43	19.38	....	....
Ferric oxide	2.85	4.40	....	....
Ferrous oxide	4.78	6.00	....	....
Lime	7.62	7.79	....	....
Magnesia	1.16	3.54	....	....
Potash	3.56	4.12	4.34	4.46
Soda	3.38	2.12	3.10	3.17
Carbon dioxide	3.72	....	....	....
Water	2.26	0.95	....	....

No. 1.—Lamprophyre from Day claim, L. 6,526, northeast of Kirkland lake.
No. 2.—Lamprophyre north of Blanche river, Eby township.
No. 3.—Lamprophyre, 500 feet south of Southwest bay, Kirkland lake.
No. 4.—Lamprophyre, north of road, near south shaft, Orr claim.

A specimen of lamprophyre from southeast of A. shaft at the Tough-Oakes mine shows prominent phenocrysts of augite, now altered to fibrous hornblende, secondary feldspar, chlorite, and calcite. The feldspar is principally orthoclase with subordinate plagioclase. Crystals of apatite are abundant and have mostly crystallized with the ferromagnesian mineral. Small grains of magnetite are scattered throughout the rock.

The analyses of the lamprophyric types of rock indicate that the orthoclase feldspar is in excess of the plagioclase even in the basic phases. As the rock becomes lighter in colour with an increase of red feldspar, the proportion of orthoclase also increases, and the rock approaches a red syenite.

The normal dark-coloured lamprophyres, occurring in large volume on the northeast shores of Kirkland lake and easterly, are accompanied by an unusual porphyritic rock to the south of the northeast bay of Kirkland lake. On the surface it contains conspicuous bleached feldspar crystals and is older looking than the normal feldspar porphyry of the Kirkland Lake area. It is intruded by a dike of feldspar porphyry in this locality and is therefore an older rock. The older porphyritic rock is syenite porphyry, containing, under the microscope, phenocrysts of orthoclase with zonal structure and numerous hornblende crystals in a fine-grained feldspathic groundmass containing apatite and magnetite with secondary calcite. Minute blades of sericite are scattered through the rock.

A diabasic rock, apparently a facies of the lamprophyre, occurs on claim No. L. 2,643.

Syenite.—As previously mentioned, there is a red rock associated with the basic lamprophyre either in broad masses or narrow dikes that occurs abundantly in the area southwest of Kirkland lake, especially around the southwest bay of the lake, and in Lebel township, north of Gull lake. The syenite, which is of a bright red colour, consists largely of orthoclase feldspar, with scattered grains of ferromagnesian mineral, altered to chlorite, calcite, and secondary feldspar, with apatite, pyrite, and magnetite as accessory minerals.

An analysis of the red syenitic rock from the shore, south bay, Kirkland lake, shows the following composition:—

	Per cent.
Silica	57.56
Alumina	18.53
Ferrous oxide	1.87
Ferric oxide	5.84
Lime	1.25
Magnesia	0.89
Potash	8.34
Soda	3.58
Carbon dioxide	0.69
Water	1.69

This analysis is very similar to that of a red porphyritic syenite, at the Davidson property in the Matachewan area, that has the following composition:—

	Per cent.
Silica	61.80
Alumina	18.86
Ferrous oxide	0.32
Ferric oxide	2.95
Lime	0.63
Magnesia	0.34
Potash	8.86
Soda	3.19
Carbon dioxide	0.84
Water	0.54
Pyrite	1.45

The red syenite is the most acid syenite seen in the vicinity. It can be traced into an intermediate rock showing less silica and more lime and magnesia with increasing percentages of ferromagnesian minerals. At times it is difficult to state whether particular specimens are syenite or lamprophyre, particularly where they grade into each other as seen on the high ridge just south of the southwest bay of Kirkland lake. In fact, the darker intermediate varieties could be called basic syenite.

In consequence of the close association of the red and black rocks, which in places are differentiation products of the same magma, a separation on the map is extremely difficult. An attempt has been made to separate them in the vicinity of the southwest bay of Kirkland lake. In this locality the veins are partly in the syenite and less basic lamprophyre types, and commercial ore shoots occur in them.

Feldspar Porphyry.—This is the latest intrusive of acid or intermediate composition occurring in the vicinity of Kirkland lake. It is present as narrow dikes, often only a few feet wide, and broad stock-like masses that may be nearly the width of a claim. This rock is usually characterized by the presence of conspicuous phenocrysts of red feldspar, but in portions of it the phenocrysts may be inconspicuous, the rock resembling more the red syenite previously described. It is generally of a bright red or pink colour, but is sometimes grey or greenish.

The porphyry intrusions, like the lamprophyre, have their long axes in a general northeast and southwest direction.

Often a mass of porphyry will include narrow strips of conglomerate and greywacké, resembling the main mass of the sedimentary rocks which occur in great volume in the central part of the area. Such small masses of conglomerate can be observed on the surface at the Wright-Hargreaves mine to the east of the main shaft. Narrow masses of conglomerate are also encountered underground at the Lake Shore mine.

Photomicrograph of reddish feldspar porphyry, from north part of Burnside claim, L. 1,823. (X 19 diameters.)

Photomicrograph of greenish feldspar porphyry from wall of gold-bearing vein on Burnside claim, L. 1,823. (X 19 diameters.)

The feldspar porphyry is often intimately associated with the lamprophyre in narrow bands. Where exposed on a point just north of the shaft at the Lake Shore mine, there are repeated alternations of porphyry and lamprophyre, the bands being only a few feet in width. In a crosscut 200 feet below these outcrops, the rock is all porphyry, showing that the bands of lamprophyre at the outcrop do not extend to great depth.

The relationship of the porphyry to the conglomerate, greywacké, and quartzite is well shown in many outcrops. There are a number of narrow dikes of porphyry intruding the conglomerate in the Kirkland Lake townsite, where outcrops show the porphyry masses cutting across the bedding of the sedimentary rock.

In addition to the feldspar phenocrysts, the rock occasionally shows "eyes" of clear quartz and blades of biotite in hand specimens.

Microscopically, the feldspar crystals often exhibit a beautiful zonal structure. Zones of sericite are frequently recognized in the phenocrysts, probably the result of alteration of some intergrown orthoclase. Multiple twinning is prominent in most of the feldspar crystals, which are therefore of the plagioclase variety, but orthoclase is intergrown with the plagioclase in some of the crystals, the intergrowth being referred to anorthoclase. There are a few scattered crystals of quartz, generally smaller than the feldspar phenocrysts, and laths of biotite, some of which show alteration to chlorite. The groundmass is fine grained, consisting largely of feldspar and quartz. Chemical analyses show plagioclase feldspar to be more prominent than orthoclase, in which respect the porphyry is different from the red syenite.

Analyses of feldspar porphyry gave the following results:—

	No. 1	No. 2
	per cent.	per cent.
Silica	66.30	66.48
Alumina	15.37	15.42
Ferrous oxide	1.47	1.18
Ferric oxide	0.37	1.05
Lime	3.06	3.15
Magnesia	1.16	1.67
Potash	3.86	2.56
Soda	4.78	5.97
Carbon dioxide	3.34	2.65
Water	0.60	0.30

No. 1.—Tough-Oakes near No. 1 vein.
No. 2.—Teck-Hughes near vein east of No. 1 shaft.

Where the red feldspar porphyry is lacking in distinct phenocrysts of feldspar, the difficulty in distinguishing it from the red syenite is increased. Analysis has shown that the syenite has a higher percentage of orthoclase than plagioclase-feldspar, whereas in the feldspar porphyry the preponderance of feldspar is plagioclase. In hand specimens it is often impossible to distinguish the red intrusive rocks, and since both the porphyry and syenite are favourable to ore deposition the distinction is not important.

Later Dikes

Diabase that is later than the post-Timiskaming intrusives is rare in the area. Two dikes occur in the vicinity of Kirkland lake. The easterly dike that can be seen to the southwest bay of Kirkland lake is an olivine diabase and in places is partly altered to serpentine. About one-quarter of a mile west is a dike of quartz diabase that has been encountered in the workings of the Teck-Hughes and Orr properties. It can be traced south and southwesterly to the Canadian Kirkland claims. Since no rocks of the Cobalt series are present in the area, the relation of these dikes to this series is not known. They may, however, be of Matachewan age, similar to other dikes in Gowganda and Matachewan.

Glacial and Recent

Drift areas, outlined on map No. 32e, consist of thin sheets of glacial sand and gravel. A part of the area is overlain by swamp. Where the soil has been recently removed, the glacial grooves and striations are quite distinct. The ice came from the north over the height of land, the movement being in a southerly direction varying from S. 20° to S. 35° E.

ECONOMIC GEOLOGY

Origin and Age of Gold Deposits

All the gold deposits of northern Ontario are in the pre-Cambrian, in rocks which, with few exceptions, are older than the Cobalt series. After the folding of the Timiskaming series and before the deposition of the Cobalt series, there was a period of igneous activity during which basic and acid rocks, including lamprophyre, porphyry, syenite, and granite, were intruded into the older rocks. The probable genetic relationship of the gold deposits of Porcupine to granite intrusions has been noted in a report on that area. There are a number of gold-bearing veins at Kirkland lake associated with feldspar porphyry and syenite, suggestive of a relationship between the intrusives and the veins. There are areas of granite and syenite within a short distance of the gold deposits. An examination of a number of specimens from these plutonic areas shows that these rocks contain albite, usually as phenocrysts, similar to the feldspar porphyry. It is quite likely that the granite, syenite, and feldspar porphyry belong to the same period of intrusion and are different facies of a magma which underlies a large part of the area. The syenite and granite have been exposed by deep erosion.

While the gold-bearing veins were formed subsequent to the intrusion of the porphyry, it is likely that they are genetically connected with the intrusive rock which occurs as dikes and boss-like masses. The cooling of the intrusive was apparently accompanied by shrinkage, faulting, and displacement in the porphyry itself and in the adjacent rocks. The gold-bearing, siliceous solutions that deposited their burdens in the fissures and other fractures in all probability represented the end product of the intrusion of the acid rocks that have been mentioned.

Lindgren[1] in his classification of mineral deposits places the gold-quartz veins of Ontario in the division of "veins and replacement deposits formed at high temperature and pressure and in genetic connection with intrusive rocks." He says: "These veins are clearly related to those of the southern Appalachian states, but, on the other hand, they present some remarkable analogies with those of California." These veins were formed at considerable depth and have been exposed by extensive erosion, but it is probable that they were not formed at as high temperatures as the veins at Porcupine, in which tourmaline and pyrrhotite frequently occur. The minerals tourmaline, pyroxene, garnet, amphibole, and biotite, characteristic of deposits formed at high temperatures, have not been recognized by the writers in the Kirkland Lake area. Albite, chlorite, sericite, and carbonates are present in the deposits as alteration products. The veins at Kirkland lake in their mineral constituents somewhat resemble those of the Sierra Nevada, California, which are described by Lindgren.[2] In these latter veins tellurides like altaite, hessite, calaverite, petzite, and melonite are associated with native gold, but only rarely.

In a comparison of the Cripple Creek and Kalgoorlie gold deposits, Lindgren has shown that telluride of gold may be deposited in large quantities both near the surface (as at Cripple creek), and at a depth of many thousands of feet below it (as at Kalgoorlie).[3] Telluride of gold is not so abundant in the Kirkland Lake deposits as telluride of lead, but probably occurs in greater quantity than

[1] W. Lindgren, Mineral Deposits, 2nd edit., p. 676.
[2] Ibid., p. 565.
[3] Metasomatic Processes in the Gold Deposits of Western Australia, Economic Geology, 1905-6, Vol. I, p. 542.

has been suspected owing to the difficulty of identifying the telluride in fine grains when accompanied by native gold. As stated above, the mineral associations at Kirkland lake are not typically those of high temperature deposits. Magnetite has been found in gold-bearing veins at the Argonaut[1] mine, a few miles east of Kirkland lake, and specularite has been reported in veins from the Tough-Oakes mine. The Kirkland Lake deposits have probably been formed at considerable depth, like the Kalgoorlie deposits, but not at such high temperatures, while the mineral association is somewhat similar in that native gold accompanies the tellurides.

Distribution of Ore Deposits

Exploration in the Kirkland Lake area has indicated one principal ore zone, running northeasterly and southwesterly along the southern expansion of Kirkland lake and along which a group of mines is being developed over a distance of two and a quarter miles. The principal mines of the area, Tough-Oakes Burnside, Sylvanite, Wright-Hargreaves, Lake Shore, Teck-Hughes, Kirkland Lake, and also several prospects are situated along this zone.

A southerly zone lies about three-quarters of a mile to the south with a similar strike, and along it are located the Montreal Ontario, Hunton, Honer, and Canadian Kirkland. Considerable work has already been done on these mines.

A northerly zone known as the Goodfish Lake gold area[2] lies about two miles north of Kirkland lake where a number of properties, including the Goodfish Gold Mining Company, La Belle Kirkland, and Fidelity, are located. This zone is not shown on the accompanying geological map.

Kirkland Lake Mineral Zone

The greatest amount of work has been done on the central zone, where a number of gold-bearing veins have been discovered extending over two and a quarter miles in length with a width of half a mile. In this zone operations have shown a major fracturing along which the principal properties are located. It is believed that after the intrusion of the porphyry and syenite, faulting took place in lines roughly parallel with the long axes of the intrusions, accompanied by fracturing and crushing of the porphyry and other rocks with the formation of the veins or lodes along these fracture planes. The principal or major fracturing can be traced across a number of properties where ore shoots are being developed at widely separated points but evidently along one system of fracturing. This fracturing has crossed all the different rocks in this zone, including feldspar porphyry, syenite, lamprophyre, and conglomerate. No. 1 vein at the Kirkland Lake mine, No. 2 vein of the Orr (now part of the Teck-Hughes), No. 3 vein of the Teck-Hughes, No. 2 vein at the Lake Shore, and No. 2 vein at the Wright-Hargreaves are being developed along the major fracturing. In addition, there are branch veins and other fractures roughly parallel, on which development has been done on a number of properties: examples are No. 1 vein at the Lake Shore, Nos. 1 and 5 veins at the Teck-Hughes, and No. 1 vein at the Wright-Hargreaves.

The fault planes along which the ore deposits have been formed dip to the south, usually at a high inclination, 80° to 85°, although locally there are rolls in the fault planes that are steeper or flatter than the average dip. A fracture zone

[1] Formerly La Mine D'Or Huronia, Gauthier township.
[2] Ont. Bur. Mines, Vol. XXV, 1916.

will contain several fault planes, which often form the boundaries of ore, and at several mines development has been carried on with regard to two prominent fault planes called footwall and hanging-wall planes. These planes are from a few feet to forty feet or more apart, the ore sometimes occurring over this whole width, or, as is more frequent, near one or the other wall, depending on subsidiary slip or fault planes. The ore will also at times extend beyond the recognizable fault planes or so-called vein boundaries.

The faulting and fracturing of the rock has permitted the circulation of mineral-bearing solutions with accompanying vapours, which have partly filled any open fissures and partly replaced the country rock in the fracture zone. The amount of vein quartz in the ore deposits is relatively small as compared with the mineralized porphyry or other rock through which the fractures have extended. In addition to irregular masses of quartz, several feet in width, that occur along the veins, there are numbers of narrow irregular quartz veins, a few inches in width, penetrating the porphyry or other rock, together with mineral-

Mineralized porphyry with quartz veinlets, showing faulting-face, in west drift, No. 1 vein, 300-foot level, Lake Shore mine.

ized or replaced rock, which make up the ore body. In consequence of the irregular distribution of quartz in the veins, the working faces along drifts on the veins vary greatly in appearance, sometimes showing considerable quartz and at other times almost entirely mineralized porphyry or other rock with minute veinlets of quartz intersecting it.

The mineralization of the veins has extended over a long period, since there has been repeated fracturing along the mineralized zone. The primary quartz is greatly brecciated and fragments of quartz and porphyry have been displaced along the fault planes. Movement along the walls in the ore bodies is evidenced by grooving and slickensided surfaces in the direction of movement. Information as to the extent of horizontal displacement may be obtained at the Teck-Hughes mines, where a north and south dike of diabase sixty feet in width has been faulted a distance of 150 feet along No. 3 vein, the part of the dike to the north of the fault planes being to the west. Several large blocks of diabase occur in the fracture zone together with masses of crushed porphyry or syenite thrust along the fault planes. Mineralization even later than this extensive movement is indicated by the presence of gold values along slip planes in fragments of diabase in the fault zone. The unaltered diabase itself does not carry gold values.

Mineralization of Porphyry and Syenite

There has been an extensive mineralization of porphyry and syenite in parts of the area that extend through the southerly part of Kirkland lake. This is apart from the mineralization that occurs with the commercial ore bodies. The long crosscuts connecting Nos. 1 and 2 veins on the 200- and 400-foot levels at the Lake Shore mine are through these rocks. The assay plans show numerous assays of gold from traces up to 40 cents with occasional higher assays of rock in the crosscuts. This rock when examined closely is seen to carry minute veinlets of quartz with disseminated iron pyrites, which would account for the frequent gold values. Similar low values are shown in crosscuts at other properties away from the veins, indicating a general mineralization of much of these intrusives away from the recognized veins. This mineralization is probably dependent on the faulting and fracturing previously referred to along the central zone, and not, as might at first be supposed, due to a gold distribution at the time of the crystallization of the intrusive rock.

Character of Gold Deposits

The early development of the Kirkland Lake area was chiefly at the Tough-Oakes mine, where a number of narrow gold-bearing veins were discovered. The most important was No. 2, which at the surface carried extremely high-grade ore over a width of 2 to 6 inches in the conglomerate, the vein fissure being largely filled with quartz. Development proved that the vein ran from the conglomerate into the porphyry on the surface and at depth; by far the greater part of the gold extraction has come from the ore shoot in the porphyry. While the high-grade quartz vein in the conglomerate carried most of the values with mill ore in the wall rock affording a narrow compact ore deposit, when it entered the porphyry the quartz usually occurred in narrower veinlets spread across a greater width with much fracturing of the porphyry along the vein. Consequently most of the ore in the porphyry is fractured porphyry with numerous slip planes, along which quartz, calcite, and ore-bearing minerals have been deposited, affording a greater width of ore than in the conglomerate. The stopes on the vein average about five feet in width. Development on other veins on the property also indicated that they contained narrow ore bodies either in the porphyry or in the greywacké and conglomerate.

The early exploration farther west along the mineralized zone did not meet with such satisfactory results, the veins in the conglomerate and porphyry along the surface not showing such high-grade ore as occurred at the Tough-Oakes, with the exception of the north vein at the Wright-Hargreaves, which produced a small amount of high-grade when it was operated for a short time in 1913.

The main fracture zone, or main vein, which for most of its length is in low ground or under the bed of Kirkland lake, was difficult to prospect, and only after several years of work has it been proven to be the locus of the principal ore deposition. Much of the previous work was done on parallel or subsidiary and narrower veins. In the main fracture the ore deposits have been found to be wider than had been expected, reaching in places forty feet in width but as a general rule running from about five to fifteen feet in width.

Strictly speaking, the ore-bearing deposits should be called lodes, as they are composite veins formed under strong compressive forces, with the solutions following openings along fracture planes in an irregular manner and partly replacing the country rock adjacent to the fractured planes. The stringers and masses of quartz intermingled with the fractured porphyry or other rock generally lie in the direction of the vein or lode, but are often connected by transverse stringers. The replacement character of the ore is frequently recognized by masses of quartz spotted with remnants of red porphyry; this ore has a faint reddish colour due to the included porphyry. In other cases masses of ore are bright red porphyry or syenite with very thin seams of quartz that are hardly recognizable. The lenses of quartz are sometimes several feet wide in portions of an ore deposit and contain much visible gold together with tellurides, pyrite, copper pyrites, molybdenite, etc. Some of the ore shows very little vein quartz, and specimens of altered red syenite from the Lake Shore mine have been found to contain grains of gold in the secondary minerals, calcite and sericite intermingled with the original feldspars of the rock.

Diamond-drilling has encountered high-grade ore on the Teck-Hughes to a depth of 1,600 feet.

Minerals in Kirkland Lake Veins

The oldest mineral in the veins, apart from the rock-forming minerals, is a coarsely crystalline quartz. Usually this quartz has been broken up and other minerals deposited in the fracture planes. Of these there is quartz, often of a somewhat darker colour than that first deposited. Carbonates of various compositions are present in the veins. A pink carbonate proved on analysis to be calcite with 5.34 per cent. of magnesium carbonate; a grey variety was ankerite. There have been different periods of fracturing; some of the quartz is later than the carbonates. Where there have been inclusions of country rock in the vein and replacement, some sericite has been developed. Chlorite also occurs as a vein material. Iron pyrites is the most abundant of the sulphides, being found both in the wall rock and in the veins, usually in well-crystallized forms. Some of the pyrite in the veins is in fine grains. Copper pyrites occurs to some extent, generally where the vein is gold-bearing. Galena and zinc blende occur in very small quantity. The latter material has been observed in small incrustation veinlets, which are later than the ore. Molybdenite has been deposited abundantly in fractures, usually as a thin film. Graphite has been recognized in some of the ore. This mineral, when in thin films, is difficult to distinguish from molybdenite. Crushed iron pyrites along slip planes has also produced a bright blackish deposit that resembles molybdenite or graphite.

Gold-bearing solutions have circulated along these planes, and the veins have been enriched by the deposition of gold in these later fractures. Later movements have often occurred along these planes, and the gold, altaite and other tellurides, pyrite, copper pyrites, molybdenite, and graphite deposited along the planes have been crushed and polished or slickensided. In some cases the gold has been deposited after the slickensides have been formed, since veinlets of the metal have been observed on the 200-foot level of the Tough-Oakes mine cutting across the smooth planes of the molybdenite.

One of the latest minerals with white calcite along fault planes is barite of a deep red colour, observed at the Teck-Hughes and Lake Shore mines.

Tellurides

Several tellurides have been recognized in ore from the Kirkland Lake area. The most abundant telluride is altaite (PbTe), telluride of lead, which has been recognized in ore from all the mines in the central zone. This mineral is readily recognized by the well-developed cubical cleavage and brilliant cleavage planes. It has a very faint greenish tinge, which aids in recognizing it in fine grains. This mineral is usually accompanied by visible gold, and its presence often indicates high-grade portions of the vein.

Telluride of gold ($AuTe_2$), calaverite, has been recognized in ore from No. 3 vein at the Tough-Oakes Burnside mine. Specimens from this vein show calaverite in quite coarse grains and readily recognizable. The mineral is of a pale brassy, almost white colour, brittle and quite soft. It resembles pale-coloured iron pyrites, but is much softer. The mineral on assay yielded 40.6 per cent. gold. This mineral is probably sparsely distributed in the ore, but if in very fine grains, it would be difficult to recognize in hand specimens.

Black tellurides carrying mercury have been recognized in specimens from the Tough-Oakes Burnside mine. One of these corresponds to kalgoorlite, a telluride of gold, silver, and mercury. An analysis of selected material by W. K. McNeill gave the following composition: Au 20.40 per cent.; Ag 31.1 per cent.; Hg 10.2 per cent. E. Thomson is of the opinion that the AuAgHg telluride is really a mixture of petzite and coloradoite and not a definite mineral. Another telluride contains mercury and tellurium with no gold or silver and is coloradoite. These mercury-bearing tellurides were definitely recognized in polished surfaces by means of the microscope and by chemical and blowpipe tests. A mercury telluride, probably coloradoite, also occurs in specimens of ore from No. 2 vein at the Lake Shore mine. The mineral is here associated with native gold, altaite, pyrite, and copper pyrites.

Petzite containing 18.74 per cent. of gold and 45.68 per cent. of silver was found in the vertical fault vein, Tough-Oakes Burnside mine.

The tellurides, tetradymite (telluride of bismuth) and hessite (telluride of silver), have been reported from No. 2 vein of the Tough-Oakes mine, but have not been recognized by the writers.

An additional telluride, melonite ($NiTe_3$), has been identified by Ellis Thomson.[1] This group gives the Kirkland Lake area more variety in tellurides than any other known area in Canada.

Ores in Thin Section

Examination of a number of thin sections of ore from the Kirkland Lake area shows that the vein material has been much brecciated. Fragments of porphyry, syenite, conglomerate, or greywacké, depending on the character of the wall rock are enclosed in vein materials, which are chiefly quartz with calcite and dolomite. Replacement of the various rocks by quartz is also in evidence. The coarsely crystallized quartz of the first generation is fractured, and the fracture is filled with later quartz, calcite, and dolomite. The principal sulphide and telluride minerals occur chiefly with the finer-grained material in the minute fracture planes in the quartz and altered rock. An interlacing meshwork of metallic sulphides and tellurides with native gold is frequently observed. Wherever the tellurides occur, native gold is usually recognized in grains close to the telluride grains. Grains of gold are seen in the tellurides, and again minute veinlets of gold sometimes traverse coarse masses of telluride. The crystallized calcite frequently contains gold that has been deposited along the rhombic cleavage planes. The contact of fragments of porphyry or other rocks with quartz is usually a place for concentration of the sulphides, tellurides, and gold.

[1] Contributions to Canadian Mineralogy, Dept. of Mineralogy, University of Toronto, 1922.

Replacement of the rock is recognized by a gradual transition to quartz and other later minerals. Native gold has been observed in contact with telluride, molybdenite, pyrite, and copper pyrites.

A section of high-grade ore from the Kirkland Lake mine shows quartz in contact with altered syenite. There is a concentration of pyrite and tellurides with gold along the contact of quartz and rock and also in the quartz, which is fractured and carries fine-grained quartz and calcite in the fracture planes. There is abundant sericite and carbonate in the altered rock. A blackish mineral in very thin films is believed to be molybdenite. A sample of high-grade ore from Kirkland Lake mine, containing 21.42 ounces of gold per ton, has the following partial composition: Fe, 1.65 per cent.; MoS_2, 0.34 per cent.; S, 0.65 per cent.; C, 0.09 per cent.; Te, 0.10 per cent. This analysis shows the presence of both molybdenite and graphite in the ore.

PRODUCTION

In the two tables which follow figures of production supplied by W. R. Rogers, Statistician of the Department, are given for the Kirkland Lake area from 1913 to 1924 inclusive.

TOTAL PRODUCTION OF GOLD AND SILVER FROM THE KIRKLAND LAKE AREA

Year	Mine	Ore milled, tons	Gold		Silver		Total value, gold and silver	Extraction per ton
			Ounces	Value	Ounces	Value		
1913	Tough-Oakes	2,220	3,164.05	64,376.30	3,890.4	$2,255.92	$66,632.22	$30.01
	Wright-Hargreaves	3	42.77	884.04	404.2	242.55	1,126.59	......
	Total	2,223	3,205.82	$65,260.34	4,294.6	$2,498.47	$67,758.81	$30.47
1914	Tough-Oakes	3,734	5,523.62	$114,153.46	6,634.3	$3,490.21	$117,643.67	$31.24
1915	Tough-Oakes	26,196	26,658.23	551,069.07	8,922.0	4,470.07	555,539.14	21.21
1916	Tough-Oakes	39,865	33,991.32	702,760.70	13,051.1	8,864.76	711,625.46	17.85
1917	Teck-Hughes	11,257	3,181.46	$65,752.96	1,154.6	$969.12	$66,722.08	$5.44
	Tough-Oakes	38,695	16,383.60	338,593.30	5,256.9	4,237.34	342,830.64	8.86
	Total	49,952	19,565.06	$404,346.26	6,411.5	$5,206.46	$409,552.72	$8.20
1918	Lake Shore	16,749	20,031.01	$415,229.75	1,188.62	$1,184.06	$416,413.81	$24.86
	Teck-Hughes	14,774	3,869.29	79,949.48	669.52	620.73	80,570.21	5.45
	Tough-Oakes	22,000	6,619.52	136,827.63	3,006.68	2,855.67	139,683.30	6.35
	Total	53,523	30,519.82	$632,006.86	4,864.82	$4,660.46	$636,667.32	$11.81
1919	Kirkland Lake	11,324	2,675.05	$55,780.38	378.9	$482.21	$56,262.59	$4.97
	Lake Shore	11,081	12,695.72	262,421.80	932.5	932.50	263,354.30	23.77
	Teck-Hughes	18,387	8,156.37	168,607.15	930.1	983.26	169,590.41	9.22
	Total	40,792	23,527.14	$486,809.33	2,241.5	$2,397.97	$489,207.30	$11.99
1920	Kirkland Lake	40,812	13,795.13	$285,170.67	1,852.9	$1,730.20	$286,900.87	$7.03
	Lake Shore	19,779	24,291.89	502,113.34	1,723.0	1,621.62	503,734.96	25.47
	Teck-Hughes	30,646	11,909.65	246,194.28	1,507.9	1,562.76	247,757.04	8.08
	Total	91,237	49,996.67	$1,033,478.29	5,083.8	$4,914.58	$1,038,392.87	$11.38
1921	Kirkland Lake	43,966	11,677.75	$241,379.11	1,665.1	$1,037.41	$242,416.52	$5.51
	Lake Shore	21,817	23,896.46	493,939.88	2,024.6	1,336.13	495,276.01	22.70
	Teck-Hughes	34,693	15,582.00	322,028.00	1,304.5	890.74	322,918.74	9.31
	Wright-Hargreaves	36,053	22,617.50	467,503.64	2,066.4	1,247.62	468,751.26	13.00
	Total	136,529	73,773.71	$1,524,850.63	7,060.6	$4,511.90	$1,529,362.53	$11.20

1922—Kirkland Lake	37,489	10,813.64	$223,517.94	1,279.2	$878.17	$224,396.11	$5.98
Tough-Oakes[1]	16,108	5,144.26	106,331.85	1,870.4	1,149.17	107,481.02	6.05
Lake Shore	24,279	22,737.17	469,977.30	1,974.5	1,363.25	471,340.55	19.41
Teck-Hughes	41,194	28,779.86	594,879.91	2,321.9	1,615.22	596,495.13	14.48
Wright-Hargreaves	66,181	36,748.21	759,585.41	4,702.3	3,167.43	762,752.84	11.52
Ontario Kirkland[2]	6,496	483.25	9,988.78	142.9	93.26	10,082.04	1.55
Total	191,747	104,706.39	$2,164,281.19	12,291.2	$8,266.50	$2,172,547.69	$9.83
1923—Kirkland Lake	45,449	10,746.66	$222,153.23	1,471.2	$949.17	$223,102.40	$4.91
Tough-Oakes[1]	1,803	579.75	11,984.45	293.8	189.72	12,174.17	6.75
Lake Shore	23,203	26,430.57	546,368.60	1,917.7	1,231.21	547,599.81	23.60
Teck-Hughes	38,314	53,954.67	1,115,342.06	4,074.9	2,621.35	1,117,963.41	29.17
Wright-Hargreaves	79,242	36,369.82	751,781.41	4,968.2	3,197.40	754,978.81	9.52
Total	188,011	128,081.47	$2,647,629.75	12,725.8	$8,188.85	$2,655,818.60	$14.79
1924—Kirkland Lake	8,091	2,235.86	$46,219.40	452.5	$293.33	$46,512.73	$5.75
Lake Shore	56,168	53,053.48	1,096,712.00	4,224.9	1,860.00	1,098,572.00	19.56
Teck-Hughes	44,209	49,350.06	1,020,166.34	4,116.9	2,859.40	1,023,025.74	23.14
Tough-Oakes Burnside	8,438	2,280.81	47,148.52	582.9	399.08	47,547.60	5.53
Wright-Hargreaves	84,487	52,464.78	1,084,447.09	6,412.5	4,278.44	1,088,725.53	12.88
Total	201,393	159,384.99	$3,294,693.35	15,789.7	$9,690.25	$3,304,383.60	$16.47
Grand Total	1,025,202	658,935.24	$13,621,339.23	99,370.9	$67,160.48	$13,688,499.71	$13.35

[1] Production from the Tough-Oakes mine was by the Kirkland Lake Proprietary (1919), Limited, during 1922 and 1923. The property was transferred August 31, 1923, to the Tough-Oakes Burnside Gold Mines, Limited.

[2] This property was later amalgamated with Montreal Kirkland under the name Montreal-Ontario, which in turn has been renamed Kirkland Rand.

TOTAL PRODUCTION (GOLD AND SILVER) BY INDIVIDUAL MINES, KIRKLAND LAKE AREA

Year	Lake Shore	Teck-Hughes	Wright-Hargreaves	Tough-Oakes	Kirkland Lake	Argonaut	Ontario-Kirkland	Total
1913	....	....	$1,127	$66,632	....	....	....	$67,759
1914	....	....	....	117,644	....	$5,204	....	122,848
1915	....	....	....	555,539	....	....	....	555,539
1916	....	....	....	711,625	....	....	....	711,625
1917	....	$66,722	....	342,831	....	....	....	409,553
1918	$416,414	80,570	....	139,683	....	....	....	636,667
1919	263,354	169,590	....	....	$56,263	2,631	....	491,838
1920	503,735	247,757	....	....	286,901	26,863	....	1,065,256
1921	495,276	322,919	468,751	....	242,417	513	....	1,529,875
1922	471,341	596,495	762,753	107,481	224,396	....	$10,082	2,172,548
1923	547,600	1,117,963	754,979	12,174	223,102	72,512	....	2,728,331
1924	1,098,572	1,023,025	1,088,725	47,547	46,512	152,072	....	3,456,453
Total	$3,796,292	$3,625,041	$3,076,335	$2,101,156	$1,079,591	$259,795	$10,082	$13,948,292

Exchange premiums received in addition to the above valuations were as follows: 1920, $110,424; 1921, $121,425; 1922, $19,590; 1923, $37,812; 1924, $24,028; or a total of $313,279 for the five years of which we have record.

Production of gold and silver for the first six months of 1925 totalled $2,628,608. Argonaut and Barry-Hollinger figures are included.

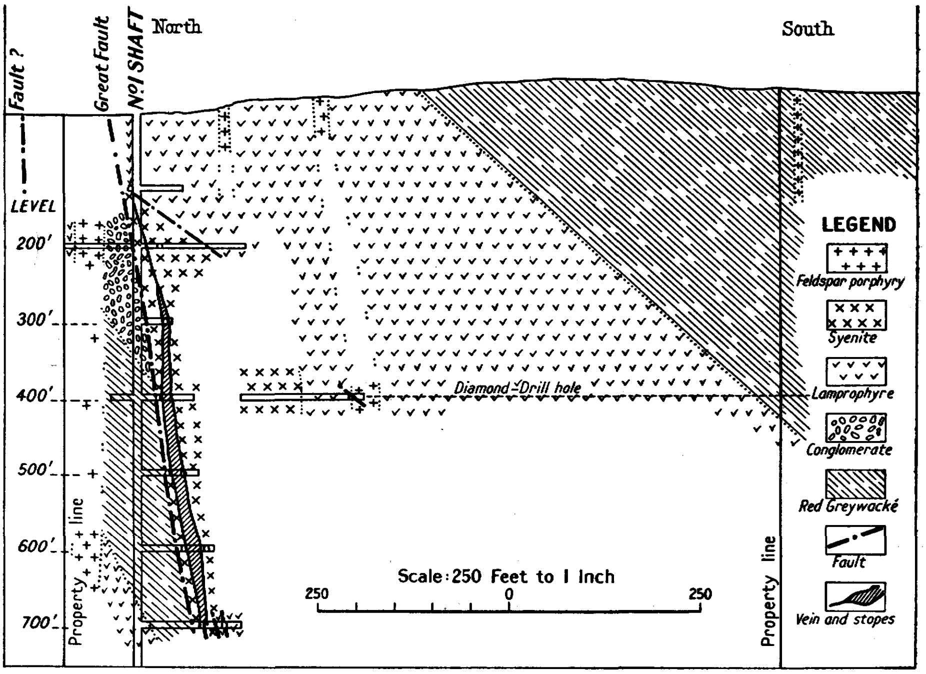
WORKING PROPERTIES

Kirkland Lake Area

The accompanying property map (insert) of the Kirkland-Larder area shows the relative position of the several mines and prospects mentioned in the report.

Elliott-Kirkland

The Elliott-Kirkland property lies to the west of the Kirkland Lake mine. It includes three claims, the principal of which is L. 1,617 on which the shaft and mine buildings are located. The main fracture zone has been traced westerly through low land from the Kirkland Lake mine. A vertical shaft has been sunk 537 feet, with crosscuts on five levels and drifts on the third, fourth, and fifth levels along fault planes. The rocks encountered are porphyry, lamprophyre, syenite, and reddish feldspathic quartzite. During the time of the strike at Kirkland lake the workings were allowed to fill with water, and no further exploratory work has since been done.



Cross-section through No. 1 shaft, Kirkland Lake mine, from plan by J. B. Tyrrell.

Kirkland Lake

The Kirkland Lake Gold Mining Company is operating claim L. 1,236, formerly known as the McKane, situated a quarter of a mile southwest of Kirkland lake. Native gold had been discovered in the main vein by the early operators, who also sank No. 1 shaft to a moderate depth. The original discovery was made through about 20 feet of overburden, the strike of the vein having been determined from workings on the Teck-Hughes and other properties.

There are two vertical shafts on the property. No. 1 is located in the northeast part of the claim near the Teck-Hughes line and has been sunk to a depth of 1,000 feet. The mineralization was followed to 104 feet, where the vein left the shaft on the south side. From the different levels, crosscuts were run to the south to intersect the vein. Since the vein dips approximately 85° S., the crosscuts are slightly longer at each succeeding level. Drifts have been run on ten levels, but those on the first and second are short, the values obtained not having been as good as those from the 300-foot to the 700-foot levels.

A main hoisting shaft is located 600 feet southwest from No. 1 shaft and to the south of the main vein as exposed on the surface. This contains two hoisting compartments and a manway compartment and is connected on most levels with the main workings along No. 1 vein. The shaft passed through the vein at a depth of 1,000 feet and has been sunk to a depth of 1,600 feet.

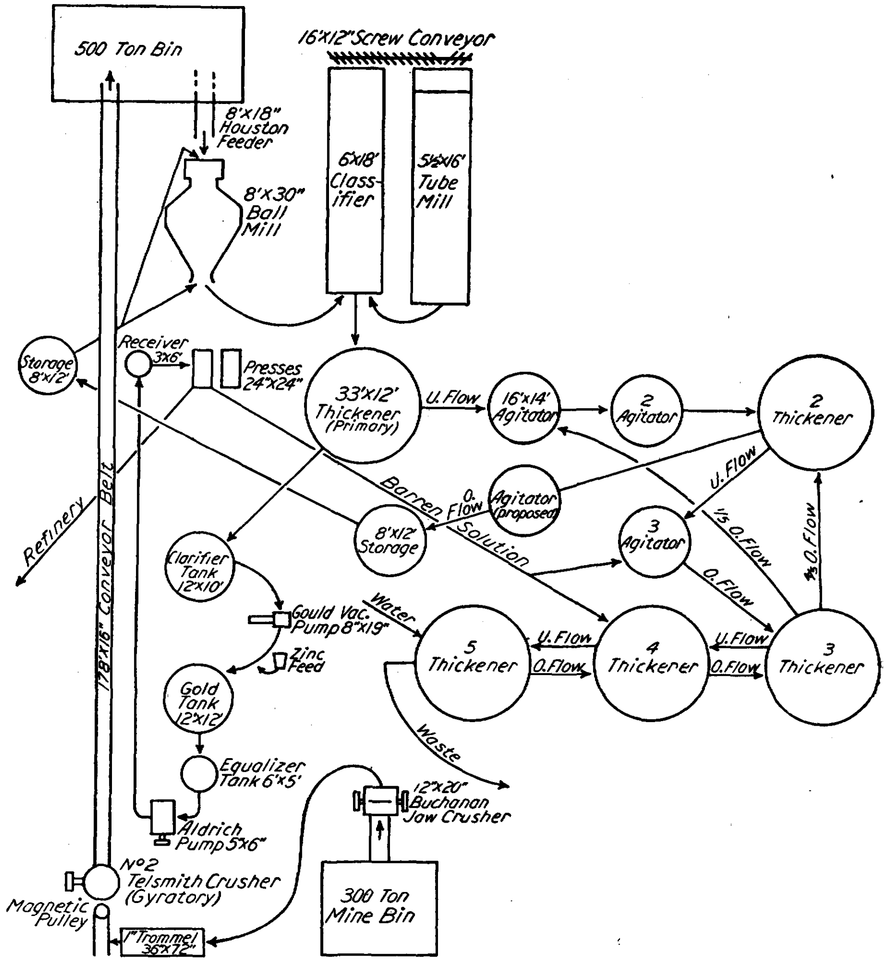
The main vein is recognized by the presence of fault planes, which dip to the south. These are called the footwall and hanging-wall planes, and they vary considerably in distance apart in different sections of the mine. At the crosscuts from No. 1 shaft on the 400-, 500-, 600-, and 700-foot levels, they are respectively 19, 33, 40, and 40 feet apart.

The area between the principal faults is very much disturbed, since minor fault planes and cross-slips have in part controlled the ore deposition. Exploration has shown that there is consequently great irregularity in the mineralization in the fractured zone, and values change quite rapidly in drifting along the vein. The development has been carried on with regard to the two principal planes or vein boundaries. On the 400- and 500-foot levels, drifts have been run on the foot- and hanging-wall sides of the vein for some distance. Large stopes were opened up, that on the 400-foot level being about 300 feet in length and 23 feet wide at one point. The assay plans of the stopes have shown the greatest values to be in the footwall section of the vein. Development has also shown that the ore sometimes extends beyond the recognized vein boundary planes. The best grade of ore has been obtained where the fault planes or vein boundaries are moderate distances apart, roughly 15 to 25 feet. Where they are within a few feet of each other, the values are not so good, and where very widely apart the values have a tendency to become more scattered. The ground between the fault planes is so broken and contains so many slip planes that it has been found advisable to leave solid backs above the drifts to protect them from the weight of broken ore in the stopes.

The development has so far indicated that the principal ore shoot extends from above the 300-foot level to the 1,100-foot level, the deepest workings developed to this time. The ore shoot pitches to the west. On the third, fourth, and fifth levels, the ore shoot extends easterly to the Teck-Hughes west boundary.

Some gold values are generally obtained along the main vein fracture, but these are not always of commercial importance. However, this mineralization indicates the possibility of exploration developing other ore shoots. A heavy fault plane is often in evidence in the workings, the gouge being frequently several inches thick. Considerable brecciation of ore has occurred, indicating faulting subsequent to ore deposition.

The best ore is a bright red porphyry or syenite through which there are ribbons of quartz carrying tellurides, copper pyrites, iron pyrites, molybdenite, graphite, calcite, and native gold. The vein is principally in the porphyry and syenite that lies adjacent to a band of conglomerate, greywacké, and quartzite, in which No. 1 shaft has been sunk entirely from above the 300-foot level to the 700-foot level. The dip of the contact is approximately the same as that of the vein, about 85° S. The north fault plane or footwall of the vein is sometimes in the sedimentary formation. High-grade ore with visible gold was observed on



Flow-sheet of mill, Kirkland Lake mine.

the 400- and 500-foot level stopes, which, together with a lower grade, averaged approximately $7 a ton.

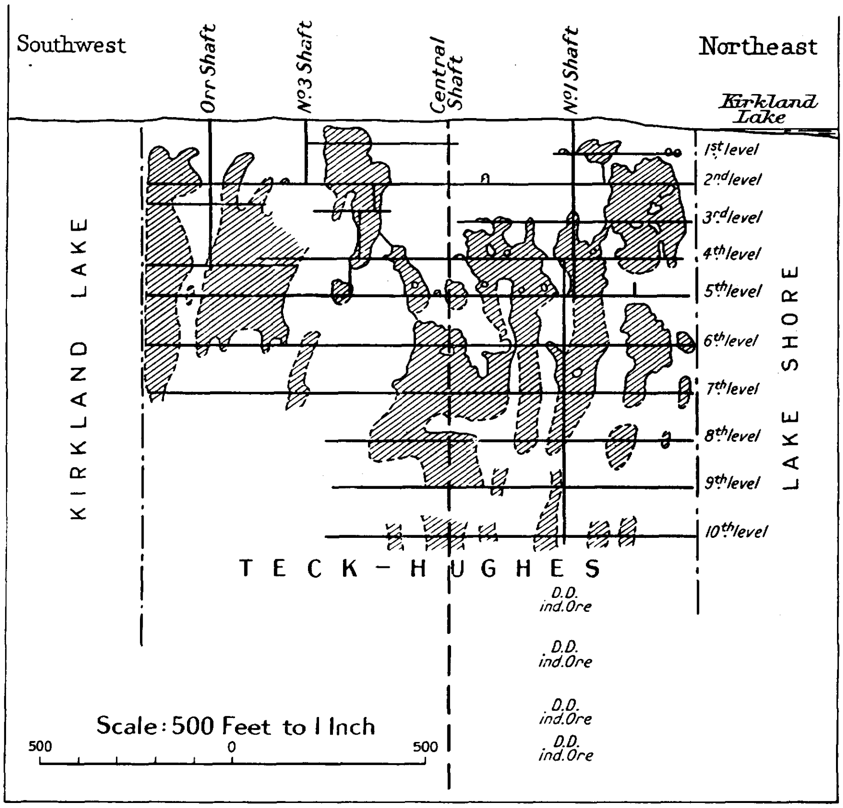
The ore is hoisted in the main shaft, passed through a crusher, and carried to the mill bin on a conveyer belt. The mill, when running, treated 140 tons per day, and the recovery is 92 to 95 per cent. The mill was closed during 1924 while an energetic development campaign was being carried out. During 1924, the Chaput-Hughes claim, L. 2,644, to the south was acquired by Kirkland Lake.

J. B. Tyrrell is general manager, and W. Sixt, superintendent.

Teck-Hughes

The main ore zone of the Kirkland Lake area passes through the southern portion of the Teck-Hughes property, L. 1,238, where it is known as No. 3 vein. In March, 1923, the Teck-Hughes Gold Mines, after 8½ years' operation, acquired the Orr Gold Mines lying adjacent to the south. The acquiring of the latter property not only added 300 feet at the surface in the length of the main ore zone, but protected the downward extension of the earlier worked ore shoots on the Teck-Hughes on the dip which is to the south and approximately 80° to 85°. Development at depth has since shown ore deposits dipping into the Orr section. During 1918, J. Houston sank the Orr shaft to the 400-foot level, opened up the main vein across the property for a distance of 400 feet, and ran a long crosscut southeast toward a second or parallel vein. The main vein occurred partly along the contact of conglomerate and syenite and partly in the syenite at this level, the ore being along prominent faults 12 to 25 feet apart.

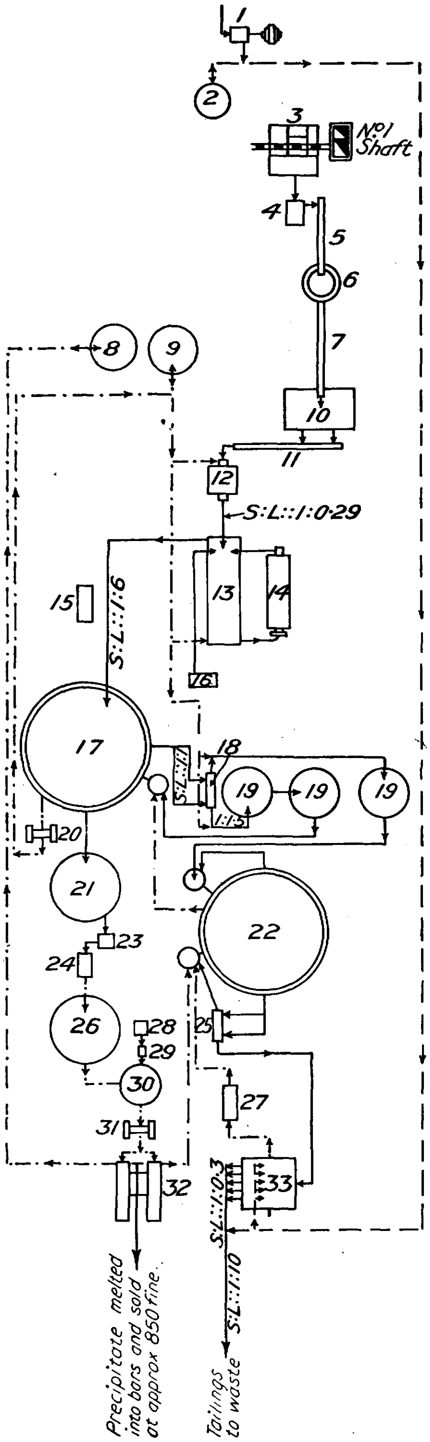
The workings on the Teck-Hughes have extended to the 10th level at 1,105 feet, the property being opened up by means of a main or No. 1 vertical shaft to the 500-foot level and a main winze from the 400-foot or 4th level to



Longitudinal stope-section, Teck-Hughes mine, from plan supplied by D. L. H. Forbes.

the 10th level, the workings being connected with the 400-foot Orr shaft and No. 3 shaft on the 200-foot level.

The main shaft at the east side of the property was started on vein No. 1, which dipped 80° S. The vein is composed of brecciated porphyry and quartz, 2 to 6 feet wide, and carried low gold values. Later, on the 7th level, a long shoot of higher grade ore was opened up on No. 1 vein. Crosscutting south from No. 1 shaft cut the main No. 3 ore zone at distances ranging from 100 to 170 feet. No. 3 vein has been explored for its length from the 2nd to the 7th level and a number of ore shoots have been opened up. In the three lower levels, the development has been carried on mostly in the eastern section of the mine, and some ore shoots have been encountered.



Key to Numbers

1. Mather & Pratt turbine pump, direct connected to 15 h.p. motor.
2. Wood tank, capacity 37 tons.
3. Weighing platform for mine cars, ore bin, 60 tons.
4. 16- by 10-inch Farrel-Bacon jaw crusher, capacity 75 tons per 8 hours.
5. 20-inch belt conveyor, 200 ft. per min., 20° incline, Ding magnetic head pulley.
6. No. 2F. Telsmith gyratory crusher, set at ¾-inch opening, capacity 75 tons in 8 hours.
7. 14-inch belt conveyor, 135 feet centre to centre, speed 270 ft. per min., 12° to 15° incline.
8. 8- by 10-foot wood tank for barren solution.
9. 10- by 8-foot wood tank for crushing solution, 20 tons capacity.
10. 12- by 16- by 17-foot deep wood ore bin, 45° bottom, capacity 110 tons.
11. 20-inch conveyor feeder, worm gear driven.
12. 5- by 5-foot P. & M. Co. ball mill, belt-driven by 60 h.p. motor.
13. 4½- by 26-foot Dorr duplex classifier.
14. 5- by 20-foot P. & M. Co. tube mill, scoop feed, El Oro liners.
15. 9½- by 8-inch Oliver F. Co. low pressure air compressor.
16. 8-inch bucket elevator, speed 275 ft. per min., returning spills.
17. 30- by 16-foot Dorr duplex thickener, capacity 500 tons solution and 100 tons dry pulp per 24 hrs., S: L: :1: 5 underflow at 1: 1.
18. No. 4 Sudbury Const. Co. 3-throw diaphragm pump.
19. Three 12- by 16-foot Dorr agitators, wood tanks, capacity of each 33 tons of dry pulp at 1: 1.5.
20. 5- by 5-inch Aldrich V.T.B.D. solution pump, 80 gals. per min.
21. 12- by 10-foot wood tank with 6 clarifying filter leaves, each 4 feet by 8 feet.
22. 30- by 16-foot wood Dorr duplex thickener, capacity 100 tons, dry pulp per day S: L: :1: 4, underflow 1: 1.
23. Roots rotary vacuum filter pump.
24. 45° V-notch solution measuring weir.
25. No. 4 Sudbury diaphragm slime pump, 20 strokes per min.
26. 12- by 10-foot wood pregnant solution storage tank, capacity 40 tons.
27. Blake-Knowles 6½- by 6-inch wet vacuum pump, 70 tons per day.
28. Merrill zinc dust feeder.
29. Zinc dust emulsifier.
30. Wood agitation-precipitating tank 4 by 6 feet, capacity 2.3 tons.
31. Aldrich 5- by 5-inch V.T.B.D. solution pump, run at 150-200 tons per day.
32. Two Perrin 23 frame filter presses, with Crowe vacuum and Merrill precipitation processes, 2 feet by 2 feet by 2 inches.
33. Oliver slime filter, 11 feet 6 inches by 8 feet.

Explanation of Flow Lines

Ore and pulp ——————— Solution —. —. —. —. Water — — — —

Solid to liquid ratios and tons per 24 hours shown thus:—S: L: :1: 6.

FLOW-SHEET (JULY, 1918) OF CYANIDE PLANT, TECK-HUGHES GOLD MINE

The ore in the main No. 3 vein, which is typical of the ore described on other properties, occurs in shoots usually between two prominent, nearly parallel seams or faults, from 6 to 40 feet apart, and dips 85° S. The faults are often filled with gouge from an inch to six inches in thickness, narrowing down in places to mere cracks. In many places secondary minerals, such as quartz, calcite, and reddish barite, fill the faults. The ore is composed of brecciated syenite, or porphyry, and quartz, cut by veinlets of quartz and some calcite, the whole containing numerous slip planes. The metallic minerals present are pyrite, copper pyrites, molybdenite, various tellurides, and gold. The shoots are irregularly disturbed through the faulted zone. Usually the shoots lie inside and adjacent to one of the main fault walls. In places, however, the ore is continuous between the fault and walls, while in other places the ore extends beyond a fault wall. The shoots vary from about 40 to 300 feet or more in drift length. By more or less connected irregular shoots, ore has been followed to the 1,105-foot level.

Early in 1924, diamond-drilling was carried on from the 10th level to explore to greater depth the ore zone which indicated highly favourable results on No. 3 vein, at a depth approximating 1,600 feet from the surface. The last drill indicated an ore width of 8.5 feet of a grade of $43 per ton midway between the 14th and 15th level horizons; while to the north of the vein, a 3-foot width of $22.40 ore was also crossed by the hole.

In the early years, the ore treated in the mill was of medium grade, but the finding of high-grade ore shoots in various parts of the mine in the last few years has greatly increased the grade. During the year end'ng August 31, 1924, 42,381 tons were treated, with an average recovery of $26.23 per ton, yielding $1,111,673.95.

During the year 1924, a new four-compartment shaft was started, being down about 700 feet at the end of 1924. The development of the property has grown to such proportions that a large shaft, located to the south of the present working, on the ore structures, which dip south at 85°, was necessary for development and explorations at depths below 1,105 feet or the 10th level.

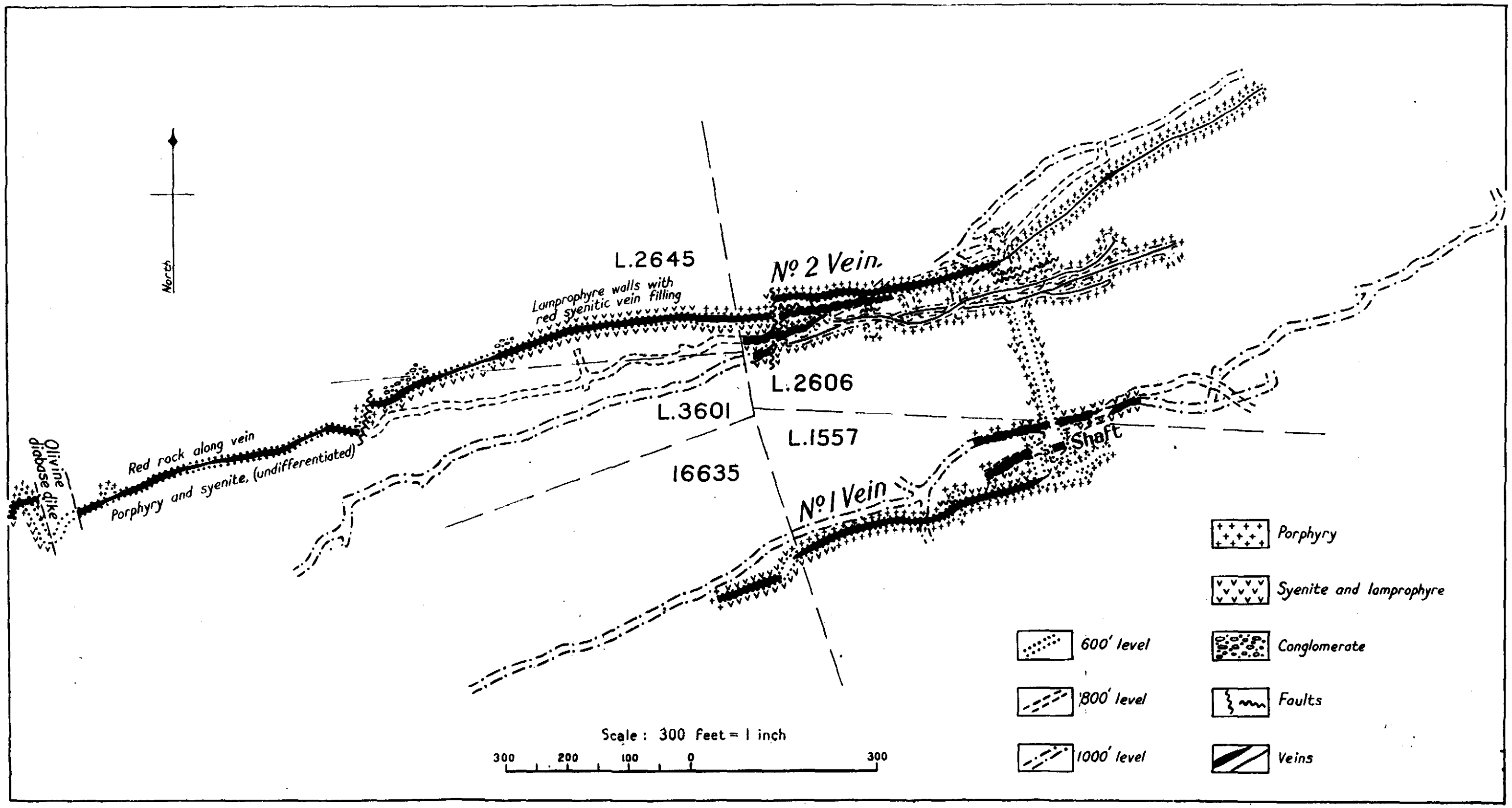
The president is C. L. Dennison, and D. L. H. Forbes is general superintendent.

Lake Shore

The Lake Shore Mines is a consolidation of a number of claims, L. 2,645, L. 2,606, L. 2,605, L. 1,557, and 16,635, along the main fracture zone that passes through Kirkland lake. The property includes land along the south shore of the lake and a portion under the body of the southeast arm of the lake. The principal mine buildings are on claim L. 1,557.

The Lake Shore Mines is capitalized at $2,000,000 with a par value of $1 per share. Harry Oakes, the discoverer and principal owner, is president, and E. B. Knapp is mine manager.

The first work was done on No. 1 vein on the south shore of the lake, and drifts were carried a hundred feet apart to the 400-foot level. The ore shoot extended westerly from the shaft. A strong fault was encountered just above the 200-foot level, dipping 25° to the south and displacing the vein 28 feet. The ore occurs chiefly in the red porphyry, but parts of the vein have conglomerate syenite, and lamprophyre as wall rocks. Owing to the small amount of crosscutting, the distribution of the bands of different rocks has not been worked out. On the 200-foot level, 100 feet west of the shaft, lamprophyre has been faulted over porphyry. A strong cross fault, 410 feet west of the shaft



PLAN OF 600-, 800-, AND 1000-FOOT LEVELS, LAKE SHORE MINE.

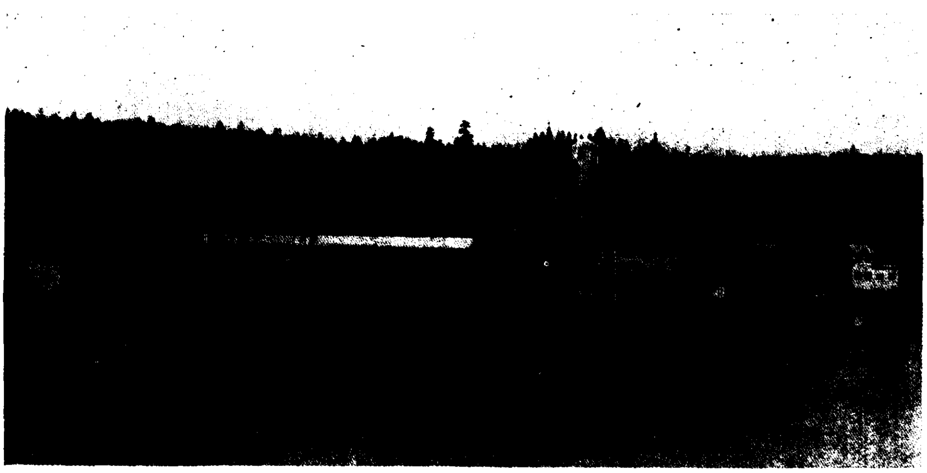
The geological examination was made in October, 1924. Workings where geology is not shown have been driven since that date.

on the 400-foot level, striking nearly north and south and dipping almost vertically, displaced the portion of the vein lying to the west 20 feet to the south. This fault is encountered on the various levels on the principal vein, No. 2, lying under the bed of the lake. The work on the vein in the vicinity of the major fault was complicated by several subsidiary faults.

The vertical two-compartment shaft which was started on No. 1 vein has been enlarged to three compartments and deepened to the 1,000-foot level, and further drifting has been done on the 600-, 800-, and 1,000-foot levels. At the lowest level, No. 1 vein lies 50 feet north of the shaft, this being the first level where ore in No. 1 vein has been extended to the east of the shaft.

Crosscuts have been run from the shaft northwesterly to No. 2 vein at the 200-, 400-, 600-, 800-, and 1,000-foot levels. This vein on the 600-foot level is nearly 350 feet north of No. 1 vein.

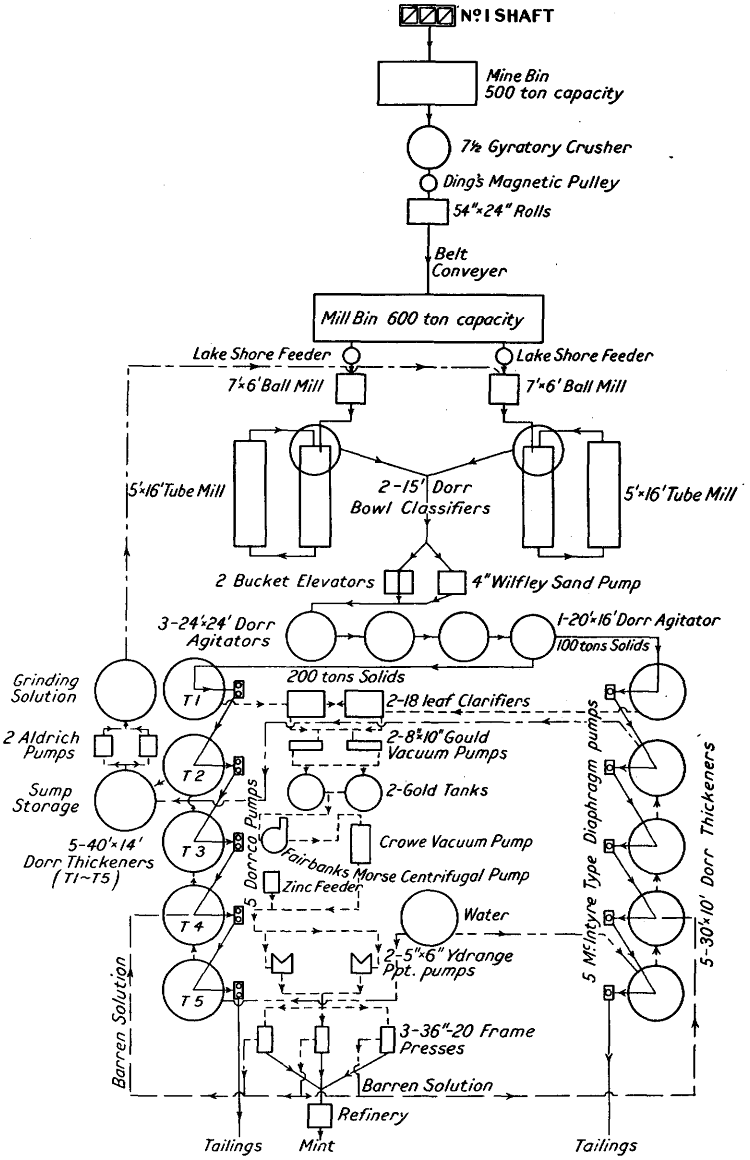
No. 2 vein is part of the main fracture along which for 2¼ miles at various properties ore shoots are being developed. In the zone of the main fracture, there are a number of faults. The faults, often showing gouge, are some-



Mill and plant of Lake Shore Mines, Limited, as viewed from the lake.

times along the ore and sometimes away from it. Some gold values are found along all the faults, but they are often not sufficiently high to be classed as ore. It was found at both the 800- and 1,000-foot levels that the fracture first drifted on to the west of the main crosscut was not the main ore channel but a subsidiary one, the ore shoot being at each level on the north side, which was determined by diamond-drilling and crosscutting. The greatest development has been done on the 200-, 400-, and 600-foot levels, drifts being carried on the 400- and 600-foot levels to the west boundary of the property. Here a north-south dike of olivine diabase has faulted the vein structure 100 feet to the north on its west side. Development is being carried on the 800- and 1,000-foot levels on high-grade ore to the west of the main crosscut.

Red feldspar porphyry is the principal rock with the vein in its eastern portion, while toward the west there is more of the red syenite, lamprophyre, and conglomerate with the vein. In some sections of high-grade ore, the wall rock is lamprophyre with red syenite masses included in the vein filling. Analyses

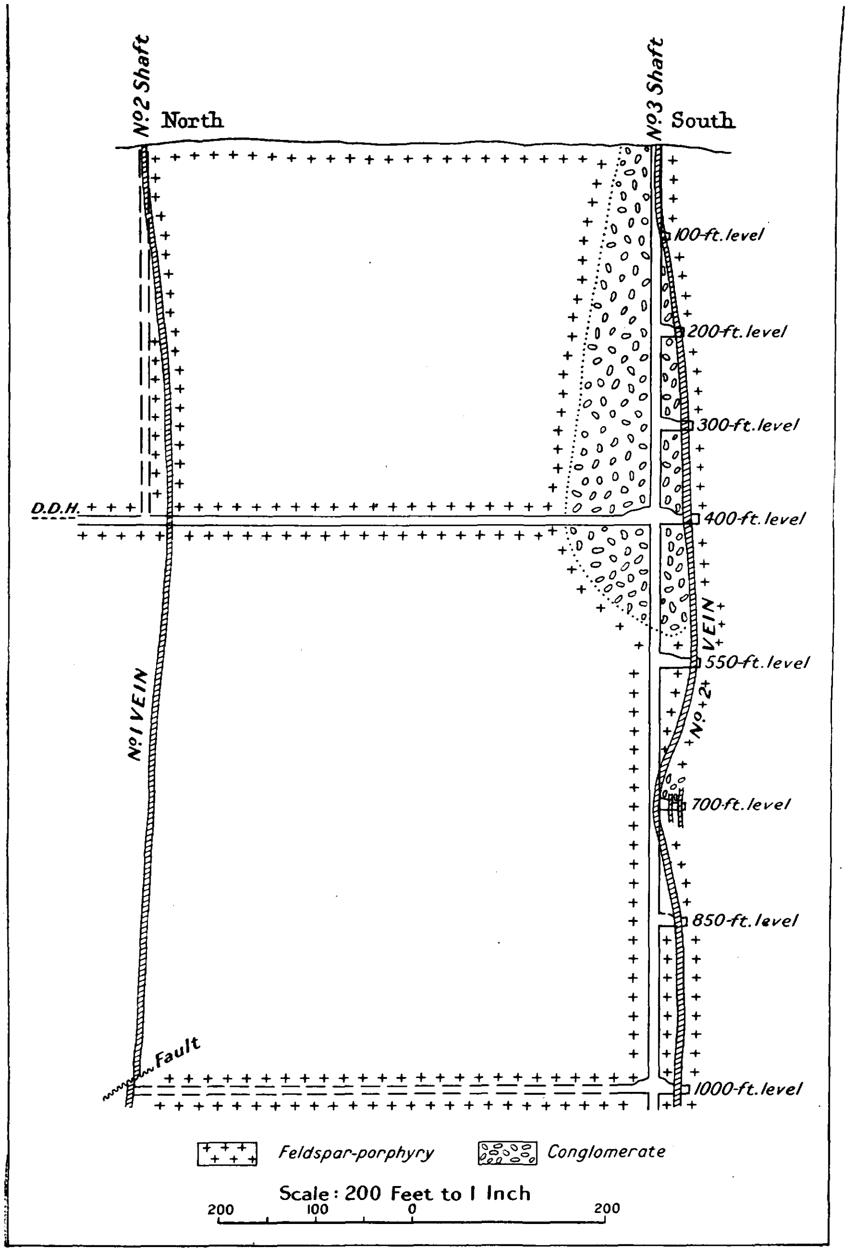


Flow-sheet, Lake Shore mill.

of red syenite from west of the main crosscut on the 600-foot level showed 4.50 per cent. potash and 3.46 per cent. soda. The red syenite is difficult to distinguish from the red porphyry where the phenocrysts are not conspicuous. From an examination of the workings it is evident that where the fracturing is strong good ore may be found in any of the rocks through which it may extend.

The ore is largely of the red porphyry or red syenite type together with quartz in lenticular masses and veinlets. Brecciation of the ore is evident in the fractured character of the included rock and vein quartz.

Minor slip planes occur along the ore bodies, and these often form the boundaries of the ore, to be repeated along the vein laterally and vertically.



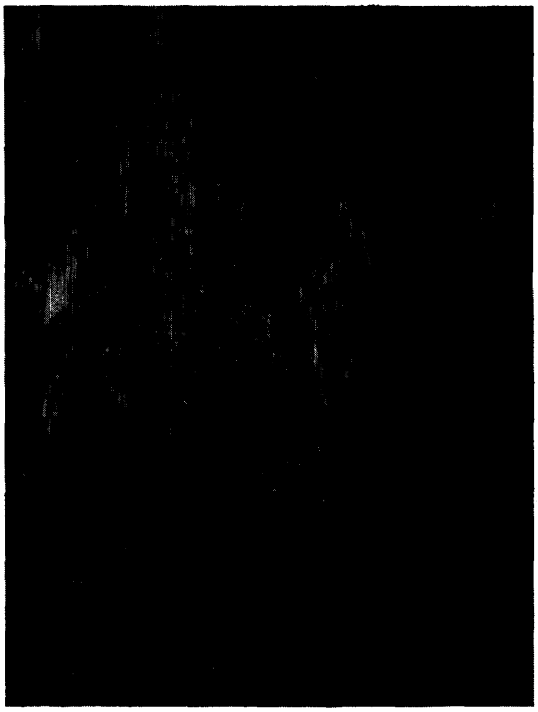
Cross-section, showing pendant of Timiskaming conglomerate in the enclosing feldspar porphyry, Wright-Hargreaves mine, November, 1924.

Constant assaying of the faces is necessary, since the ore sometimes turns off from where it has been following a well-defined wall, diagonally along another wall.

The ore bodies vary in width but would average seven or eight feet. Much of the ore in the 400-foot level stopes averaged eleven feet in width. Wonderfully long ore shoots have been developed along No. 2 vein on several levels.

On the 600-foot level, most of the drift to the west of the main crosscut and extending to the west boundary is in high-grade ore with a few short sections of low-grade. The first stope has a length of 375 feet, extending from the main crosscut westerly to a north-south fault. In mining in the stopes, the walls are tested by horizontal drill holes at regular intervals, and the stoping is carried to the boundary of the ore. In recent work, box holes have been used in place of taking down backs and timbering the drifts.

The mill, which for some years treated sixty tons a day, has been enlarged to treat 300 tons a day. Recently the mill has been treating ore averaging around $17 per ton.



No. 1 vein, 1,000-foot level, Wright-Hargreaves mine.

Wright-Hargreaves

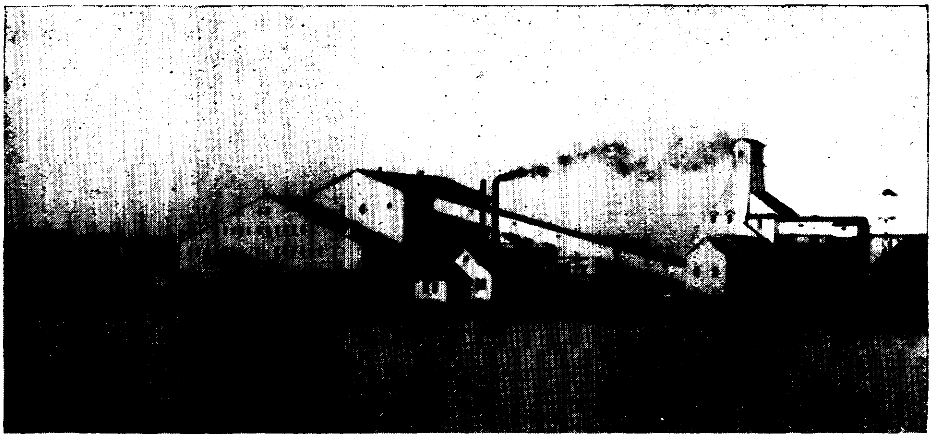
The Wright-Hargreaves mine consists of three adjacent mining claims along the main fracture and a fourth lying south of the Sylvanite. The company is capitalized at $2,750,000 with a par value of $1 per share. Oliver Cabana is president; Albert Wende, managing director; and James Grant, superintendent.

The main No. 2 vein, by exposures on the surface and exploration under the bed of Kirkland lake, is known to have a length of 3,900 feet, the greatest length of vein on any of the Kirkland Lake properties.

In 1911, W. H. Wright, prospector, who staked the claims, found gold in quartz veinlets in the porphyry, this being the first discovery in the camp. During the autumn of that year two shot-drill holes were put down on the vein.

In 1913, a rich vein was discovered about 550 feet north of No. 2 vein, while the property was under option to Mr. R. Cartwright. A shaft was sunk sixty feet on the vein showing about five feet in width, and 3.4 tons of high-grade ore averaging $331.35 per ton were shipped to a smelter. The option was allowed to lapse, and for some years the property was inactive, until it was taken over by the present Wright-Hargreaves Mining Company.

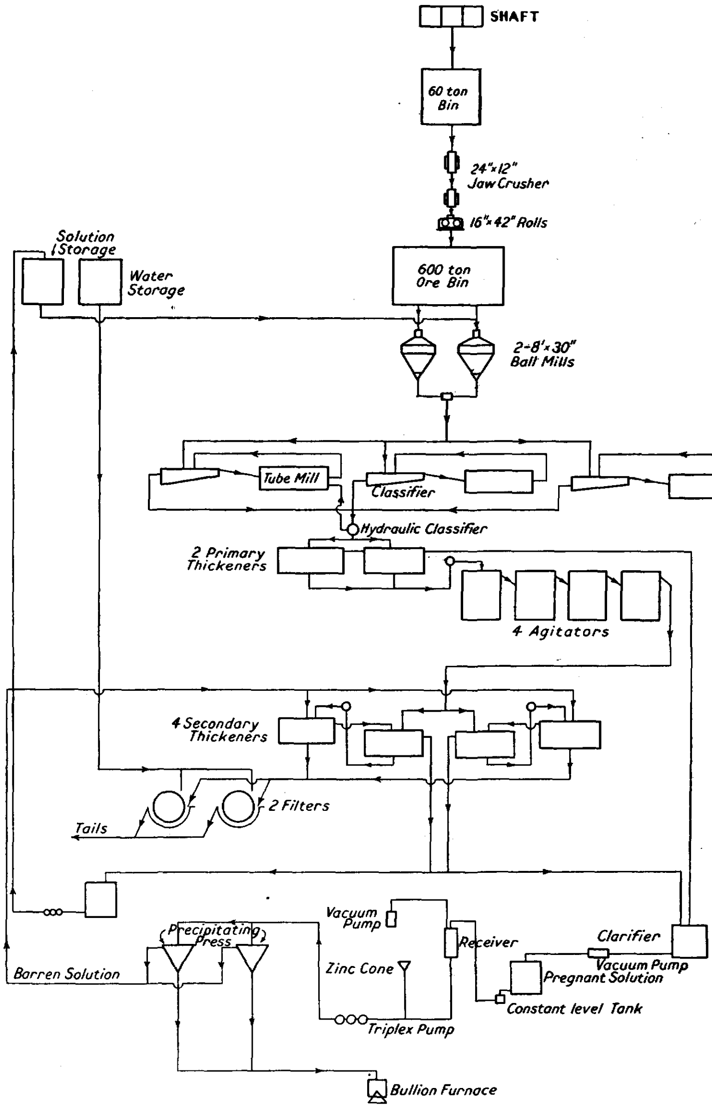
Two shafts, 950 feet apart, have been sunk on the main vein. The westerly or No. 3 shaft with three compartments is now down to the 1,000-foot level, while No. 1 is down 300 feet. No. 2 shaft is on No. 1 vein and is connected with the main No. 3 shaft on the 400-foot level. The main fracture is partially opened on eight levels from the main shaft, but as yet only a small part of the total length of vein has been explored, even on the upper levels. The greatest amount of work was done on the 400-foot level where six separate stopes have been opened up along the main vein. Development is showing that the ore occurs in shoots in various parts of the vein, and, as mining progresses, separate stopes are being opened up on various levels. The stopes vary in length up to 320 feet. One ore shoot lying east of the shaft has been followed from the surface to the 1,000-foot level, being nearly vertical. Development of a large



Mill cf Wright-Hargreaves Mines, Limited.

ore shoot lying west of the shaft indicates a pitch to the east. This ore shoot has been faulted by a strong fault which strikes N. 15° E. and dips 75° W. The westerly part of the shoot was displaced 140 feet to the south, and work indicates a probable downward throw of 190 feet on the west side. Numerous minor faults and slips are encountered in the workings. The most recent development is a No. 1 vein which was intersected in a long crosscut to the north on the 1,000-foot level. This vein is narrower than No. 2 and of much higher grade, opening up to a stoping width of five feet. The ore contains much visible gold and tellurides. This vein, in October, 1924, showed one ore shoot at the crosscut 165 feet in length, and a second to the east was 400 feet in length with the east face in high-grade ore. Most of the ore supplied the mill is taken from development and shrinkage in stoping, consequently a large tonnage of broken ore reserves is gradually being built up.

The rocks exposed in the workings are feldspar porphyry and conglomerate. A wedge of conglomerate lies on the north side of No. 2 vein near No. 3 shaft, continuing downward to the 500-foot level. At the 1,000-foot level, No. 1



Flow-sheet, 400-ton mill, Wright-Hargreaves Mines, Limited.

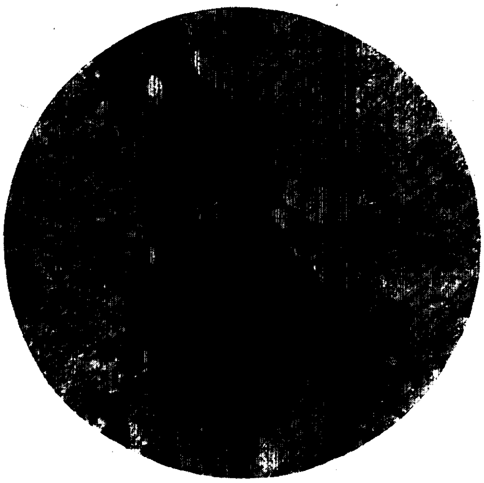
vein is in feldspar porphyry, as is also No. 2 vein. Along the vein the porphyry is often sericitized, showing a light greenish colour.

Treating about 230 tons per day in the latter part of the year, the mill has been enlarged to treat 400 to 450 tons per day.

The quality of the ore milled has also improved, the grade being over $15 per ton for several months. Broken ore reserves at the beginning of 1924 were estimated at 75,815 tons, and this amount has been greatly increased during 1924.

Sylvanite

The Sylvanite mine includes three claims adjoining the Wright-Hargreaves on the north and east. Most of the development has been done on claim



Thin section of gold-bearing quartz from No. 2 vein, Tough-Oakes Burnside mine. Quartz has been replaced by carbonate. Black spots are native gold. (X 19 diameters.)

Thin section of gold-bearing quartz from vein on Wright-Hargreaves. Carbonate, molybdenite, chlorite, telluride (altaite ?), gold, and other minerals occur in the fracture planes of the quartz. (X 19 diameters.)

L. 2,100, across which the main Kirkland Lake fracture extends. The property is controlled by Wright-Hargreaves interests. Exploration has been carried on by means of a three-compartment shaft to the 1,000-foot level, and lateral work has been done on the 300-, 500-, 700-, 800-, and 1,000-foot levels. Most of the work has been done on the 1,000-foot level. Here what is considered the main vein was found 100 feet south of the shaft, and a drift was run along it, indicating a high-grade ore shoot about 250 feet in length; 100 feet to the south, a second vein was drifted on for 180 feet. These veins are enclosed in red feldspar porphyry.

A long crosscut was driven northwesterly from the shaft, which was in feldspar porphyry for 560 feet, beyond which the crosscut intersected three bands of conglomerate separated by intrusions of porphyry, the crosscut ending in conglomerate at 1,080 feet. Several veins were encountered, two of which were being drifted on. The veins in parts of the drifts occur along the contact of conglomerate and porphyry, the conglomerate being on the north sides of the veins. Some strong faults occur in the workings.

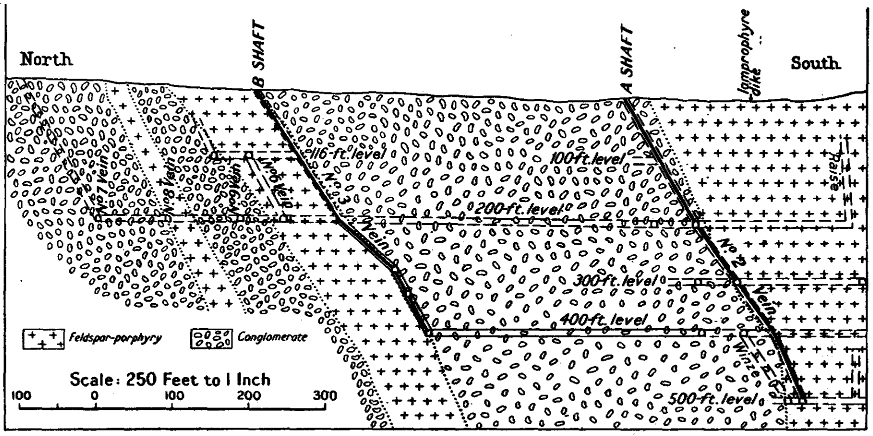
The manager is A. Wende, and Earl Rodgers is superintendent.

Tough-Oakes Burnside

This property was the first to be operated in the area following the discovery in January, 1912, of gold-bearing veins in the porphyry and conglomerate. It formerly consisted of five claims: L. 2,372 to L. 2,376, situated along the boundary lines between Teck and Lebel townships, the major operations having been on L. 2,375. Surface prospecting in the early years of the mine resulted in the finding of eleven veins in the porphyry, greywacké, and conglomerate, some of the veins passing from one to the other formation. The veins are roughly parallel with the average strike, somewhat south of west. The principal development has been on veins Nos. 2, 3, and 6, the first two producing most of the ore already taken from the mine. The veins were traced on the surface by trenching. No. 2 vein was traced for 370 feet; No. 3 for 830 feet; No. 6

for 1,460 feet, entirely in porphyry, with 740 feet of it showing an assay value of about $12 per ton for a width of sixty inches; No. 7 was trenched for 245 feet in the greywacké, the quartz rib of which averaged eighteen inches with stringers in both walls.

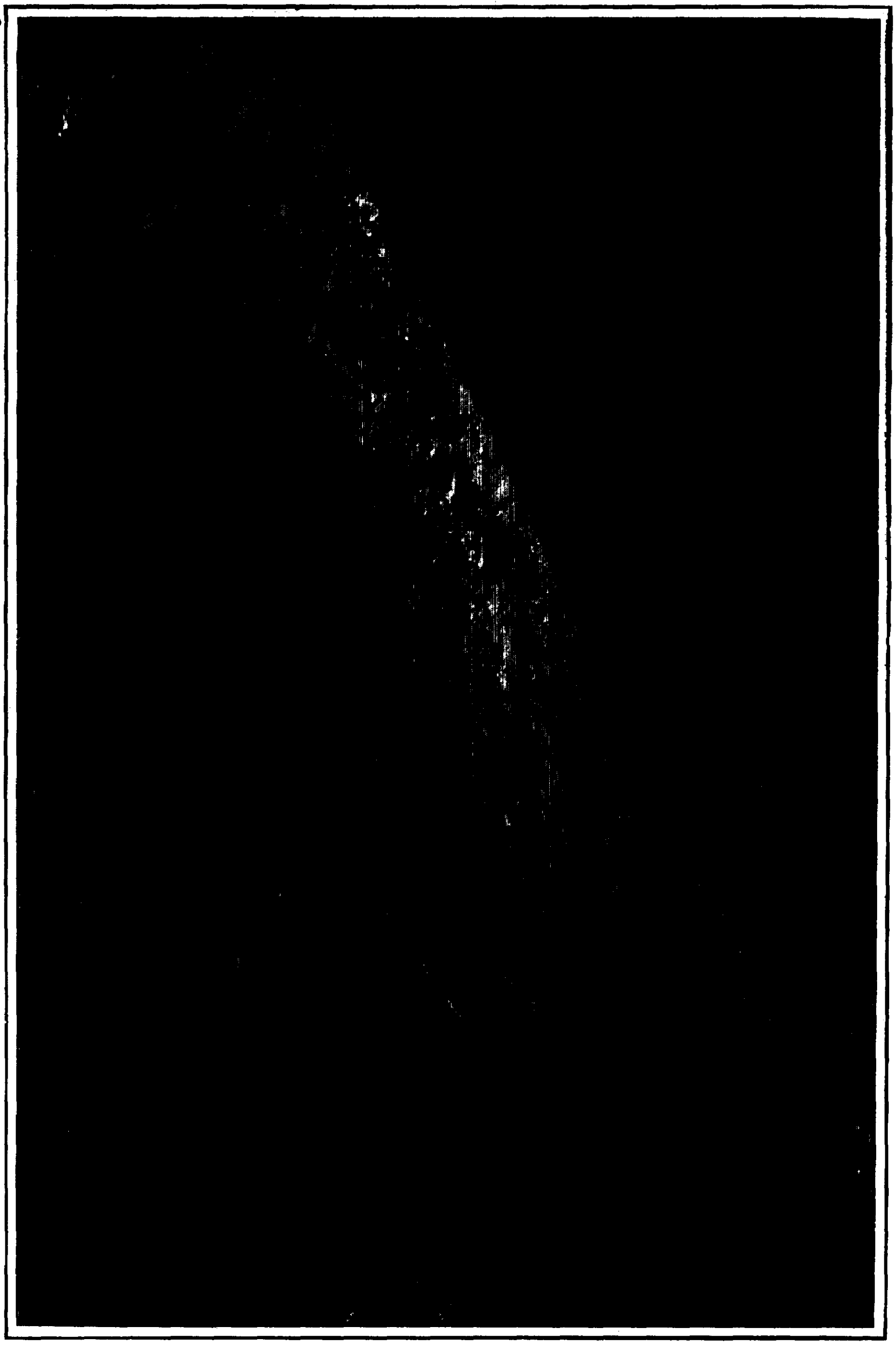
In the first three years of operations, high-grade ore was hand-sorted and shipped to smelters. The richness of the ore can be judged from shipments. In 1912 and 1913, 101.04 tons with a value of $46,221, or $457 per ton, were shipped to smelters. In 1914, 212.79 tons, with a value of $781,590.38, or $350.53 per ton, were shipped. After being hand-sorted, the remaining ore was treated in a 5-stamp mill by amalgamation, with a recovery of fifty-five per cent. The tailings from this treatment were impounded and later treated in the 100-ton cyanide plant in operation in March, 1915. The operations of the small stamp mill may be judged from the statement that during 1914 there were treated 3,493 tons of ore with a head value of $22.35 per ton for a recovery of $43,053.84. The ore raised from the mine in 1914 had an average value of $41.18 per ton.



Cross-section, showing old workings on Nos. 2 and 3 veins, illustrating the occurrence of ore near contacts of the conglomerate and feldspar porphyry, Tough-Oakes Burnside mine.

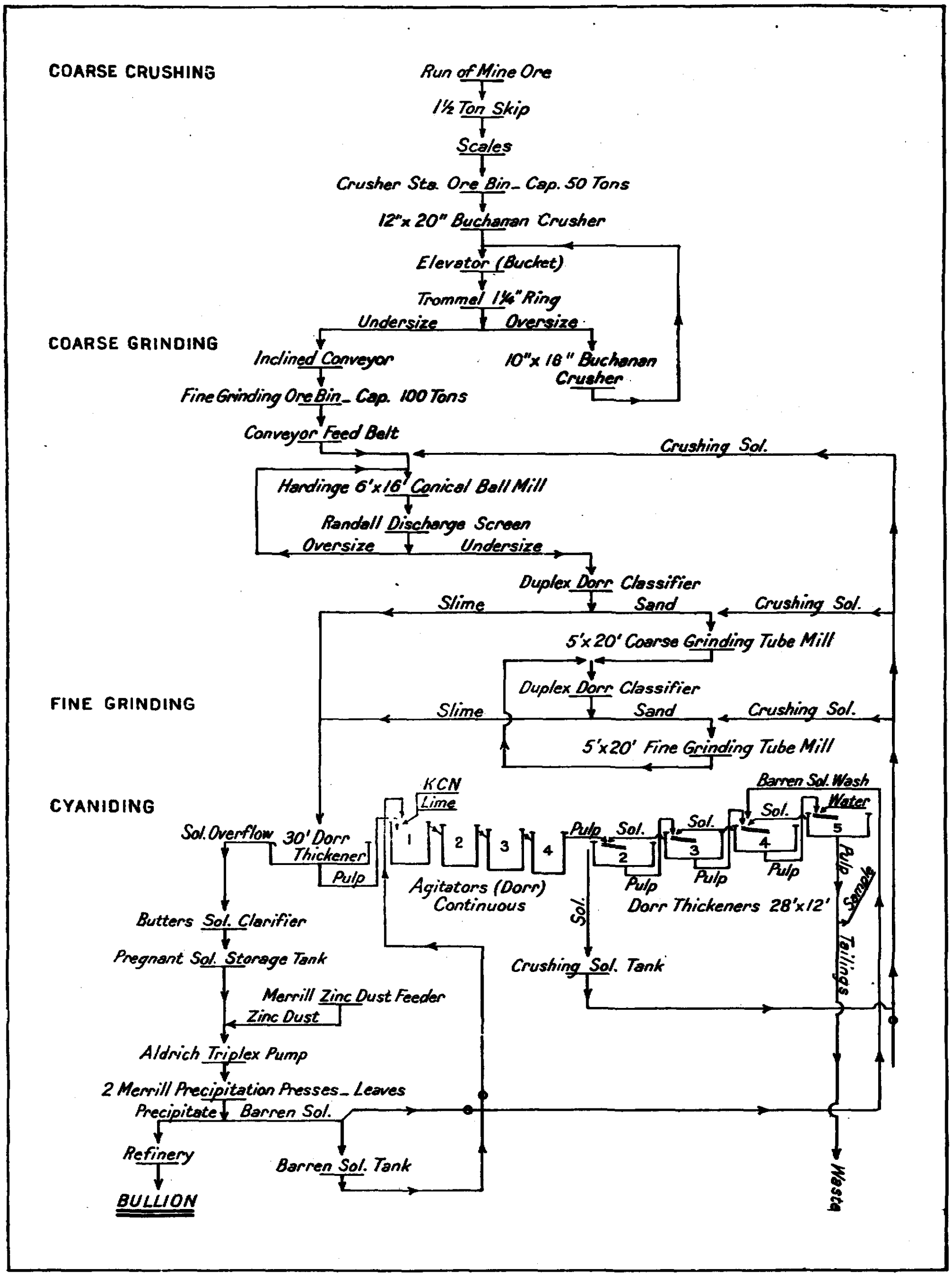
The veins that were developed were comparatively narrow, and the average stoping width was about five feet. An idea of the value of the ore along drifts is obtained from statements in annual reports of the company. For instance, in No. 2 vein one section of ore on the 200-foot level had an assay value of $78 for a length of 218 feet and a width of sixty-five inches. A section on the same vein on the 300-foot level showed an assay value of $32 over sixty-five inches; 180 feet of drifting on vein No. 3 on the 200-foot level had an assay value of $32 over a stoping width of sixty-three inches.

The early development was on No. 2 vein, the first work being an open-cut, from which the first shipments of high-grade ore to smelters were made. An incline shaft (A) was then sunk on the vein, which has a dip of 55° S., and the main ore shoot developed on four levels. The workings that started in conglomerate passed into porphyry, and the high-grade character of the ore was maintained. In drifting westward on different levels, the ore was cut off abruptly by a basic dike, a few feet in width, that strikes N. 20° W. and dips nearly vertically. Within the dike, there are heavy fault planes. The dike was encountered 295 feet west of the shaft on the 200-foot level. The extension



Tough Oakes Burnside mine, No. 3 vein, as exposed on the east side of the shaft between depths of 61 and 67 feet. The vein is in the porphyry, the fractured character of which is shown in the illustration.

of the vein on the west side of the dike has never been determined. The dike is known to have displaced a strong east and west fault, dipping 87° S. on the Burnside to the south, a distance of only about eight feet horizontally; while No. 11 vein, with a dip of 80° S. on the Tough-Oakes 180 feet north of No. 2, has been apparently faulted only very slightly. In view of these facts, it may be that the displacement has been largely in a vertical direction. Another



Flow-sheet of mill at Tough-Oakes Burnside mine. The capacity is 100 to 125 tons of ore daily.

theory is that the north-south basic dike may have acted as a dam for the mineralizing solutions in some of the veins. The main ore shoot on No. 2 vein has a stope length of about 250 feet on the 300-foot level. The easterly margin of the ore shoots indicates a pitch to the west. Ore shoots were also developed on subsidiary veins to No. 2.

Shaft B was sunk on No. 3 vein, which also dips to the south, and development continued below the 100-foot level by means of a number of winzes to the 400-foot level. The main ore shoot on No. 3 vein also pitches to the west. No. 6 vein and other parallel veins near No. 3 vein were also opened from the workings at B shaft.

The workings on No. 3 and parallel veins are connected with A shaft on No. 2 vein by a long crosscut on the 200-foot level.

Gold-bearing ore from vein No. 2 in the conglomerate, Tough-Oakes Burnside mine. The specimen shows the repeated fracturing to which the vein has been subjected.

Following the amalgamation of the Tough-Oakes and Burnside mines, development was carried on from No. 3 shaft of the latter property. This shaft was connected with A shaft at the 400-foot level and also gradually carried to a depth of 1,025 feet. Vein structures have been intersected at intervening levels and drifted on. Much work was done on the main break, which extends northeasterly from the Sylvanite property. On the Tough-Oakes this is known as No. 1 vein, in which the original discovery of visible gold was made. The north-south basic dike, which lies about 340 feet east of the west boundary of the Tough-Oakes, appears to limit the main break in this direction. The 100- and 200-foot levels are on Tough-Oakes ground, while the lower levels are on the Burnside, owing to the south dip of the vein. Stopes have been opened up on lenses of ore at several levels to the 1,025-foot level horizon. Development has proceeded on several other veins, including No. 11, which occurs in the conglomerate greywacké, an ore shoot of 250 feet in length having been opened up on the 400-foot level. Mention may be made of the vertical fault vein lying below No. 2 vein and vein No. 18 in which some ore was developed. The mill, treating about 100 tons daily, was reopened in September, 1924, the ore being raised from No. 3 shaft.

Townsite Mine

During the greater part of 1924, the Anglo-Canadian Explorers, Limited, continued operations at the Townsite mine, situated at the east end of Kirkland lake. From a shaft 317 feet in depth, lateral work was done on the 150- and 300-foot levels.

A northwest-southeast crosscut 645 feet in length was run at right angles to the general trend of the formations on the 300-foot level. This cut two narrow bands of feldspar porphyry and penetrated the large mass of feldspar porphyry which extends across the Wright-Hargreaves property near the north line; short drifts were also run on vein structures from the crosscut. The most promising of these lies thirty feet south of the shaft in drift No. 304, which extends southwesterly for 120 feet in the sediments. Two shallow winzes were sunk on the vein material, which contains fine-grained pyrite and shows some gold values over widths up to thirty-five inches. The structure dips 45° S.E. The rocks exposed underground are dominantly Timiskaming sediments intruded by bands of massive feldspar porphyry. Some diamond-drilling was done from the surface.

John McPhee is superintendent.

Kirkland Combined

The Kirkland Combined Mines operated the Day claims, L. 6,526 and L. 6,527, which adjoin the Sylvanite on the north and corner the Tough-Oakes on the northwest. These two claims were formerly known as the Wishman claims, and considerable trenching and surface sampling were done in 1913 under the supervision of H. E. T. Haultain. The claims, which were allowed to revert to the Crown, were restaked and operated in the autumn of 1919 by the Kirkland Combined Mines under the direction of W. F. Greene and A. W. Greison. Air was delivered from the electrically driven compressor on the Sylvanite.

The west claim is practically all lamprophyre, while the east claim, L. 6,527, on which most of the work has been done, has about equal proportions of conglomerate, lamprophyre, and porphyry. Extending along the porphyry-lamprophyre contact and passing into the lamprophyre to the west is a pronounced fracture zone, which is five feet wide and traceable on the surface for over 500 feet in an east-west direction. Veinlets of quartz and considerable iron pyrites and some molybdenite occur in the fault zone. Samples yielding low gold contents on assay have been obtained from a few places in the vein. By diamond-drilling it was found that the fracture zone was mineralized with pyrite to a depth of about 200 feet. At a point on the surface where the vein passes from the lamprophyre into the porphyry-lamprophyre contact, a vertical shaft was sunk to a depth of 200 feet, and a 106-foot crosscut was driven to the south. The vein passes out of the shaft on the south wall at a depth of eighty-five feet. In the crosscut on the 200-foot level, two nearly parallel mineralized fractures were encountered, twenty and forty feet, respectively, south of the shaft upon which drifting is being done, the south fracture being on the porphyry-lamprophyre contact.

Black

The Black claim, L. 2,728, lies immediately south of the Wright-Hargreaves east claim. Near the north boundary is a vein striking northeast in the conglomerate, on which a shaft has been sunk to a depth of 155 feet. No mining has been done since 1917. The vein, which is mineralized conglomerate with quartz stringers, is lenticular and narrow. It is said to contain in places high-grade ore over a width of four or five inches.

Kirkland Rand

The Ontario Kirkland Gold Mines operated for some years two claims, L. 2,678 and L. 2,679, formerly known as the Hurd claims, which are situated about three-quarters of a mile south of the Wright-Hargreaves. These claims were optioned during the early part of 1917 to La Rose Mines, which stripped and sampled a part of the surface and sank a 100-foot shaft on the main vein, after which the option was dropped. The Ontario Kirkland Company continued the shaft to a depth of 450 feet and performed considerable work at different levels on vein structures in the altered sediments and porphyry. Several strong faults were found to displace the veins. A 100-ton cyanide plant was erected on the property.

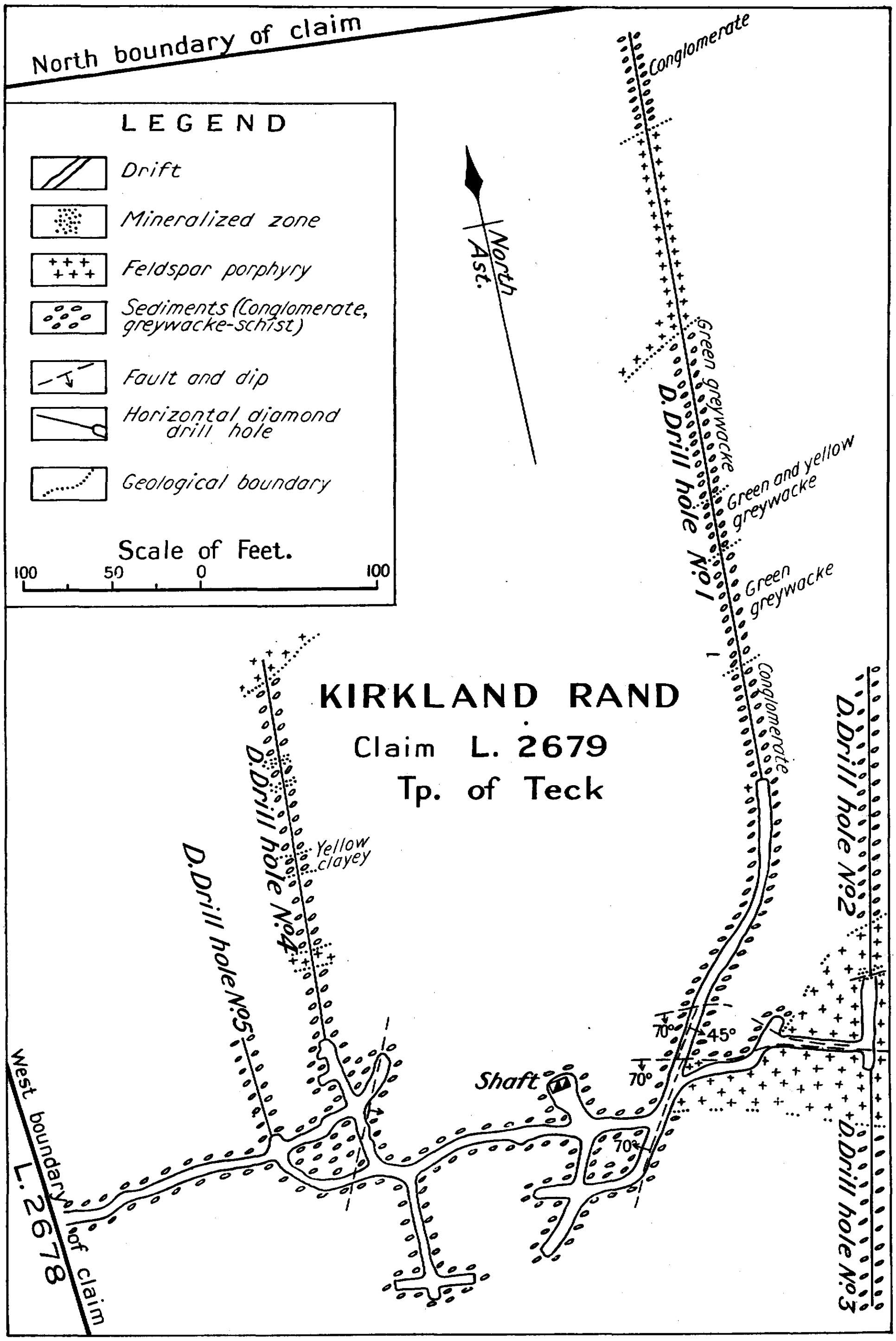
The rocks consist of schistose conglomerate and greywacké, which have been intruded by typical reddish feldspar porphyry. The largest porphyry mass in the area extends across the northern part of the property. It is 250 feet wide on the surface and one-half that width where it has been pierced by a diamond-drill hole on the 300-foot level. The porphyry in the southwest part of L. 2,678 is unusually schistose.

The Ontario Kirkland, after producing $10,082 during January and February, 1921, ceased operations and was taken over by the Montreal Kirkland, whose claims were situated immediately to the south. The new company was called the Montreal-Ontario. Diamond-drilling in the spring of 1923 revealed a highly silicified gold-bearing zone in porphyry in the northeast part of claim No. L. 2,679. Later, in crosscutting on the 450-foot level, two "veins" some twenty-five feet apart were encountered. The ore consists of fractured red feldspar porphyry with numerous quartz veinlets and much coarse-grained copper pyrites and smaller quantities of iron pyrites, molybdenite, and gold. What is believed to be the upper continuation of the vein has been found on the 300-foot level about 325 feet northeast of No. 1 shaft.

A company known as Kirkland Rand, Limited, incorporated April 9, 1924, and with head office at 46 Bank of Ottawa Building, Montreal, superseded the Montreal-Ontario Company. This new company has eight claims, or 314 acres, and the capitalization is $3,500,000. The mine superintendent is W. R. Osborne.

Hunton

The Hunton property is situated nearly a mile south of the southwest end of Kirkland lake and consists of two claims, 16,621 and 16,620. A porphyry dike with strike N. 66° E. intrudes the schistose sedimentary rock near the line between the claims; most work has been done so far on the northerly claim, 16,621. A mineralization occurs along the south contact, extending into both formations. An open-cut was made along a series of narrow quartz veinlets one to three inches wide, which intersect the sediments and porphyry, the cut passing from the sediments to the porphyry to the northeast. A shaft was sunk to a depth of forty feet in the sediment with the porphyry on the north wall. The mineralization is reported to extend to the bottom of the shaft, while visible gold was encountered down to about thirty feet. Diamond-drilling indicated gold in the core from a depth of 254 feet from the surface, vertically. By open-cuts and pits, the mineralization has been traced for 300 feet along the surface. Just northeast of the shaft, three quartz stringers dipping south are exposed in the open-cut; while twenty-five feet from the shaft there is a quartz vein two inches wide running diagonally across the trench, N. 30° E. in the porphyry, carrying extremely rich showings of gold with pyrite. The gold is very fine, almost like "mustard" gold, and shows as a yellow stain throughout



Plan of the 300-foot level, Kirkland Rand gold mine, showing drifts, crosscuts, horizontal diamond-drill holes, geology, and faults.

the quartz. The porphyry and quartz along the rich streak carry abundant iron pyrites. This mineralization is adjacent to a fault plane that strikes in the same direction as the vein.

H. M. Porteous is in charge of the property.

A vertical shaft has been sunk to a depth of 400 feet and stations cut at 125, 250, and 275 feet. The vein, which dips steeply to the south, has been drifted on at the first level for 250 feet and much quartz, pyrite, molybdenite, and films of specular hematite were observed. About 4,000 feet of diamond-drilling has been done from the third level in exploring the ground lying principally to the north of the shaft. A crosscut was driven northward to intersect a mineralized zone containing promising gold values, which had been discovered in the drilling operations. This crosscut is 1,050 feet in length and, for the greater part of this distance, is in conglomerate which replaces the porphyry 140 feet to the north of the shaft. At a point approximately 800 feet along the crosscut, the conglomerate is intruded by a dike of brecciated porphyry fifty feet in width. Movement has taken place along the plane of the dike, resulting in the development of sheared zones in the porphyry along which considerable mineralization, principally in the form of pyrite, is in evidence.

About 500 feet of drifting has been done along a narrow pyritized break in proximity to the conglomerate-porphyry contact north of the shaft. A crosscut was also driven south from the shaft 200 feet to the southern contact of the porphyry with conglomerate. In all, the workings on the 375-foot level total about 1,800 feet.

Kirkland-Kalgoorlie (Honer)

This property, claim L. 5,433, is located just west of the Hunton. The rocks are sediments intruded by narrow dikes of red porphyry striking northeast and southwest. Several quartz veins have been found, the principal one of which is in the southwest part of the claim. It has been traced about 300 feet and prospected by means of several pits and a shallow prospect shaft. It occurs in schistose sediment on the northwest side of a porphyry dike. Where seen in one pit, the structure shows a somewhat banded character of quartz veinlets in the sediment over a width of six feet, with the wider quartz bands toward the centre of the deposit. The quartz veins dip 70° to 80° S.E., and the best values are reported to occur in the footwall side in the narrow seams of quartz. The principal metallic sulphide is iron pyrites. A working shaft was being sunk near the northeast end of the exposure of the vein. The property was active in 1919.

Canadian Kirkland

The property is situated a few hundred feet south of the Swastika-Kirkland Lake road, one mile and a quarter southwest of Kirkland lake. The surface exposures are schistose sediments, conglomerate, greywacké, and slate, intruded by narrow dikes of red feldspar porphyry and a younger diabase dike that runs southwest through the property. There is a thin mantle of drift on much of the surface, requiring trenching to expose the rocks. Two vertical shafts and several pits have been sunk on mineralized zones. The main shaft on claim L. 6,687, fifty feet from the north line, was sunk on a mineralized zone in the greywacké, consisting of quartz veinlets and greywacké impregnated with iron pyrites, copper pyrites, galena, and calcite. The strike of the mineralized zone is east-northeast and west-southwest. A section exposed in the shaft shows a series of quartz veinlets about one inch wide, dipping steeply to the south across the shaft to the 150-foot level. A short crosscut was made southward at the

100-foot level, and on the 150-foot level a crosscut was made to the north and south of the shaft. Promising assays were obtained for about eighty-five feet in the shaft, but no drifting was done to determine whether the mineralized zone pitched eastward or westward. The crosscut at the 150-foot level is in greywacké with fine-grained, slate-like rocks eighty-five feet south of the shaft.

The property was under option to the Crown Reserve Mining Company in 1919. At a later date the shaft was continued to a depth of 400 feet.

Highland Kirkland

This company owns a large group of claims extending from the Kirkland Rand to the Canadian Kirkland. In 1922, two diamond-drill holes, each 1,000 feet in length, were put down on claim L. 1,356. The cores are dominantly fine-grained hornblende syenite and red and yellowish felsite, with some grey feldspar porphyry, pegmatite, aplite, and veins of rusty carbonate and quartz with pyrite. Mr. Barney, the manager, reports that assays of a few dollars in gold per ton were obtained from a number of the veins.

Early in 1923, a shaft was sunk 100 feet with an inclination of 65° to the south on claim 16,555. The vein occurs near the contact of reddish felsite and Timiskaming conglomerate and greywacké. Drilling was done by steam.

Goodfish Lake Area

Goodfish lake lies two miles northeast of Kirkland lake. Gold was found on the Costello claim, L. 2,194, in 1912 shortly after the discovery of gold on the Tough-Oakes. References to the area may be found in several of the publications of the Ontario Department of Mines.[1] The deposits are narrow, lenticular quartz veins and sheeted zones along the contacts of Keewatin basic volcanics and Algoman quartz-feldspar porphyry. The various properties, La Belle Kirkland, Fidelity, Brennan, Costello, and Martin, have all been described. The last three have been consolidated into the Goodfish Gold Mines; the latter property and the Providence were the only two properties operating in 1922.

Goodfish Gold Mines (2,184, 2,232, 2,603, 2,195, 2,194, 2,202 and 2,571).—All work on this property was confined to the Martin claim, No. 2,232. An inclined shaft has been sunk on the vein to a depth of 200 feet, and about 500 feet of lateral work has been done at the 200-foot level. The deposit consists of numerous narrow quartz veinlets across a width of six feet, carrying much pyrite and molybdenite in a basalt-porphyry contact striking N. 30° E. and dipping 65° to the N. 60° W. The plant consists of a 5-drill compressor and hoist. E. Martin is president and manager. All work was suspended in February, 1923.

Providence (L. 2,758).—An inclined shaft has been sunk 100 feet on a contact deposit with porphyry on the footwall and greenstone on the hanging-wall. Sinking was done by hand and hoisting by steam. In 1923, a new shaft was commenced on claim 2,632 to the north.

[1]Vol. XXIII, pt. 2, 1914, p. 31, and map No. 23a; Vol. XXV, pt. 1, 1916, pp. 260-263, with accompanying geological map, No. 25 f, "Goodfish Lake Gold Area"; Vol. XXIX, pt. 4, 1920, pp. 20, 46.

Swastika Area[1]

Rich showings of gold were found on the Lucky Cross (now Kirkland Gateway) and Swastika properties in 1910, one year previous to the discovery of gold at Kirkland lake. These prospects are equipped with steam power-plants and small mills. Some bullion has been produced. The gold occurs with pyrite, molybdenite, etc., in quartz-calcite veins and lodes in Keewatin green schists, near the contact with Algoman red feldspar porphyry dikes.

The *Swastika* mine (R.S.C. 204 and N. ½ lot 9, concession VI, Otto township) has a 3-compartment vertical shaft, 400 feet deep, with considerable lateral work on the 35-, 100-, 200-, 300-, and 400-foot levels. Some gold was recovered in a 10-stamp mill, the ore coming largely from two small shoots.

The *Kirkland Gateway*, formerly known as the Lucky Cross or Marigold, owns several claims, namely, T. C. 59 (2,693), T. C. 58 (2,696), T. C. 57 (2,692), H. R. 587 (12,088), etc., near Swastika village. In 1911 and 1912, some gold was recovered in a 5-stamp mill, the ore coming largely from vein No. 16 in the vicinity of the main shaft and from No. 5 vein on the 100-foot level to the west. During 1922 and 1923, several men were engaged in constructing buildings and in doing diamond-drilling and underground development under the supervision of R. Jowsey. The main inclined shaft has been sunk to 360 feet, and much lateral work accomplished on the 100- and 200-foot levels. The shaft follows the vein down below the 100-foot level. On the 200-foot level, the main vein is twenty feet east of the shaft. Lateral work is now being done on the 350-foot level. Numerous veins and faults were encountered in all levels.

Baldwin.—The Baldwin is located to the west of the map-sheet on the railway two and half miles west of Swastika station and consists of the N. ½, lot 2, concession VI, Eby township. The rocks are Keewatin basalt schists and Timiskaming sediments intruded by syenite and reddish feldspar porphyry dikes. In these rocks have been located several small gold-bearing veins, striking nearly east and west, with a mineralization somewhat similar to the Swastika and Kirkland Lake deposits. Extremely fine-grained gold was seen in quartz stringers on the surface and on the 100- and 200-foot levels. These veins are being drifted on at the 200-foot level, and a long crosscut is being made to the north.

[1]E. L. Bruce, Swastika Gold Area, Ont. Bur. Mines, Vol. XXI, pt. 2, 1912, pp. 256-265; A. G. Burrows and P. E. Hopkins, The Kirkland Lake and Swastika Gold Areas, Ont. Bur. Mines, Vol. XXIII, pt. 2, 1914, p. 20.

LEBEL AND GAUTHIER TOWNSHIPS[1]

(Area between Kirkland and Larder Lakes)

By
Percy E. Hopkins

INTRODUCTION

The following report deals with the geology and mineral deposits of Lebel and Gauthier townships and the western part of McVittie township, the eastern extension of the Kirkland Lake gold area or the area between Kirkland lake and Larder lake. Much of this area was covered in a general way by the map of the Kirkland Lake and Swastika gold area, No. 23a, accompanying Part II of the Twenty-Third Report of the Ontario Bureau of Mines, 1914. Owing to the numerous gold discoveries that have since been made, it was thought desirable that a more detailed map of the whole area should be prepared. The mines and prospects are described in this report; notes have also been given on the working prospects in Katrine and Ossian townships, which lie north and northeast of Gauthier township.

The field work that was done during the season of 1922 was confined chiefly to Lebel, Gauthier, and the western part of McVittie. Although these three townships have not been subdivided into lots and concessions, practically the whole area has been surveyed into mining claims of approximately forty acres in size, which greatly facilitated the geological mapping. These claims, on a scale of twenty chains to the inch, were used as a base for plotting purposes. Most of the boundary lines were travelled and intervening traverses were made where the geology was complicated. Compass and pacing courses were made where there were no surveyed claims. A coloured geological map, No. 32e, on a scale of forty chains to the inch, accompanies this report. It extends from Swastika to Larder lake and covers 160 square miles.

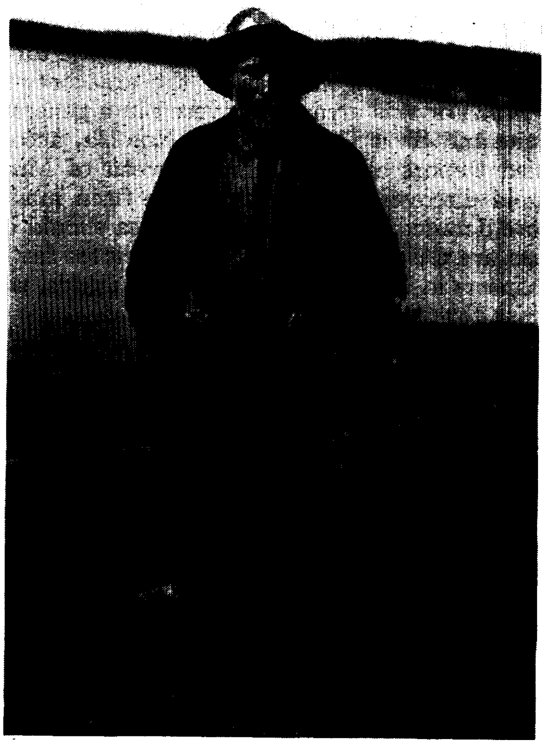
The writer was ably assisted by A. W. Carlyle, W. Greenwood, and K. B. Heisey. Mr. Carlyle also contributed to the report, notes on the petrology of the porphyries. Many thanks are due to the mining men of the area for courtesies extended to the party, particularly to the management of the Argonaut, Bidgood, Crown Reserve, King-Kirkland, and Queen Lebel mines. The assays and analyses mentioned in the report were made by W. K. McNeill and T. E. Rothwell, Provincial Assay Office.

Location and Access to Area

The area lies fifty miles north of Cobalt in latitude 40° 10′ north, between longitude 79° 40′ west and 80° 05′ west. Teck and Lebel townships and Goodfish lake, the western part of the area, are reached by good roads from Swastika, a station on the Temiskaming and Northern Ontario railway, sixty-three miles north of Cobalt. A good stage service operates over an excellent 7-mile

[1]This report was prepared in 1923, but it was deemed advisable to hold it until the Kirkland-Larder map, No. 32e, was available, and until the underground workings of the mines at Kirkland lake were re-examined. The map serves for the report on Kirkland Lake as well as for Lebel and Gauthier townships.

macadam road between Swastika and Tough-Oakes Burnside, the easterly mine at Kirkland lake. Kirkland Lake is a thriving community in the centre of the producing zone, with hotel accommodation, also local and long-distance telephone service. A fairly good road runs eastward from Kirkland Lake to the Bidgood mine; in a year or two this road will probably be extended to Larder Lake. The main road between Swastika and Dane has also been completed. In April, 1923, the T. and N.O. Railway Commission decided to construct a branch line from Swastika to Kirkland Lake and eastward to the Crown Reserve



Alexander McIntyre, one of the early prospectors in the Kirkland-Larder area and staker of the McIntyre mine at Porcupine.

and Associated Goldfields mines at Larder lake. The right-of-way location is shown on the map. This railway was placed in operation in November, 1924.

Gauthier and McVittie, the eastern townships, are entered from Dane station by way of the well-known Larder Lake road. Branch roads leave the main road for the Northland, Elstone-Dunkin, Tobico, Argonaut, and other properties. These roads are used by motor cars and trucks during the summer. Transportation will be much improved when the branch railway is completed. There is also a local telephone service between Dane, Larder Lake, and the Argonaut mine.

Both the Kirkland and Larder areas are supplied with hydro-electric power, the former from Cobalt and Long lake, and the latter from Raven falls.

History

The finding of gold at Larder lake in August, 1906, by Dr. Reddick, caused a rush of prospectors to the area, which resulted in claims being staked as far west as Swastika and at what is now known as Kirkland lake. During the next few years most of these claims were allowed to revert to the Crown; however, work was done on some, and as discoveries were made, the lands were again taken up. The outlines of Lebel, Gauthier, and McVittie townships were surveyed in 1907 by J. J. Newman, O.L.S. In the early years, the Reddick and Harris-Maxwell each produced a few thousand dollars in gold. In 1911 and 1912, the Swastika and Lucky Cross (now Kirkland Gateway) produced some gold. The first gold discovery in the vicinity of Kirkland lake was made in the autumn of 1911 on the Wright-Hargreaves. Since then six mines at Kirkland lake have been developed; from 1913, when production began, up to the end of December, 1923, these mines yielded gold with some silver valued at $10,384,166. The output by five producers during 1923 was $2,655,819 from 188,011 tons of ore milled. The Argonaut, formerly La Mine D'Or Huronia, has been developed almost continuously since its discovery in 1912 and up to the time the mill was burned, in the summer of 1921, had produced $33,062 in gold. A new 200-ton mill was completed in June, 1923, and during the remainder of that year produced an additional $72,512. In the year 1912, gold was found at Goodfish lake, where considerable underground work has been done on La Belle Kirkland, Fidelity, Providence, and Goodfish Gold Mines. The last two were the only ones operating in 1922. Since 1919, there has been considerable activity in Lebel township, particularly on the Bidgood, King-Kirkland, Lebel Oro, and more recently the Continental. In 1916, gold was found on the Elstone-Dunkin claim in Gauthier township, and considerable work was done during that year and again in 1922. In 1921, a rich showing was found three-quarters of a mile northeasterly on the Tobico. One of the most important finds was made in 1921 in the eastern part of the area on the Crown Reserve property near Pancake lake in McVittie township. The Canadian Associated Goldfields Company has taken over the adjoining Costello claim on which the first discovery of gold in that vicinity was made. The veins are being developed to depths of 550 and 700 feet, respectively, by the Crown Reserve and Associated Goldfields. During 1922 there were probably more prospectors in that area than in any previous year, and there is scope for their work for years to come.

It is interesting to note that the first real activity in gold prospecting in northeastern Ontario took place in Larder lake, through which passes probably one of the most favourable belts of gold-bearing rocks in the province. Here the first boom reached its climax in 1906. Gold at Swastika, Kirkland lake, Lebel, Gauthier, and Larder lake in Ontario; Lake Fortune, Rouyn township, and the Harricanaw area in Quebec, all occur along this general belt of rocks.

Previous Work

In 1902, W. G. Miller[1] gave a brief account of the geology of Larder lake (then called Lake Present), Blanche river, Beaverhouse lake, and Victoria lake. In 1904, W. A. Parks[2] also referred to the geology between Larder lake and

[1]Miller, W. G., Lake Temiscaming [Timiskaming] to the Height of Land, Ont. Bur. Mines, Vol. XI, 1902, pp. 214-230.

[2]Parks, W. A., The Geology of a District from Lake Timiskaming Northward, Geol. Surv. Can., Sum. Rept., 1904, pp. 198-225.

Beaverhouse lake. In 1907, R. W. Brock and N. L. Bowen[1] mapped the Larder Lake area. In 1909, a more detailed map was made by M. E. Wilson.[2] In 1911, E. L. Bruce[3] mapped the area in the vicinity of Swastika. During parts of 1913 and 1914, A. G. Burrows and P. E. Hopkins[4] made their first report on the Kirkland Lake area. The same writers described the Goodfish area[5] in 1916. In September, 1916, A. G. Burrows[6] revised a portion of the geology of Gauthier township and described the Elstone-Dunkin and La Mine D'Or Huronia (now Argonaut). In 1919, a second report was made on Kirkland Lake area, with a more detailed map, by A. G. Burrows and P. E. Hopkins.[7] During the same year C. W. Knight[8] made a detailed map of the Argonaut gold mine and mapped the townships to the north. In 1920, D. G. H. Wright[9] mapped several townships north of Kirkland lake. A detailed map of parts of McVittie and McGarry townships, Larder lake, was made in 1920 by H. C. Cooke.[10]

GENERAL GEOLOGY

The compact rocks are all pre-Cambrian. They have been glaciated and are thinly covered in places with Pleistocene deposits, largely of sand and gravel. In the western part of Gauthier township the sand covering is over 100 feet thick in places, with only an occasional rock outcrop.

The map-sheet comprises a small part of a long, narrow east-west belt of Timiskaming rocks which have been infolded in the Keewatin; these sediments which pass beyond the map boundaries, extend from Kenogami lake on the west nearly to Bell river, Quebec, on the east, a distance of 130 miles. For a distance of three or four miles near the Quebec boundary these rocks are covered by younger, flat-lying Cobalt sediments. The metamorphosed Timiskaming sediments with their strata, lying in a nearly vertical attitude, formed a zone of weakness into which numerous porphyry and related rocks, known as "gold bringers," have been intruded. The typical feldspar porphyry, which is so important at Kirkland lake, occurs at random throughout these sediments in Lebel, Gauthier, and McVittie townships, and abundantly in certain Keewatin areas, as at Goodfish and Beaverhouse lakes and elsewhere.

Following the Algoman epoch, considerable erosion and then submergence took place when the Cobalt sediments were laid down. Only a few erosion remnants of these rocks now remain. Following the Cobalt epoch came an intrusion of Keweenawan (Nipissing) diabase. The diabase dikes are rare, only two or three of them being found in each township. Some of these dikes may be of Matachewan age or older.

The rocks of the area have been subdivided in the following table according to their relative ages, the oldest being placed at the bottom.

[1]Brock, R. W., The Larder Lake District, Ont. Bur. Mines, Vol. XVI, pt. 1, 1907, pp. 202-220 Bowen, N. L., Ont. Bur. Mines, Vol. XVII, 1908, pp. 10-11.

[2]Wilson, M. E., Larder Lake District, Geol. Surv. Can., Mem. No. 17, 1912.

[3]Bruce, E. L., The Swastika Gold Area, Ont. Bur. Mines, Vol. XXI, 1912, pp. 256-265.

[4]Burrows, A. G., and Hopkins, P. E., Kirkland Lake and Swastika Gold Areas, Ont. Bur. Mines, Vol. XXIII, pt. 2, 1914, pp. 1-39.

[5]Burrows, A. G., and Hopkins, P. E., Goodfish Lake Gold Area, Ont. Bur. Mines, Vol. XXV, pt. 1, 1916, pp. 260-263.

[6]Burrows, A. G., Gold in Gauthier Township, Ont. Bur. Mines, Vol. XXVI, 1917, pp. 252-257.

[7]Burrows, A. G. and Hopkins, P. E., Kirkland Lake Gold Area, Ont. Dept. Mines, Vol. Vol. XXIX, pt. 4, 1920, pp. 1-48.

[8]Knight, C. W., Argonaut Gold Mine, Ont. Bur. Mines, Vol. XXIX, pt. 3, 1920, pp. 65-76; Ben Nevis Gold Area, ibid., pp. 1-27.

[9]Wright, D. G. H., Black River Area, Ont. Dept. Mines, Vol. XXX, pt. 4, 1921, pp. 27-62.

[10]Cooke, H. C., Larder Lake District, Geol. Surv. Can., 1922, Mem. No. 131.

Table of Formations[1]

PLEISTOCENE—	
GLACIAL AND RECENT	Clay. Sand, gravel, and boulders.
PRE-CAMBRIAN—	
KEWEENAWAN (?)	Quartz diabase and olivine diabase dikes.
	Intrusive contact
ANIMIKIE (Cobalt series)	Conglomerate, arkose, quartzite, greywacké, and slate.
	Great unconformity
ALGOMAN[2]	Red and grey feldspar porphyry dikes, sills and stocks, syenitic and felsitic in places.[3] Reddish felsite, syenite, lamprophyre, and feldspar porphyry, intimately mixed.[4] Black lamprophyre grading occasionally into a reddish lamprophyre or syenite. Granite porphyry and quartz porphyry. Hornblende-mica granite and syenite, hornblendite, diorite and diorite porphyry. Serpentine.[5]
	Intrusive contact
TIMISKAMIAN	Schistose conglomerate, greywacké, quartzite, slate, and iron formation.
	Great unconformity
KEEWATIN	Iron formation and tuff. Altered andesite, andesite porphyry, rhyolite, quartz porphyry, and tuffs, differentiated on the map from the basic lavas. Altered basalt, dacite and diabase with subordinate amounts of andesite and rhyolite and carbonate schist.

Pre-Cambrian

Keewatin

An almost continuous outcrop of Keewatin lava borders the Timiskaming series on the north in Teck, Lebel, Gauthier, and McVittie townships. These volcanics extend northerly across many townships to Lake Abitibi and beyond. Similar rocks occur at intervals along the edge of the Timiskaming sediments in the southern parts of the same townships, except where they have been interrupted by the syenite bosses in Teck and Lebel townships or by glacial drift in Gauthier township. The rocks on the whole are quite massive; however, they are frequently schistose and rusty along the Keewatin-Timiskaming contact, or in the vicinity of certain porphyry or other intrusions. They comprise dark-green, highly altered basalt, dacite, diabase, and agglomerate, associated with which are light-green and grey andesite, andesite porphyry, rhyolite, rhyolite tuff, and quartz porphyry.

[1]The Keewatin, Timiskaming, and Algoman rocks have been altered in places to carbonate rocks which are indicated on the accompanying map.

[2]The Algoman intrusives are differentiates from one magma and associated with the gold mineralization.

[3]The feldspar porphyry in places contains sufficient quartz phenocrysts to be called granite porphyry.

[4]Included in this group, particularly in eastern Gauthier and McVittie townships, are certain rocks which resemble trachyte.

[5]The serpentine may be of two ages.

Basic Lavas.—The amygdaloidal and ellipsoidal structures are common in the basic lavas, while the spherulitic texture is rarely found. An example of spherulitic lava may be seen on the north shore of Doig lake in Lebel township. Owing to the green bush and other overburden, the contacts between the individual flows were seldom seen; however, the lavas are believed to lie in a nearly vertical attitude. The rock minerals are generally altered to chlorite, calcite, sericite, quartz, and leucoxene; a basaltic texture is frequently seen under the microscope. Much epidote occurs in the basalt at the Argonaut mine. A typical fine-grained basalt forms the northeast wall of the Costello vein on the Goodfish Gold Mines claim, No. L. 2,202, Morrisette township. The southwest wall of the same vein resembles a dacite.

Andesite and Rhyolite.—Accompanying the basalts in the northern parts of Teck and Lebel, and elsewhere, are large areas of coarse, massive, green, quartz-bearing rocks, chiefly quartz diabase, dacite, and andesite, which could not be mapped separately without considerable effort. One large area of these lighter-coloured rocks, lying between Timiskaming sediments and Keewatin basalts and extending northwesterly across Gauthier township, has been differentiated on the map. On the Argonaut road this andesite-rhyolite group of rocks is two miles in thickness, with the Argonaut gold veins in basalt on one side and the Timiskaming sediments on the other, or southwestern edge. The rocks seldom reveal any good pillow or other flow structures. Irregular areas of breccia and masses of agglomerate with bomb-like inclusions are common. The only pronounced amygdaloidal and pillow andesite was seen on claims Nos. L. 9,394 and L. 9,395 in central Gauthier township. Obscure amygdules may be seen in the andesite farther northeast, on the northeast corner of claim No. 8,793. When the country is burned over and studied more closely, no doubt the flow structure will be more clearly understood. Andesite occurs on claims L. 9,903 and L. 9,904 north of McTavish lake in Lebel township. Under the microscope can be seen phenocrysts of plagioclase set in a groundmass of feldspar, chlorite, calcite, and sericite. Dr. Cook refers to a porphyritic andesite at Malone lake in McVittie township.

Banded andesite tuff occurs on claim J. S. 133 east of Little Larder lake and on the Miller-Middleton claim, No. 9,502, near the central part of Gauthier township.

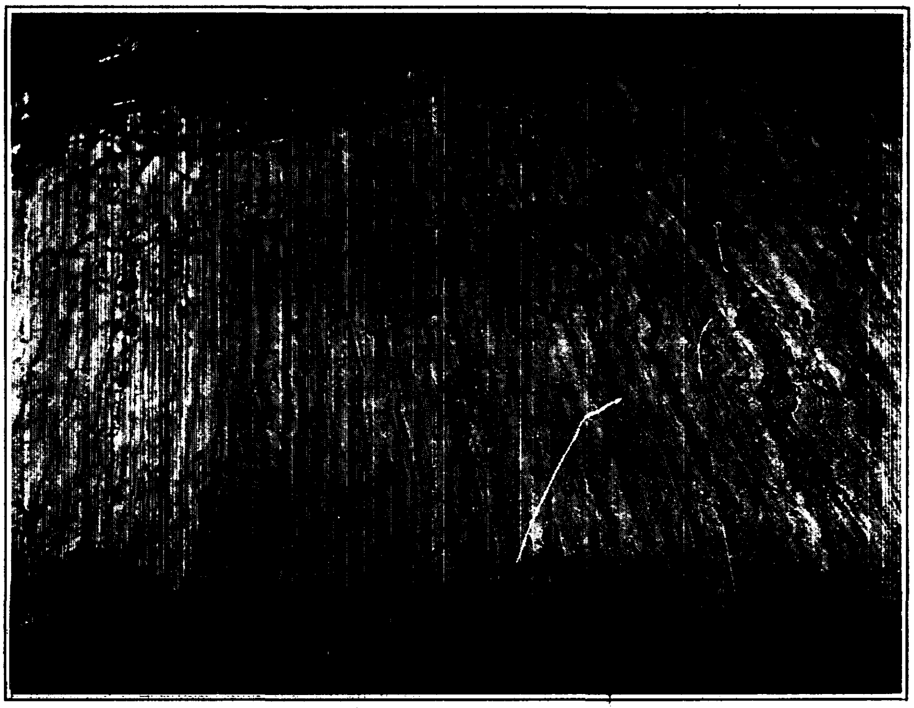
Typical rhyolite may be seen on claim No. 10,028 in the eastern part of Gauthier township. On the adjoining claim to the north, the rhyolite grades into a typical white quartz porphyry with quartz phenocrysts over half an inch across. Farther north, on claim No. 9,430, the quartz porphyry is quite schistose. The rhyolite and andesite near the large hornblende-syenite intrusion, on claims J. S. 129, J. S. 130, and 10,010, are highly altered and contain an abundance of secondary calcite or dolomite. The light-coloured volcanics of Gauthier resemble the andesites and dacites in Bayly, Skead, Catharine, and McElroy townships[1] and of Bryce township[2] where gold-bearing veins have been found in them. The andesites of McElroy township extend northwesterly into Boston township. The Hurd-Fishley veins in Ossian township are in andesite which has the following composition: silica, 68.84 per cent.; alumina, 13.79; ferrous oxide, 2.38; ferric oxide, 0.82; lime, 2.28; magnesia, 3.29; potash, 1.08; soda, 3.71; water, 0.98; carbon dioxide, 2.86; total, 100.03 per cent. These Keewatin light-

[1]A. G. Burrows and P. E. Hopkins, Boston-Skead Gold Area, Ont. Dept. Mines, Vol. XXX, pt. 6, 1921, pp. 5-6.

[2]A. G. Burrows and P. E. Hopkins, Blanche River Area, Ont. Dept. Mines, Vol. XXXI, pt. 3, 1922, p. 5.

coloured porphyritic rocks have undoubtedly furnished many pebbles for the Timiskaming conglomerate.

Iron Formation.—Isolated outcrops of iron formation, represented chiefly by black slaty tuffs, whitish chert, and interbands of silica, red jasper, and magnetite, form part of the Keewatin to the south of the Timiskaming series. These beds, which are indicated on the map, lie conformably on the Keewatin basalts and occur along one general course from northern Otto township to the Crown Reserve mine in McVittie township. The bands occurring in Boston township and along parts of the Dane-Larder road have been described by W. G. Miller,[1] A. G. Burrows and P. E. Hopkins,[2] and H. C. Cooke.[3] Some of the chert contains much disseminated iron pyrites, as on J. S. 127 in the south-



Iron formation of the Timiskaming series, north of Mud lake, Lebel township.

east corner of Gauthier township. Some red jasper and magnetite may be seen on claim C. E. 25, south of Pancake lake. The ore bodies of the Crown Reserve and Associated Goldfields are partly enclosed by a black slaty tuff which resembles true slates. Cherty rocks also adjoin the Elstone-Dunkin deposit.

Timiskaming Series

Lying unconformably and infolded with the Keewatin is a band of Timiskaming sediments, which with its extensions east and west has a length of over 100 miles and a width of about two miles. In addition, there are a few isolated

[1]Boston Township Iron Ranges, Ont. Bur. Mines, Vol. XIV, 1905.
[2]Ont. Bur. Mines, Vol. XXIII, pt. 2, 1914.
[3]Larder Lake District, Ontario. Geol. Surv. Can., Mem. No. 131, p. 21.

outcrops of this series near Doig lake in Lebel township, at Nettie lake[1] in Morrissette township, along the Larder road in Boston and McElroy, and in McVittie township. The Keewatin-Timiskaming unconformity is difficult to see owing to the contact being frequently drift-covered, faulted, or altered to schists, due to folding or by some intrusion. At two points, however, it can be seen clearly that the sediments are younger than the Keewatin, as has been pointed out in the preceding report on Kirkland lake. Farther east in central Gauthier township, on claims 9,394 and 9,395, the conglomerate can be seen lying on Keewatin andesite with numerous pebbles of the andesite showing in the upturned overlying conglomerates. The Timiskaming, on the whole, is more altered than the Keewatin. This may be due to the difference in the nature of the rocks and to the large volume of intrusives in the sediments.

The Timiskaming series comprises various bands of conglomerate, slate, greywacké, and quartzite, with the strata dipping nearly vertically. The rocks in places are quite schistose, the schistosity usually cutting across the bedding planes, as indicated in numerous places on the map. For instance, on the Queen Lebel the strike of the bedding is N. 95° E., whereas that of the schistosity is N. 35° E. There is a great variety of pebbles in the conglomerate, representatives of all the Keewatin rocks being present, together with syenite, granite, and quartz. The pebbles are generally rounded and several inches in diameter. Some of the matrix and certain layers in the conglomerate contain much dolomite or ankerite. Greywacké is the dominant rock in the series. Some of the impure quartzites or sandstones are reddish in colour, as on the Elliott-Kirkland and in the vicinity of Munro lake, Lebel township. Some of these fine-grained beds contain apparent ripple marks and mud cracks. Associated with the Timiskaming series is an occasional outcrop of interbedded chert, slate, and greywacké, resembling iron formation, as on the west end of Crystal lake and on claim L. 9,614 near the junction of the Argonaut road with the railway.

Algoman

The Algoman rocks are the most important ones in the area since the common magma from which they came has been the source of the gold. Moreover, most of the gold recovered at Kirkland lake has come from deposits in these rocks. They occur in great volume in the form of bosses, stocks, dikes, and sills and are represented by numerous varieties, namely, serpentine, hornblendite, granite, syenite, lamprophyre, diabase, diorite, diorite porphyry, feldspar porphyry, granite porphyry, quartz porphyry, felsite, etc. The writer has tried to separate many of these rocks on the map, but in places this is difficult to do owing to many types grading into one variety or another. Most of these rocks are clearly Algoman, but the age of the serpentine and some of the more basic varieties, not in contact with the Timiskaming, is not definitely known.

Algoman Rocks South of the Timiskaming Series

Serpentine.—Narrow dikes of serpentine cut the Algoman hornblendite and hornblende syenite on the Teck-Lebel boundary. Larger masses occur on the Boston-McElroy line to the south of the Dane-Larder road. Map No. 30d, published by the Ontario Department of Mines, shows considerable serpentine extending southeasterly across McElroy and Skead townships. Serpentine similar in appearance occurs to the north of Grassy lake in Gauthier

[1] Map No. 30c, Ont. Dept. Mines.

township, but this serpentine has been intruded by a porphyry dike; hence, there may be serpentine of two ages.

Various rocks of different ages have been in part altered to serpentine and carbonate. Among these may be mentioned the following: the Keewatin basic lavas on H. F. 100 and H. F. 101 at Pancake lake, the Keewatin tuffs occurring near the footwall of the ore body in the Crown Reserve and Associated Goldfields, the tufaceous greywacké on C. E. 19 north of Enright point, and the lamprophyres on the Queen Lebel and elsewhere.

Granite, Syenite, Hornblendite, Etc.—A stock-like mass of granite and syenite occurs along Murdock creek in Teck township. On the east side of the creek, the rock becomes a grey feldspar porphyry. Farther east near the two-mile post on the Teck-Lebel boundary, the rock becomes basic and is known as hornblendite, the hornblende crystals being in places over two inches across. Cutting this hornblendite are several narrow dikes of serpentine as stated above.

In the south part of Lebel township and the north part of Boston township is a boss of grey hornblende syenite which clearly intrudes the Timiskaming slates. The rock is a massive, coarse, grey, hornblende syenite, somewhat pinkish in places, and in parts containing large phenocrysts of orthoclase. Farther east near Grassy and Forks lakes are numerous dikes of hornblende syenite, diorite, and diorite porphyry, cutting the Keewatin. A large mass of red hornblende syenite occurs on claim No. 7,994, about one mile northwest of Larder village.

Granite Porphyry.—This is, in all probability, the most acid phase of the feldspar porphyry. The rock occurs as stocks and dikes in various parts of the area, being most prominent in the vicinity of Goodfish lake, where gold deposits have been found at the porphyry basalt contacts. The porphyry at Goodfish lake has been described by A. G. Burrows and the writer,[1] and the northeasterly extension of the porphyry masses in Morrissette township have been mapped by D. G. H. Wright.[2] Mr. Wright found that an analysis of the granite porphyry showed a silica content of 72.86 per cent.

Occasionally the pink feldspar porphyries grade into granite porphyries by the addition of quartz phenocrysts and biotite blades. Examples may be seen at the Lake Shore mine, Bidgood property, Argonaut mine, and on claim H. F. 138, McVittie township and elsewhere.

The granite porphyries near the Victoria Creek prospect in Gauthier township have in places a holocrystalline texture resembling granite.

The quartz-porphyry dikes on L. S. 191 and L. S. 417, near Pancake lake, McVittie township, may have altered the adjoining Keewatin basalt to ferruginous dolomite. One of these dikes was described by H. C. Cooke.[3]

A. W. Carlyle, who examined several thin sections of this porphyry, describes it as follows:—

> What in all probability is an acid phase of the feldspar porphyry is represented by a granite porphyry which in addition to the feldspar phenocrysts contains regular crystals and rounded grains of quartz.
>
> The quartz phenocrysts are remarkably free from inclusions and occasionally exhibit strain shadows. The feldspar phenocrysts consist of about equal amounts of orthoclase and oligoclase-andesine, and predominate over the quartz. The twinning is similar to that observed in the feldspar porphyry.
>
> A fine-grained mosaic of minute feldspar and quartz grains composes the groundmass. The accessories and the decomposition of this rock are similar to those of the feldspar porphyry described above.

[1]Ont. Bur. Mines, Vol. XXV, pt. 1, 1916, p. 260.
[2]Ont. Bur. Mines, map No. 30c, Black River Area.
[3]Can. Geol. Surv., Mem. No. 131, p. 47.

Lamprophyre, Syenite, and Feldspar Porphyry Occurring in the Timiskaming Sediments

These intrusives, which solidified from one parent magma in the order of decreasing amounts of silica, namely, lamprophyre, syenite, and feldspar porphyry, are described in the accompanying report on the Kirkland Lake area. These rocks extend easterly from Kirkland lake through Lebel and Gauthier townships and are of economic importance.

The intrusives occur as dikes, sills, and stocks up to three-quarters of a mile in width, the longer axes being parallel to the bedding planes in the Timiskaming sediments. These metamorphosed sediments lying in a nearly vertical attitude have been a zone of weakness through which the Algoman rocks have found their way into the earth's crust.

Lamprophyre, the basic phase, is cut in places by red syenite, while both these rocks are intruded by a reddish or greyish feldspar porphyry and felsite. In other places, as on the Continental, Lebel township, and in central Gauthier township, one may see the dark-coloured lamprophyric rock grade into a red syenitic type with many hybrid varieties.

Lamprophyre.—The lamprophyre is a black to dark grey rock frequently showing phenocrysts of augite, hornblende, or mica, in a groundmass of secondary feldspar, calcite, sericite, etc. The rock usually has a pitted surface due to the leaching of the ferromagnesian phenocrysts. Quite frequently it is traversed by numerous dikelets of red syenite, which stand out as ribs, giving the weathered surfaces a peculiar rough appearance.

Although the rock is usually massive, it is also schistose in places, as on the north shore of Gull lake, on the Queen Lebel, on claim L. M. 60 (central Gauthier), and in many places around Larder lake. Generally northeast of Kirkland lake, the lamprophyre has a diabasic appearance. At Larder lake, the basic portion of the magma is a diorite, while the acid phase is a diorite porphyry. These rocks are described in detail by H. C. Cooke.[1]

Several lamprophyres were found cutting the Timiskaming near Larder lake, but these dikes were too small to map. Since a lamprophyre dike was seen cutting the granite near Swastika, there are probably lamprophyres of different ages.

Generally the lamprophyre is not an ore container. At Kirkland lake, when one wall is lamprophyre ore may be present, but usually the values become low when the veins pass entirely into lamprophyre, as has been proven on the Tough-Oakes and Kirkland Lake mines. At the latter property, one good ore shoot passed into lamprophyre for a horizontal distance of 100 feet on the 800-foot level. Encouraging assays have been obtained in a quartz vein in a greenish lamprophyre on the Lebel Oro, Lebel township.

Syenite.—The syenite is a red hornblende syenite consisting largely of orthoclase with some secondary feldspar, chlorite, calcite, and other minerals. Considerable rock of this type can be seen on the accompanying map on the Continental property. A mass too small to map, but containing commercial ore shoots, occurs on the Teck-Hughes.

Syenite Porphyry or Feldspar Porphyry.—The syenite grades into a feldspar porphyry in which the feldspar phenocrysts are altered to albite, a more basic plagioclase and orthoclase. In other places, the porphyry intrudes the syenite and is the latest Algoman intrusive rock. As the amount of orthoclase decreases and the quantity of ferromagnesian minerals increases, the rock resembles a

[1]Can. Geol. Surv., Mem. No. 131, pp. 43-45.

diorite porphyry. As the phenocrysts disappear, the rocks resemble the syenite just described. Examples of localities having diorite porphyry are as follows: northwest corner of L. S. 110, Crystal lake; southeast corner of J. S. 127, Gauthier township; and the south boundary of Gauthier township where it is crossed by the Blanche river. The largest mass of diorite porphyry occurs at the Harris-Maxwell, and this has been described in detail by H. C. Cooke.

The porphyry which economically is so important at Kirkland lake is largely red in colour, there being only small amounts of the grey porphyry present. Similar porphyries extend easterly into Lebel and Gauthier townships. In Lebel township, the grey or more altered porphyry is commoner than the red variety. The porphyry near Mud lake, Lebel township, is almost one mile in width. An analysis of a sample of grey feldspar porphyry from the station on the 250-foot level of the King-Kirkland was found to have the following composition:—

	Per cent.
Silica	55.58
Alumina	14.73
Ferrous oxide	1.84
Ferric oxide	3.38
Lime	6.15
Magnesia	3.30
Potash	2.83
Soda	2.75
Carbon dioxide	6.73
Water	1.27
Sulphide of iron	1.50
Total	100.06

Gauthier township has considerable reddish-coloured porphyry. One of the largest masses of red feldspar porphyry, which has recently attracted the attention of the prospectors, extends in a crescent-shaped form from the outlet of Beaverhouse lake through Monocle lake to Bear lake in McVittie township. The porphyry, which in places contains sufficient quartz to be called granite porphyry, occurs as dikes and stocks cutting Keewatin and small amounts of Timiskaming rocks.

Feldspar Porphyry

A. W. Carlyle, who examined numerous thin sections, has furnished the following descriptions of the porphyries:—

These rocks in general have either a reddish or greyish colour and a well-pronounced porphyritic structure, although the latter is not always readily discernible to the naked eye.

These rocks contain phenocrysts of oligoclase-andesine and orthoclase in a groundmass composed of the same minerals.

Iron ores, small amounts of quartz and apatite are present as accessories, together with variable amounts of an undeterminable ferromagnesian mineral which is now completely altered to chlorite and carbonates. Other secondary minerals present are sericite (derived from the feldspar) and leucoxene.

The orthoclase and oligoclase-andesine phenocrysts have usually good idiomorphic outlines, the orthoclase being quite frequently twinned according to the Carlsbad law, and the oligoclase-andesine generally showing albite and occasionally pericline twinning, which in many cases is very faint.

These phenocrysts average from about one-twentieth to one-tenth of an inch in length and are rarely longer than one-quarter of an inch (the oligoclase-andesine being in excess); the groundmass is a mosaic of minute feldspar grains with subordinate quartz.

The relative proportion of groundmass to phenocrysts is extremely variable. In some cases the phenocrysts are sparsely scattered throughout groundmass, while in others they occupy more than fifty per cent. of the rock volume. They sometimes develop a good zonal structure. The accessories, not being remarkable in any way and being present only in very subordinate amounts, need no further elaboration.

All the feldspar porphyries examined showed evidences of alteration. In some cases the rock is comparatively fresh, while in others the alteration is intense.

This alteration is evidenced by the breaking down of the orthoclase to form sericite, the plagioclase to sericite with some carbonate, and any ferromagnesian mineral to an aggregate of chlorite and carbonates.

Leucoxene is usually present and in all probability is derived from the black iron ore, which is thus shown to be titaniferous.

Penninite is often associated with ordinary chlorite in the more altered phases in which the feldspar phenocrysts alter almost entirely to masses of fine sericite needles and small patches of carbonate, sericite and irregular carbonate aggregations being also developed extensively in the groundmass.

The normal order of crystallization has been followed.

Diorite Porphyry

The basic phases of the feldspar porphyry are represented by a diorite porphyry. This rock resembles the feldspar porphyry in many respects, due to its greater basicity; however, the ferromagnesian minerals are present in greater abundance and orthoclase is less prevalent.

In the field it may be distinguished from the feldspar porphyry in general by its colour, which tends to be greenish rather than red or grey. Small altered green phenocrysts of hornblende or some other ferromagnesian mineral can usually be seen.

The ferromagnesian mineral, even in the freshest phases of this rock, is altered somewhat and in most cases is completely decomposed to chlorite and carbonates. Hornblende is the predominant ferromagnesian mineral, with occasionally small quantities of biotite.

Secondary carbonate is formed usually in greater abundance than in the feldspar porphyry.

A few small grains of epidote and occasionally some sphene are also present.

From field evidence and from the microscopic study of these rocks, it is clear that the feldspar and diorite porphyries are differentiation products of the same magma, as all gradations from one to another are found.

The gradation between the feldspar porphyry and the granite porphyry, however, is not as evident. In all probability the granite porphyry is an acid phase of some of the common magma, but the possibility of there being a difference in their age of intrusion must not be lost sight of.

Lamprophyre, Syenite Porphyry, Felsite, and Trachyte (?), Undifferentiated on the Map

Many of these rocks are so intimately mixed that it was almost impossible to separate them in mapping, hence they have been grouped together. They extend almost continuously from the Harvey-Kirkland, south of Gull lake, easterly across Lebel and Gauthier townships and into McVittie township. In fact the so-called feldspar porphyry on the Highland Kirkland in Teck township may belong to this group.

In McVittie and McGarry townships, H. C. Cooke has made a detailed map in which these rocks are shown as a lava, soda trachyte. The writer did not examine enough of Mr. Cooke's area to satisfy himself whether the rocks are lavas or an intrusive with various differentiation phases.

The analyses of some of these rocks are as follows:—

	No. 1	No. 2	No. 3
	per cent.	per cent.	per cent.
Silica	54.43	47.59	52.74
Alumina	20.36	14.92	17.96
Ferrous oxide	1.90	3.69	3.87
Ferric oxide	4.90	5.85	5.66
Lime	2.12	6.38	4.12
Magnesia	0.73	2.26	3.76
Soda	3.52	3.66	5.63
Potash	8.02	5.72	1.93
Water (combined)	1.68	0.72	2.72
Carbon dioxide	2.56	9.35	1.54
Total	100.22	100.14	99.93

No. 1. Altered diorite porphyry from northeast shore of Crystal lake. The rock resembles a felsite with altered green phenocrysts.

No. 2. Red felsite at shaft, Wood-Kirkland property, Lebel township.

No. 3. Typical greenish hornblende syenite with a reddish hue from portage between Marjorie and Binney lakes.

Carbonate Rocks

Isolated areas of carbonate rocks, composed almost entirely of secondary minerals, namely, carbonate of lime, magnesium, and iron, occur in the area. They are more abundant and sometimes contain gold in the Larder Lake area, hence they are more fully described in the report on that area. The presence of carbonate pebbles in the basal conglomerate of the Timiskamian series on the Miller-Middleton claim, No. L. 9,394, Gauthier township, suggests that the carbonization took place in the Keewatin period, although it is pointed out in the succeeding report on Larder Lake that most of the carbonization took place during the Algoman epoch.

Animikie (Cobalt Series)

The Cobalt series, which consists of flat-lying conglomerate, greywacké, arkose, and slate, occurs as erosion remnants on the north shore of Larder lake and on claims S. V. 506 and L. 4,438, McVittie township, and on the west shore of Binney lake. The rocks have a wide distribution to the east of the map-sheet where they overlie the Timiskamian sediments for a few square miles near the interprovincial boundary. They also extend southerly for 20 miles. They are described in detail by M. E. Wilson.[1]

Keweenawan (?)

Rocks of later age than the Algoman are rare in the area. Two or three diabase dikes, some of which clearly intrude the Algoman rocks, occur in each township; these rocks are classed provisionally as Keweenawan, although some of the more altered dikes may be Matachewan or pre-Algoman in age. The dikes vary from a few feet to 60 feet in width and generally strike north and south. In McVittie township, the diabase clearly intrudes the Algoman porphyry on an island in Beaverhouse lake on claim No. 5,171. In central McVittie township, on claims C. E. 122, C. E. 125, and C. E. 126, is a diabase dike cutting rocks of Keewatin, Timiskaming, and Algoman age. Three dikes were noted in Gauthier township, one cutting Timiskaming conglomerate on claims Nos. 9,111 and 2,806, one intruding Algoman porphyry on the Northland claim, No. 8,653, and lastly one cutting lamprophyre and sediments on an unsurveyed claim, No. 8,114. The last dike may be a continuation of the dike on the Northland. Two diabase dikes were seen in Lebel township, one cutting lamprophyre on the Crystal Lake claim, No. L. S. 452, and the other, a more altered dike, cutting Timiskamian sediments on claim L. 2,791, directly north of Gull lake. Three dikes in Teck township have already been referred to in the preceding report on the Kirkland Lake area. One of these is a narrow diabase dike, from 4 to 6 feet wide, occurring in a post-ore fault on the Tough-Oakes mine. An olivine-diabase dike, 30 feet in width, passes from the Lake Shore southwesterly to the Canadian Kirkland. A quartz-diabase dike has been encountered on the workings of the Teck-Hughes.

Pleistocene (Glacial and Recent)

The area has been heavily glaciated, the ice having moved in a general S. 20° E. direction, as can be seen by numerous striae indicated on the map.

[1]Larder Lake District, Ontario, Geol. Surv. Can., Mem. No. 17, 1912, pp. 35-37.

The rocks, which have been laid bare, occupy the greater portion of the map-sheet. The drift areas, which are also shown on the map, consist largely of sand and gravel with some minor clay areas and swamp. The western part of Gauthier township is one vast area of sand and gravel representing probably large terminal moraines and outwash plains which extend southerly for about 20 miles. Diamond-drilling has shown that the drift in places is over 150 feet thick.

ECONOMIC GEOLOGY

The Kirkland-Larder map-sheet embraces an area contiguous to a long narrow belt of Timiskaming sediments that extends across the entire area and in or near which lie the important mines at Kirkland lake and numerous prospects in Lebel, Gauthier, and McVittie townships, including the Bidgood, Argonaut, Crown Reserve, Associated Goldfields, and many other properties. Algoman intrusives of the granite, syenite, and porphyry type have a wide distribution, which accounts for the importance of the area. The sediments are often spoken of as a good indicator of gold-bearing veins. The writer believes, however, that the sediments are no better than any other rock except from a structural standpoint, i.e., the bedding planes between the upturned strata made zones of weakness along which the porphyry sills and dikes and gold solutions could easily penetrate and frequently find their way into the earth's crust. Fault zones in the greenstone have also been intruded by porphyry, and the quartz-porphyry-greenstone contacts at Goodfish lake, Monocle lake, and elsewhere frequently contain gold-bearing veins. The ore at Kirkland lake occurs largely in the porphyry and syenite and near its outer margins, although important shoots are found in conglomerate; only rarely does ore occur in lamprophyre. Also in Lebel and Gauthier townships, many of the discoveries are in porphyry. The Argonaut, Elstone-Dunkin, Kirkland Gateway, and Swastika veins, however, are largely in altered basalt near porphyry intrusions, while the ore deposits of the Crown Reserve and Associated Goldfields at Larder lake comprise in part highly altered quartz syenite and quartz occurring largely in reddish tuffs, black tufaceous slates, and carbonaceous schists.

The deposits at Kirkland lake dip vertically or steeply to the south. Most of the veins in Lebel and Gauthier townships dip steeply to the north or north-west. In McVittie township, the Costello vein on the Crown Reserve and Associated Goldfields dips about 60° southeasterly. The writer has observed that a favourable place to search for gold deposits is where a quartz syenitic magma has been readily differentiated into various basic and acid phases as in the Kirkland Lake area, in the vicinity of the Argonaut, Larder village, south-east Katrine township, etc. The real value of the various types of gold deposits in the area will be known only after much development work; undoubtedly, other important mines will be found in this large area of promising gold-bearing formations.

Everything suggests that the ore-bearing solutions have emanated from the granite-syenite-porphyry magmas during the final stages of cooling. These solutions ascended and entered fractures and shear zones in the older rocks and in portions of the porphyry which had already solidified. Various types of gold-bearing deposits were formed over a wide area, and in favourable localities commercial ore bodies were deposited. The two and a quarter mile fracture at Kirkland lake is a good example.

DESCRIPTION OF MINES AND PROSPECTS

For convenience and comparison the mineral deposits are described according to location or by townships. The deposits at Kirkland lake which are in Teck township are described in the preceding report on the area.

Lebel Township

As has been stated, Lebel township is reached by a wagon road from Kirkland lake. The Swastika-Larder Lake branch of the T. and N. O. railway now under construction crosses the township. Since 1919, there has been continuous activity on a number of claims in various parts of Lebel. As yet no mines have been developed, although some encouraging results have been obtained on the Bidgood, King-Kirkland, Lebel Oro, and other properties. The deepest underground workings are as follows: 600 feet on the Bidgood; 400 feet on the King-Kirkland; 300 feet on the Harvey-Kirkland; 200 feet on the Lebel Oro; 150 feet on the Continental and Queen Lebel; 100 feet on the Wood-Kirkland and Dane Copper; and 60 feet on the East-Kirk.

The same general assemblage of rocks that occurs around Kirkland lake is encountered in Lebel township. The feldspar porphyry has a wide distribution but the rock is usually more altered and greyer in colour than the reddish porphyries at Kirkland lake. The large masses of porphyry in Teck township, occurring from the Kirkland Lake mine to the Tough-Oakes Burnside, formerly the Kirkland Lake Proprietary, extend easterly into Lebel township for three-quarters of a mile. Directly east of this, in Lebel, the intrusives consist dominantly of hornblende syenite and lamprophyre with subordinate amounts of porphyry. The largest masses of porphyry in Lebel township extend from the southeast end of Gull lake through King and Mud lakes to the north end of Crystal lake. This larger mass of porphyry is dominantly of the grey feldspar-porphyry type, but there are several other associated varieties, such as red feldspar porphyry, red granite porphyry, quartz porphyry, red hornblende syenite and felsite, etc.

Certain veins on the Tough-Oakes Burnside, the easterly mine at Kirkland lake, extend for a short distance into Lebel township, but the Lebel extensions of the veins are narrow; however, some 1,000 feet or more of underground work has been done on them and a little ore developed. The Continental, the adjoining property, has uncovered, by trenching on claims 2,452 and 2,557, an east-west fractured zone 1,500 feet in length which resembles the Kirkland Lake veins and is probably a continuation of one of the Tough-Oakes Burnside veins. No ore has been developed in the Continental portion of this vein as yet; however, on the Continental claim No. 2,557, a shaft has been sunk 150 feet, the commencement of which was on a north-south quartz vein which yields encouraging assays. Many of the veins on the Burnside portion of the Tough-Oakes Burnside will probably be found to extend into Lebel and into the north-west bay of Gull lake, but this cannot be definitely ascertained until further underground work has been done. The rocks in this particular area are covered with a thick overburden of clay. During 1922, the Nipissing Mining Company did some diamond-drilling in this area on a small fracture on the west shore of Gull lake on claim L. 2,504; but the results were not encouraging enough to warrant the option being exercised.

Most of the other veins in Lebel township have a slightly different appearance from the Kirkland Lake deposits, and yet many of them are similar to one another. For instance, those occurring on the Queen Lebel, Myles, King-Kirkland, Lebel Oro, and Bidgood, over a distance of three miles, have a common matrix consisting of white granular quartz, calcite, ferruginous dolomite, barite, and some feldspar, in which are dark thin seams of iron pyrites, pyrrhotite, galena, zinc blende, and other sulphides. Quartz and sulphides are more abundant in the Lebel Oro vein than in the average vein of this type. The veins usually strike northeasterly and dip from 60° to 80° northwesterly, while the productive veins at Kirkland lake dip vertically or steeply to the south. The wall rocks at the King-Kirkland, Myles, Moffat-Hall, and Queen Lebel are altered grey feldspar porphyry. Diorite or green lamprophyre and sediments form the wall rocks on the Lebel Oro vein on the surface, although the porphyry is only a few hundred feet distant. At the Bidgood grey porphyry, granite porphyry, red hornblende syenite, and sediments are all present, the vein usually occurring near the contact of the hornblende syenite and granite porphyry.

Reddish felsite, heavily mineralized with iron pyrites and carrying some quartz and calcite, yields encouraging gold values on the Pawnee and Wood-Kirkland. A southern vein on the Pawnee is composed of mineralized conglomerate dipping steeply to the south. No. 10 deposit on the Moffat-Hall claim, No. 154, is mineralized porphyry with brecciated quartz and numerous fractures.

Description of Deposits in Lebel

The several deposits in Lebel township on which considerable prospecting has been done are described as follows:—

Tough-Oakes Burnside.—This mine has produced over $2,000,000 from that part of the property lying in Teck township, and it has been described in a previous report. By means of trenching a few veins have been traced easterly over the Teck-Lebel boundary line. The veins are narrow and occur in a zone over a quarter of a mile in width. Over 600 feet of workings have been completed on the 200-foot level of the Burnside, claim L. 2,374. Some ore has been mined from the eastward extensions of veins Nos. 3 and 6, which continue a short distance into Lebel township on claim No. L. 2,373.

L. 2,504.—This claim, which is situated on the west end of Gull lake, has a small east-west fracture containing some quartz and pyrite in porphyry. During the summer of 1922, the Nipissing Mining Company optioned the property. The vein was cut at depth by means of two diamond-drill holes; the option, however, was not exercised.

Continental.—The Continental Mines has a large group of claims lying in Lebel township directly east of the Tough-Oakes Burnside and in the strike of the producing mines at Kirkland lake. During 1922, much surface work was done, and a detailed geological examination was made for the company by Professor A. MacLean. The rocks are somewhat similar to, but much more altered than the rocks at Kirkland lake. The intrusives consist dominantly of hornblende syenite and lamprophyre with subordinate amounts of porphyry. The sediments are intensely altered, particularly along the southern margins of the intrusives. A pronounced fracture zone, some 1,500 feet in length and probably a continuation of one of the veins on the Tough-Oakes, extends across claims 2,452 and 2,557. It passes from the sediments into hornblende syenite; as yet no ore has been developed in the vein. Running at right angles to this vein, however, is the "Post" vein, a quartz vein 2 feet in width which carries iron pyrites, copper pyrites, galena, specular hematite, and gold. On this vein, which dips 65° west, was sunk a vertical two-compartment shaft to a depth of 150 feet by hand-drilling and a horse whim. From this point, a crosscut was driven 150 feet to the west, at which point the vein was encountered. It was reported that the vein on this level was similar to the surface outcrop. The vein dipped out of the shaft at a depth of 20 feet. An electric plant has been installed, and both the "Post" vein and the adjacent east-west fracture will be exploited from the No. 1 shaft.

The shaft was later sunk to the 800-foot level, when some exploratory lateral work was done.

It is proposed to sink No. 2 shaft on another pronounced east-west fracture some 1,000 feet distant on the Croteau claim, No. 2,807; the mine buildings are located on this claim.

Horse whim at No. 1 shaft, Continental Mines, Lebel township.

Lebel Lode (2,908, 2,909, 2,262, 2994, and 2,995).—The Keewatin-Timiskaming contact passes through this group of claims. The sediments, which are frequently reddish in colour, have been intruded by lamprophyre and porphyry. Much trenching has been done, which resulted in the finding of a few veins that were explored by shallow shafts, test pits, and open-cuts. Some diamond-drilling was done in 1923.

Queen Lebel.—This company owns a group of claims on the southeast shore of Gull lake. In the northeast corner of one of the claims, L. 2,924, a lenticular white granular vein of quartz, calcite, barite, and ferruginous dolomite has been exposed by trenching for a length of 60 feet. The vein varies from 2 to 4 feet in width, and there are frequently vein stringers in the yellowish porphyry wall which is altered largely to calcite, sericite, and chlorite. The vein strikes northeast-southwest, and dips 68° to the northwest. Through the vein are dark streaks containing molybdenite, iron pyrites, galena, zinc blende, and copper pyrites, portions of which contain low values in gold.

A shaft has been sunk to a depth of 60 feet. At the 50-foot level a crosscut has been driven 12 feet to the northwest. No. 1 vein, which lies 45 feet west of the shaft on the surface, has been trenched for 600 feet along a pronounced fault which roughly follows a contact between porphyry and conglomerate. No work was in progress between July, 1922, and May, 1923. Some of the rocks on these claims resemble trachyte.

The Anglo-Canadian Syndicate optioned the property in May, 1923, and carried on underground work until the end of the year under the supervision of Dan Hughes. The two-compartment shaft was continued to the 300-foot level, from which point a crosscut was driven 110 feet before the vein was reached. The vein was drifted on for over 200 feet each way from the crosscut.

On the property is a boiler, hoist, and a 3-drill compressor. B. Woods is president of the Queen Lebel company.

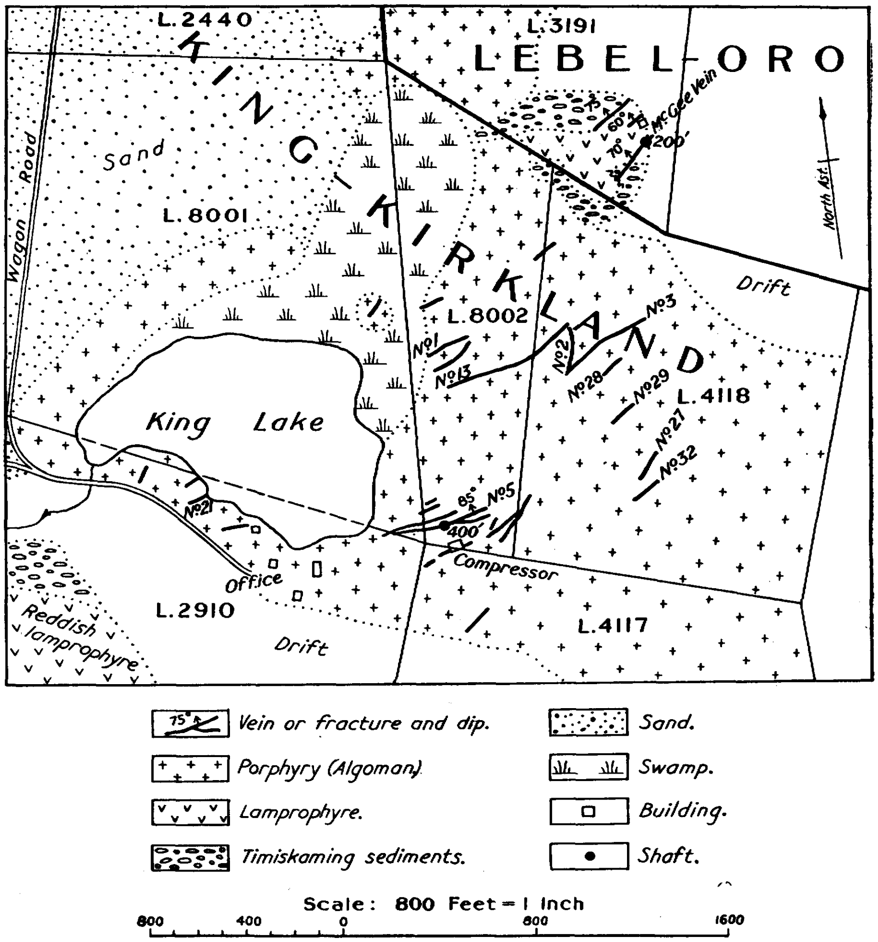
Mining plant on the King-Kirkland, showing the Kirkland Lake and Tough-Oakes Burnside shafts in the distance.

J. W. Myles.—This claim, No. L. 1,005, corners the Queen Lebel on the northeast. Various veins, probably extensions of the Queen Lebel veins, occur in the southwest corner of the claim. Several years ago a pit was sunk on the south central part of the claim on an east-west vein 6 or 8 inches wide in porphyry. The vein material on the dump has turned a brownish colour, due to the weathering of the ferruginous carbonate.

King-Kirkland.—The King-Kirkland Gold Mines, Limited, comprises a group of nine claims having an area of approximately 420 acres in the central part of Lebel township. Gold was found on these claims in 1918 by R. Montgomery, and the early discoveries are described by A. G. Burrows and P. E. Hopkins in the 1919 report of the Ontario Department of Mines.[1] Crossing the central portion of the property is a mass of altered grey feldspar porphyry, one-half mile in width, in which about 30 narrow parallel veins or fractures were located by systematic trenching in 1920. Most of the veins consist of

[1]Ont. Dept. Mines, Vol. XXIX, pt. 4, p. 48.

silicified and pyritized porphyry with fillings of granular white quartz, calcite, barite, and ferruginous dolomite. The veins are only a few inches in width, widening occasionally to one foot and rarely to 6 feet. They have a north-easterly strike and a steep dip to the north. Ernest Craig, the manager, has sampled most of the veins at intervals of 5 or 10 feet and made a survey plan showing the trenches and vein outcrops. His plan, which also shows the geology of the area, is reproduced in this report.



Geological plan of King-Kirkland and Lebel Oro properties, showing a northeast-southwest system of veins and fractures.

No. 5 vein, which is considered the most important one at present, has been trenched on the surface for 300 feet, exposing 30 feet of enriched material with a width of 4 or 5 feet. On the 90-foot level this enriched zone, which rakes about 45 degrees to the west, has lengthened to 50 feet; it crosses the shaft between 60 and 125 feet in depth. On the first level, 170 feet of lateral work has been done. A portion of the quartz on this level has a fault running through it approximately parallel to the strike of the vein. Mr. Craig found the ore to lie to the south of this fault, while the quartz to the north of the fault contained little or no gold. The fault-filling is of the nature of a pegmatite, and the striations on the fault plane are vertical. The enriched vein material contains hair-like seams of fine-grained pyrite and a little black material, in which visible gold may sometimes be seen with a hand lens. Under this section, the gold is seen to occur in these fractures with light-greenish chloritic material, very fine-grained iron pyrites, and calcite. The main mass of quartz is crushed and contains masses and veinlets of calcite, a few scattered grains of pyrite and probably some feldspar, presenting a pegmatitic appearance. Near the enrichments there is usually much pyrite both in the veins and in the porphyry.

The inclined shaft, which dips 75° to the north, follows the hanging-wall part of No. 5 vein most of the way to the 400-foot level. On the 400-foot level, No. 5 vein has been drifted on to the east of the shaft for 300 feet and to the west for 300 feet. The vein usually occurs between two pronounced faults from 2 to 4 feet wide, but on the whole the assays are low. According to the manager the west 30 feet in the west drift gave encouraging assays.

Vein No. 25 lies a short distance south of No. 5 vein and shaft. It varies from 6 inches to 2 feet in width, and carries gold values for a length of 100 feet. The vein material comprises silicified and pyritized porphyry, grains of quartz and calcite, scales of sericite, and veinlets of iron pyrites.

The mining plant comprises two 80 h.p. locomotive boilers, a 6-drill Ingersoll-Rand convertible air compressor, and a 10- by 12-foot hoist.

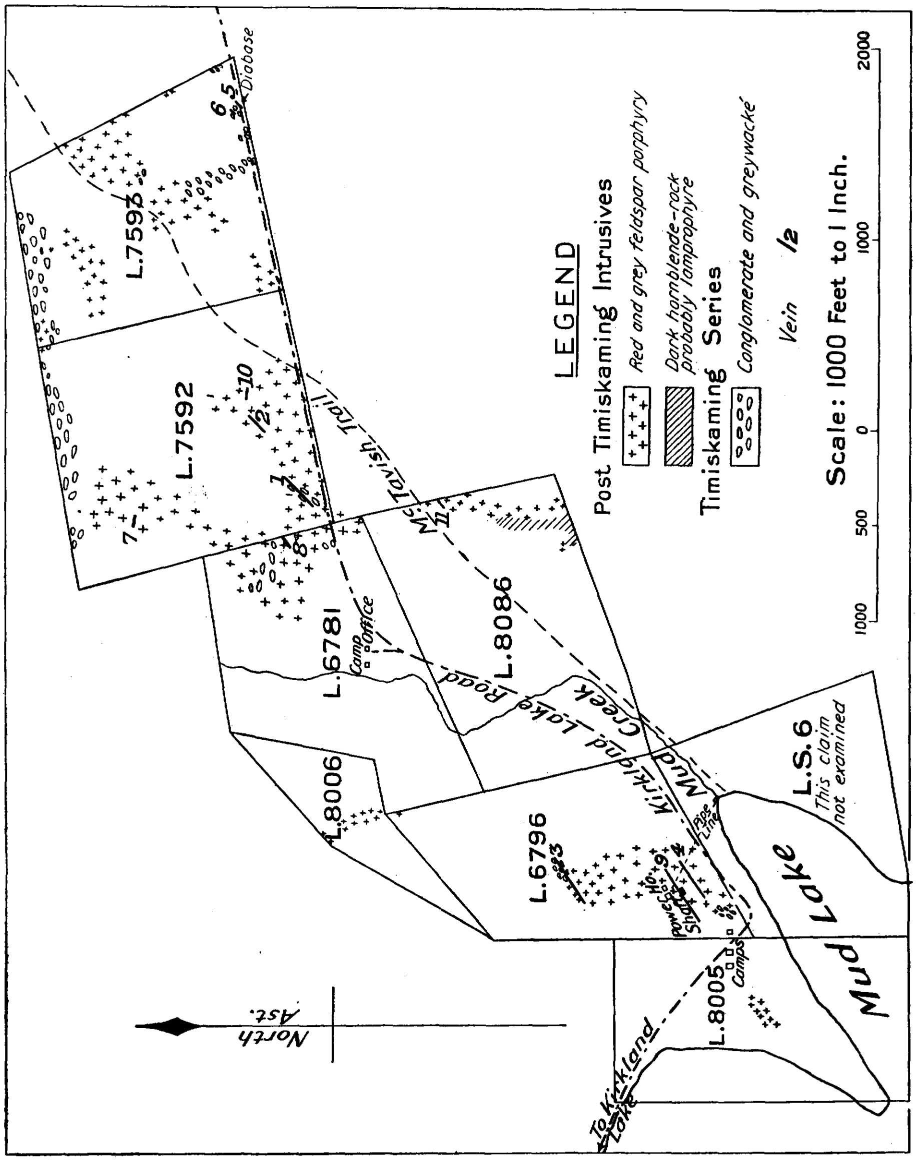
Fred Jordan is president of the company.

A working option was obtained on this property and also on the Moffat-Hall and the Wood-Kirkland by the Tonopah Mining Company, which commenced work during the first week of May, 1923. On the King-Kirkland, the drifts on the 400-foot level were continued both east and west on No. 5 vein, and two long crosscuts were driven to the north. In the east crosscut some narrow dikes of reddish hornblende syenite were found cutting the grey feldspar porphyry. The west crosscut passed well out under King lake. All underground work ceased at the end of 1923, and the option was allowed to expire. The plant was kept running to supply power for operating on the adjoining Lebel Oro deposit.

Kirk Gold Property (*L. 3,686*).—During 1924, a shaft was sunk to a depth of 190 feet on a vein in the slates to the south of the railway. The shaft was commenced on a 2-foot quartz vein which dipped out of the shaft on the south side at a depth of 42 feet. Where the vein left the shaft it was reported to be seven feet wide.

Lebel Oro (*3,191, 3,500, 3,066, 3,411, and 3,067*).—On claim No. 3,191 is a vein 200 feet in length which strikes approximately northeast-southwest and dips 70° northwest. The vein on the surface passes from a diorite or dark green lamprophyre into Timiskaming greywacké, the porphyry being 100 feet to the southwest. A 60-foot inclined shaft has been sunk on the vein, but it was filled with water during 1922. From the dump one can see much finely disseminated iron pyrites with some galena and zinc blende in a matrix similar to the King-Kirkland deposit. Portions of the vein on the surface are largely bluish and greenish quartz with veinlets of white quartz and much fine-grained pyrite. In places along the surface the vein has been faulted, the displacements being only one or two feet to the right in going to the northeast. According to some engineers who sampled the vein the shaft is reported to average from $5 to $10 in gold per ton.

Late in the year 1923, the property was reopened, the power being supplied from the adjoining King-Kirkland power plant. The inclined shaft was continued to a depth of 200 feet, from which point the vein was drifted on for 100 feet at the time of my visit in December, 1923. Most of this level is an altered diorite, although some fine-grained, yellowish, altered diorite porphyry was noted in the west face. Encouraging values were obtained over 8 to 10 inches, and in one place the quartz and schist are four feet wide. The work was done under the supervision of Ernest Craig and, afterwards, of F. Smith.

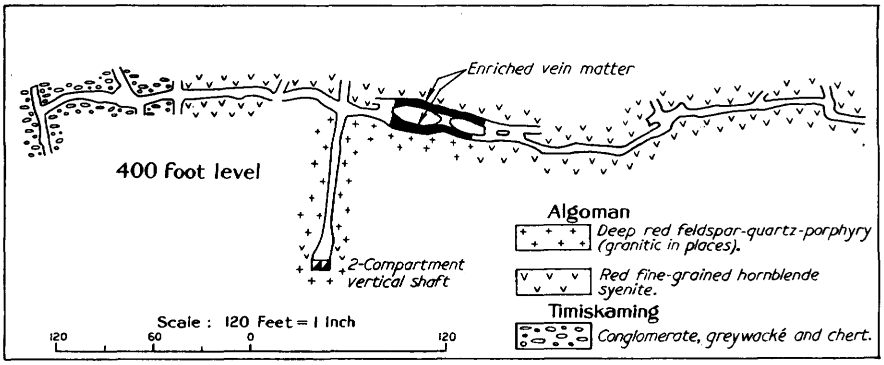


Geological plan, Bidgood gold mine, township of Lebel.

Bidgood (*L. 6,796, Etc.*).—The Bidgood Gold Mines, Limited, own a group of ten claims, comprising approximately 300 acres between Mud and McTavish lakes in Lebel township. On the surface several veins have been located with a northeast-southwest strike and steep dips to the northwest. The veins are in Timiskaming sediments and intrusive reddish rocks, namely, feldspar porphyry, quartz-feldspar porphyry, fine-grained hornblende syenite, and lamprophyre. Some grey feldspar porphyry occurs on the south part of L. S. 6. A geological plan of the property and the early workings are given in the second report on the Kirkland Lake area.[1] All the underground work has been done on claim L. 6,796, mostly on vein No. 9, which dips about 75° northwest. The two-compartment vertical shaft which commenced on the vein was sunk to a depth of 600 feet; at the 300-, 400-, and 600-foot levels crosscuts were driven approximately 90, 100, and 115 feet, respectively, before the vein was encountered. From 400 to 500 feet of drifting has been done on the vein on the three levels, exposing on the third and fourth a short shoot of enriched material.

The vein occurs on or near the contact between a deep red feldspar porphyry, showing an occasional quartz phenocryst and a flesh-coloured, medium-grained, hornblende syenite similar to the intrusives at the Argonaut. The vein is usually in the syenite, a short distance from the porphyry.

The vein comprises lenticular masses of quartz and other minerals from a few inches to 4 feet in width, with parallel or branch stringers extending for a few feet into the altered wall rock, giving the vein in places a width of 5 or 6 feet.



Plan showing the geology of the 400-foot level, Bidgood property. The vein extends along the main drift near the porphyry-syenite contact and into the conglomerate.

The hornblende syenite for many feet from the vein is shattered, and in places silicified and pyritized. The vein material is similar to the veins on the King-Kirkland, consisting largely of calcite and quartz with some ferro-dolomite, barite, and feldspar. Minute fractures in the gangue contain fine-grained pyrite, chalcopyrite, specular hematite, and molybdenite. Stringers of aplite or felsite are associated with the veins.

The higher gold values were obtained in the drift to the east of the main crosscut on the 300-foot level. On the 400-foot level, the enrichment also occurred in the east workings vertically beneath the good showing on the 300-foot level. In addition, a branch or parallel vein some 10 feet to the north was located and drifted on for over 100 feet. There is considerable fracturing in the enriched portions of the vein.

As stated, most of the work has been done on the No. 9 vein. At present a long crosscut is being driven north on the 600-foot level to locate other veins which are known to occur on the surface.

The plant consists of a 125 h.p. and a 50 h.p. boiler, a 3-drill compressor, a steam pump, and a 10- by 12-foot hoist.

George Tough is president and managing director; John McPhee, engineer; and D. Hughes, mine captain.

[1]Ont. Dept. Mines, Vol. XXIX, pt. 4, 1920, pp. 47-48.

Moffat-Hall.—This company owns a group of nine claims lying between the Bidgood and Crystal lake. Much of the area has been burned over, exposing one of the widest portions of feldspar porphyry in Lebel township. The only prospecting consists of a small amount of trenching and a few shallow test pits. Near the northwest corner of claim L. S. 4, trenching has revealed a large altered porphyry zone containing much disseminated iron pyrites and a little bluish quartz. In one pit there are two pronounced fault planes striking 15° east of north and dipping 85° to the west. A channel sample taken by the writer across 7 feet of the mineralized porphyry between the faults yielded $2.50 in gold per ton. This property was also optioned by the Tonapah Mining Company, and considerable surface prospecting was done during 1923 under the direction of A. W. Bancroft.

Harvey-Kirkland (1,872, 1,873, 2,769, 2,770).—These claims are situated near the Teck-Lebel boundary to the south of Gull lake. The rocks are largely Timiskaming sediments which have been highly schisted. Three veins comprising parallel veinlets of quartz with some iron pyrites occur along the bedding planes of the highly contorted sediments. These veins will be tested from a 400-foot, vertical, two-compartment shaft. On June 15, 1923, the shaft was 275 feet deep with a 90-foot crosscut on the 200-foot level in altered conglomerate, greywacké, and slate, dipping 87°S. The plant is operated by electricity. G. G. Thomas is manager.

Pawnee.—The four Pawnee claims, L. S. 464 to 467 inclusive, lie directly south of the King-Kirkland. Near the centre of L. S. 466, a narrow fracture has been uncovered for several hundred feet in an east-west direction. The wall rocks, hornblende syenite, reddish lamprophyre, and flesh-coloured felsite, have been impregnated with iron pyrites and replaced by quartz and calcite for a few inches on either side of the fracture. One portion of the vein some 50 feet in length gave encouraging assays in gold over widths ranging from 3 to 15 inches. About 150 feet to the north is a large quartz vein carrying iron pyrites, copper pyrites, and tetrahedrite. Near the south central part of L. S. 466 is a rusty conglomerate outcrop with two pronounced fractures striking nearly east and west and dipping 85°S. The sediments adjoining the fractures are replaced by considerable iron pyrites and some quartz which yield low values in gold.

Brant.—Some diamond-drilling has been done on the Brant claims, which lie east of the Pawnee, but no work was in progress during 1922.

Wood-Kirkland.—The Wood-Kirkland claims, Nos. 6,406, 7,127, 7,477, 7,479, and 7,748, lie directly south of Mud lake and southwest of Crystal lake in Lebel township. Crossing the latter three claims in an east-west direction is a large hill of igneous rocks consisting of hornblende syenite, reddish hornblende lamprophyre, pink felsite, and porphyry. On claim 7,479 a shaft has been sunk 100 feet on a fractured red felsite containing much disseminated iron pyrites and some quartz and calcite. However, the shaft was filled with water at the time of inspection. The Tonapah Mining Company optioned the claims and commenced trenching in May, 1923.

Lebel Crystal Lake.—Rock formations similar to the Wood-Kirkland extend eastward on the Lebel Crystal where some assessment work has been performed. Felsite carrying iron pyrites, copper pyrites, tetrahedrite, and specularite were observed in some pits.

Gauthier Township[1]

Gauthier township is reached by the well-known Larder Lake road from Dane station, and branch roads extend to various properties. The Swastika-Larder Lake branch of the T. and N. O. railway crosses Gauthier township. The Timiskaming sediments which traverse Teck and Lebel townships in an east-west direction extend southeasterly across Gauthier. These highly altered sedimentary schists have also been intruded by numerous isolated masses of Algoman porphyry and other related types of igneous rocks. The largest porphyry mass, which is similar to the typical Kirkland Lake porphyry, occurs in the vicinity of the Northland property. Much of the area between the south end of Victoria lake and Forks lake contains favourable formations for gold prospecting. Prospecting has been carried on in the township at intervals since 1906, when gold was found at Larder lake. The Argonaut, formerly La Mine D'Or Huronia, is the principal property in the township and has been working intermittently since 1912, having produced $259,795 in gold and silver up to end of 1924. The Argonaut, Elstone-Dunkin, Tobico, Northland, and other properties are described in the following pages.

Shaft-house and 200-ton mill, Argonaut mine, June, 1923.

Argonaut

The Argonaut gold mine, formerly La Mine D'Or Huronia, is situated on the southwest end of Beaverhouse lake near the northeast corner of Gauthier township. The property is reached by an 18-mile wagon road from Dane station and also by the railway which has been built from Swastika to Larder Lake and which passes within three miles of the Argonaut. It was in 1912 that gold-bearing veins were found on these claims, L. 2,586 and L. 2,587, to the west end of Beaverhouse lake along York lake, an expansion of the Blanche river. Work has been carried on intermittently by the company ever since, except in 1915, when the property was under option to N. A. Timmins. Since

[1]Three geological maps of portions of the township have been published by the Ontario Department of Mines. They are as follows: Kirkland Lake-Swastika Gold Areas, map accompanying Vol. XXIII, pt. 2, 1914; and maps Nos. 26d and 29d.

1919, the mine has been known as the Argonaut. The total value of the gold and silver produced up to the summer of 1921, when the 15-ton experimental mill was burned, was $35,211. A 200-ton mill was erected which commenced operations on June 24, 1923. The boundaries of the property have been enlarged from time to time, until at present the mine has an area of approximately 1,000 acres lying in one block along the Gauthier-McVittie boundary. The underground workings are all in Gauthier township.

Literature.—As pointed out by C. W. Knight, the early references to the geology along the well-known water route which crosses the property were made in 1901 by W. G. Miller[1] and W. J. Wilson,[2] and in 1904 by W. A. Parks.[3] The first description of the gold deposits was made in 1913 by A. G. Burrows and P. E. Hopkins.[4] In 1916, Mr. Burrows gave a fuller account of the deposits.[5] The most detailed description was given by C. W. Knight in 1920[6]; this report is accompanied by a coloured geological map of the property. The writer[7] has also referred to the property in reports published in 1919 and 1921.

Geology.—The rocks in the vicinity of the mine workings are largely Keewatin basalt and andesite which have been cut by dikes and irregular masses of hornblende syenite, feldspar porphyry, granite porphyry, felsite, diabase, and lamprophyre, of Algoman age. The veins occur in all the rocks. The ore, however, is confined largely to the Keewatin basalt, and to a less extent, the hornblende syenite. The basalt is a massive, dark green, fine-grained rock which frequently shows a pillow and amygdaloidal structure. Under thin section, the basalt is seen to consist of plagioclase, augite, and magnetite, with secondary hornblende, chlorite, calcite, and epidote. A short distance to the west of the mine workings, the basalt is in contact with a large volume of light-greenish and grey coloured lava resembling andesite. Thin layers of banded chert and iron formation occur at intervals along the andesite-basalt contact. Some of the andesites and basalts, particularly in the proximity of certain intrusives, are altered to schists and to ferruginous carbonate and ankerite.

As stated above, there are on this property several types of Algoman rocks which are probably differentiates from one parent magma. These have all been mapped together under one group. The lamprophyres contain both hornblende and augite phenocrysts set in a matrix of reddish feldspar, mica, and quartz. A diabase from the 361 east crosscut on the 300-foot level was seen to consist of plagioclase, augite altering to chlorite, and magnetite. To the west of the main shaft, the basic or dark-coloured rock is a norite with plagioclase-feldspar and hypersthene. These basic intrusives (lamprophyre, diabase, etc.) grade in places into a typical, fine-grained, reddish hornblende syenite. Numerous grey and red felsite dikes occur on the southwest and southeast shores of Ava lake.

Apparently the latest phase of the Algoman is represented by a fresh red feldspar porphyry which resembles the Kirkland Lake porphyry. In the vicinity of the mine workings, there are two nearly parallel dikes between which the ore is found. As was pointed out by Mr. Knight, the larger or easterly

[1]Lake Timiskaming to the Height of Land, Ont. Bur. Mines, Vol. XI, 1902, p. 223.
[2]Geol. Surv. Can., Vol. XIV, 1901, p. 119a.
[3]Geol. Surv. Can., Vol. XVI, 1904, p. 217a.
[4]Ont. Bur. Mines, Vol. XXIII, pt. 2, 1914, pp. 31-32.
[5]Gold in Gauthier Township, Ont. Bur. Mines, Vol. XXVI, 1917, pp. 255-256.
[6]Argonaut Gold Mine, Ont. Dept. Mines, Vol. XXIX, pt. 3, 1920, pp. 65-76.
[7]Larder Lake Gold Area, Ont. Bur. Mines, Vol. XXVIII, pt. 2, 1919, pp. 76-77; Ontario Gold Deposits, Ont. Dept. Mines, Vol. XXX, pt. 2, 1921, p. 22.

dike, which is from 50 to 150 feet in width, is rudely horseshoe in shape. The westerly arm dips about 60 degrees to the north. The northeasterly arm of the dike, which crosses the central part of York lake, was encountered a few feet to the north of the shaft on the 500-foot level, hence portions of the dike dip from 35° to 55° northwest. The feldspar phenocrysts average from a sixteenth to half an inch in diameter, and there is an occasional quartz phenocryst present. A thin section shows an abundance of orthoclase, with some plagioclase-feldspar and an occasional quartz phenocryst, in a groundmass of feldspathic material, partly altered to sericite, calcite, and kaolin. Chlorite, epidote, quartz, leucoxene, magnetite, and pyrite are also present in the matrix.

As was stated above, the older rocks in the vicinity of the Algoman intrusives, particularly on the township boundary line directly south of Beaverhouse lake, are frequently altered to ankerite or ferruginous carbonate. These rocks have been described by C. W. Knight as follows[1]:—

> At the northwest corner of claim L. 2,589 there is a band of ankerite rock 100 feet or more in width. It first outcrops at the dam at the foot of Beaverhouse lake and strikes to the southwest. This rusty rock was noted by W. G. Miller in 1901 and by W. J. Wilson in the same year, also by W. A. Parks in 1904.
>
> The ankerite band consists of Keewatin rocks through which the ankerite is disseminated in grains. The mineral also occurs in numberless irregular veinlets which intersect the Keewatin in a most complex manner. The veinlets vary from fractions of an inch to several inches in width. Here and there are irregular stringers of quartz carrying pyrite and copper pyrites. The quartz veins are but a few inches in diameter.
>
> Judging from the outcrop at the dam, the ankerite appears to be dipping towards the northwest. It would be unwise, however, to infer from the structure at the dam that the whole band of ankerite dips in that direction. It will require diamond-drilling or underground working to find out definitely the direction of the dip.
>
> Considerable trenching and blasting has been done along this band. Work was done on it long before the property was acquired by the Argonaut gold mine. As early as 1901, Miller stated that there had been some blasting. No work was being carried on during the summer of 1919.
>
> A sample of the material was submitted to W. K. McNeill, Provincial Assayer, who determined it to be ankerite, a carbonate of iron, calcium, and magnesium. This material occurs in a great many localities in northern Ontario. The ankerite at the Argonaut gold mine appears to be a replacement deposit in which the mineral replaces the Keewatin rocks. The origin of the solutions which carried the ankerite appears to be obscure.
>
> The rock weathers readily, and turns a brownish, rusty colour on the surface.
>
> There are other occurrences of ankerite on the property. The rusty schist at the rapids on Victoria creek in L. 2,601 is impregnated with the mineral. There is also an occurrence on L. 2,602.

Ore Bodies.—The earliest surface work was done to the southwest of Beaverhouse lake on ankerite which showed some gold on assay.

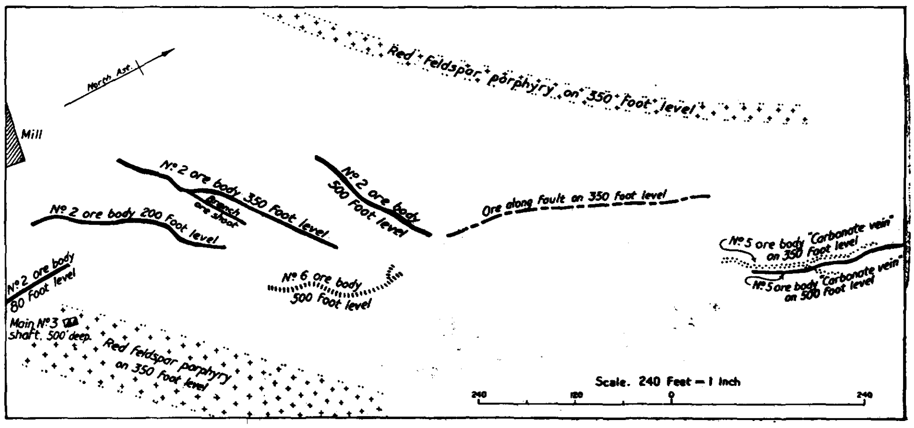
The first shaft was sunk to a depth of 102 feet on a pink felsite dike, 14 feet in width, situated on the southwest shore of Ava lake on claim L. 2,586. The dike contains veinlets of magnetite[2] carrying native gold. Small amounts of chalcopyrite and quartz are also present. Several veins have been located, but most of the development work is being done on No. 2 vein, which outcrops to the west of the main, No. 3, shaft near the southwest corner of claim L. 2,587. C. W. Knight has described this deposit and his description[3] is quoted, as it illustrates the character of the ore on the four levels:—

> Vein No. 1A is at the southwest corner of L. 2,587. A shaft, known as No. 2, has been sunk to a depth of 75 feet, and 125 feet of drifting has been done on the 50-foot level. The shaft was full of water in the summer of 1919, but an open-cut exposed the vein. At the southwest end of this open-cut the character of the deposit may be examined. Commencing at the southeast corner of the open-cut, it is seen that the first thirteen inches consist of basalt which is intersected by veinlets of calcite and pink

[1]Ont. Dept. Mines, Vol. XXIX, pt. 3, 1920, pp. 68-69.
[2]Magnetite is also common in the Windpass gold mine, B.C.
[3]Ont. Dept. Mines, Vol. XXIX, pt. 4, 1920, p. 71.

felsitic or feldspathic material, these veinlets being small fractions of an inch in diameter. This is followed by fourteen inches of pink felsitic or feldspathic material containing much country rock. Calcite and copper pyrites are present in veinlets and disseminated grains. Next comes a pinkish-white calcite vein two to four inches wide containing some copper pyrites; then seven inches of basalt containing veinlets of calcite; next a zone fifteen inches wide consisting mainly of copper pyrites together with other material. This is followed by thirty inches of pink felsitic material with some basalt. Stringers of magnetite fractions of an inch wide cut the pink material. This gives a total width to the southwest face of the open-cut of about seven feet. It will be seen that quartz forms little or no part of this particular deposit. The large amount of felsitic or feldspathic material shows that there is in all probability some connection between the felsite dikes and the origin of the deposits.

It may be added to Mr. Knight's description that the veins underground have a faint ribbon structure in which the magnetite and pyrite crystallized out early. The copper pyrites and tetrahedrite are much intergrown. A little tourmaline is present. The gold appears to have come in with the calcite and is usually associated with felsitic material. The minerals present suggest that the deposits were formed at high temperatures.



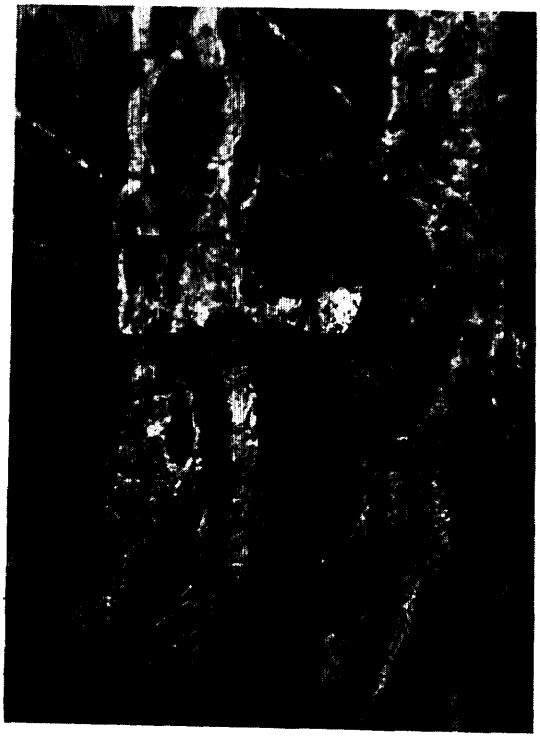
Composite plan of ore shoots, Argonaut mine. The ore shoots lie in Keewatin basalt between two prominent red feldspar-porphyry dikes. The No. 2 ore body pitches to the north and at the same time changes slightly in strike.

As shown on the accompanying plan, No. 2 ore body pitches to the northeast. The present workings are largely under York lake. On the 80-foot level, two lenses of ore were encountered, and some drifting was done. On the 200-foot level, there is an ore shoot about 225 feet long occurring largely in basalt and hornblende syenite. Some of the ore was stoped and treated in the experimental mill which was burned in the summer of 1921.

No. 2 ore shoot on the 350-foot level is ore of a good milling grade for a length of 275 feet or more, there being also a branch ore shoot over 50 feet in length. The ore is in basalt with the exception of the western 40 feet, which is in hornblende syenite. The ore is similar in character to that on the surface described by Mr. Knight. The northeastern end of the ore shoot on this level has apparently been cut off by a strong north-south fault, which passes through the various levels and probably extends along the western shore of York lake. Sufficient drag material to yield a considerable length of mill-grade ore is found along the fault.

Some 800 feet to the northeast of the shaft on the 350-foot level, a vein known as the "carbonate vein" has recently been discovered and drifted on for 200 feet. The vein occurs in basalt near a diabase which apparently is a basic phase of the hornblende syenite. The ore is 6 to 10 feet wide and consists largely of white, grey, and black calcite with some highly altered fragments of basalt and felsite, and small amounts of disseminated copper pyrites, iron pyrites, and molybdenite. Some visible gold and specular hematite are also present.

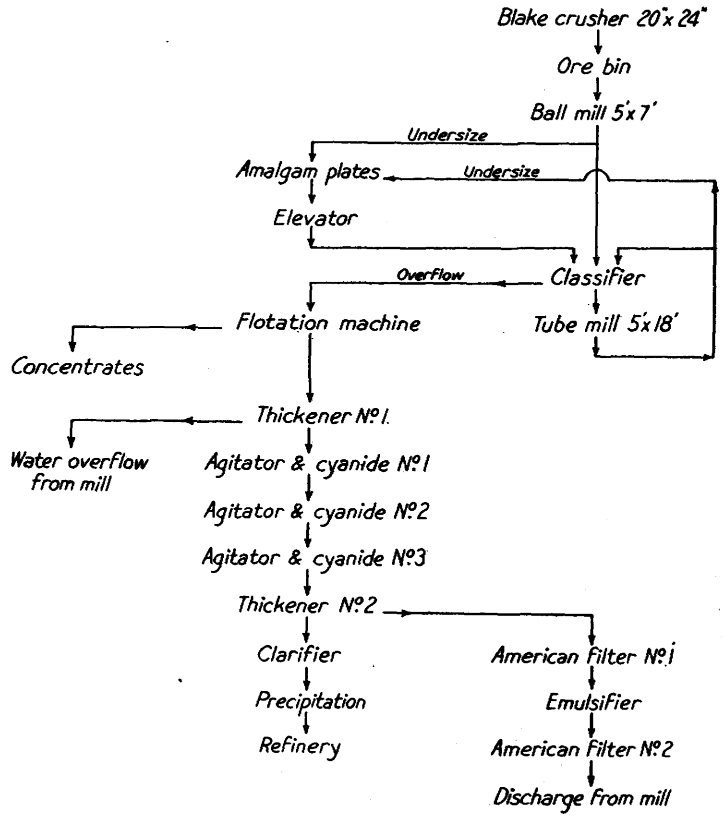
The downward extension of No. 2 ore body has been picked up on the 500-foot level. A parallel vein, No. 6, has also been encountered on the lower level. This vein has considerable visible gold, and its quartz resembles the quartz on the fault vein on the 350-foot level. The "carbonate vein" has also been drifted on for a considerable distance on this lower level. The vein dips about 85°S. and the ore rakes to the east.



Ore body over 7 feet wide on the 350-foot level, Argonaut mine. The light parts are calcite, while the darker material is largely copper pyrites and altered basalt.

Owing to the fact that certain of the ores are highly cupriferous, carrying 3 per cent. or more of metallic copper, a treatment quite different from the usual cyanide methods was at first adopted, namely, amalgamation, flotation, and cyanidation of the tailings, as shown in an accompanying flow-sheet. As work progressed, the percentage of copper diminished and the ordinary cyanide practice was reverted to, namely, crusher, Hardinge ball mill, classifier, tube mill, agitators, settlers, united rotary filters, etc. In December, 1923, the mill was treating 80 tons daily and recovering $10 per ton. The mine and mill were operated by electric power supplied by the Associated Goldfields' plant at Raven falls, until late in 1924. A new power line connecting with Kirkland Lake was then installed. Figures of production ($259,795) to the end of 1924 are given on page 28.

The writer is much indebted to J. W. Morrison, the general superintendent, for placing at his disposal assay charts and geological plans made by K. B. Heisey, which have greatly assisted in the writing of this description. Chas. Spearman is consulting engineer, and toward the end of 1923, G. R. McLaren became superintendent.



Flow-sheet, Argonaut Gold Mines, March, 1923.

Description of Other Properties in Gauthier Township

Northland.—The Northland Gold Mining Company owns 14 mining claims, or approximately 600 acres, in the northwest quarter of Gauthier township. On these claims, there are several outcrops of red feldspar porphyry, similar to the porphyry at Kirkland lake, which protrude through sand and swamp and suggest the probability of there being an extensive area of underlying porphyry. During the autumn of 1922, several long fractures, striking slightly south of east, were revealed by trenching on claims Nos. 8,653 and 8,689. A 50-foot shaft was sunk on three closely spaced parallel fractures in the southwest part of claim 8,689. Some brecciated quartz, felsite, pyrite, and chalcopyrite occur between the vertical fractures and, according to manager John Byrne, favourable assays were obtained. Good camps have been built. Exploration was carried on during 1923, and a promising vein uncovered about 150 feet south of the shaft. It is the intention to do considerable diamond-drilling.

Noranda.—The Noranda has a group of claims to the southwest of the Northland. These are covered with a great thickness of sand, with the exception of one small syenite outcrop, 75 feet in diameter, containing pyrite, on claim No. 9,227. It is reported that diamond-drilling will be done here during the year.

C. McIntyre–R. Montgomery.—A quartz vein some four feet in width has been traced for several hundred feet in a N. 65° E. direction across part of the unsurveyed claim No. 8,113, which lies directly north of the surveyed claim No. 9,224. In places where the vein carries considerable iron pyrites, gold colours may be panned. The vein cuts Timiskaming sediments, lamprophyre, and porphyry.

Miller–Middleton.—The northern contact of the Timiskaming with Keewatin rhyolite or andesite passes through the Miller-Middleton group of claims. Where this contact crosses the line between claims Nos. 9,501 and 9,502 a pit has been sunk in a siliceous rock resembling rhyolite that has been replaced by quartz and calcite carrying iron pyrites, galena, zinc blende, and arsenopyrite. One-half mile southeasterly on 9,394 is a similar deposit occurring partly in amygdaloidal lava and partly in Timiskaming reddish conglomerate. The assays made were all said to give low values in gold.

Elstone–Dunkin.—Early in 1916, gold was discovered on the Elstone-Dunkin claims, 3,894, 3,893½, and 5,732, in the central part of Gauthier township. During that summer considerable surface prospecting was done and the deposit was examined and reported on by A. G. Burrows. Considerable surface exploration and diamond-drilling were done in the summer of 1922 by Messrs. Thompson and Chadbourne under the supervision of B. Ashley. The option was not exercised and all work was stopped in September, 1922.

The principal mineralized zone lies in a Keewatin basalt which has been ntruded by small Algoman porphyry dikes, the outcrop being surrounded by a large sand area. In 1916, Mr. Burrows wrote about the deposit and early prospecting as follows[1]:—

> In places the mineralized zone which strikes N. 60° W. has a width of over twenty feet, and where stripped is quite rusty-weathered, due to the oxidation of disseminated iron pyrites. Native gold, some in quite coarse grains, was observed at a few points, and an attempt was being made to locate an ore shoot in the mineralized band, which usually shows low gold values on assay. A section exposed in one cross-trench shows from the northeast hanging-wall of greenstone six feet of fine-grained greenish altered rock, four and a half feet of reddish porphyry greatly fractured and containing a number of quartz veinlets, one foot of fine siliceous material resembling chert with parallel bands of fine-grained iron pyrites, two and a half feet of very rusty-weathered altered rock showing considerable iron pyrites and lenses of white quartz in the direction of the schist, and seven feet of similar rock to the greenstone footwall. Some of the showings of visible gold occur in the two-and-a-half foot section just described. This pyrites band appears to be largely the result of alteration of the greenstone along a line of weakness in which a porphyry dike has been formed, the greenstone having been replaced by a fine-grained greenish silica. A short distance to the north there is a narrow feldspar-porphyry dike, which can be traced across the property. Gold is reported to have been found in veinlets to the north of this porphyry dike.

During 1922, this mineralized zone was opened up by several closely spaced pits and open-cuts for a length of 350 feet and proved by diamond-drilling to extend to a depth of 300 feet and to be at least 400 feet in length, the dip being 84°N. 30°E. The deposit lies close to the southerly edge of, and nearly parallel to, a red feldspar porphyry dike, which is from 10 to 100 feet in width. In places there is a narrow band of chert or graphitic schist, separating the porphyry and the vein. The gold-bearing zone is comprised of numerous small irregular patches of highly altered, replaced basalt, extending along the general strike N.60°W. The ore patches are frequently bounded by small slips or faults

[1]A. G. Burrows, Gold in Gauthier township, Ont. Dept. Mines, Vol. XXVI, 1917, p. 257.

extending in various directions; hence, the ore will sometimes end abruptly at a slip with nothing to indicate what distance it is to the next gold-bearing patch. The largest ore lens occurs in the bottom of a large open-cut where the vein crosses the boundary between claims 3,894 and 3,893½; it is 30 feet long, 10 feet wide, and tapers down to 2 feet in width at the ends. It assays approximately $7 in gold per ton across these widths. The ore is an altered grey basalt which has been metasomatically replaced by calcite or dolomite and cut by irregular quartz veinlets. Iron pyrites is the principal sulphide; some copper pyrites and coarse gold were also noted. Four shallow diamond-drill holes, placed about 200 feet apart, have cut the carbonated, silicified, and brecciated zone at depths ranging from 100 to 300 feet. The vein material from the cores was reported by the manager to have a greater width than the vein outcrop and to have yielded a gold content quite similar to the surface assay results.

South of the main vein about 175 feet is a similar but smaller vein which is 2 feet in width and has been trenched for 50 feet. It dips approximately 65° to the south and is probably a branch of the main vein, the upper parts having been eroded. Channel samples across a few inches of this southern vein gave $25 in gold per ton. There are also other minute branches from the main vein. The small lenses of porphyry and felsite in the veins suggest a relationship between the gold and the porphyry.

Tobico.—Near the northwest corner of claim 9,532 is a small outcrop of red feldspar porphyry some 50 by 150 feet which occurs in a large drift-covered area. In 1921, Messrs. Tobico and Perry found gold in a narrow quartz vein in this rock exposure. George Tough optioned the claims and sank a shaft to a depth of 25 feet. In the shaft is an east-west fault and several narrow quartz stringers dipping steeply to the north. The quartz is extremely fine grained, like chalcedony, and carries visible gold, tellurides, and iron pyrites. The adjoining porphyry also contains some iron pyrites. One sample across the shaft gave an assay $3.50 in gold per ton.

Victoria Creek.—"A considerable amount of work has been accomplished on claim J. S. 126, and includes a shaft 100 feet deep, and 115 and 125 feet of drifting at the 40- and 100-foot levels, respectively."[1] No work has been done since 1912. The rock in the vicinity of the shaft is a quartz porphyry altered to rusty carbonate.

McIntyre (L. M. 62, 63, Etc.).—On L. M. 63 are two veins, 6 inches to 2 feet wide in reddish lamprophyre, which are reported to carry encouraging gold values. The veins contain pyrite, copper pyrites, and molybdenite. The porphyry on parts of L. M. 62 contains numerous sulphides, which are said to be gold-bearing, over wide widths.

McVittie Township

Although the accompanying map, No. 32e, includes part of McVittie township, the mining properties in the township are referred to in the report on the Larder Lake gold area.[2] The developments in this township are among the most important that have taken place in the province during recent years. Figures 1, 2, and 3 are reproduced from the above-mentioned report.

[1]M. E. Wilson, Larder Lake District, Ontario, Geol. Surv. Can., Mem. No. 17, 1912, p. 56.
[2]Ont. Dept. Mines, Vol. XXXIII, pt. 3.

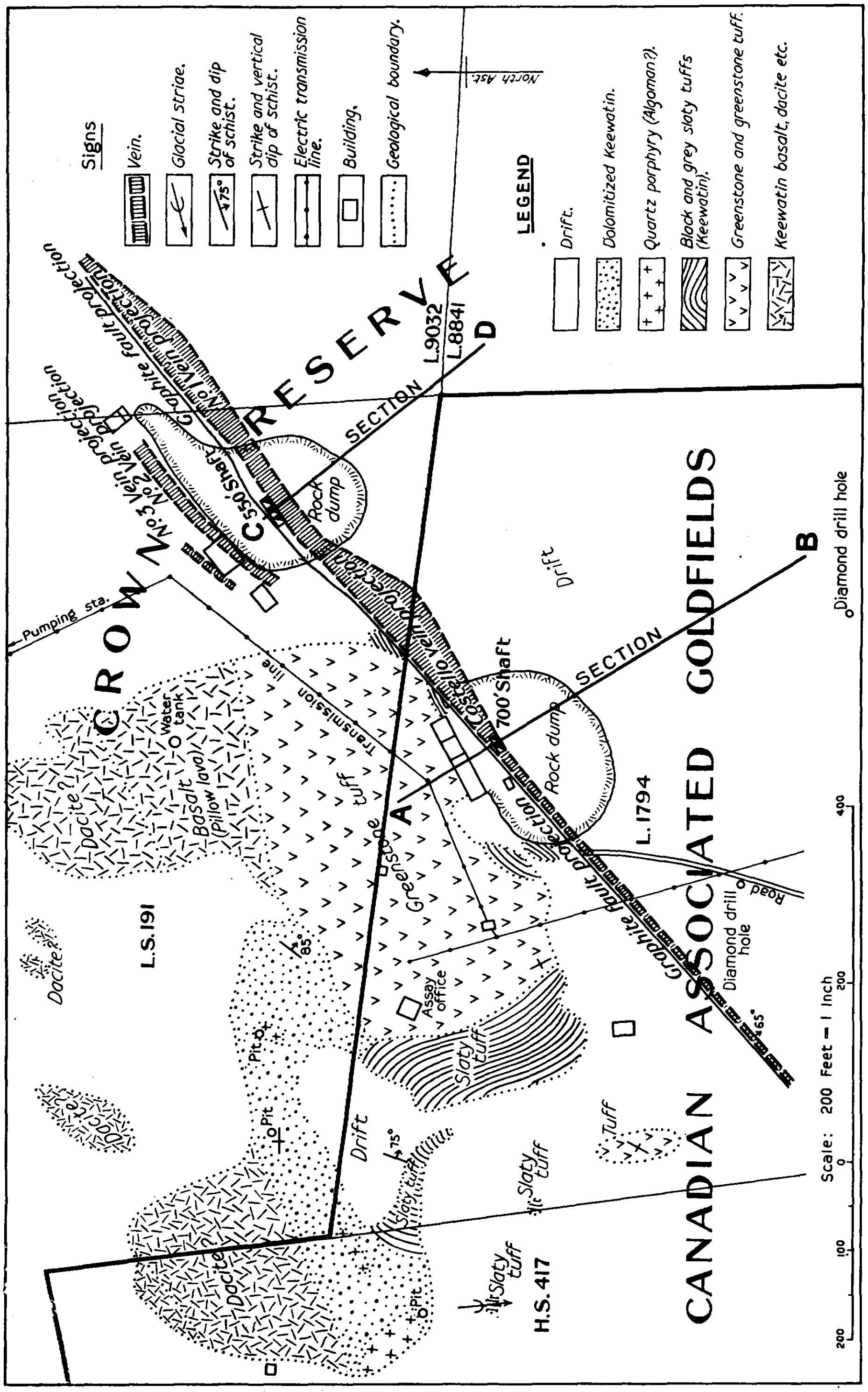


Fig. 1—Geological plan of Canadian Associated Goldfields and Crown Reserve near Pancake lake. The positions of cross-sections A-B (Fig. 2) and C-D (Fig. 3) are shown on the plan.

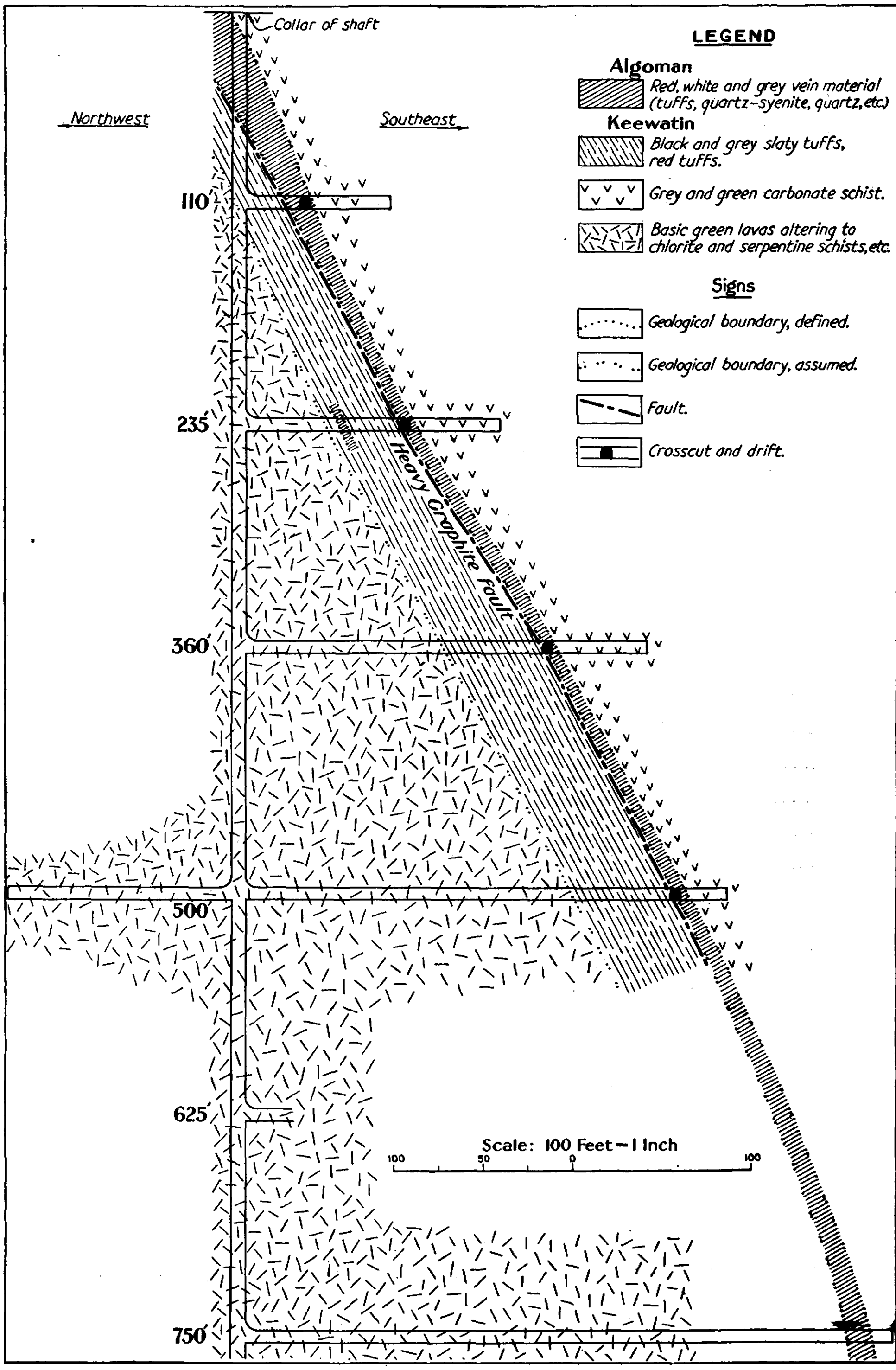


Fig. 2—Vertical section A-B, running in a northwest-southeast direction through the Associated Goldfields shaft on claim L. 1794.

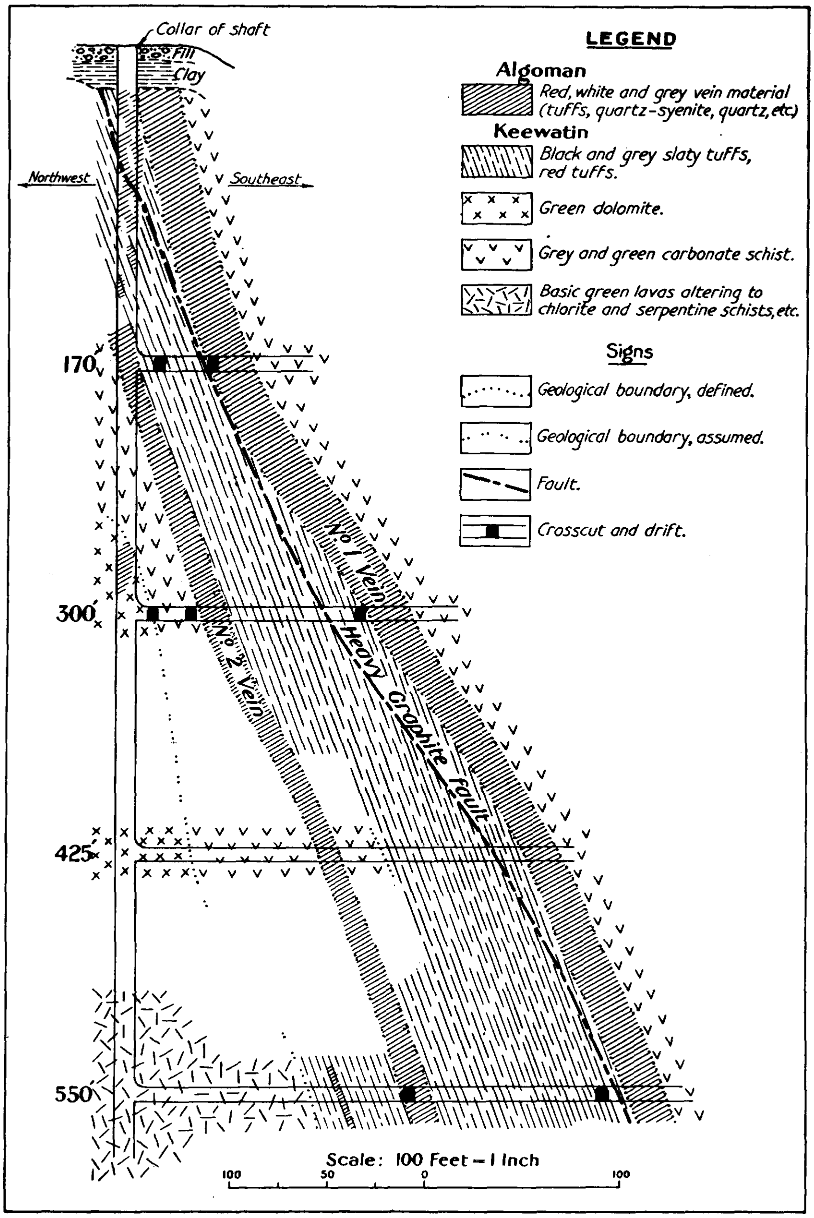


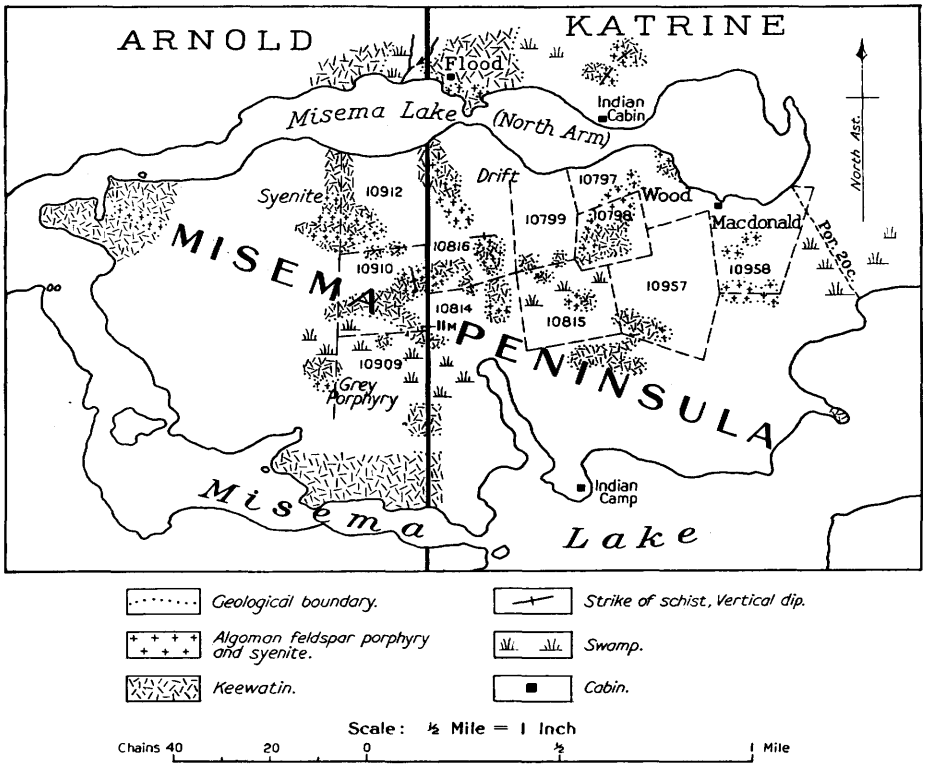
Fig. 3—Vertical section C-D running in a northwest-southeast direction through the Crown Reserve shaft on claim No. L.S. 191.

Arnold, Katrine, and Ossian Townships

The following notes on these townships were written by A. W. Carlyle:—

During the summer of 1922, considerable interest began to be manifested in the townships of Arnold, Katrine, and Ossian. Many claims were staked and several extremely interesting discoveries were made.

In Katrine and Arnold, activity centred around the Katrine-Arnold boundary line in the vicinity of mile post XI, which may be reached by gasoline boat from the Argonaut mine. Prospectors were led to this area owing to C. W. Knight indicating schist and porphyry in the vicinity. In this area the massive Keewatin volcanics have been intruded by numerous small dikes and bosses



Geological plan of Misema peninsula, Arnold and Katrine townships.

of red feldspar porphyry of Algoman age, as shown on the accompanying plan. The dikes average from one to ten chains in width and have a general east-west strike.

The majority of these dikes which, due to drift, are not immediately exposed at the surface, have been joined on a pensinsula bounded on the south by Misema lake and on the north by the North Arm. This ground was largely staked by Hugh Macdonald and Chas. W. Dalby.

On the north of the North Arm there are also some exposures of red feldspar porphyry. Associated with these porphyry intrusions in places is considerable quartz with some pyrite, indicating later fracturing and mineralization. Exploration work has been mainly confined to surface stripping with some trenching, and further work is undoubtedly warranted. Gold can be panned on the Macdonald, Wood, and Flood claims.

Considerable diamond-drilling was being done on the Walsh-Tucker claims in the southeast corner of Katrine, but unfortunately this area was not visited. These deposits have been described by C. W. Knight.[1]

Ossian township, lying to the east of Katrine, is reached by a trail starting from the north end of Kinabik lake. A rough road has also been made from the Argonaut mine by way of the Walsh-Tucker claims in the southeast part of Katrine township. Here, two extremely interesting discoveries were made during the summer by Frank Fishley and Ralph Hurd. The first lies just east of the Katrine-Ossian boundary line on claims L. 10,803 and L. 10,806, and from what could be seen of the surface work done it consisted of an area from 6 to 7 chains wide and 10 chains long, of altered basalt or andesite, probably a flow top, through which is disseminated much fine pyrite. Assays up to $2 in gold per ton are reported from here.

The second discovery lies roughly in the centre of the township on the north and south claim line of L. 11,131 and L. 11,132. Here a quartz vein or lens was discovered and stripped for 500 feet, having a maximum width of 50 feet in the centre and tapering to 3 or 4 feet at either end. The vein has a general east-west strike and is enclosed in a band of Keewatin schist resembling a rhyolite or andesite schist, having a similar strike. This area of schist extends at least several chains north and south of the vein and is picked up to the east on the adjoining claim. The quartz is accompanied by considerable mineralization, coarsely crystallized pyrite with some galena and sphalerite, while the schist also is mineralized over a large area. Low assays were reported over considerable widths with an occasional high assay over two or three feet.

At the end of 1922, a 30 h.p. boiler was taken to the property, and shaft-sinking was carried on during the winter. In June, 1923, the vertical shaft was 100 feet deep and lateral work was being carried on to cut the vein at this level. On the surface, there appear to be numerous quartz lenses from a few feet to 30 feet in width and dipping at all angles. Some of the veins are flat.

Alfred Rogers also discovered gold in basalt to the west of Wawagoshe lake in the southwest part of Ossian township.

[1]Ont. Dept. Mines, Vol. XXIX, pt. 4, 1920, pp. 22-27.

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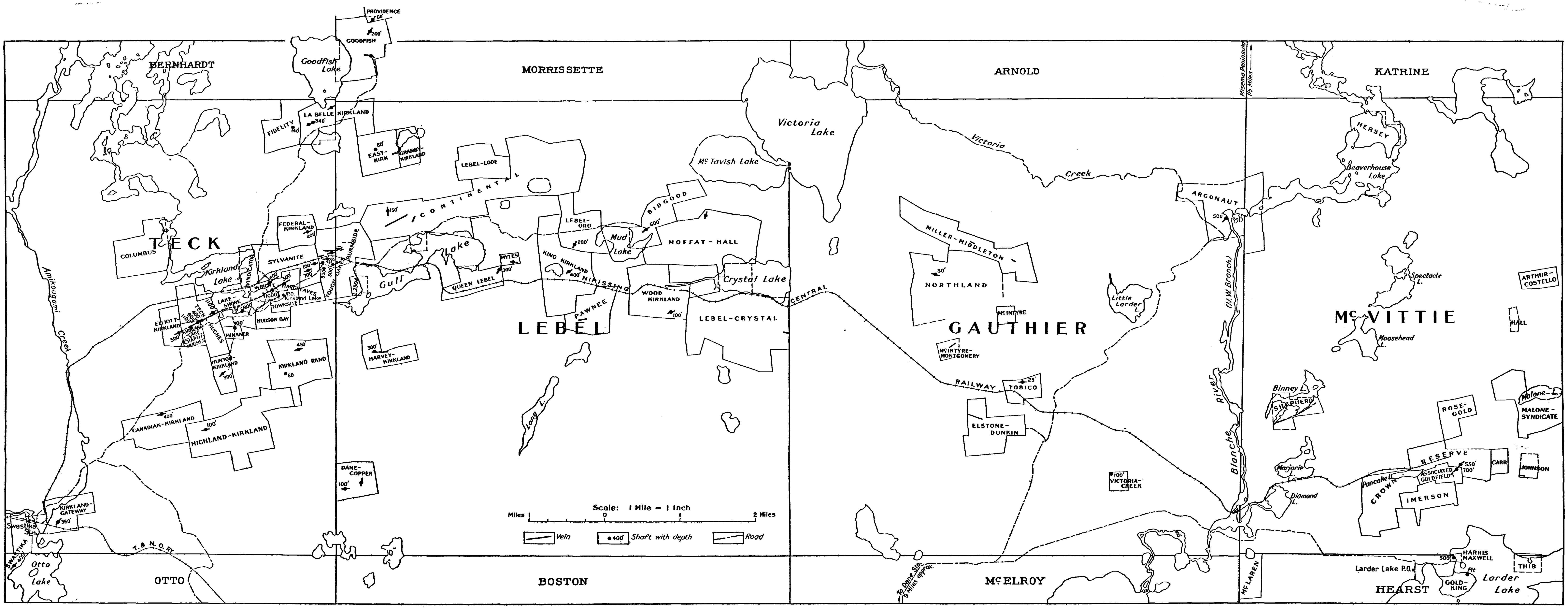
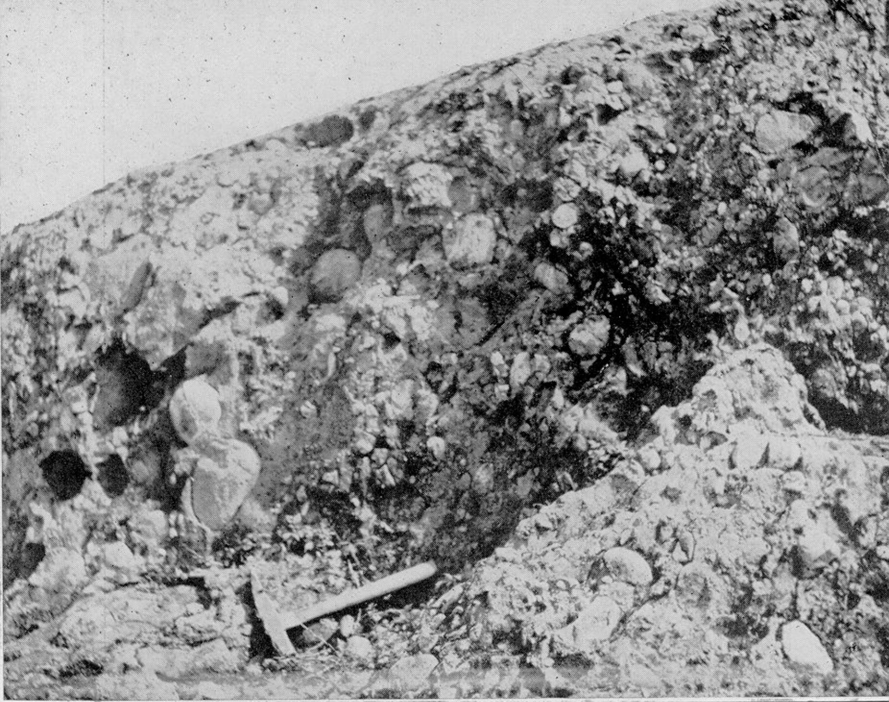
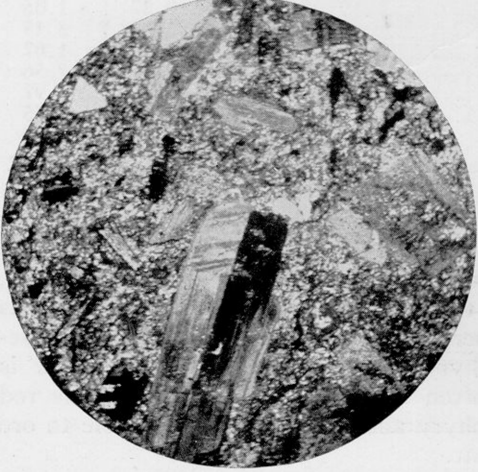
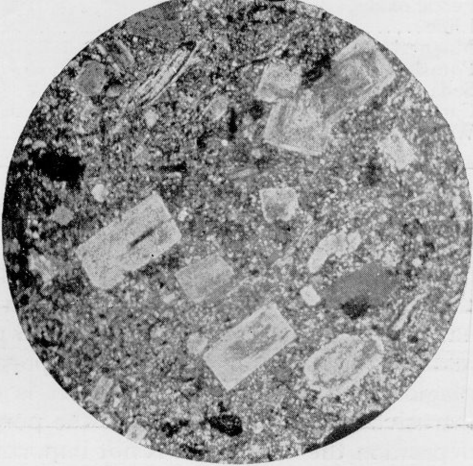


Plan Showing the Location of Several Mines and Prospects in the Kirkland-Larder Area.

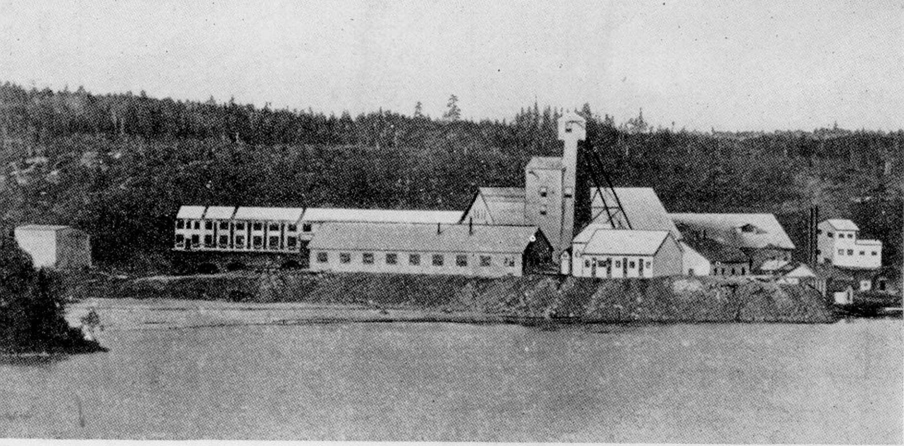
Polished Sample (natural size) of high-grade Gold Ore in Red Porphyry and Syenite, from Kirkland Lake mine. This ore is typical of the Kirkland Lake Area.

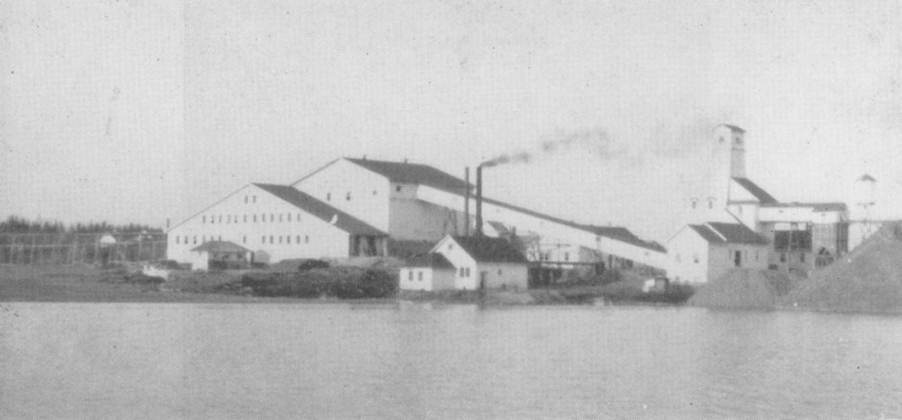


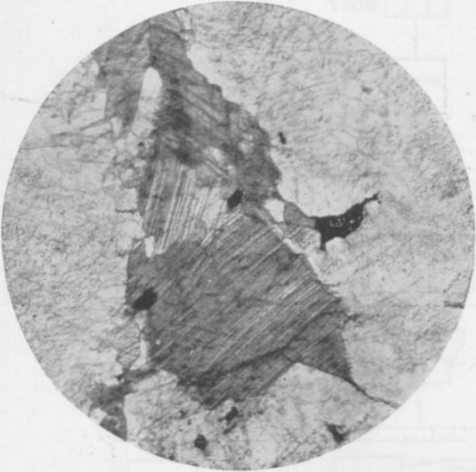


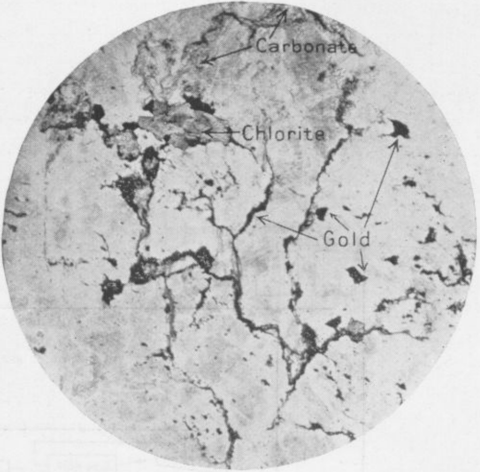


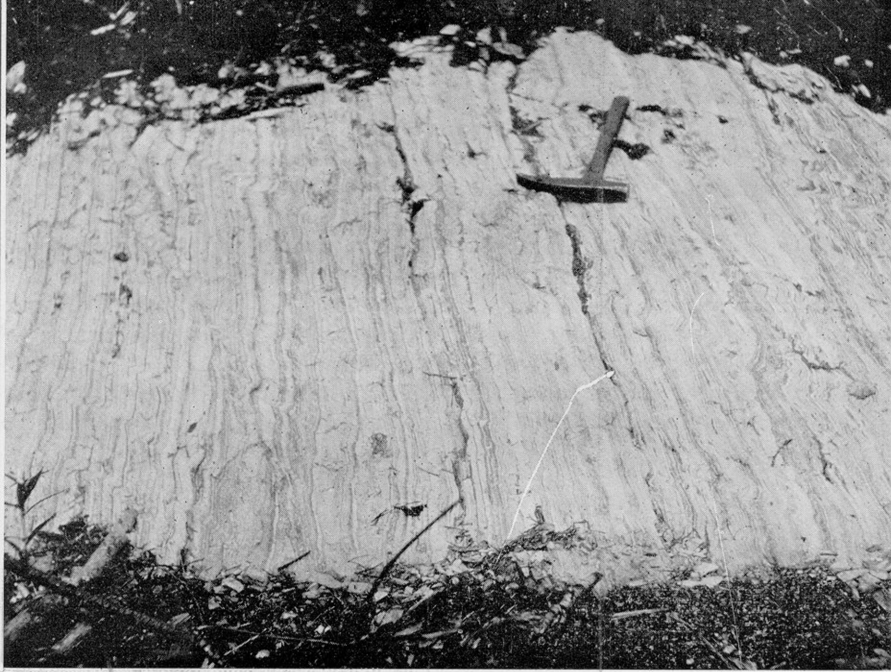

Kirkland Lake Townsite
Lake Shore
Power House
Kirkland Lake
Teck-Hughes
Wright-Hargreaves

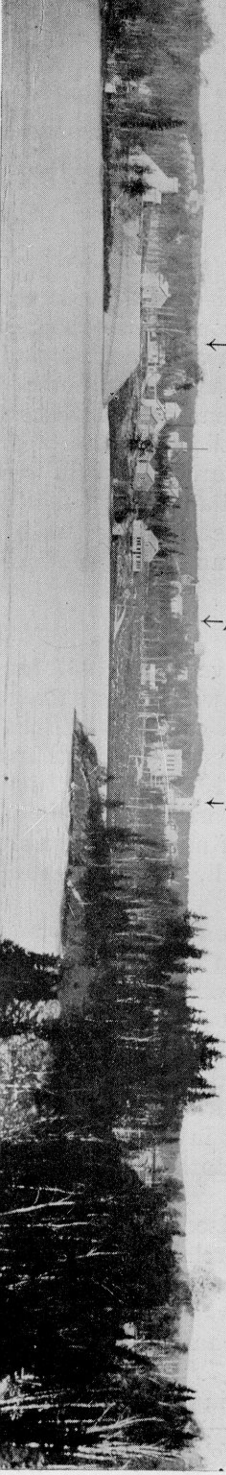







Carbonate
Chlorite
Gold





←Wright-Hargreaves
←Tough-Oakes
←Burnside

←Lake Shore
Kirkland Lak
← Mill
←Teck-Hughes

Kirkland Lake
Tough-Oakes

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. CHAS. MCCREA, MINISTER OF MINES THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-SECOND ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXII, PART V, 1923

Natural Gas in 1922

AND

Petroleum in 1922

By

R. B. Harkness, Commissioner of Natural Gas

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NATURAL GAS IN 1922

By

R. B. Harkness

General Conditions

The temperature from the month of January to May, 1922, was quite moderate, consequently the precautions taken to curtail the use of gas for industrial purposes enabled a satisfactory service to be given throughout the Province. Only three complaints were made on account of low pressure. In two cases the fault was found to be in the consumer's appliances and service pipes, the burners being too low and the service pipes too small. In the third case the company's pipes were too small and an auxiliary high pressure line was laid which provided a remedy.

During the winter of 1922-23 conditions were not so satisfactory. The prolonged strike of the hard coal miners in the United States had resulted in a very serious coal shortage, and although a warning was sent out to all the natural gas users that there was not nearly sufficient gas in the field to satisfy the ordinary demands for heating purposes and that the extraordinary conditions must be met by using some other fuel, either the warning was not taken seriously or the substitute fuel was not procurable, hence a severe shortage of gas was felt in many large centres, especially those at the end of the pipe lines. The unusually cold months of March and April, 1923, made conditions much worse, as many people depend on gas for heating in these months when customarily it is necessary only to have a fire for a few hours in the morning and evening. The small towns were better off as most of them draw from the high pressure mains that supply the large cities.

These conditions were felt more in Essex, Kent, and Lambton counties than in the eastern portion of the southern part of Ontario that is supplied with natural gas. Having in mind the experience of 1920 and 1921[1] a meeting was called at Windsor on November 10th, 1922, which the officials of the gas companies and the cities and larger towns in these counties were asked to attend and discuss the fuel shortage, to the end that an order might be framed that would restrict the use of gas for heating purposes to such an extent that there would be no shortage for cooking. It was brought out at this meeting that in the city of Sarnia more gas was being used in the month of October than was used in the same month in the year 1921, whereas the reverse should have been the case. Even forbidding the use of gas for heating purposes in all business blocks and buildings "centrally heated", having a floor space of over 3,000 square feet, would not relieve the situation entirely, therefore, it remained with the householder to use fuel other than gas for heating in furnaces for the greater portion of the day. It was the unanimous opinion of the representatives of the gas companies and municipalities present that no solution could be found by regulation, and that in their opinion when the gas pressure became so low that there would not be enough for cooking and heating purposes, the situation would auto-

[1]Ont. Dept. Mines, Vol. XXXI, Part V, charts p. 13.

matically regulate itself. Those who lived in the cities, however, know that this does not follow in practice and that so much gas is used for heating as to cause a grave shortage for cooking purposes. The best regulation to meet this condition is a sufficiently high rate for gas to make it too expensive for general heating.

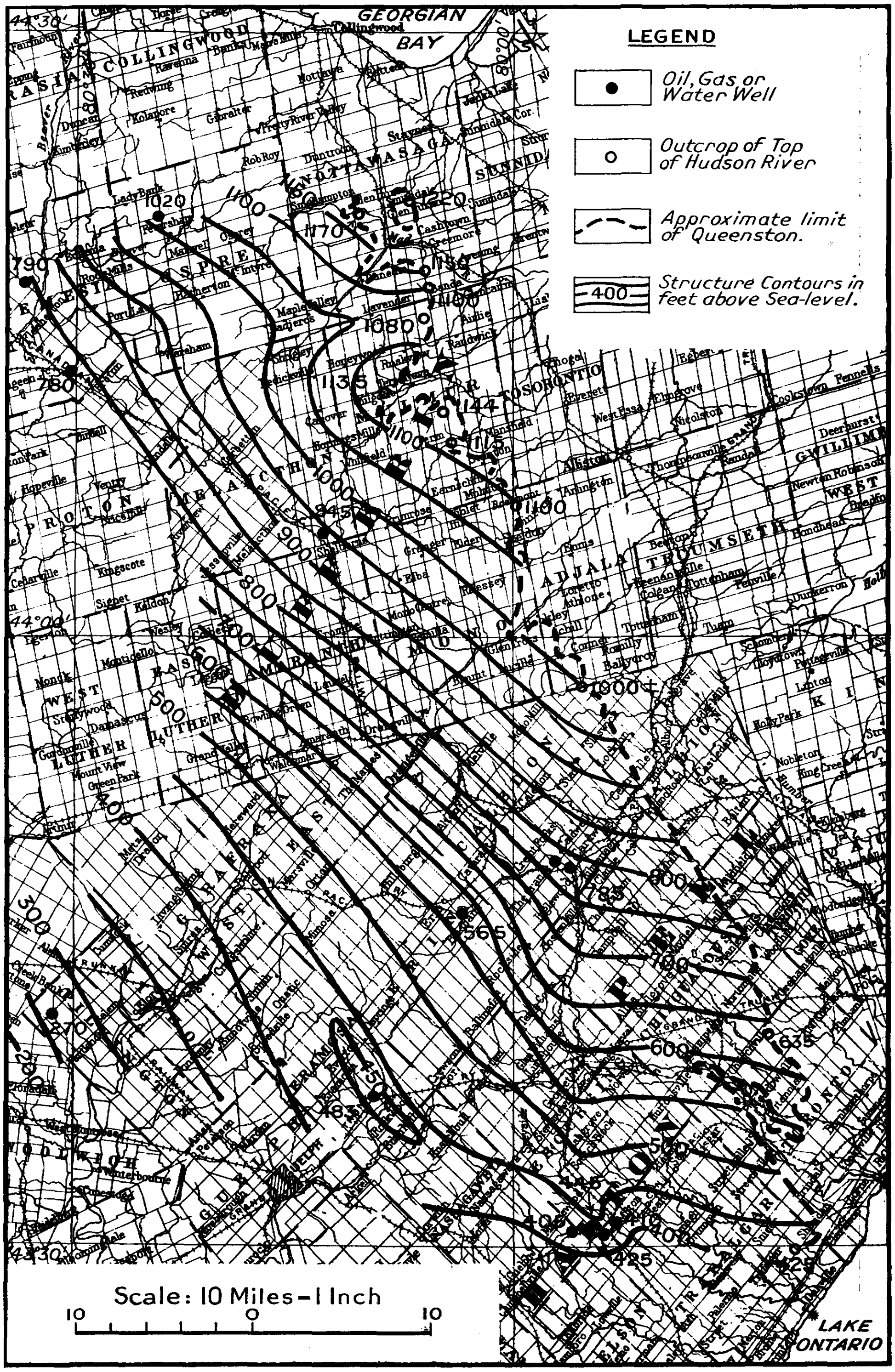
Where the price of gas is more than sixty cents per thousand cubic feet this condition did not exist. Gas at this price is much too expensive to use for heating purposes in large furnaces and consequently no regulation is necessary other than a rate high enough to prevent the use of gas for heating purposes in such furnaces[1]. For heating apartments and small houses gas will still be found cheaper than coal if used in well designed appliances.

Work of the Year

For the past few years it has been apparent that some effort must be made to co-ordinate the work of the many companies producing oil and gas in the Province. Many new companies beginning operations in an unprospected area could be guided by the results of work in nearby fields. Accordingly, two assistants, John Dow and Stanley M. Campbell, began, on July 3rd, to make a survey of the wells drilled in Ontario and record the elevations of a selected number. The field work was carried out in a remarkably short time and was completed in November. A portion of the results is published in a map which accompanies this report. The map shows by contours the upper horizon of the Trenton formation in a large part of southwestern Ontario. Some idea of the work accomplished in this short time can be had from the fact that over 10,000 miles was travelled by the automobile used for this work.

Following the discovery of gas in the Hudson River (Lorraine) shales in Mulmur township, Caledon township and Trafalgar township, search was undertaken to locate if possible a geological structure favourable for the accumulation of oil and gas. A. Ross Clarke was engaged to follow the contact of the Queenston (red) shale and the Hudson River (Lorraine) shale from Lake Ontario to Georgian bay and note the elevations where possible. The results of this field work, together with other available data already published, is presented in a map accompanying this report. These maps, however, do not exhaust the whole of the data gathered. Further expansion must be left for another year.

[1]Ont. Dept. Mines, Vol. XXXI, Part V, pp. 14 and 22.



Map of the area between Oakville and Collingwood showing by structure contours the contact between the Queenston (Richmond) red shale and the Hudson River (Lorraine) shale.

An exposure of the Middle (Red) Richmond or Queenston shale, better known as the Medina formation, at Glen Cross, Dufferin county. This formation is about 250 feet thick. It is a thinly bedded, hard red, or mottled red and green shale, separated by from two to six-inch layers of soft, friable red shale. No fossils are in evidence. The structure appears to be quite flat in a north and south direction. The dip to the west could not be observed.

An exposure of the Hudson River or Lorraine shale on Lake Ontario, two miles west of Oakville. This is ten feet below the contact with the Red Queenston shale. It consists mostly of thin bedded blue shale with occasional bands of hard, limy shale from two inches to four inches in thickness. Many fossils are to be found. The dip, about one degree southwest, is quite noticeable.

Public Hearings

Public hearings were held at the following places:

Place	Date	Subject
Welland	January 18	Free gas
Ridgeway	January 27	Free gas
Wallaceburg	July 31	Industrial permits in Wallaceburg
Windsor	October 23	" " " Windsor
Chatham	October 23	" " " Chatham
Sarnia	October 24	" " " Sarnia
Windsor	November 10	Reducing heating load in Essex, Kent and Lambton counties

Public rate hearings attended by Official Referee were as follows:

Place	Date	Subject
Hamilton	January 17	Rates in Barton township
Cayuga	February 23	Rates in Elgin, Norfolk and Haldimand counties

Public rate hearings attended by the Board of Reference were:

Place	Date	Subject
Chatham	September 27	Rates in Essex, Kent and Lambton counties
Chatham	November 7	" " " " " " "

An order was issued, being No. 21, restraining the Glenwood Natural Gas Company from supplying Hill Bros. with gas until a permit should be issued for the same.

This order was appealed against to the Board of Reference who sustained it, and on further appeal to the Appellate Division of the Supreme Court, the order was annulled.

Removal of Pipe Lines

During the year the Union Natural Gas Company removed the 4-inch pipe line from Charing Cross to Blenheim. This line was part of a line laid from Chatham to Blenheim for the purpose of supplying the latter town with gas. It is not now required as Blenheim is being supplied from the 6-inch line which passes a mile to the south. It had become very heavily corroded, the leakage was excessive, and the revenue from the fourteen paying consumers was not sufficient to pay the expense of repairing the line. It naturally became a burden on the remainder of the paying consumers, and permission was therefore granted to remove it.

Transfers of Property

Many properties changed hands during the year. The Allied Petroleums Company, Limited, and Martin Battle have disposed of their leases, wells and pipe lines to R. H. Smith of Lowbanks. The plants of the Darling Road Co-operative Company and Messrs. Lalor & Vokes were purchased by the Canboro Gas & Oil Company. The National Gas Company disposed of the greater part of its holdings to the Ralph King Gas Company which has also purchased the pipe line of the Manufacturers Gas Company from the King gas field to Hamilton. The Medina Natural Gas Company sold out to the Central Pipe Line Company, and the Southern Ontario Gas Company took over the Beaver Gas & Oil Company and the Glenwood Natural Gas Company.

Inspections

Inspector B. D. Burn visited and tested the pressure at the consumers' appliances at various places in most of the low pressure distributing plants in Ontario. The inspections have shown defects in some plants that have been or are being remedied. Where pressures were too low to give good service, additional pipes were laid; where the pressures were too great or fluctuating, lines were ordered to be laid in order to reduce it and allow a more even pressure through the plant. This work is only partially completed. Some sections of plants will require relaying.

The high pressure transmission line from the Kent field to Hamilton was patrolled in part to detect excessive leakage if possible. This line is buried, and although a number of leaks were found, no single large one was located. The excessive leakage on this line is no doubt due to the accumulation of leaks of moderate size. A careful survey must be made to segregate the worst portions.

Following complaints that gas wells have been improperly plugged in the past, an inspector has been present at the plugging of as many wells as possible during the year. All gas companies are now required to report the method of plugging abandoned wells.

The use of natural gas in industries having been restricted to those who required it both in winter and summer, the necessity of issuing permits twice yearly has been removed. Permits are being renewed where necessary on the 31st of October.

Out of a number of requests to visit and report on areas where showings of of oil and gas have been discovered, the following localities have been visited and reported on. These reports are on file:

St. Vincent township, Grey county.
Collingwood township, Grey county.
Mulmur township, Dufferin county.
Pickering township, Victoria county.
Rawdon township, Hastings county.

The remainder were dealt with by correspondence or personal interview, and did not require a visit.

New Gas Fields

The new Dawn gas field mentioned in last year's report has been more extensively drilled, and although the results have been below expectations, there are now five wells producing gas out of a total of fifteen wells drilled. This gas was turned into the mains on December 4th, 1922, and in consequence the town of Petrolia had a full supply throughout the winter and the service in Sarnia was much improved.

The productive horizon in the Dawn field is in the Lower Niagara or the Clinton limestone, 1,600 to 1,900 feet below the surface. It is a non-sulphurous gas of 0.682 gravity.

The new gas field in Sarnia township mentioned in the last report has not yet been utilized. It is understood that the owners are about to enter into an agreement whereby the city of Sarnia will have the benefit of this gas. The productive horizon in this field is in the Onondaga limestone at a depth of approximately 450 feet. The rock pressure is about 200 pounds per square inch.

Near the village of Inglewood in Caledon township, Peel county, a promising area is being tested. A well was drilled years ago and abandoned, although a fairly good flow of gas was found in the Hudson River (Lorraine) shale it was disregarded. It was found that this well still had an open flow of over 100 M. cubic feet in 1921 and two additional wells gave much better results. The rock pressure is low, not over sixty-five pounds. The company operating this field is planning a large extension in the near future.

Gas Flares

During the past few years several complaints have reached this office that gas is being burnt in open flares in Sarnia township, Lambton county, and near Leamington in Essex county, contrary to the terms of the Natural Gas Conservation Act. These flares have been burning for years and it appears to be a great waste of gas.

In Sarnia township this gas is coming from shallow oil wells. If the gas were closed in, no oil would be recovered as the gas escaping from the small pores of the rock brings the oil with it into the bottom of the well. The pressure and volume of gas in these wells is very small, not nearly sufficient to make it profitable to increase the volume by pumping.

No doubt the best possible use is made of this gas. It is collected from the oil wells and piped to the nearest dwelling house and as the gas cannot be stored or confined, the small excess is allowed to escape, but even this is made use of as a flare to light the barnyard. If there is sufficient for more than one house it is piped to as many as can be supplied at a profit. The best producers are on lot 3, concession VI, Sarnia township, where three wells supply all or part of the needs of eleven consumers.

In Essex county, near Leamington, these flares are in the old flooded Leamington gas field. In 1902, the supply of gas in this field failed, and in July, 1904, it finally ceased to be an operated field. The rock pressure at that time was about 320 pounds. The operators pulled out the casing without plugging the wells, and allowed the surface water to enter the gas producing rock. The weight of down flowing water was approximately 400 pounds per square inch and it naturally forced the gas away from the wells even those that were good producers, in other words "drowned the field". There are still no doubt many "pockets" of gas trapped in this old field at the same pressure as the water, and it is this gas flowing intermittently through the water that is escaping and is being burned under the same conditions as in Sarnia township. If these wells are shut in at the surface, the gas instead of escaping would then be forced away from the wells by the down flowing water and find its way perhaps under Lake Erie where it will never be recovered.

Paraffin or Ozocerite and Salt in Gas Wells

One of the many and serious problems met in the production of natural gas is the accumulation of salt and paraffin wax (ozocerite) at the bottom of tubing. The compressed gas in the rocks, entering a drilled hole from which the gas is being rapidly drawn, expands and cools. The paraffin or salt is deposited in the tubing as a condensate. This is not so serious in wells where some salt water enters with the gas, as pumping the salt water brings the salt and paraffin along with it; but in wells that have a mere trace or no salt water in them, either salt or paraffin may accumulate and cause a well to cease production for weeks or in many cases months.

In both cases the production and the rock pressure decline in like proportion as in the case of an exhausted well. Paraffin will be recognized in the early stages by "blowing". Salt, however, will not be discovered in this manner. Many wells are in the process of abandonment when they are discovered to be "salted up".

The treatment of "salted wells" is simple. Open the top of the well, pour in a barrel or more of fresh water (depending on the size of the tubing) allow it to stand twelve hours or more, agitate if necessary, bale out and repeat the process until the well is producing gas as usual. Paraffin must be treated differently and must be watched very closely, for a well once sealed with paraffin presents a most difficult and stubborn problem. The well should be "blown" frequently so that the paraffin is not allowed to accumulate, but, if it shows signs of accumulation, from ten gallons to one barrel of kerosene (depending on the size of the tubing) should be poured into the well and allowed time enough to run down the tubing and come in contact with the paraffin. It should then be blown out, or in case it has not softened the paraffin, blown up the tubing and allowed to run back again. Better results will be obtained if the kerosene is hot. This is a safe treatment for any well in which paraffin is found. Should the rock pressure be too low to blow out the softened paraffin, a bailer must be used. The same process is used in a well that is being pumped. The kerosene is introduced between the pump and tubing and is either blown out or pumped out. If a gas well with a pump in it becomes sealed with paraffin a most expensive and long drawn out fishing job is certain to result before the well will ever again produce gas.

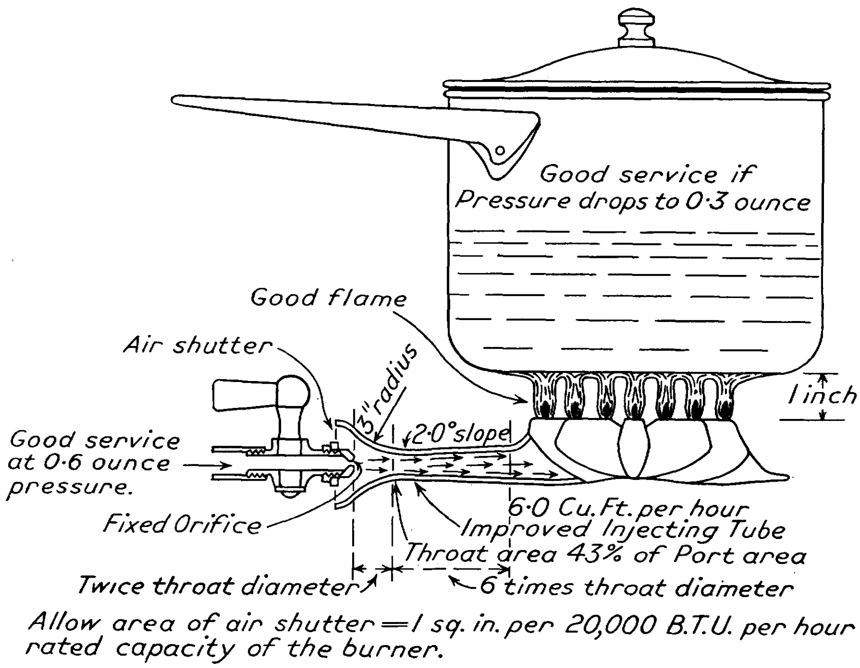
Experiments carried out by the Union Natural Gas Company in the Dover field where gas and oil is produced from the Trenton limestone and paraffin is prevalent show that kerosene is the best solvent of paraffin. Steam had the effect of "vulcanizing" it, gasoline and benzene made it brittle. With kerosene it took the form of heavy grease and by adding more made a heavy black oil.

Standardization of Equipment

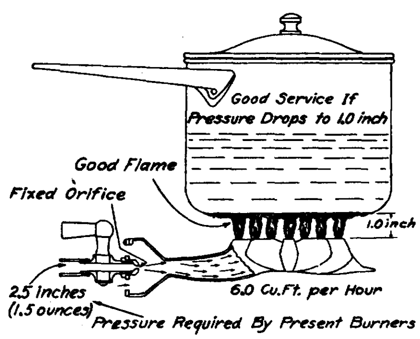
During the last two years great efforts have been made by both the manufacturers of equipment and producers of gas and oil to standardize materials used in the gas and oil industry and by doing so reduce the overhead cost of the equipment used in its manufacture and thereby effect a reduction in the price of the finished article. A Committee of Standardization was formed by the Natural Gas Association of America, which is working in conjunction with the various petroleum associations, the American Engineering Standards Association and the manufacturers of equipment, along these lines. A few of the items the committee are working on are: Oil and gas well casing and tubing, rig irons, threads on box and pins of drilling tools, line pipe, weights of valves, flanges, gas connections, etc., and the possibility of making materials manufactured by different companies interchangeable. The report of the work of this very important committee can be got from the secretary of the Natural Gas Association of America.

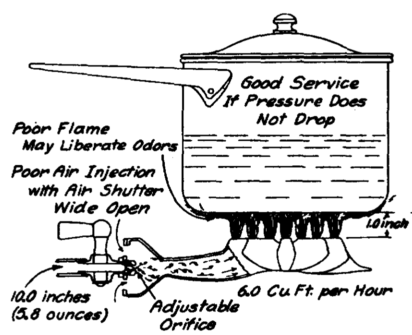
New Burner

The accompanying cut shows the latest and most improved type of gas burner as given to the public by the United States Bureau of Standards, Washington, D.C. This burner has been tested both in their laboratories and in general use for over a year and is pronounced a success.

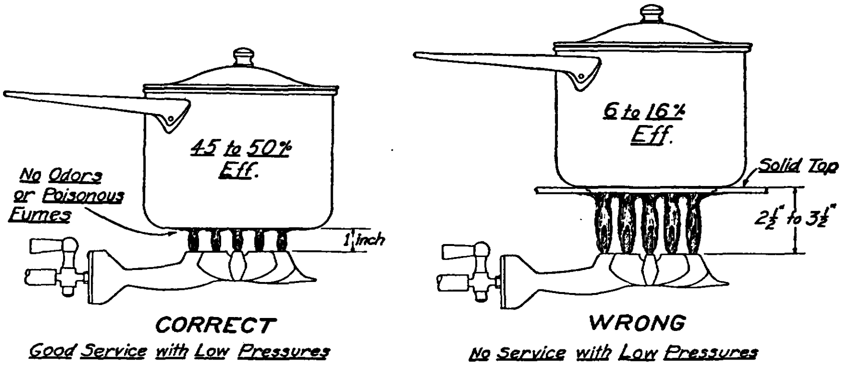


Improved type of Gas Burner designed by U.S. Bureau of Standards.





The burners in use at the present day are shown in the above cuts. If a fixed orifice is used and the mixture carefully adjusted, it will give service at 1½ ounces pressure, as on the left. Burners with adjustable orifices such as that on the right will liberate poisonous gases if the pressure is high and the air mixture incorrect. Better results will be had if a fixed orifice and a fixed air mixture is used and the pressure regulated with the valve.



The burner on the right will require from 8 to 10 ounces pressure to give satisfactory results, while the one on the left can be operated at 2 ounces pressure. The amount of gas used is quite in proportion to the pressure.

It is especially designed to give service at very low pressures to meet the conditions of a failing gas supply. This burner will give satisfactory service at a pressure of 6/10 oz. It is recommended that the burner should be one inch below the cooking vessel and to get the same economical service at a higher pressure it is only necessary to open the valve part way. If these burners were used generally, the gas could be delivered throughout all distributing plants at not more than two ounces pressure. This would result in a very important means of reducing losses in a distributing system for the leakage at four ounces pressure is stated to be forty per cent. greater than at two ounces pressure. Unfortunately, some distributing plants are still delivering gas at pressures varying from six ounces to ten ounces. The other four cuts show defects in types of burner now in use.

Sulphur Gas

The gas in the Kent field, better known as the Tilbury field, contains about 350 grains of sulphur per hundred cubic feet in the form of hydrogen sulphide (H_2S) or about one-half of one per cent. by volume. Although this hydrogen sulphide gives the gas a very offensive odour and is mildly poisonous as compared with manufactured gas, which contains usually about fifteen per cent. carbon monoxide (a deadly poison), it has one advantage, namely, that of rendering great assistance in detecting leaks, which if not discovered corrode steel pipe and leaks are developed very rapidly. Hydrogen sulphide is combustible although it contains less heat (B.T.U.) than methane. When burnt it is converted into sulphur dioxide which causes intense irritation to the eyes and nose and on this account cannot be taken in sufficient quantities to injure the health[1]. For this reason all equipment in which this gas is burned must have vent pipes to carry away the products of combustion. Open top stoves cannot very well be used with this gas.

Two or three small cities, where manufactured gas was used prior to the advent of natural gas, have been able to remove the hydrogen sulphide from the Tilbury gas through the same equipment used for that purpose in manufactured gas; provided, however, that the capacity of the existing plant was not exceeded.

[1]G. R. Mickle address, first meeting Natural Gas and Petroleum Association of Canada, Transactions, 1919.

In 1914 and 1915 the Glenwood Natural Gas Company built a purifier in the Tilbury gas field at a cost of about $190,000, which gave satisfaction for a short time. The process used was as follows: The gas was allowed to bubble through a solution of aqueous ammonia which took the hydrogen sulphide out of the gas and changed the solution into ammonium sulphide and polysulphides. The hydrogen sulphide was driven out of the ammonia solution by heating and washing. This last process caused such rapid corrosion in the heat interchanging system that at the end of a year the plant was found to be useless and they were forced to abandon the scheme or else rebuild it in cast iron which was too expensive. Lately, a new scheme has been developed and the Union Natural Gas Company has had a company carry out tests at Port Alma which are understood to be practical and very successful. This process is much the same excepting that soda ash is used instead of ammonia. The sulphur content has been reduced at a moderate cost from 350 grains to about ten grains per hundred cubic feet. It can be entirely eliminated if necessary by either of the above processes.

It is hoped that in the near future the gas from this important field may be freed from this most objectionable odour.

Specific Gravity or Density of Gases in Ontario

It has been stated by different authorities on natural gas that as a gas field diminishes in volume and rock pressure, the gas becomes "richer" or denser; apparently due to the law of diffusion of gases, i.e., the lighter gases will escape from the minute pores of the rocks more readily than the heavier gases, "the viscosity of a gas or the measure of difficulty with which it flows through an orifice of any kind is supposed to vary directly with the square of its density.[1] On page 28 will be found a table which shows to what extent the volume of gas decreased, and on pages 14 to 18 is shown the decline in rock pressure in the Haldimand field.

In the year 1914 the samples were taken from the known gas fields of Ontario and a complete analysis made.[2] This highly technical work afforded an opportunity after a lapse of nine years for comparison with present conditions. Samples were taken on the edges and centre of gas fields for the purpose of determining whether or not the specific gravity of the gas was affected by the proximity of edge water.

The previously recommended method of sampling[3] was used and found to be thoroughly reliable for all gases, excepting those containing hydrogen sulphide. Great care must be taken to have the container completely filled with water and some means must be taken to protect the rubber tube while in transit from being cut or damaged against the sharp edge of the tin. It was found advisable to put some pressure in the container when sealing at the well. Where there is reason to believe that hydrogen sulphide is present in a gas it was found best to use a dry glass container and allow the gas to flow through it slowly for at least twenty minutes, then close in the usual way. When water was used in the container, sufficient adhered to the sides to so alter the hydrogen sulphide that no reaction was noticed on the iodine.

All samples were first tested for oxygen. Those found to contain any oxygen were discarded and new samples taken; in every such case the con-

[1]Ont. Dept. of Mines, Vol. XXIII. The chemical analysis of natural gases found in Ontario, p. 32.

[2]Opus cit.

[3]Opus cit., p. 4.

tainer or tube was found to be defective, and in consequence none of the samples used in this report contain any oxygen.

It must be borne in mind that the work done in 1914 was a technical work to discover variations in the gases in different fields and in different formations. Wells were chosen on account of the formation penetrated and not as in this case for their location in each field. Therefore, in taking the averages used in the following comparisons there is a possibility of error. The same applies to the chemical analysis. Present samples were taken from the main transmission line which is a mixture of all the wells, whereas the averages of 1914 samples are from a limited number of wells.

The analysis and specific gravity of gases in 1923 were made by Professors J. W. Bain and E. G. R. Ardagh of the University of Toronto, who made the analysis in the same way in 1914. The calculated specific gravity of 1914 and B.T.U. of 1914 and 1923 samples were made by the writer.

TABLE I.—SPECIFIC GRAVITY OF ONTARIO GASES

County	Township	Lot	Con.	Number of well	Formation	Specific gravity, 1923	Average specific gravity 1914	Average specific gravity 1923
Kent......	Romney	190	N.T.R.	2–Dawson	Salina or Guelph	0.700	0.637	0.692
"	"	179	N.T.R.	221–Union	"	0.709		
"	Tilbury E.	13	M.R.S.	5–McCord	"	0.658		
"	Raleigh	4	XII	2–Houston	"	0.702		
"	Dover W.	2	III	No. 13	Trenton	0.615	....	0.615
Lambton..	Dawn	24	VII	No. 1	Niagara	0.682	new field	....
" ..	Enniskillen	pt 19	II	No. 6	"	0.673	0.640	0.673
" ..	"	"	"	No. 7	Trenton	0.690	....	0.690
"	Sarnia	8	VII	2–Hancock	Onondaga (Corniferous)	0.885	new field	....
Elgin.....	Bayham	15	III	1–Teall	Medina	0.653	0.628	0.653
Norfolk..	Woodhouse		Port Dover	1–Company	White Medina	0.669	0.665	0.669
" ...	"		"	1–Kelly	Red Medina	0.660	....	....
Haldimand	Rainham	25	I	1–Austin	Clinton	0.655	0.647	0.657
"	Canboro	7	Dochstead-er Tract	1–Jardine	White Medina	0.659		
Welland...	Willoughby	2	IV	No. 61	Trenton	0.605	0.588	0.605
" ...	Bertie	35	III	1–Zavitts	White Medina	0.649	0.643	0.649
Peel......	Caledon E.	3	IV	No. 2	(Lorraine) Hudson River	0.635	new field	....
Grey......	St. Vincent	24	VII	2–Doran	Trenton	0.752	new field	....

Without exception it will be seen that in all gas fields there is an increase in the density of the natural gases of Ontario and every formation shows this increase.

TABLE II.—ANALYSES OF NATURAL GASES (a)

Name of Gas Field	Year	H_2S	CO_2	Methane CH_4	Ethane C_2H_6	Propane C_3H_8	N	B.T.U.
Tilbury......(b).	1914	0.57	0.10	82.7	11.4	....	5.3	1039.4
" ......(c).	1923	0.30	....	87.3	5.5	1.4	5.5	1015.0
Haldimand....(d).	1914	....	....	78.5	13.2	0.3	7.8	1040.3
" ....(e)	1923	....	0.10	83.5	7.1	1.9	7.4	997.5
Welland......(f)..	1914	....	0.03	83.5	11.9	....	5.8	1040.9
" ......(g)..	1923	....	....	79.8	9.0	1.8	9.4	1009.2
Caledon E., tp.....	1923	....	....	86.7	....	....	13.3	950.5

(a) Professor J. W. Bain, University of Toronto, states that there is the suggestion of a trace of butane (C_4H_{10}) in the samples taken this year.
(b) Average of five analyses.
(c) Taken at Port Alma station from main transmission line to Sarnia.
(d) Average of thirteen analyses.
(e) Taken from main transmission line to Hamilton.
(f) Average of seven analyses.
(g) Taken at Niagara Falls from main transmission line.

Although Table I shows that the density of the gases is increasing, the above analyses unfortunately show that the most essential element, the B.T.U. (heating value) is lowering, but fortunately only three per cent. True to theories the heavier gases, propanes and butanes are present but at the expense of ethane and in one case, an increase in nitrogen which has no calorific value. This again is offset to a certain extent by the fact that the heavier hydrocarbons require more air per cubic foot to complete combustion.

AIR REQUIRED TO BURN ONE CUBIC FOOT OF GAS.

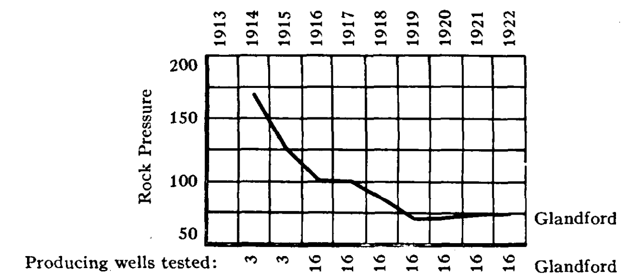
Methane (CH_4)..................................	9.57 cu. ft.
Ethane (C_2H_6)..................................	13.16 "
Propane (C_3H_8)..................................	16.75 "
Butane (C_4H_{10})..................................	23.92 "

Although it would appear that Ontario has a diminishing supply of gas of a poorer quality, the public can still have practically the same result as heretofore by increasing the proportion of air in the mixture at the stove.

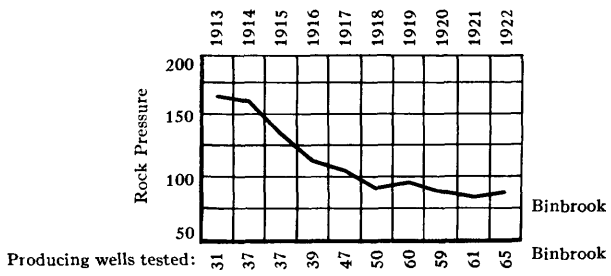
Rock Pressures in Norfolk-Haldimand Gas Field

During the past year an effort has been made to determine the residue supply of gas in the Haldimand gas field, but such difficulty was experienced in arriving at the total annual production, along with the fluctuations in rock pressure (pounds per square inch) from year to year, that the result was not dependable.

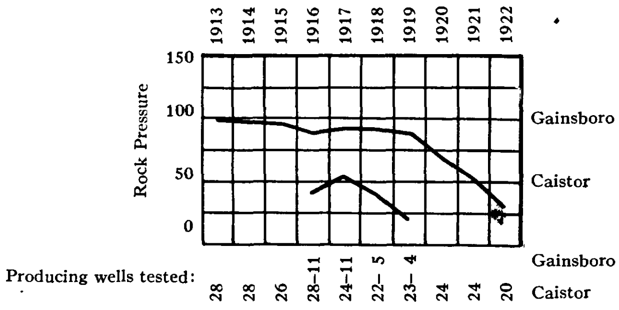
The Dominion Natural Gas Co. has kindly furnished the annual rock pressure of their wells in the Norfolk-Haldimand field, as shown by the accompanying graphs. This will fairly represent the general pressure of the wells in the township mentioned.



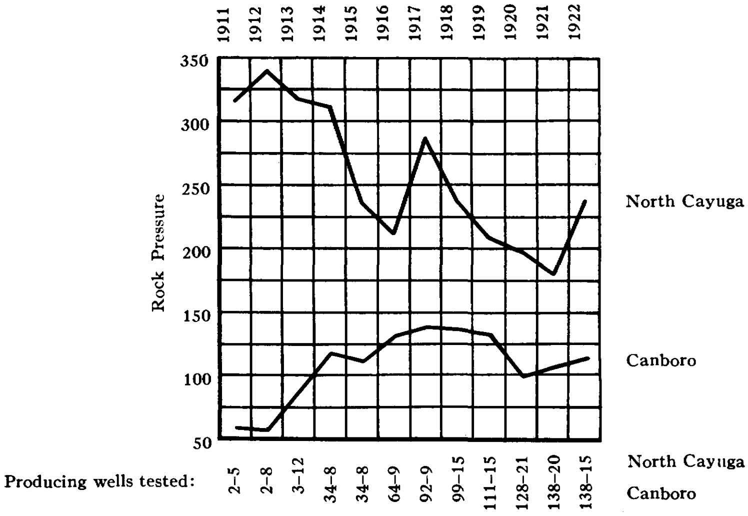
Rock Pressure in Glanford township.



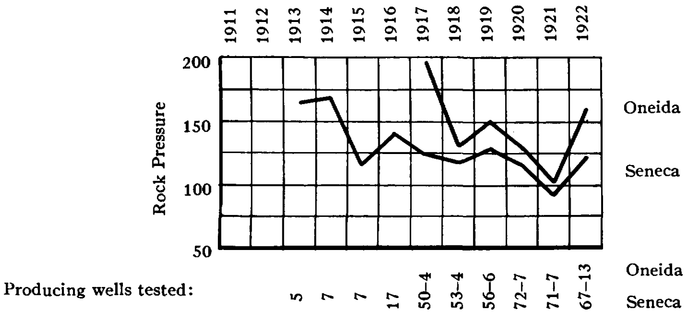
Rock Pressure in Binbrook township.



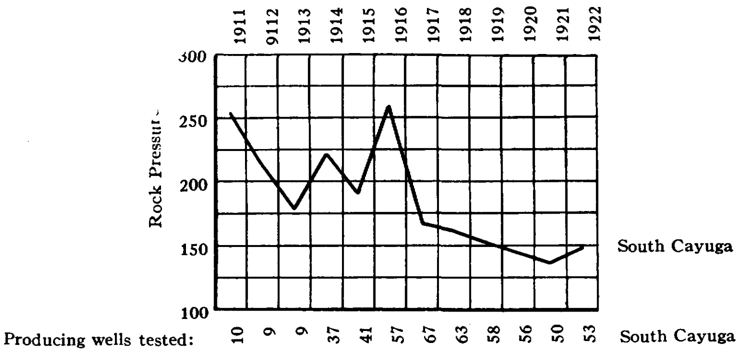
Rock Pressure in Gainsboro and Caistor townships.



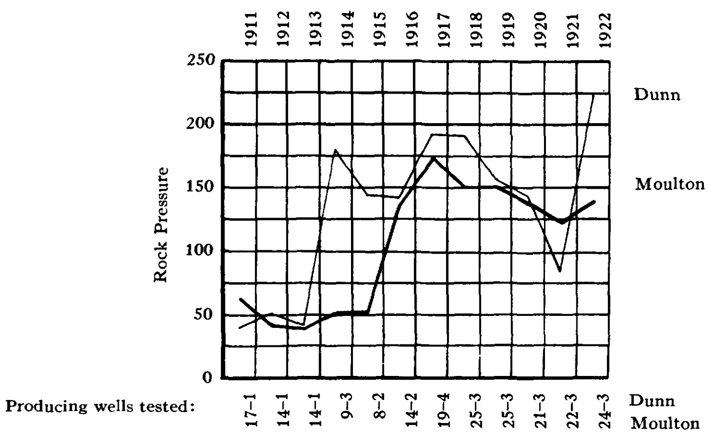
Rock Pressure in North Cayuga and Canboro townships.



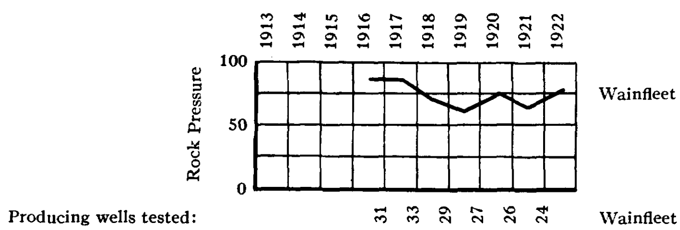
Rock Pressure in Oneida and Seneca townships.



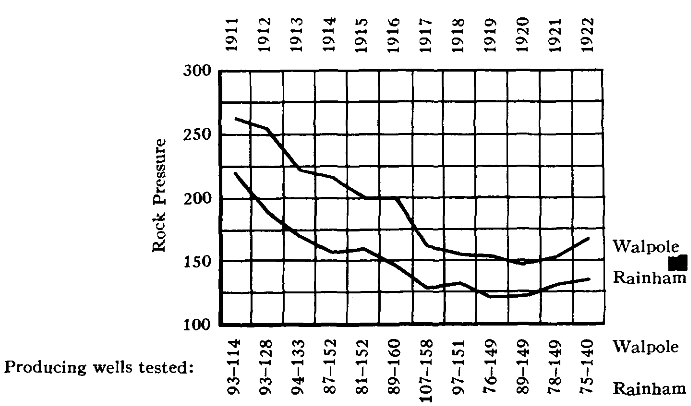
Rock Pressure in South Cayuga township.



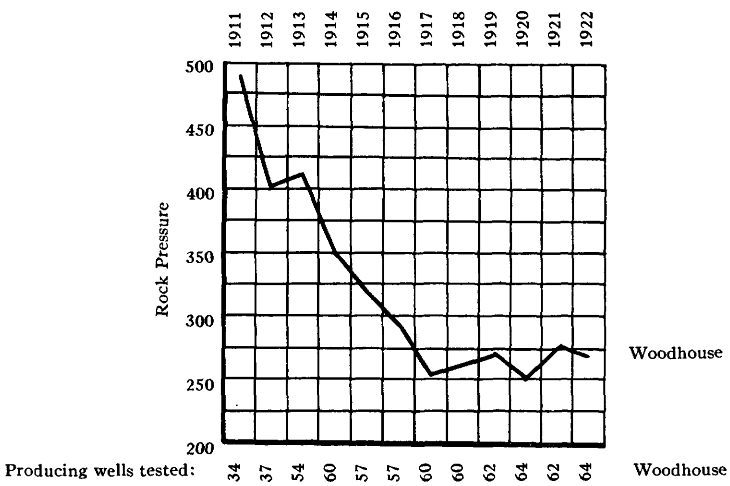
Rock Pressure in Dunn and Moulton townships.



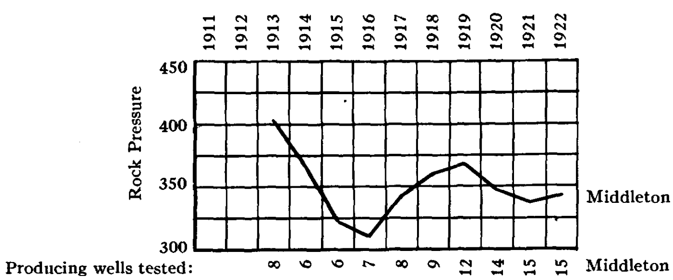
Rock Pressure in Wainfleet township.



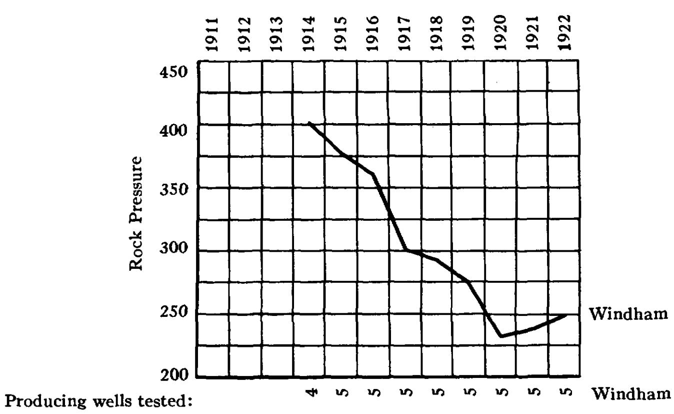
Rock Pressure in Walpole and Rainham townships.



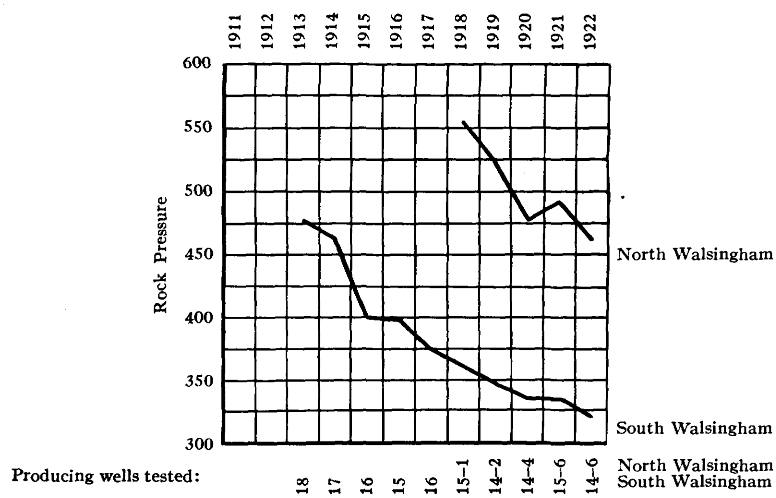
Rock Pressure in Woodhouse township.



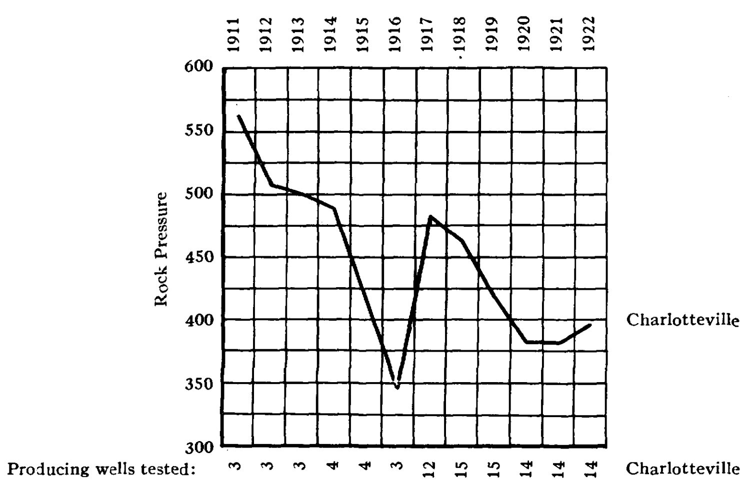
Rock Pressure in Middleton township.



Rock Pressure in Windham township.



Rock Pressure in North and South Walsingham townships.



Rock Pressure in Charlotteville township.

Gas Used for Industrial Purposes

In the year 1922, the gas used for industrial purposes amounted to 656,629 M. cubic feet, this being 201,112 M. cubic feet less than was used in 1921.

The reduction made in the amount of gas used by industries in Ontario in the past six years is as follows:

Years	M. cu. ft.	Years	M. cu. ft.
1917	9,124,752	1920	1,423,825
1918	2,744,866	1921	857,741
1919	1,584,479	1922	656,629

In March, 1922, the detailed statement of "gas used in industries in 1921"[1] was sent to every natural gas-using municipality in Ontario and criticism was invited. The amount of gas used for glass manufacturing in Wallaceburg was the only item complained of. This was made the subject of a public hearing in Wallaceburg and it was clearly shown that the employment of hundreds in Wallaceburg was so dependent on the supply of natural gas to the glass industry that no one demanded that they be cut off. The supply to this industry during the past year has been limited to bare necessities. The policy adopted in 1921 has been carried out in 1922 with the result shown in Table I, and there is no doubt that the natural gas used for industrial purposes has been reduced to the same basis as manufactured gas is used in industries. Permits are now issued once yearly, in October. Changes and improvements in processes of manufacture are being watched and it is proposed that no one shall be allowed to waste gas by obsolete methods if a more up-to-date method is proved successful and economical. No great reduction in the amount of gas sold to industries need therefore be effected.

There is on file a report on nearly every manufacturer using more than 5,000 cubic feet of gas per month. Inspections are made annually by Inspector Burn and all reductions possible are made in the amount of gas allowed to be used under permit.

One gas company was prosecuted and convicted of selling gas to industries without a permit. This company has now improved their system of checking industrial sales, and the possibility of repeating this offence has been eliminated.

TABLE III.—GAS USED BY INDUSTRIES IN TOWNS, CITIES AND TOWNSHIPS IN ONTARIO DURING THE YEAR, 1922.

Municipality.	M cu. ft.	Municipality.	M cu. ft.
Aldboro township	849	Port Colborne	2,985
Bertie township	114	Port Dover	1,157
Belle River	757	Raleigh township	1,384
Blenheim	933	Rainham township	1,106
Brantford	5,800	Ridgetown	3,282
Bridgeburg	70	Rodney	548
Caledonia	2,213	Sarnia township	5,033
Chatham	9,673	Sarnia	4,987
Courtright (Moore township)	2,091	Simcoe	13,373
Delhi	1,488	Sombra township	2,677
Dresden	2,647	St. Catharines	3,980
Dundas	621	St. George	25
Dunnville	27,655	Southwold township	2,829
Dunwich township	623	Thorold	20,103
Dutton	1,028	Tilbury	8,994
Essex	5,814	Tilbury East township	7,538
Fort Erie	51	Tillsonburg	2,318
Galt	2,495	Wallaceburg	183,454
Hamilton	29,756	Walkerville	3,424
Highgate	56	Welland	583
Ingersoll	3,215	Wainfleet township	250
Jarvis	1,138	Windsor	11,697
Kent, North	12,401	Woodstock	4,282
Kent, South	13,071		
Kingsville	44,905		459,114
London (Westminster township)	124	Used by Gas Companies for power purposes	143,619
Niagara Falls	271	Miscellaneous use	53,896
Oil Springs	289		
Paris	670		
Petrolia	2,287	Total	656,629

[1]Ontario Dept. of Mines, Vol. XXXI, pp. 30-31.

Gas in Greenhouses and Tobacco Kilns

The manner in which gas was used in greenhouses and for curing tobacco was made the subject of an investigation following a complaint that this was the cause of a shortage of gas in the locality south of Essex town and it was found that gas was used in individual heaters in greenhouses during the night in such a way that no other fuel could easily be adapted. The method of curing tobacco was very much the same excepting that it was a matter of economy; other fuel could be used but the cost was prohibitive. For instance, in the Southern States wood is the most used fuel but in Essex and Kent it is not procurable at a reasonable rate. There is much room for improvement in the method of heating kilns. One firm has brought out a new furnace which is apparently showing much economy in the use of gas.

Leakage

The measured leakage of natural gas in Ontario amounted to 1,218,678 M. cubic feet in 1922. This is probably two-thirds of the actual leakage, as the eastern fields are so scattered and the markets are so near that it is impractical to measure the gas. However, more meters are being put in each year, the numbers increasing with the advance in gas rates, i.e., as gas becomes more valuable and as the supply decreases greater efforts are put forth to reduce leakage. Based on the above the total leakage for the Province would be 1,625,000 M. cubic feet, or nearly one-fifth of the total production. By consulting the table of leakage it will be noted that the major portion of the leakage is on the main transmission lines. So far as it known to date the leakage on a pipe is more or less proportionate to the pressure carried.[1] Pressures of 350 lbs. were recorded on transmission lines from the Kent field in 1910-1917 (three times the present pressure); the same is true of low pressure plants when double and treble the present pressures were carried. Modify this by the fact that the pipe lines were then new or six years old and naturally in much better condition, then a supposition that the leakage in past years will be proportionate to the leakage at present, and the result will not fall very short of accuracy, viz., one-fifth of the annual production.

[1]Test by the Louisville Gas and Electric Co., Louisville, Ky., U.S.A.

TABLE IV.—LEAKAGE ON RURAL LINES.

Township	Name of Line	Equivalent miles of 3-inch pipe in distribution plants and transmission lines	Volume received 1922 M. cu. ft.	Volume delivered 1922 M. cu. ft.	Leakage for year Actual M. cu. ft.	Leakage for year Allowable M. cu. ft.	Average No. Consumers	Leakage per Consumer, cu. ft.	Distributing plant pressures
Raleigh	Middle Rd.	.09	988	901	87	18	5	17,400	6 ounces
"	7th Con.	.25	841	758	83	50	3	27,670	8 lbs.
"	3rd Con.	.06	533	467	66	12	3	22,000	10 ounces
"	Chrysler	.18	858	711	147	36	4	34,750	5 "
"	Chinnick	.14	1,168	454	714	28	3	238,000	10 "
"	Moore and Phipps	.07	473	310	163	14	2	81,500	5 "
"	8th Con.	.33	1,965	1,436	529	66	9	58,780	5 "
"	6th Con.	1.70	4,776	3,288	1,488	340	20	74,400	9 "
"	Rhodes	.82	3,510	3,091	419	164	19	22,050	8 "
"	9th Con.	1.90	5,333	3,703	1,630	380	29	56,200	12 lbs.
Harwich	Cemetery Line	.54	1,758	1,183	395	108	5	79,000	5 ounces
Dover	4th Con.	1.56	2,429	1,540	889	312	10	88,900	10 "
"	No. 2 Union	.06	356	391	gain	....	2	......	4 "
"	No. 4 Union	.23	448	299	149	38	3	49,700	5 "
"	No. 5 Union	.20	391	314	77	30	3	25,700	5 "
"	No. 1 Northern	.18	375	267	108	21	2	54,000	5 "
"	No. 5 Northern	.33	1,358	776	592	66	5	118,400	5 "
"	No. 2 Northern	.21	2,833	2,172	661	42	4	165,250	9 "
"	Cassidy	.09	143	89	54	5	5	10,800	5 lbs.
Chatham	No. 6 Northern	.12	268	197	71	24	2	35,500	5 "
Rochester	Ruscomb	.12	483	427	56	24	13	4,300	5 ounces
"	St. Joachim, 2 months only	3.06	4,119	2,195	1,924	612	76	25,300	25 lbs.[1]
"	Parker, 11 months only	.10	158	154	4	18	3	1,300	5 ounces
Moore	Brigden	.65	1,872	1,002	870	165	9	96,700	5 "

[1]Transmission line.

TABLE V.—LEAKAGE ON TRANSMISSION LINES.

From	To	Equivalent miles of 3" pipe in distribution plants and transmission lines.	Volume received, 1922 M. cu. ft.	Volume delivered, 1922 M. cu. ft.	Total leakage M. cu. ft.	Leakage per mile of 3" pipe per year. M. cu. ft.	Pressure lbs. Transmission lines.
Tilbury Field.....	Chatham.....	40.5	744,163	659,261	84,902	2,096	80 to 140
" "	Ridgetown....	54.	346,257	278,589	67,668	1,253	80 to 140
" "	Sarnia........	299.	915,077	878,966	36,111	121	80 to 140
" "	Windsor......	227.8	1,650,221	1,402,725	247,496	1,086	80 to 140
" "	Wallaceburg..	64.5	432,009	377,322	54,687	848	80 to 140
" "	Kingsville....	84.5	637,134	498,615	138,519	1,639	80 to 140
" "	Hamilton.....	625.9	1,031,675	705,312	326,363	522	80 to 140

NOTE.—The leakage per mile of 3-inch pipe on transmission lines is given for methods of comparison only. No standard has yet been set. The rural lines given are owned both by private individuals and gas companies. The allowable leakage on low pressure distributing plants has been placed at 200 M. cu. ft. per mile of 3-inch pipe.

A striking example of the corrosive action of soil and escaping gas, which contains hydrogen sulphide, on iron or steel pipe. In this case the leaks all occurred on the bottom of the pipe. The 'U'-shaped iron rods are the means of clamping a curved iron plate lined with a rubber gasket over the leak and thereby stopping it.

TABLE VI.—LEAKAGE IN DISTRIBUTION PLANTS IN ONTARIO.

Company	Cities and Towns	Equivalent miles of 3-in. pipe in distribution plants	Volume received, 1922	Volume delivered, 1922	Leakage for year		Average No. of Consumers	Leakage per Consumer	Pressure
					Actual	Allowable			Distribution plants
			M. cu. ft.	M. cu. ft.	M. cu. ft.	M. cu. ft.		cu. ft.	
Union Natural Gas Co.	Blenheim	11.27	77,686	71,778	5,908	2,310	510	11,584	5 ounces
Brantford Gas Co.	Brantford	89.57	144,325	122,534	21,791	17,914	4,378	4,980	5 "
Chatham Gas Co.	Chatham	54.5	605,890	607,758	gain	10,900	3,554	....	5-10 "
Union Natural Gas Co.	Dresden	11.81	63,702	57,906	5,796	2,362	530	10,900	6 "
Dominion Natural Gas Co.	Dundas	9.96	48,069	36,135	11,934	1,992	1,050	11,370	5 "
Dominion Natural Gas Co.	Dunville	12.9	125,181	112,645	12,536	2,584	942	13,300	7 "
Dominion Natural Gas Co.	Galt	30.57	73,541	58,486	15,055	6,114	1,500	10,000	5 "
Ingersoll Gas Light Co.	Ingersoll	22.11	81,565	78,024	3,541	4,422	1,180	3,000	5 "
Southern Ontario Gas Co.	Kingsville	14.31	120,028	110,805	9,223	2,862	600	15,500	5 "
Corporation of Town	Leamington	No measurement	195,581	181,554	14,027	....	1,100	12,750	9 "
Dominion Natural Gas Co.	Paris	13.6	32,027	26,704	5,323	2,720	580	9,180	4 "
Petrolia Utilities, Ltd.	Petrolia	26.5	125,871	110,533	15,538	5,300	829	18,740	5 "
Union Natural Gas Co.	Ridgetown	14.9	90,798	83,730	7,068	2,980	610	11,590	5 "
Sarnia Gas Co.	Sarnia	77.5	526,437	467,406	59,031	15,500	4,000	14,760	6 "
United Gas Cos.	St. Catharines	49.46	195,892	177,021	18,871	9,892	3,480	5,430	4 "
United Gas Cos.	Thorold	8.1	27,513	25,793	1,720	1,620	500	3,440	5 "
Wallaceburg Gas Co.	Wallaceburg	22.	176,579	138,895	37,683	4,400	1,000	37,683	6 "
Windsor Gas Co.	Windsor	151.47	1,170,921	1,194,303	gain	30,294	9,000	....	4 "
Woodstock Gas Light Co.	Woodstock	47.31	101,694	94,895	6,799	9,462	2,050	3,320	4 "

Tables IV, V, and VI give two bases of comparing the leakage in distributing plants and rural lines. As previously stated, transmission line leakage has not been sufficiently investigated to date to set a standard to work to.

It is encouraging to note that there is a decided reduction in the leakage of gas in the distributing plants in Chatham, Sarnia and Wallaceburg over that shown in the last report and that the distributing plants not previously checked by measurement show that they are being kept in a fair state of repair.

The gain shown in the Chatham and Windsor plant has occasioned much enquiry and at the time of writing is still unsolved. The orifice meters that measure the gas into these plants have been calibrated, checked, and even changed in order to detect any possible error but they have invariably been found to be accurate within reasonable limits. In the case of Chatham, the measurements had always shown very considerable leakage to exist but when in the autumn of the year 1921 the method of reading consumers meters was changed from a monthly basis to a continuous reading, the previous loss was at once transformed into a gain. The case of Windsor is almost identical with the exception that gas is measured into Windsor on a basis of eight ounces per square inch and is sold by meter tested to register correctly at a pressure of 1.2 ounces per square inch. This would make the amount delivered, calculated on the same basis as it is sold, 1,203,222 M. cubic feet and show a leakage in the Windsor plant of 8,919 M. cubic feet or about 58 M. cubic feet per mile of 3 inch pipe per annum; a most remarkable record. In the case of Chatham, the amount delivered on a basis of 1.2 ounce pressure would be 622,604 M. cubic feet and the leakage 14,864 M. cubic feet, just about the allowable amount.

It is unnecessary to comment on the cases of excessive leakage, except to add that a considerable amount of money is being spent each year in improvements and repairs.

The Gas Question

The history of nearly all gas fields[1] can be divided into three periods. First: During the "flush" period of almost any gas field when it is first discovered, and possibly for from one to five years, gas is very plentiful. Numerous small companies are operating in one field and to find a sale for their gas there is keen competition for markets, resulting in franchises and agreements being entered into which fix a very low price for gas. To make a profit at such low prices large volumes must be sold, consequently these large volumes must be used by large manufacturers, as a substitute for coal under boilers in which coal has heretofore been used and for like uses in equipment not designed to use natural gas. This results in a great waste, i.e., much more gas is used than if the equipment had been designed for gas only. These low rates drive out the small companies with less profitable markets and in a few years time one or two companies control the field.

Very shortly, a cold winter usually finds the demand greater than the supply and the second period is entered. The householder demands that the manufacturer cease using large quantities of gas at once. The manufacturer complains that he is unprepared for a sudden change and that if he must cease at once serious unemployment will result. As a rule a compromise results and shortly a sweeping reduction in the gas used in industries is effected. Meanwhile the public in their fight for sufficient gas for their domestic needs and the fulfillment of the franchise entered into between the gas company and themselves

[1]Geol. Survey of Ohio, Oil and Gas, 1903, pp. 32 to 45.

have overlooked the important point, that these franchises (and low rates mentioned in them) were made possible by other agreements, equally sacred, entered into between the gas company and the manufacturer who used the large quantities of natural gas at the low franchise rate and which gave the gas company a revenue sufficient to cover a loss on many small consumers and provide a substantial dividend on the whole. With the improvement in service follows a very serious reduction in the gas company's revenue and a demand is sure to follow for a greater rate from the domestic consumer to compensate for the loss following the restricted sales. With this comes a period of legal battles, political interference, commissions, etc., and the inevitable raise in rates.

A glance at the rock pressure charts on pages 14 to 18 and in previous publications[1] will show that the rock pressure declines very rapidly at first (first period), then at a moderate rate (second period), and a lower rate at the last (third period). The amount of gas that a field will deliver is directly proportional to the open flow of the wells in the gas field and in due course the time arrives when even with no industries using gas the supply fails in times of peak load demands. Further reductions in the use of gas must now be made which brings us to the third period, the declining days of the field, the period in which we find most Ontario gas fields.

The regulations made under the Natural Gas Conservation Act subdivide allowable uses of gas into different classes, viz.:

(1) For cooking and lighting in dwelling houses.
(2) For cooking of meals elsewhere.
(3) For heating in dwelling houses.
(4) Heating—other than above—according to the following order of preference:

Where individual rooms are each heated by separate appliances in:
(A) Hospitals and Sanitaria.
(B) Apartment Houses.
(C) Boarding Houses.
(D) Hotels.
(E) Charitable Institutions.
(F) Schools that require less than 60,000 cu. ft. in any one month.
(G) Offices.
(H) Stores, where merchandise is exposed for sale, wholesale and retail.
(I) Private Garages—not used commercially.
(J) Churches—in heaters designed for the use of gas only.

(5) Same as in (4), but where such places are heated with one furnace.
(6) New Domestic Consumers—where the property to be supplied abuts upon the present mains and can be reached by private service line from the said mains.

It is found that in the case of the city of Windsor even with classes 4, 5 and 6 eliminated that there will not be sufficient gas to heat private dwellings. Smaller cities served from the Tilbury gas field are affected in a lesser degree. To eliminate the use of gas for heating would leave more than enough gas for cooking and force gas rates to a point greater than the public are prepared to pay although the supply would last very many more years.

The problem of how best to apportion a supply of gas too great for cooking only and too small for cooking and heating remains to be solved in 1923 and unless a rate is made that will automatically limit the amount of gas used for heating the problem will be exceedingly difficult as any regulations directed against heating private houses are exceptionally difficult to enforce.

[1]Ont. Dept. of Mines, Vol. XXX, part V, page 7; Vol. XXXI, part V, page 8.

The Three Part Rate

The conditions outlined above have caused gas men grave concern, and it has been the subject of much debate and political controversy among all interested. No government official would make a regulation demanding an equal distribution of gas among all consumers. Necessary demands vary so within households and in classes of houses that scores of inspectors would be required to enforce it. An order might be enforced curtailing the amount of gas used for heating the larger buildings with the co-operation of the gas company and the municipality, but there are many objections against such an order as it interferes with personal liberty to some extent. Apparently a solution has been found by an American gas company in the "three part rate". This has been tried out in the State of Kansas and after a year's experience it has been endorsed by the Public Service Commission of that State. A summary of its principles are interesting, the details of which have been very kindly furnished by the Cities Service Company of New York.

The foundation of the three part rate is built on a *sufficient service to every consumer*, and that each shall bear the proportion of the cost of operation. The three features are as follows:

1.—Customer charge; to cover fixed expenses which are the same for all consumers, office maintenance and operation, meter reading, delivering bills and making collections.

2.—Demand charge. A uniform charge per unit of demand which is proportional and increases with the amount used.

3.—A charge for the gas used at a fixed rate per M cubic feet.

Knowing that the peak can never exceed the amount demanded by consumers and also knowing the supply of gas available, with a small margin of safety the gas company can never be caught by a shortage.

The details of how this proved in Ottawa, Kansas, U.S.A., are as follows:

Vocation	Maximum hourly demand in cubic feet per hour		Price of Gas, cents per M. cubic feet		Sales per meter per year in cubic feet	
	1918	1922	1918	1922	1918	1922
Labourers	102	46	80	79	51,600	61,400
Skilled workmen	117	47	80	79	43,600	61,500
Clerical and salaried	134	53	80	72	52,800	79,600
Business and professional	143	65	80	68	62,400	107,300
Offices, shops and industrial,	160	93	80	61	47,600	78,500
Widows, retired and miscellaneous	132	59	80	76	82,800	160,000
Average	134	58	80	72	55,000	88,000

The rate per M. cubic feet was fixed at 40 cents, the customer charge at \$9.00 per year and the demand charge 32 cents per cubic foot per hour, demand. Average demand charge would be $58 \times 32 = \$18.56$ per year. Total average monthly charge in 1922 would be $[18.56 + 9.00 + (88 \times 40)] \div 12 = \$5.23$.

The answer to "How could one possibly use 88,000 cubic feet of gas at a rate of 58 cubic feet per hour in 1922 when only 55,000 cubic feet of gas was used in 1918 at a rate of 134 cubic feet per hour?" is, that instead of a government inspector on each home a mechanical inspector is installed in the form of a "limiting demand regulator" which is set to allow only the requested hourly demand to pass through at a fixed pressure. This device defeats the consumer nearest the source of supply from using more than his demand. When consumers in general find that there is always a fixed amount of gas available at any hour, substitute fuels are not required and more gas is used between "peaks", furthermore the rate is lower and more people can afford to use gas for heating.

The secret of the low average rate is in demanding the lowest possible rate per hour and using more gas between peak loads.

A resident of Windsor, Ontario, passing through Ottawa, Kansas, in 1922 made many enquiries at all classes of homes as to the results of this new method. Without exception he was told that the service was now satisfactory whereas in previous years there was always a shortage of gas. Questioned as to the rates the dissatisfied ones were asked if they would prefer the old system, but none would consider such a thought.

Causes of Increases in Gas Rates

The cost of distributing natural gas must increase as the supply in the gas wells fail; for three main reasons:

1.—The pressure in the wells fails at times of peak demand and in order to get more gas to the consumer larger mains and more mains must be laid.

2.—About the time that the rock pressure fails usually from seven to fifteen years, soil electrolysis and normal corrosion will have caused much deterioration in pipes, regulators, valves and other equipment that leakage of gas will become excessive necessitating very many repairs and replacements.

3.—In order to maintain a supply many more wells must be drilled and if the limits of the gas field have been reached much money must be expended in prospecting for new gas fields.

The sum of expenditures and legitimate profit divided into total sales will give the rate per thousand cubic feet[1]—and if the total sales are declining the rate must necessarily raise every year. An examination of natural gas rates on this continent will show that very rarely does it exceed eighty cents per M. cubic feet. The explanation being that sales decrease so rapidly beyond this rate that it is unprofitable to operate. And the feature now becomes noticeable, viz., many consumers do not produce enough revenue to pay the fixed charges against each consumer. In one Ontario city the gas company discovered that electricity was being used in very many houses for cooking and gas used only for emergency water heating and when the electricity failed. Nevertheless the meter must be read monthly and clerical help paid to keep accounts and collect payments, in short the large consumer paid the loss on the small consumer and the company's profit.

The most undesirable feature is that when the supply fails to meet the demand, the consumer nearest the source of supply can still have enough gas to heat and cook when those farthest away cannot get even enough to cook with, let alone heat their houses. In short, the gas company contracts to supply every one on their system but having no control over the amount any one person may use the result is that a few people get their own share and the major portion of that which belongs to their neighbour.

[1]Ont. Dept. of Mines, Volume XXXI, Part V, p. 34.

Gas Legislation

Following a demand for a revision of the gas legislation a questionnaire was circulated in January, 1922, among all the municipalities in Ontario using natural gas. The great majority of the replies to this questionnaire showed that the people desired a rate-making tribunal and that the control of natural gas should rest with the Government. This was made the basis of new legislation.

TABLE VII.—PRODUCTION OF NATURAL GAS BY FIELDS, 1906-1919.

Year	Norfolk Welland Haldimand mill. cu. ft.	Kent mill. cu. ft.	Elgin mill. cu. ft.	West Lambton mill. cu. ft.	Total mill. cu. ft.	Total Value $
1906	......	....	.....	.....	2,534.2	533,446
1907	3740.3	415.6	....	.....	4,155.9	756,174
1908	3635.0	848.6	....	.....	4,483.0	988,616
1909	2347.0	3401.0	....	.....	5,388.0	1,188,179
1910	3422.1	3841.2	.....	.....	7,263.3	1,491,236
1911	4000.0	5649.0	126.0	.....	12,311.9	2,186,762
1912	4246.0	7752.5	456.4	.....	12,454.9	2,268,022
1913	4115.8	7975.8	466.8	.....	12,558.4	2,362,021
1914	3306.0	10121.6	465.6	169.6	14,062.8	2,346,687
1915	3592.9	10819.1	399.1	401.2	15,212.3	2,622,838
1916	3769.5	13752.5	351.9	55.2	17,929.1	2,404,499
1917	3760.2	15450.4	290.8	44.6	20,026.4	3,220,123
1918	3357.0	9316.6	338.8	37.0	13,067.4	2,498,769
1919	3300.0	7891.3	340.0	52.0	11,563.3	2,583,324

TABLE VIII.—NATURAL GAS PRODUCTION, 1920, 1921 AND 1922.

Year	Welland M cu. ft.	Norfolk and Haldimand M cu. ft.	Elgin M cu. ft.	Tilbury M cu. ft.	Dover M cu. ft.	Lambton M cu. ft.	Bruce M cu. ft.	Middlesex M cu. ft.	Total M cu. ft.	Total Value $
1920	527,151	2,149,158	215,822	6,800,264	1,009,342	25,181	1,411	......	10,729,303	3,163,500
1921	494,752	1,991,029	182,359	5,386,159	435,946	31,489	1,250	250	8,523,234	4,018,190
1922	463,675	2,067,991	166,714	5,484,618	322,984	56,295	953	5,071	8,568,301	4,024,767

Recoverable Residue Supply

It has been the aim of the writer to keep the gas-using public informed as to the probable life of gas fields and the quantity of gas available. In the many and bitter rate controversies of the past few years an opportunity has not been afforded to see whether or not the statements made by the gas companies or their own advisers are well founded and with this in mind the following figures are presented and explanations offered:

Rock Pressures

A study of the rock pressures, pages 14 to 18, for the past ten years or more shows that in nearly every field the pressure has increased during the year 1922 after a more or less steady decline for a number of years. This was not altogether unexpected, as curtailing the amount of gas sold in the summer months was bound to arrest the decline in rock pressure, but to show an actual increase in rock pressure was undoubtedly a surprise. The explanation of this can only lie in two facts:

1.—The great demand for gas during the summer months would not allow of sufficient wells being shut in for a long enough period to allow the pressure of gas in the rock to equalize, i.e., while wells in a certain small area were shut in some gas from that area would be escaping to wells that were delivering gas to the mains.

2.—Some old wells of low rock pressure have been abandoned which improves the average. The pressure of past years should undoubtedly be raised a proportion of the difference.

This raise in rock pressure need not be taken to indicate that too many restrictions are being used or that the service will be greatly improved nor that more gas can now be sold in winter. It simply goes to show that methods now being used are bringing good results and that in reality the residue supply is being conserved. It will as a matter of fact show a slight increase in the residue supply and calculations must be revised.[1]

As previously mentioned the residue supply of natural gas in any gas field may be approximated by applying Boyle's Law or the ratio of decline in rock pressure to volume of gas produced during such period of decline, the residue supply of gas being in the same ratio to the remaining rock pressure. For instance, if a gas field has an original pressure of 1,000 lbs. per square inch and after five years has elapsed 300 million cubic feet of gas has been sold leaving a rock pressure of 400 lbs. (a decline in pressure of 600 lbs. per square inch) the residue supply (X) will be as follows:—600:300,000,000 cubic feet = 400 : X or X = 200,000,000 cubic feet.

After these data have been collected the major problem presents itself: *How much of this gas can be recovered?*

Most of the residents of south and west Essex county will recall the sudden failure of the Leamington gas field in 1902 while it had still a pressure of over 300 lbs. This sudden failure is attributed in part to other causes but it goes to show the gas pressure can not be reduced to zero and that a point is reached when it is not economical to operate a well or a gas field for the simple reason that it does not produce enough gas to pay charges. The rock pressure at this point may be from 25 lbs. to 100 lbs. It is the intention of the writer to begin at once a study of this problem and if possible establish some basis for determining the average amount of gas recoverable from a gas field depending on the conditions in the field.

In fields such as the Kent field where the gas comes from one area only this will probably be found fairly accurate, but a study of the rock pressures in the Haldimand field, *see* chart on pages 14 to 13, which shows a great fluctuation, presents quite a different problem. Again, the production figures from 1906 to 1919 given above cover too great an area to be of any value. There are many miles separating the Norfolk fields from the Haldimand field and again

[1]Ont. Dept. of Mines, Vol. XXX, Part V, p. 8.

many miles separating the Haldimand field from the Welland and all areas are made up of smaller pools.[1]

Until a more careful study can be made and the figures available treated by smaller fields, the rock pressure graphs on pages 14 to 18 must suffice as an indication of the residue supply of gas in the Haldimand and Welland fields. The more detailed figures in Table VIII will be of great assistance in pursuing this enquiry.

Water Well Logs

In January, 1922, the Agricultural College at Guelph requested that something be done to assist the farmers in finding a permanent supply of water. The Department of Mines after due investigation decided that an extensive survey would not add any material information as the glacial drift presented a most complex mixture in which no continuous water-bearing strata had been found to date. In October, 1922, the Engineering Institute of Canada made a somewhat similar request, limiting it, however, to saving and collecting all available data from wells drilled at present and a more accurate record of those drilled in future, that water-bearing strata in any locality might be known and used to the best advantage in tracing further supplies.

The legislation pertaining to plugging abandoned wells, which was first passed in 1872 and added to and amended in 1892, 1907, 1913 and 1916, had grown very cumbersome. The Well Driller's Bill was framed to meet the above requirements. It was, however, withdrawn after presentation to the Ontario Legislature during the session of 1923.

Gas Consumption in Municipalities

In order to give the gas consumers of Ontario a means of comparing the quantity of gas used in their own locality with that of other localities, the following tables are submitted showing gas used by free and pay consumers and by industries. The effect of rates on the consumption is interesting, so also is the comparison of amounts used by consumers in towns, villages and townships at equal rates.

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[1]Ont. Dept. of Mines, Vol. XXIX, Part V, p. 22.

TABLE IX.—GAS CONSUMPTION IN TOWNS, 1922.

	Population	No. of Consumers		Amount of gas used M. cu. ft.			Distance from gas fields. Miles	Rate per M. cu. ft.
		Pay	Free	Pay	Free	Industrial		
Aylmer	2,251	700	....	39,475	......	....	12	.60–.75
Bridgeburg and Fort Erie	2,163 1,556	937	6	63,325	1,990	121	8	.50–.75
Belmont	....	106	....	4,187	......	....	9	.75
Blenheim	1,580	539	3	68,813	1,556	933	20	.40–.50
Belle River	580	165	2	19,572	199	757	29	.45
Brantford	31,362	4,312	....	117,789	......	5,800	141	.80
Chippawa	1,029	62	....	2,120	......	....	3	.40
Caledonia	1,335	453	....	49,295	......	2,213	6½	.45
Chatham	15,084	3,600	....	593,757	......	9,673	22	.50–.70
Cayuga	767	207	....	26,437	......	....	6.	.45
Comber	....	150	....	20,309	......	....	19	.45
Crystal Beach	....	630	....	11,129	......	....	..	1.00
Dunnville	3,583	950	6	108,200	900	27,655	12	.45
Dundas	5,100	1,040	....	35,646	......	621	172	.70
Delhi	706	250	....	22,103	......	1,488	4	.60
Dresden and Tupperville	1,456	587	....	62,472	......	2,647	30	.45–.50
Dutton	845	265	3	29,969	197	1,028	52	.55
Essex	1,591	455	....	56,610	......	5,814	33	.45–.50
Fonthill	739	....	....	....	......	....	25	.70
Galt	13,332	1,434	....	53,736	......	2,495	147	.80
Hamilton	118,243	22,680	....	572,431	......	29,756	166	....
Hagersville	1,273	369	....	35,997	......	....	13½	.50
Highgate	417	123	1	16,209	27	56	32	.45
Hepworth	330	25	....	953	......	....	½	.50
Ingersoll	5,253	1,190	....	82,366	......	3,215	100	.80
Jarvis	480	184	....	24,030	......	1,138	9	.45
Kingsville	2,010	557	....	82,759	......	44,905 (Kingsville and Leamington)	30	.40
Leamington	3,864	1,175	....	180,694	......		20	.40
Lynedoch	....	40	....	3,406	......	....	......	.45
Niagara Falls	15,895	2,549	....	135,138	......	271	11	.50–.70
Oil Springs	491	150	....	9,489	......	289	1	.75
Petrolia	2,911	800	....	108,039	......	2,287	60	.50–.70
Paris	4,400	570	....	25,945	......	670	129	.80
Port Colborne and Humberstone	3,123 1,455	1,500	....	103,116	......	2,985	5	.50
Port Dover	1,380	470	....	55,071	......	1,157	5	.45
Port Rowan	637	245	....	20,216	......	....	......	.60
Port Burwell	....	237	....	15,422	......	....	3	.65
Rodney	756	241	1	30,685	49	548	40	.50
Ridgetown	2,267	630	3	79,140	2,076	3,282	28	.45–.50
Sarnia	14,905	4,010	....	460,019	......	4,987	55½	.50–.70
Simcoe	3,951	1,318	....	193,499	......	13,373	20	.45
St. Catharines	2,961	3,420	....	173,523	......	3,980	35	.75
St. George	....	225	....	7,988	......	25	148	.80
St. Williams	....	99	....	7,024	......	....	1	.60
Selkirk	....	137	....	18,097	......	....	2	.25–.30
Smithville	....	156	....	13,786	......	....	7	.75
Thorold and Merritton	5,243 2,589	483	....	25,792	......	20,103	35	.75
Tilbury	1,851	402	2	51,428	301	8,994	13½	.45–.50
Tecumseh	1,019	145	....	19,069	......	....	50	.45
Tillsonburg	3,027	922	....	79,140	......	2,318	14	.50
Vienna	302	120	....	10,698	......	....	......	.45–.65
Welland	8,880	1,911	3	93,198	197	583	3	.50.–70
Walkerville	7,303	1,395	....	172,134	......	3,424	43¼	.50
Sandwich	4,922	443	....	55,751	......	....	43¼	.50
Ford	5,113	438	....	55,122	......	....	43¼	.50
Windsor	38,530	7,189	....	893,029	......	11,697	43¼	.50
Wallaceburg	3,921	1,014	....	136,458	......	183,454	27½	.50
Wheatley	641	221	....	31,572	......	....	3	.40
Woodstock	10,164	2,046	....	94,892	......	4,282	108	.80
West Lorne	803	215	3	28,722	147	....	45	.50
Wellandport	....	38	1	1,284	325	....	10	.75
Miscellaneous manufacturing purposes	....	....	....	....	......	53,896	......	....
Total	366,369	76,924	34	5,588,275	7,964	462,920	......	....

TABLE X.—GAS CONSUMPTION IN TOWNSHIPS, 1922.

Township	Population	No. of Consumers		Amount used, M. cu. ft.			Rate cents per M. cu. ft.
		Pay	Free	Pay	Free	Industrial	
ESSEX—							
Gosfield, N.	2,067	143	4	9,602	62		.40
Gosfield, S.	2,291	282	2	34,511	91		.40
Maidstone	2,181	53	3	7,728	584		.45
Rochester	2,009	166	6	24,207	1,247		.45
Sandwich, S.	1,481	44		6,416			.45
Sandwich, W.	2,764	20		2,915			.45
Sandwich, E.	1,300	211	2	30,775	230		.45
Mersea	3,974	264	2	44,310	788		.40
Tilbury, N.	1,814	20	1	2,916	88		.45
Tilbury, W.	1,545	18		2,624			.45
LAMBTON—							
Enniskillen	2,815	68		9,919			.45-.30
Moore	3,412	440		64,164		2,091	.45-.35
Sombra	2,689	130		18,958		2,677	.45-.30
Sarnia	2,289	14	3	2,237	577	5,033	.45-.30
Euphemia	1,360	20		2,623		3,447	.25
Dawn	2,499	3		437			.45
KENT—							
Raleigh	3,625	724	50	107,861	11,728	1,384	.35-.15
Tilbury, E.	3,057	274	92	39,995	35,746	7,538	.35-.15
Romney	1,521	106	34	14,075	10,229		.35-.20
Harwich	4,665	450	6	64,021	1,540	13,071	.45-.15
Orford	1,868	82	1	13,557	106		.45-.15
Howard	2,777	151	2	22,470	520		.45-.20
Chatham	5,130	80	1	11,666	244		.45-.30
Camden	2,074	20		2,916		12,401	.45-.30
Dover	3,885	233	2	33,848	293		.35-.25
ELGIN—							
Aldboro	2,991	21	1	2,735	434	849	.25
Dunwich	2,678	125	2	12,035	58	623	.30
Southwold	3,553	248	2	20,761	82	2,829	.35
Malahide	2,782	61		2,640			.35
Bayham	3,230	132	11	11,421	1,836		.45-.65
MIDDLESEX—							
Westminster	5,846	234	1	22,140	150	124	.70
Dorchester, N.	3,049	155		13,121			.70
NORFOLK—							
Houghton	1,253	15		892			.45
Middleton	1,996	7	7	379	1,239		.45
Walsingham, S.	2,814		9		1,512		.45
Charlotteville	2,536	71	9	6,146	1,557		.45
Windham	3,258	14		1,904			.45
Woodhouse	2,128	154	20	22,792	3,458		.45
Townsend	3,748	35		4,973			.45
BRANT—							
Onondaga	1,017	28	36	3,080	4,739		.80
Dumfries, S.	2,577	134		6,035			.80
Brantford		169		10,160			.80
OXFORD—							
Oxford West	1,767						.80
HALDIMAND—							
Canboro	900	82	56	8,183	10,679		.45
Moulton	1,626	129	42	9,842	8,544		.40

TABLE X.—GAS CONSUMPTION IN TOWNSHIPS, 1922—*Continued.*

Township	Population	No. of Consumers		Amount used, M cu. ft.			Rate cents per M cu. ft.
		Pay	Free	Pay	Free	Industrial	
HALDIMAND.—*Continued.*							
Seneca	1,576	174	71	18,222	12,671	....	.45
Cayuga North	1,334	102	25	11,881	4,225	....	.45
Cayuga South	571	67	29	4,579	5,577	....	.45
Rainham	1,689	146	43	21,369	9,614	1,106	.30
Sherbrooke	272	27	10	2,313	2,520	....	.40–.50
Dunn	818	134	21	15,334	2,206	....	.20–.40
Walpole	3,018	242	50	31,627	10,355	....	.45
Oneida	1,215	67	9	9,353	1,664	....	.40–.50
WELLAND—							
Wainfleet	2,433	118	48	6,972	12,113	250	.40–.75
Humberstone	1,948	127	49	8,076	12,904	....	.50
Bertie	3,201	563	78	33,870	22,208	114	.60
Pelham	2,392	......	......	....	....	....	.60
Thorold	3,536	5	1	296	225	....	.60
Willoughby	873	23	4	1,439	550	....	.70
Crowland	3,465	55	25	3,343	5,839	....	.50
Stamford	5,031	......	3	....	910	....	.50–.70
LINCOLN—							
Caistor	1,235	61	50	5,702	4,718	....	.45
Gainsboro	2,086	12	20	....	....	....	.50
Grimsby	3,267	......	......	....	....	....	.75
Louth	2,518	5	......	317	....	....	.60
Grantham	3,977	19	......	1,290	....	....	.60
WENTWORTH—							
Binbrook	1,127	68	53	9,753	9,400	....	.40
Glanford	1,405	107	10	15,642	1,908	....	.40
Barton	7,435	966	2	70,651	300	....	.40
Ancaster	4,349	51	......	4,263	....	....	.40
Saltfleet	4,672	16	......	2,821	....	....	.40
Used by Gas Companies for drilling and power purposes	....	......	......	....	....	143,619	....
Total	180,184	8,985	1,008	1,013,103	218,268	197,102	....

TABLE XI.—GAS WELLS IN ONTARIO BY TOWNSHIPS.

County	Township	Production	Rock Pressure	Acreage under Lease	Rentals Paid	No. of Wells Producing	No. of Wells Abandoned	Wells Drilled: No. Dry	Wells Drilled: No. Producing	Wells Drilled: Open Flow Pressure
		M. cu. ft.	Lbs.		$					
Essex	Tilbury West			1,000	500			1		
	Gosfield, S.						1			
	Mersea					4		2		
Kent	Romney					97	4	1		
		5,484,618	272	24,866	45,758					
	Tilbury East					137	13		4	832
	Raleigh					24	2			
	Dover West	322,984	500	4,146	400	9		3	1	463
Lambton	Sarnia		100	5,000	300	16		3	1	35
	Enniskillen		100	300	150	3				
	Dawn	56,295	852	15,427	3,000	5		4	3	570
	Euphemia		425	7,000	600	6				
Elgin	Bayham		215			55	1			
	Malahide	166,714	525	9,360	4,235	2			1	156
	Dunwich						1			
Middlesex	Dorchester N	5,071	90	12,000	800	3				
Norfolk	Houghton		480			3				
	Middleton		350			19			2	112
	Walsingham N		493			6				
	Walsingham S	434,147	330	7,086	6,533	14	1			
	Windham		248			5				
	Charlotteville		395			16			2	115
	Woodhouse		280			65	1		3	236
Haldimand	Walpole		169			161	7	2	12	1,718
	Rainham		132			120	6			
	Cayuga North		238			52	1	1	6	1,024
	Cayuga South		148			59	3			
	Oneida		159			30	1	3	8	1,125
	Seneca		122			163	14	9	15	1,240
	Canboro		111			164	6	2	6	271
	Dunn		223			17	2			
	Moulton		264			102	3	2	19	1,068
	Sherbrooke	1,616,916	181	143,103	86,213	12		1		

Wentworth	Ancaster							1		
	Binbrook		88			70	4			
	Glanford		75			27				
	Barton		90			2				
	Gainsboro		125			2				
Lincoln	Caistor		97			49	1			
	Wainfleet		75			49	3	1		
Welland	Humberstone					107	11	1		
	Crowland					49	1	1		
	Willoughby	463,675	94	28,732	5,845	44	7			
	Bertie					87	14	2	4	440
Brant	Onondaga	16,928	90	2,000		51				
Peel	Caledon East		65	500	100				2	775
Bruce	Amabel	953	140	500	100	1	1			
	Total in 1922	8,568,301		261,020	153,634	1,907	109	40	89	10,180

License Fees Paid by Operators in Ontario

Under the terms of the Natural Gas Conservation Act, 1921, and Regulations made thereunder, those who lease and prospect for, drill and bore for natural gas must procure a license before conducting such operations; so also must those who produce, transmit by pipe line, and distribute natural gas, procure a license before doing so.

The fee for the licenses "to produce, transmit by pipe line and distribute natural gas" is ten dollars ($10.00). It was found that an unnecessary burden was being added to the prospector for natural gas by requiring a license fee of ten dollars ($10.00) and the fee for prospecting and to drill and bore was reduced to five dollars ($5.00).

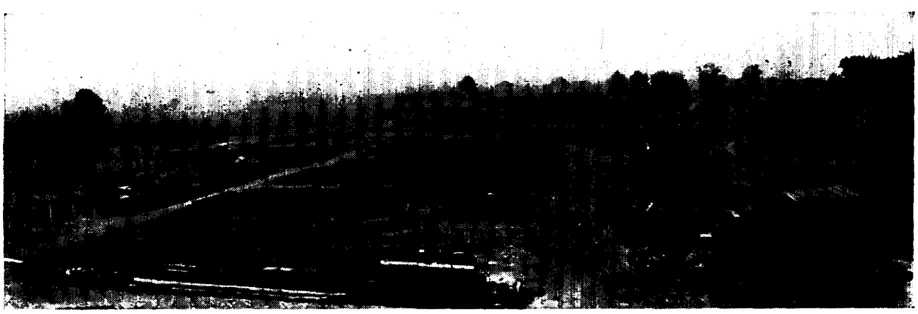
License fees as above were paid by the following:

TABLE XII.—OPERATORS LICENSED TO LEASE AND PROSPECT FOR NATURAL GAS, 1922.

License No.	Name	Address
103	Anderson, J. H.	Oil Springs. Ont.
122	Anderson, Walter	9 Maple Ave., Hamilton. Ont.
117	Barr, D.	298 Talbot St., St. Thomas, Ont.
99A	Beaver Oil & Gas Co.	Buffalo, N.Y.
108	Coste, Eugene, & Co., Ltd.	Niagara Falls, Ont.
96	Clover Gas & Oil Co.	1711 Main St., Buffalo, N.Y.
99	Dominion Natural Gas Co., Ltd.	518 Jackson Bldg., Buffalo, N.Y
109	Dover Oil & Gas Co.	79 Adelaide E., Toronto, Ont.
120	Eagle Oil & Gas Co.	508 Lumsden Bldg., Toronto.
100	Glenwood Natural Gas Co.	Buffalo, N.Y.
118	Hoover, A. E.	Selkirk, Ont.
102	Industrial Natural Gas Co.	Thorold, Ont.
98	Jasperson, Bon	Kingsville, Ont.
114	Jones, J. S.	Port Maitland, Ont.
111	Maple Leaf Oil & Gas Co.	48 St. Johns Pl., Buffalo, N.Y.
119	Middlesex Dover Oil Co.	26 King St. W., Toronto, Ont.
107	Petrol Oil & Gas Co.	Royal Bank Bldg., Toronto. Ont.
104	Provincial Natural Gas Co.	Niagara Falls, Ont.
101	Pilkington Bros.	Thorold, Ont.
110	Port Colborne-Welland Gas Co.	Port Colborne, Ont.
138	Parks, A. W.	Oil Springs, Ont.
121	Stringer, Harrison	Simcoe, Ont.
106	Snively, F. L.	90 Melrose Ave., Hamilton, Ont.
113	Sarnia Oil & Gas Co.	Sarnia, Ont.
105	Union Exploration Co.	Chatham, Ont.
112	Valley Oil & Gas Co.	42 Home Bank Bldg., Hamilton.
116	Winger, S. W.	R. R. No. 4, Hagersville, Ont.
115	Williams, Albert	Clark St., Leamington, Ont.

TABLE XIII.—OPERATORS LICENSED TO DRILL OR BORE FOR NATURAL GAS, 1922.

License No.	Name	Address
97	Berry & Anderson	Caledonia, Ont.
100	Bostaph, H. P	Detroit, Mich.
94	Featherstone, C. W	Dunnville, Ont.
95	"	"
96	"	"
81	Hoover & May	Selkirk, Ont.
99	Hamaker, Wesley	Port Dover, Ont.
75	Industrial Natural Gas Co	Thorold, Ont.
74	Jasperson, Bon	Kingsville, Ont.
93	King, Ralph	37 King St. E., Hamilton, Ont.
89	Kiser & Louer	Tillsonburg, Ont.
90	McCutcheon, T. J	Dunnville, Ont.
92	McLister, J. J	Dunnville, Ont.
101	McKillopp, Wm	Hamilton, Ont.
88	McKechnie, Sam	Dunnville, Ont.
76	Provincial Natural Gas Co	Niagara Falls, Ont.
80	Petrol Oil & Gas Co	Royal Bank Bldg., Toronto, Ont.
77	Snively, F. L	Hamilton, Ont.
78	"	"
91	Sarnia Oil & Gas Co	Sarnia, Ont.
79	Union Exploration Co	Chatham, Ont.
82	" " "	" "
83	" " "	" "
84	" " "	" "
85	" " "	" "
86	" " "	" "
98	Williams, Geo	Delhi, Ont.



A field depot of the Union Natural Gas Company, Limited. at Port Alma, showing iron pipe, equipment and some buildings.

TABLE XIV.—OPERATORS LICENSED TO PRODUCE NATURAL GAS DURING 1922.

License No.	Name	Address
159	Aldrich Gas & Oil Co.	Merchants Bank Bldg., Hamilton, Ont.
168	Azoff Natural Gas Co.	Canfield, Ont.
152	Beer, Geo.	Binbrook, Ont.
164	Beaver Gas & Oil Co.	Buffalo, N.Y.
157	Bertie Natural Gas Co.	Ridgeway, Ont.
202	Battle Natural Gas Co.	Sun Life Bldg., Hamilton, Ont.
196	Binbrook Gas Co.	Binbrook, Ont.
181	Bennett, Robert	Dunnville, Ont.
195	Castle Oil & Gas Co.	Niagara Falls, Ont.
175	Chippawa Development Co.	Chippawa, Ont.
201	Chippawa Oil & Gas Co.	Tavistock, Ont.
177	Coleman, J. A.	Wellandport, Ont.
156	Canfield Natural Gas Co.	Canfield, Ont.
154	Canby, B. F.	R.R. No. 2, Marshville, Ont.
187	Canboro Gas & Oil Co.	Selkirk, Ont.
200	Clover Gas & Oil Co.	714 Mutual Life Bldg., Buffalo, N.Y.
152	Darling Road Co-op. Co.	Canfield, Ont.
162	Dunn Natural Gas Co.	Dunnville, Ont.
163	Dominion Natural Gas Co.	518 Jackson Bldg., Buffalo, N.Y.
151	Duxbury, J. H.	Hagersville, Ont.
180	Empire Limestone Co.	191 Hudson St., Buffalo, N.Y.
174	Eastside Gas Co.	Lowbanks, Ont.
194	Fisherville Gas Co.	Fisherville, Ont.
166	Glenwood Natural Gas Co.	Buffalo, N.Y.
171	Industrial Natural Gas Co.	Thorold, Ont.
198	Jasperson, Bon	Kingsville, Ont.
178	King, Ralph	837 King St. E., Hamilton, Ont.
161	Lalor & Vokes	Dunnville, Ont.
160	Lalor, F. R.	Dunnville, Ont.
191	Midfield Natural Gas Co.	9 Maple Ave., Hamilton, Ont.
193	Medina Natural Gas Co.	Chatham, Ont.
199A	Marshall, J.	Hamilton, Ont.
203	Maple Leaf Oil & Gas Co.	14 Brisbane Bldg., Buffalo, N.Y.
170	National Gas Co.	Hamilton, Ont.
158	North Shore Gas Co.	Hamilton, Ont.
150	Niece, Hosea, & Son.	R.R. No. 2, Lowbanks, Ont.
167	Oil Springs Oil & Gas Co.	Oil Springs, Ont.
182	Provincial Natural Gas Co.	Niagara Falls, Ont.
188	Port Colborne-Welland Gas Co.	Port Colborne, Ont.
172	Pilkington Bros.	Thorold, Ont.
186	Petrol Oil & Gas Co.	Royal Bank Bldg., Toronto, Ont.
155	Progressive Gas & Oil Co.	Imperial Bank Bldg., Hamilton.
183	Sparham, A. F.	R.R. No. 1, Caledonia, Ont.
192	Sterling Natural Gas Co.	Port Colborne, Ont.
173	Stevensville Gas Co.	Stevensville, Ont.
197	Springvale Gas & Oil Co.	Springvale, Ont.
184	Union Natural Gas Co.	Chatham, Ont.
165	United Gas Companies	St. Catherines, Ont.
185	Union Exploration Co.	Chatham, Ont.
179	Vacuum Oil & Gas Co.	509 Lumsden Bldg., Toronto, Ont.
190	Wardell, Theo. J.	Dunnville, Ont.

TABLE XV.—OPERATORS LICENSED TO OPERATE PIPE LINES, 1922.

License No.	Name	Address
32	Glenwood Natural Gas Co.	518 Jackson Bldg., Buffalo, N.Y.
28	Dominion Natural Gas Co.	" " " " "
29	Beaver Gas & Oil Co.	" " " " "
30	Southern Ontario Gas Co.	" " " " "
31	United Gas Companies.	" " " " "
33	Union Natural Gas Co.	Chatham, Ont.
34	Northern Pipe Line Co.	Chatham, Ont.
35	Port Colborne-Welland Gas Co.	Port Colborne, Ont.
36	Central Pipe Line Co.	Chatham, Ont.
37	Castle Oil & Gas Co.	Imperial Bank Bldg., Niagara Falls, Ont.

TABLE XVI.—OPERATORS LICENSED TO DISTRIBUTE NATURAL GAS, 1922.

License No.	Name	Address
126	Bertie Natural Gas Co.	Ridgeway, Ont.
128	Brantford Gas Co.	Brantford, Ont.
131	Beaver Oil & Gas Co.	Buffalo, N.Y.
160	Binbrook Gas Co.	Binbrook, Ont.
139	Coleman, J. A.	Wellandport, Ont.
158	Central Pipe Line Co.	Chatham, Ont.
138	Chippawa Development Co.	Chippawa, Ont.
144	Corp. Town of Leamington	Leamington, Ont.
149	Chatham Gas Co.	Chatham, Ont.
163	Chippawa Oil & Gas Co.	Tavistock, Ont.
145	Canboro Oil & Gas Co.	Selkirk, Ont.
127	Dominion Natural Gas Co.	518 Jackson Bldg., Buffalo, N.Y.
154	Dunn Natural Gas Co.	Dunnville, Ont.
146	Fisherville Gas Co.	Fisherville, Ont.
135	Glenwood Natural Gas Co.	518 Jackson Bldg., Buffalo, N.Y.
159	High Grade Gas Co.	Chatham, Ont.
137	Industrial Natural Gas Co.	Thorold, Ont.
130	Ingersoll Gas Light Co.	Ingersoll, Ont.
164	Jones, J. S.	Port Maitland, Ont.
156	Kerlin, R. G.	19 King William St., Hamilton, Ont.
151	Midfield Natural Gas Co.	9 Maple Ave., Hamilton, Ont.
132	Manufacturers Gas Co.	Hamilton, Ont.
162	Marshall, James	Hamilton, Ont.
155	Northern Gas & Gasoline Co.	Hepworth, Ont.
136	Oil Springs Oil & Gas Co.	Oil Springs, Ont.
124	Petrolia Utilities Ltd.	Petrolia, Ont.
140	Provincial Natural Gas Co.	Niagara Falls, Ont.
148	Port Colborne-Welland Gas Co.	Port Colborne, Ont.
125	Progressive Gas & Oil Co.	Hamilton, Ont.
147	Rosehill Natural Gas Co.	Buffalo, N.Y.
153	Sterling Natural Gas Co.	Port Colborne, Ont.
141	Sarnia Gas Co.	Sarnia, Ont.
150	Shetland Gas Co.	Florence, Ont.
133	Southern Ontario Gas Co.	518 Jackson Bldg., Buffalo, N.Y.
161	Springvale Gas & Oil Co.	Springvale, Ont.
143	Union Natural Gas Co.	Chatham, Ont.
134	United Gas Companies.	St. Catharines, Ont.
157	United Gas & Fuel Co.	Hamilton, Ont.
142	Windsor Gas Co.	Windsor, Ont.
152	Wallaceburg Gas Co.	Wallaceburg, Ont.
129	Woodstock Gas Light Co.	Woodstock, Ont.

Logs of Wells

The following logs of wells drilled in Ontario during 1922 are given as received from the drillers. Samples of drill cuttings have been received from about 25 per cent. of the wells and are available for reference at any time. It is regrettable that the same nomenclature is not used throughout the Province but changes in formation occur that are most confusing to the geologist as well as the driller. The logs as given will be a very good guide even if not complete in detail. The alphabetical arrangement is by townships, and not according to county or field; Log 103 (Dover West) was added after the report was in print, and is the only exception to the order above mentioned.

Log No. 1—Information by Wm. McKillop, Hamilton, Ont.

Lot	Concession	Township	County
38	I	Ancaster	Wentworth

Open flow:
Very small.

Completed Feb. 28, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Sand and gravel	65 feet	
Red Medina and broken lime	35 "	100
Blue shale	50 "	150
White Medina	12 "	162
Red shale	438 "	600
Hudson River	590 "	1,190
Utica black shale	170 "	1,360
Trenton	778 "	2,138
Potsdam	20 "	2,158
Granite	2 "	2,160
Total depth	2,160 feet	

Gas at 2,120 and oil at 2,124 feet.

Log No. 2.—Information by F. L. Snively, Hamilton

Lot	Concession	Township	County
3	III	Binbrook	Wentworth

Open flow: 50,000 cu. ft.
Rock pressure: 125 lbs.

Completed Feb. 23, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	80 feet	
Brown lime	70 "	150
Niagara	115 "	265
Grey shale	40 "	305
Clinton (gas sand)	30 "	335
Red Medina (sand No. 2)	35 "	370
Blue shale	55 "	425
White medina	10 "	435
Red shale	25 "	460
Total depth	460 feet	

Log No. 3.—Information by F. L. Snively, Hamilton

Lot	Concession	Township	County
5	III, block 3	Binbrook	Wentworth

Open flow: 50,000 cu. ft.
Rock pressure: 135 lbs.

Completed March 21, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	80 feet	
Brown lime	70 "	150
Niagara	115 "	265
Grey shale	40 "	305
Clinton	30 "	335
Red Medina	35 "	370
Blue shale	55 "	425
White Medina	10 "	435
Red shale pocket	30 "	465
Total depth	465 feet	

Gas at 430 feet.

Log No. 4—Information by A. McArthur, Dunnville, Ont.

Lot	Concession	Township	County
5	I—W.C.R.	Caledon	Peel

Open flow: 300,000 cu. ft.
Rock Pressure: 60 lbs.

Completed June 2, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Gravel	39 feet	
Red shale	76 "	115
Hudson River	590 "	705
Utica	175 "	880
Trenton	55 "	935
Total depth	935 feet	

Gas at 204, 284, 330, 375, 555 and 935 feet.

Log No. 5—Information by F. L. Snively, Hamilton, Ont.

Lot	Concession	Township	County
6	I—W.C.R.	Caledon	Peel

Open flow: 475,000 cu. ft.
Rock pressure: 62 lbs.

Completed Aug. 15, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Gravel, river sand and quicksand	141 feet	
Lime	20 "	161
Grey shale with lime shells	474 "	635
Total depth	635 feet	

Gas at 460, 480 and 533 feet.

Log No. 6—Information by J. J. McLister, Dunnville

Lot	Concession	Township	County
N.W. 7	III	Canboro	Haldimand

Open flow: 37,000 cu. ft.
Rock pressure: 185 lbs.

Completed Feb. 7, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	57 feet	
Shale	153 "	210
Niagara	200 "	410
White lime	50 "	460
Shale	41 "	501
Clinton	30 "	531
Red Medina	38 "	569
Blue shale	60 "	629
White Medina	12 "	641
Red shale	35 "	676
Total depth	676 feet	

Gas at 546 and 634 feet.

Log No. 7—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township,	County
10	II	Canboro	Haldimand

Dry hole

Completed June 20, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	100 feet	
Lime and shale	103 "	203
Niagara	220 "	423
Shale	50 "	473
Clinton	30 "	503
Red Medina	45 "	548
Grey shale	55 "	603
White Medina	12 "	615
Red shale	5 "	620
Total depth	620 feet	

Log No. 8—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township	County
9	II	Canboro	Haldimand

Open flow: 68,000 cu. ft.

Completed May 26, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	94 feet	
Lime and shale	107 "	201
Niagara	225 "	426
Shale	50 "	476
Clinton	30 "	506
Red Medina	45 "	551
Grey shale	55 "	606
White Medina	16 "	622
Red shale	50 "	672
Total depth	672 feet	

Gas at 531 and 616 feet.

Log No. 9—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township,	County,
9	II	Canboro	Haldimand

Open flow: 34,000 cu. ft. Completed April 11, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	93 feet	
Lime and shale	107 "	200
Niagara	230 "	430
Shale	50 "	480
Clinton	30 "	510
Red Medina	43 "	553
Grey shale	55 "	608
White Medina	15 "	623
Red shale	50 "	673
Total depth	673 feet	

Gas at 500, 530 and 613 feet.

Log No. 10—Information by J. J. McLister, Dunnville.

Lot	Concession	Township	County
16	I	Canboro	Haldimand

Open flow: 52,000 cu. ft. Completed April 7, 1922.
Rock pressure: 60 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	70 feet	
Lime	15 "	85
Shale	30 "	115
Niagara	200 "	315
White lime	50 "	365
Shale:	26 "	391
Clinton	26 "	417
Red Medina	35 "	452
Blue shale	62 "	514
White Medina	12 "	526
Red shale	49 "	575
Total depth	575 feet	

Gas at 411, 437, and 522 feet.

Log No. 11.—Information by J. J. McLister, Dunnville.

Lot	Concession	Township	County
16	I	Canboro	Haldimand

Open flow: 37,000 cu. ft. Completed March 18, 1922.
Rock pressure: 160 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	67 feet	
Blue lime	15 "	82
Shale	25 "	107
Niagara	200 "	307
White lime	50 "	357
Shale	25 "	382
Clinton	27 "	409
Red Medina	35 "	444
Blue shale	58 "	502
White Medina	12 "	514
Red shale	53 "	567
Total depth	567 feet	

Gas at 429 and 512 feet.

Log No. 12.—Information by J. J. McLister, Dunnville

Lot	Concession	Township	County
16	I	Canboro	Haldimand

Open flow: 43,000 cu. ft.
Rock pressure: 228 lbs.

Completed June 23, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	67 feet	
Lime and shale	72 "	139
Niagara	200 "	339
White lime	50 "	389
Shale	25 "	414
Clinton	25 "	439
Red Medina	35 "	474
Shale	60 "	534
White Medina	12 "	546
Red shale	19 "	565
Total depth	565 feet	

Gas at 419, 457, and 544 feet.

Log No. 13.—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township	County
N½ 1 A & B	I N.T.R.	Cayuga North	Haldimand

Open flow: 16,000 cu. ft.
Rock pressure: 140 lbs.

Completed Sept. 6, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	52 feet	
Lime and shale	128 "	180
Niagara lime	220 "	400
Shale	49 "	449
Clinton rock	30 "	479
Red Medina	40 "	519
Grey shale	55 "	574
White Medina	14 "	588
Red shale	52 "	640
Total depth	640 feet.	

Log No. 14.—Information by Hoover and May, Selkirk

Lot	Concession	Township	County
5	II	Cayuga North	Haldimand

Open flow: 59,400 cu. ft.
Rock pressure: 255 lbs.

Completed Oct. 14, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	59 feet	
Limestone	155 "	214
Niagara	258 "	478
White lime	30 "	508
Blue shale	32 "	540
Clinton	28 "	568
Red Medina	40 "	608
Grey shale	50 "	658
White Medina	15 "	673
Red shale	50 "	723
Total depth	723 feet	

LOG NO. 15.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
20	VI	Caistor	Lincoln

Open flow: 9,000 cu. ft. Completed May 3, 1922.
Rock pressure: 70 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Clay	62 feet	
Niagara	161 "	223
Grey shale	40 "	263
Clinton gas sand	30 "	293
Red Medina sand	40 "	333
Blue shale	55 "	388
White Medina	15 "	403
Red shale	17 "	420
Total depth	420 feet	

Gas at 391 feet.

LOG NO. 16.—INFORMATION BY GEO. WILLIAMS, DELHI

Lot	Concession	Township	County
3	XII	Charlotteville	Norfolk

Open flow: 155,000 cu. ft. Completed Sept. 15, 1922.
Rock pressure: 415 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	98 feet	
Lime	132 "	230
Flint	40 "	270
Sharp sand	70 "	340
Hard lime	50 "	390
Lime and shale	90 "	480
Brown lime	100 "	580
Hard lime	170 "	750
Niagara lime	261 "	1,011
Shale	34 "	1,045
Clinton	30 "	1,075
Red Medina	5 "	1,080
Grey shale	37 "	1,117
Total depth	1,117 feet	

Gas at 1,060 feet.

LOG NO. 17.—INFORMATION BY J. J. MCLISTER, DUNNVILLE

Lot	Concession	Township	County
8	III	Canboro	Haldimand

Open flow: Completed Jan. 12, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	87 feet	
Shale	119 "	206
Niagara	200 "	406
White lime	50 "	456
Shale	26 "	482
Clinton	26 "	508
Red Medina	38 "	546
Blue shale	65 "	611
White Medina	12 "	623
Red shale	7 "	630
Total depth	630 feet	

LOG NO. 18.—INFORMATION BY MESSRS. HOOVER & MAY, SELKIRK

Lot	Concession	Township	County
6	II	Cayuga North	Haldimand

Open flow: 380,000 cu. ft.
Rock pressure: 265 lbs.

Completed Nov. 18, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	66 feet	
Blue shale	142 "	208
Niagara	275 "	483
White lime	18 "	501
Shale	40 "	541
Clinton	28 "	569
Red Medina	37 "	606
Grey shale	38 "	644
White Medina	16 "	660
Red shale	50 "	710
Total depth	710 feet	

LOG NO. 19.—INFORMATION BY MESSRS. HOOVER & MAY, SELKIRK

Lot	Concession	Township	County
7	II	Cayuga North	Haldimand

Open flow: 29,000 cu. ft.
Rock pressure: 257 lbs.

Completed Dec. 30, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	68 feet	
Blue shale	148 "	216
Niagara	266 "	482
White lime	20 "	502
Casing shale	38 "	540
Clinton	30 "	570
Red Medina	41 "	611
Gray shale	48 "	659
White Medina	15 "	674
Red shale	40 "	714
Total depth	714 feet	

LOG NO. 20.—INFORMATION BY S. MCKECHNIE, DUNNVILLE

Lot	Concession	Township	County
54	I	Cayuga North	Haldimand

Open flow: 24,000 cu. ft.
Rock pressure: 400 lbs.

Completed March 21, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	18 feet	
Flint	42 "	60
Lime and shale	383 "	443
Niagara	250 "	693
Shale	15 "	708
Clinton	41 "	749
Red Medina	27 "	776
Shale	55 "	831
White Medina	12 "	843
Red shale	4 "	847
Total depth	847 feet	

Gas at 715 and 740 feet.

LOG NO. 21.—INFORMATION BY GEO. WILLIAMS, DELHI

Lot	Concession	Township	County
12	III	Charlotteville	Norfolk

Open flow: 60,000 cu. ft.
Rock pressure: 350 lbs.

Completed Dec. 11, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	97 feet	
Lime	133 "	230
Flint	40 "	270
Sand	70 "	340
Lime	60 "	400
Lime and shale	80 "	480
Brown lime	100 "	580
Hard lime	170 "	570
Niagara	270 "	1,020
Shale	20 "	1,040
Clinton sand	30 "	1,070
Red Medina	5 "	1,075
Shale	37 "	1,112
Total depth	1,112 feet	

Gas at 1,052 and 1,062 feet.

LOG NO. 22.—INFORMATION BY H. P. BOSTAPH, CHATHAM

Lot	Concession	Township	County
18	II	Colchester South	Essex

Formation	Thickness of Formation	Total Depth (feet)
Surface	72 feet	
Sharp lime and flint	253 "	325
Brown lime	170 "	495
First gypsum bed	5 "	500
Gypsum and lime	160 "	660
Brown lime	140 "	800
Broken lime shells	85 "	885
Brown lime	150 "	1,035
Gray lime	55 "	1,090
Brown lime	208 "	1,298
White lime	77 "	1,375
Shale brake	7 "	1,382
Lime shell	8 "	1,390
Light shale and shells	10 "	1,400
Red shale	25 "	1,425
Blue shale	45 "	1,470
Lime shells and shale	30 "	1,500
White Medina lime and sand	52 "	1,552
Pink sand	103 "	1,655
Light blue shale	395 "	2,050
Brown shale	50 "	2,100
Black shale	150 "	2,250
Trenton limestone	not penetrated	
Total depth	2,250 feet	

Log No. 23.—Information by Robert Cherry, Collingwood

Lot	Concession	Township	County
27	VIII	Collingwood	Grey

Oil well: Small.

Completed April 5, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay, sand and gravel	12 feet	
Blue and black shale	98 "	100
Trenton	20 "	120
6 in. blue clay at	110 "	230
6 in. blue clay at	25 "	235
Trenton (dark grey)	115 "	350
Trenton (oily)	25 "	375
Trenton (oily)	25 "	400
Trenton (oily)	50 "	450
Hard gray rock	30 "	480
Trenton (grey, oily)	20 "	500
Trenton (softer)	50 "	550
Total depth	550 feet	

Water at 7 feet. Oil at 80, 100, 375, 400, 450 and 500 feet.

Log No. 24.—Information by Union Exploration Company, Chatham

Lot	Concession	Township	County
26	VI	Dawn	Lambton

Open flow: very light.

Completed March 22, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	98 feet	
Black shale	12 "	110
Grey lime	75 "	185
Black shale	65 "	250
Soap	187 "	437
Grey lime	143 "	580
Sharp sand	40 "	620
Dark grey lime	95 "	715
Brown lime	205 "	920
White lime	150 "	1,070
Niagara lime	110 "	1,180
Grey lime	270 "	1,450
Salt and lime shells	140 "	1,590
Brown lime	50 "	1,640
Blue lime	40 "	1,680
Black lime	86 "	1,766
Sharp crystalline dolomite	49 "	1,815
Grey and blue lime shells	375 "	2,190
Red shale	310 "	2,500
Green and purple shale	380 "	2,880
Black shale	42 "	2,922
Trenton	948 "	3,870
Sharp sand	15 "	3,885
Brown lime	83½"	3,968½
Granite		
Total depth	3,968½ feet	

Trace of oil at 570 feet.

Log No. 25.—Information by Messrs. Kiser, Kiser & Lauer, Tillsonburg

Lot	Concession	Township	County
S½33	II	Malahide	Elgin

Open flow: 156,000 cu. ft.
Rock pressure: 525 lbs.

Completed Oct. 10, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	283 feet	
Lime	219 "	502
Flint	150 "	652
Lime	423 "	1,075
Niagara lime	287 "	1,362
Shale	53 "	1,415
Clinton	23 "	1,438
Red Medina	60 "	1,498
Total depth	1,498 feet	

Gas at 1,431 and 1,436 feet.

Log No. 26.—Information by Bon Jasperson, Kingsville

Lot	Concession	Township	County
E½ 15	A	Mersea	Essex

Open flow: 11,000 cu. ft.

Completed Feb. 2nd. 1922.

Formation	Thickness of Formation	Total Depth (feet)
Drift, clay	85 feet	
Brown lime	395 "	480
Grey lime	40 "	520
Brown lime	370 "	890
Grey lime	105 "	995
Total depth	995 feet	

Log No. 27.—Information by Bon Jasperson, Kingsville

Lot	Concession	Township	County
20	II	Mersea	Essex

Open flow: dry.

Completed May 23, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Drift clay	105 feet	
Grey lime	245 "	350
Sharp sand	105 "	455
Grey lime	115 "	570
Blue lime	130 "	700
Grey lime	140 "	840
Blue lime	120 "	960
Brown lime and shale	100 "	1,060
Blue lime	40 "	1,100
White salt sand	18 "	1,118
Total depth	1,118 feet	

Show of gas at 960 feet.

LOG NO. 28.—INFORMATION BY GEO. WILLIAMS, DELHI

Lot	Concession	Township	County
42	III	Middleton	Norfolk

Open flow: 70,000 cu. ft. Completed June, 1922.
Rock pressure: 525 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	168 feet	
Lime	145 "	313
Flint	40 "	353
Sharp sand	58 "	411
Hard lime	51 "	462
Lime and shale	98 "	560
Brown lime	100 "	660
Hard lime	165 "	825
Niagara lime	245 "	1,070
Shale	35 "	1,105
Clinton	30 "	1,135
Red Medina	5 "	1,140
Grey shale	9 "	1,149
Total depth	1,149 feet	

Gas at 1,120 feet.

LOG NO. 29.—INFORMATION BY GEO. WILLIAMS, DELHI

Lot	Concession	Township	County
44	II	Middleton	Norfolk

Open flow: 42,000 cu. ft. Completed April 15, 1922.
Rock pressure: 540 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	183 feet	
Lime	140 "	323
Flint	42 "	365
Sharp sand	65 "	430
Hard lime	50 "	480
Lime and shale	100 "	580
Brown lime	100 "	680
Hard lime	160 "	940
Niagara lime	225 "	1,095
Lime and shale	25 "	1,120
Clinton	30 "	1,150
Red Medina	3 "	1,153
Total depth	1,153 feet	

Gas at 1,135 feet.

LOG NO. 30.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
W½ 13	III	Moulton	Haldimand

Open flow: 65,000 cu. ft. Completed Sept. 12, 1922.
Rock pressure: 150 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Clay	65 feet	
Shale and gypsum	150 "	215
Niagara	225 "	440
Grey shale	52 "	492
Clinton	25 "	517
Red Medina	40 "	557
Blue shale	60 "	617
White Medina	15 "	632
Red shale	50 "	682
Total depth	682 feet	

Gas at 537 and 625 feet.

LOG NO. 31.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
W½ 11	III	Moulton	Haldimand

Open flow: 166,000 cu. ft.
Rock pressure: 90 lbs.

Completed Aug. 11, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	65 feet	
Shale and gypsum	150 "	215
Niagara	225 "	440
Grey casing shale	52 "	492
Clinton	30 "	522
Red Medina	40 "	562
Blue shale	63 "	625
White Medina	15 "	640
Red shale	50 "	690
Total depth	690 feet	

Gas at 527, 572 and 644 feet.

LOG NO. 32.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
16	II	Moulton	Haldimand

Open flow: 25,000 cu. ft.
Rock pressure: 125 lbs.

Completed April 6, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	90 feet	
Shale	110 "	200
Niagara	224 "	424
Grey shale	50 "	474
Clinton	32 "	506
Red Medina	38 "	544
Blue shale	58 "	602
White Medina	10 "	612
Red shale	50 "	662
Total depth	662 feet	

Gas at 607 feet.

LOG NO. 33.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
11	II	Moulton	Haldimand

Open flow: 125,720 cu. ft.
Rock pressure: 190 lbs.

Completed July 7, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	65 feet	
Shale	154 "	219
Niagara	225 "	444
Grey shale	52 "	496
Clinton	25 "	521
Red Medina	40 "	561
Blue shale	63 "	624
White Medina	12 "	636
Red shale	50 "	686
Total depth	686 feet	

Gas at 514, 551 and 630 feet.

LOG NO. 34.—INFORMATION BY T. J. MCCUTCHEON, DUNNVILLE

Lot	Concession	Township	County
10	IV	Moulton	Haldimand

Open flow: 43,000 cu. ft. Completed Dec. 22, 1922.
Rock pressure: 221 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	85 feet	
Lime and shale	130 "	215
Niagara	240 "	455
Shale	47 "	502
Clinton rock	30 "	532
Red Medina	40 "	572
Grey shale	53 "	625
White Medina	16 "	641
Red shale	22 "	663
Total depth	663 feet	

LOG NO. 35.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
12	III	Moulton	Haldimand

Open flow: 116,000 cu. ft. Completed Aug. 10, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	65 feet	
Shale and gypsum	150 "	215
Niagara	225 "	440
Grey shale	52 "	492
Clinton	30 "	522
Red Medina	40 "	562
Blue shale	63 "	625
White Medina	15 "	640
Red shale	50 "	690
Total depth	690 feet	

Gas at 527, 572 and 644 feet.

LOG NO. 36.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
9	II	Moulton	Haldimand

Open flow: 106,176 cu. ft. Completed Nov. 24, 1922.
Rock pressure: 150 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Clay	76 feet	
Shale and gypsum	152 "	228
Niagara	225 "	453
Grey shale	46 "	499
Clinton	30 "	529
Red Medina	40 "	569
Blue shale	59 "	628
White Medina	14 "	642
Red shale	50 "	692
Total depth	692 feet	

Gas at 504, 554 and 638 feet.

LOG NO. 37.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
W½ 13	III	Moulton	Haldimand

Open flow: 60,000 cu. ft. Completed Oct. 20, 1922.
Rock pressure: 150 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Clay	78 feet	
Shale and gypsum	149 "	227
Niagara	225 "	452
Grey shale	51 "	503
Clinton	25 "	528
Red Medina	41 "	569
Blue shale	59 "	628
White Medina	12 "	640
Red shale	50 "	690
Total depth	690 feet	

Gas at 508, 550 and 645 feet.

LOG NO. 38.—INFORMATION BY F. L. SNIVELY, HAMILTON

Lot	Concession	Township	County
9	II	Moulton	Haldimand

Open flow: 37,320 cu. ft. Completed Dec. 29, 1922.
Rock pressure: 125 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Clay	67 feet	
Shale and gypsum	150 "	217
Niagara	225 "	442
Blue shale	53 "	495
Clinton	30 "	525
Red Medina	40 "	565
Blue shale	63 "	628
White Medina	15 "	643
Red shale	50 "	693
Total depth	693 feet	

Gas at 500, 545 and 693 feet.

LOG NO. 39.—INFORMATION BY T. J. MCCUTCHEON, DUNNVILLE

Lot	Concession	Township	County
11	III L.E.	Moulton	Haldimand

Rock pressure: 268 lbs. Completed June 3, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	132 feet	
Lime and shale	118 "	250
Brown lime	105 "	355
Niagara brown lime	230 "	585
Shale	45 "	630
Clinton	32 "	662
Red Medina	44 "	706
Grey shale	55 "	761
White Medina	14 "	775
Red shale	31 "	806
Total depth	806 feet	

Log No. 40.—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township	County
10	III	Moulton	Haldimand

Rock pressure: 235 lbs. Completed Aug. 22, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	139 feet	
Lime and shale	140 "	279
Brown lime	71 "	350
Niagara lime	230 "	580
Shale	50 "	630
Clinton	30 "	660
Red Medina	45 "	705
Grey shale	57 "	762
White Medina	15 "	777
Red shale	25 "	802
Total depth	802 feet	

Gas at 634 and 770 feet.

Log No. 41.—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township	County
14	III	Moulton	Haldimand

Rock pressure: 280 lbs. Completed March 28, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	140 feet	
Lime and shale	110 "	250
Brown lime	120 "	370
Niagara	220 "	590
Shale	50 "	640
Clinton	30 "	670
Red Medina	45 "	715
Grey shale	55 "	770
White Medina	12 "	782
Red shale	28 "	810
Total depth	810 feet	

Log No. 42.—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township	County
15	III L.E.	Moulton	Haldimand

Completed Feb. 11, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	128 feet	
Lime and shale	120 "	248
Brown lime	117 "	365
Niagara lime	225 "	590
Shale	45 "	635
Clinton	30 "	665
Red Medina	45 "	710
Grey shale	58 "	768
White Medina	12 "	780
Red shale	2 "	782
Total depth	782 feet	

Gas at 640 feet.

Log No. 43.—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township	County
13	III L.E.	Moulton	Haldimand

Rock pressure: 308 lbs. Completed July 15, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	130 feet	
Lime and shale	150 "	280
Brown lime	70 "	350
Niagara lime	230 "	580
Shale	45 "	625
Clinton	30 "	655
Red Medina	45 "	700
Grey shale	57 "	757
White Medina	15 "	772
Red shale	31 "	803
Total depth	803 feet	

Gas at 629 and 767 feet.

Log No. 44.—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township	County
9	III L.E.	Moulton	Haldimand

Dry. Completed Oct. 25, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	118 feet	
Lime and shale	152 "	270
Brown lime	170 "	340
Niagara lime	230 "	570
Shale	46 "	616
Clinton rock	35 "	651
Red Medina	40 "	691
Grey shale	54 "	745
White Medina	12 "	757
Red shale	3 "	760
Total depth	760 feet	

Log No. 45.—Information by T. J. McCutcheon, Dunnville

Lot	Concession	Township	County
13	III L.E.	Moulton	Haldimand

Rock pressure: 300 lbs. Completed May 4, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	139 feet	
Lime and shale	121 "	260
Brown lime	105 "	365
Niagara lime	225 "	590
Shale	45 "	635
Clinton	30 "	665
Red Medina	45 "	710
Grey shale	57 "	767
White Medina	12 "	779
Red shale	25 "	804
Total depth	804 feet	

LOG NO. 46.—INFORMATION BY D. W. ADAIR, EVERETT

Lot	Concession	Township	County
15	4	Mulmur	Dufferin

Completed May 15, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	45 feet	
Red shale	45 "	90
Blue shale	100 "	190
Slate, shale and blue rock (hard)	40 "	230
Total depth	230 feet	

Gas and water at 228 feet.

LOG NO. 47.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
62	River Range	Oneida	Haldimand

Open flow: 272,000
Rock pressure: 320 lbs.

Completed June 13, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	61 feet	
Lime and shale	189 "	250
Niagara	231 "	481
Shale	31 "	512
Clinton	30 "	542
Red Medina	38 "	580
Blue shale	55 "	635
White Medina	12 "	647
Red shale	55 "	702
Total depth	702 feet	

Gas at 527 and 640 feet.

LOG NO. 48.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
72	River Range	Oneida	Haldimand

Open flow: Dry.

Completed March 4, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	51 feet	
Lime and shale	197 "	248
Niagara	242 "	490
Shale	30 "	520
Clinton	24 "	544
Red Medina	42 "	586
Blue shale	65 "	651
White Medina	12 "	663
Red shale	10 "	673
Toral depth	673 feet	

LOG NO. 49.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
62	River Range	Oneida	Haldimand

Open flow: dry. Completed July 29, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	47 feet	
Lime and shale	190 "	237
Niagara	267 "	504
Shale	24 "	528
Clinton	25 "	553
Red Medina	40 "	593
Blue shale	50 "	643
White Medina	10 "	653
Red shale	10 "	663
Total depth	663 feet	

LOG NO. 50.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
62	River Range	Oneida	Haldimand

Open flow: 395,000 cubic feet. Completed May 22, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	59 feet	
Lime and shale	191 "	250
Niagara	235 "	485
Shale	36 "	521
Clinton	34 "	555
Red Medina	42 "	597
Blue shale	46 "	643
White Medina	10 "	653
Red shale	10 "	663
Total depth	663 feet	

Gas at 531 and 546 feet.

LOG NO. 51.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
76	River Range	Oneida	Haldimand

Open flow: 43,000 cubic feet. Completed March 30, 1922.
Rock pressure: 265 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	34 feet	
Lime and shale	206 "	240
Niagara	217 "	457
Shale	56 "	513
Clinton	28 "	541
Red Medina	34 "	575
Blue shale	60 "	635
White Medina	12 "	647
Red shale	15 "	662
Total depth	662 feet	

Gas at 518 and 538 feet.

LOG NO. 52.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
61	River Range	Oneida	Haldimand

Open flow: 272,000 cubic feet. Completed June 12, 1922.
Rock pressure: 320 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	61 feet	
Lime and shale	189 "	250
Niagara	231 "	481
Shale	31 "	512
Clinton	30 "	542
Red Medina	38 "	580
Blue shale	55 "	635
White Medina	12 "	647
Red shale	55 "	702
Total depth	702 feet	

LOG NO. 53.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession,	Township	County
61	River Range	Oneida	Haldimand

Open flow: 60,000 cubic feet. Completed Aug. 23, 1922.
Rock pressure: 235 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	56 feet	
Lime and shale	169 "	225
Niagara	247 "	472
Shale	18 "	490
Clinton	30 "	520
Red Medina	40 "	560
Blue shale	54 "	614
White Medina	10 "	624
Red shale	20 "	644
Total depth	644 feet	

Gas at 493 and 515 feet.

LOG NO. 54.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
65	River Range	Oneida	Haldimand

Open flow: dry. Completed Dec. 1, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	32 feet	
Lime and shale	193 "	225
Niagara	264 "	489
Shale	10 "	499
Clinton	19 "	518
Red Medina	41 "	559
Blue shale	50 "	609
White Medina	10 "	619
Red shale	6 "	625
Total depth	625 feet	

LOG NO. 55.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
64	River Range	Oneida	Haldimand

Open flow: 231,000 cubic feet. Completed Nov. 7, 1922.
Rock pressure: 280 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	55 feet	
Lime and shale	195 "	250
Niagara	252 "	502
Shale	21 "	523
Clinton	25 "	548
Red Medina	45 "	593
Blue shale	51 "	644
White Medina	10 "	654
Red shale	8 "	662
Total depth	662 feet	

Gas at 526 and 543 feet.

LOG NO. 56.—INFORMATION BY EUGENE COSTE & CO., LTD., NIAGARA FALLS

Lot	Concession	Township	County
21	VI.	Romney	Kent

Open flow: very small. Completed Dec., 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	135 feet	
Hard shell	20 "	155
Soap with hard streaks	245 "	400
Lime	97 "	497
Flint	18 "	515
Gypsum, small showing at		655
Broken lime	180 "	695
Hard lime	64 "	759
Light brown sand	16 "	775
Hard dark lime	20 "	795
Gypsum	20 "	815
Hard dark lime	60 "	875
Coarse salty formation	310 "	1,185
Dark grey and brown lime	170 "	1,355
Hard light grey sandy lime	25 "	1,380
Light brown lime	5 "	1,385
White sand	15 "	1,400
Dark brown lime	215 "	1,615
Coarse grey lime	60 "	1,675
Blue shale	37 "	1,712
Showing brown lime at 1,732 feet		
Red Medina	13 "	1,725
White and pink shale	100 "	1,825
White Medina	35 "	1,870
Big red shales	275 "	2,145
Big grey shales	515 "	2,660
Trenton lime	65 "	2,725
Light sandy lime	45 "	2,770
Fine light sand	15 "	2,785
Hard light lime	25 "	2,810
Dark lime	50 "	2,860
Light sandy lime	15 "	2,875
Dark lime	20 "	2,895
Light sandy lime	15 "	2,910
Streaks of slate in lime	15 "	2,925
Fine sand	20 "	2,945
Light hard lime	60 "	3,005
Sandy light lime	10 "	3,015
Very fine sand	20 "	3,035
Bottom of well		3,145
Total depth	3,145 feet	

LOG NO. 57.—INFORMATION BY HOOVER & MAY, SELKIRK

Lot	Concession	Township	County
1	II	Seneca	Haldimand

Open flow: 59,000 cubic feet.
Rock pressure: 225 lbs.

Completed Feb. 4, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	48 feet	
Shale	99 "	147
Niagara	181 "	328
White lime	19 "	347
Shale	33 "	380
Clinton	32 "	412
Red Medina	41 "	453
Grey shale	54 "	507
White Medina	26 "	533
Red shale	47 "	580
Total depth	580 feet	

LOG NO. 58.—INFORMATION BY HOOVER & MAY, SELKIRK

Lot	Concession	Township	County
13	II.	Seneca	Haldimand

Open flow: 60,000 cubic feet.
Rock pressure: 228 lbs.

Completed March 16, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	52 feet	
Shale	180 "	232
Niagara	139 "	371
Limestone	25 "	396
Shale	37 "	433
Clinton	28 "	461
Red Medina	40 "	501
Grey shale	30 "	531
White Medina	20 "	551
Red shale	50 "	601
Total depth	601 feet	

LOG NO. 59.—INFORMATION BY HOOVER & MAY, SELKIRK

Lot	Concession,	Township	County
A	I	Seneca	Haldimand

Open flow: 150,000 cubic feet.
Rock pressure: 225 lbs.

Completed April 26, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	66 feet	
Shale	168 "	234
Niagara	132 "	366
White lime	24 "	390
Shale	44 "	434
Clinton	25 "	459
Red Medina	40 "	499
Shale	66 "	465
White Medina	11 "	476
Red shale	50 "	526
Total depth	526 feet	

Gas at 450, 468 and 565 feet.

LOG NO. 60.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
W. ½ of E. 190 acres	Young Tract	Seneca	Haldimand

Open flow: 37,000 cubic feet.
Rock pressure: 160 lbs.

Completed May 30, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	83 feet	
Lime and shale	95 "	178
Niagara	245 "	423
Shale	40 "	463
Clinton	30 "	493
Red Medina	40 "	533
Blue shale	50 "	583
White Medina	11 "	594
Red shale	47 "	641
Total depth	641 feet	

Gas at 483 and 589 feet.

LOG NO. 61.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
Young Tract	II	Seneca	Haldimand

Open flow: 35,000 cubic feet.
Rock pressure: 210 lbs.

Completed Feb. 22, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	103 feet	
Lime and shale	102 "	205
Niagara	245 "	450
Shale	44 "	494
Clinton	30 "	524
Red Medina	40 "	564
Blue shale	45 "	609
White Medina	14 "	623
Red shale	3 "	626
Total depth	626 feet	

LOG NO. 62.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
Young Tract	II	Seneca	Haldimand

Open flow: 9,000 cubic feet.
Rock pressure: 494 lbs.

Completed Jan. 20, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	83 feet	
Lime and shale	102 "	185
Niagara	250 "	435
Shale	47 "	482
Clinton	30 "	512
Red Medina	39 "	551
Blue shale	55 "	606
White Medina	15 "	621
Red shale	2 "	623
Total depth	623 feet	

LOG NO. 63.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
Young Tract	II	Seneca	Haldimand

Dry hole. Completed Feb. 7, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	81 feet	
Lime and shale	119 "	200
Niagara	250 "	450
Shale	47 "	497
Clinton	25 "	522
Red Medina	40 "	562
Blue shale	50 "	612
White Medina	15 "	627
Red shale	3 "	630
Total depth	630 feet	

LOG NO. 64.—INFORMATIOM BY BERRY & ANDERSON, CALEDONIA

Lot	Concession	Township	County
10 & 11	Young Tract	Seneca	Haldimand

Completed Sept. 6, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	54 feet	
Rotten lime and gypsum	130 "	184
Brown lime	40 "	224
Niagara	240 "	464
White lime	40 "	504
White shale	15 "	519
Clinton	20 "	539
Red Medina	40 "	579
Blue shale	60 "	639
White Medina	12 "	651
Red shale	50 "	701
Total depth	701 feet	

Gas at 524, 528, 538, 545 and 644 feet.

LOG NO. 65.—INFORMATION BY BERRY & ANDERSON, CALEDONIA

Lot	Concession	Township	County
10 & 11	Young Tract	Seneca	Haldimand

Completed Aug. 4, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	62 feet	
Rotten lime and gypsum	128 "	190
Brown lime	40 "	230
Niagara lime	230 "	460
White lime	40 "	500
White shale	15 "	515
Clinton	21 "	536
Red Medina	40 "	576
Blue shale	60 "	636
White Medina	12 "	648
Red shale	52 "	700
Total depth	700 feet	

Gas at 520, 533, 544 and 636 feet.

Log No. 66.—Information by Berry & Anderson, Caledonia

Lot	Concession	Township	County
10 & 11	Young Tract	Seneca	Haldimand

Completed Sept. 30, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	57 feet	
Rotten lime and gypsum	130 "	187
Brown lime	35 "	222
Niagara lime	240 "	462
White lime	40 "	502
White shale	18 "	520
Clinton	27 "	547
Red Medina	40 "	587
Blue shale	60 "	647
White Medina	10 "	657
Red shale	48 "	705
Total depth	705 feet	

Gas at 526, 547 and 656 feet.

Log No. 67.—Information by Berry & Anderson, Caledonia

Lot	Concession	Township	County
10 & 11	Young Tract	Seneca	Haldimand

Dry hole. Completed Oct. 20, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	55 feet	
Rotten lime	120 "	175
Brown lime	32 "	207
Niagara lime	240 "	447
White lime	40 "	487
White shale	12 "	499
Clinton	25 "	524
Red Medina	35 "	559
Blue shale	65 "	624
White Medina	14 "	638
Total depth	638 feet	

Log No. 68.—Information by C. W. Featherstone, Dunnville

Lot	Concession	Township	County
Young Tract	River Range	Seneca	Haldimand

Dry hole. Completed Nov. 30, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	94 feet	
Lime and shale	131 "	225
Niagara	250 "	475
Shale	39 "	514
Clinton	20 "	534
Red Medina	40 "	574
Blue shale	50 "	624
White Medina	13 "	637
Red shale	4 "	641
Total depth	641 feet	

LOG NO. 69.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Township	County
Nelles Tract	Seneca	Haldimand

Open flow: 78,000 cubic feet.
Rock pressure: 30 lbs.

Completed Aug. 1, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	47 feet	
Lime and shale	177 "	224
Niagara	240 "	464
Shale	41 "	505
Clinton	25 "	530
Red Medina	33 "	563
Blue shale	65 "	628
White Medina	12 "	640
Red shale	48 "	688
Total depth	688 feet	

Gas at 508, 522, 538 and 636 feet.

LOG NO. 70.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Township	County
Nelles Tract	Seneca	Haldimand

Open flow: 62,000 cubic feet.
Rock pressure: 255 lbs.

Completed Aug. 21, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	56 feet	
Lime and shale	180 "	236
Niagara	250 "	486
Shale	47 "	533
Clinton	25 "	558
Red Medina	40 "	598
Blue shale	42 "	640
White Medina	15 "	655
Red shale	45 "	700
Total depth	700 feet	

Gas at 538, 553 and 643 feet.

LOG NO. 71.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Township	County
Nelles Tract	Seneca	Haldimand

Completed Sept. 6, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	56 feet	
Lime and shale	169 "	225
Niagara	250 "	475
Shale	40 "	515
Clinton	25 "	540
Red Medina	40 "	580
Blue shale	47 "	627
White Medina	15 "	642
Red shale	3 "	645
Total depth	645 feet	

Log No. 72.—Information by C. W. Featherstone, Dunnville

Lot	Township	County
Nelles Tract	Seneca	Haldimand

Open flow: 55,000 cubic feet.
Rock pressure: 310 lbs.

Completed Sept. 28, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	78 feet	
Lime and shale	157 "	535
Niagara	240 "	475
Shale	35 "	510
Clinton	25 "	535
Red Medina	40 "	575
Blue shale	52 "	627
White Medina	15 "	642
Red shale	50 "	692
Total depth	692 feet	

Gas at 512 and 530 feet.

Log No. 73.—Information by C. W. Featherstone, Dunnville

Lot	Concession	Township	County
Parts Nelles	Lawson & Thomas Tract	Seneca	Haldimand

Open flow: 221,000 cubic feet.
Rock pressure: 210 lbs.

Completed Dec. 22, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	105 feet	
Lime and shale	123 "	228
Niagara	250 "	478
Shale	35 "	513
Clinton	25 "	538
Red Medina	35 "	573
Blue shale	57 "	630
White Medina	12 "	642
Red shale	40 "	682
Total depth	682 feet	

Gas at 521 and 546 feet.

Log No. 74.—Information by C. W. Featherstone, Dunnville

Lot	Township	County
Nelles Tract	Seneca	Haldimand

Open flow: 60,000 cubic feet.
Rock pressure: 260 lbs.

Completed April 19, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	65 feet	
Lime and shale	115 "	180
Niagara	235 "	415
Casing shale	39 "	454
Clinton	30 "	484
Red Medina	38 "	522
Blue shale	60 "	582
White Medina	12 "	594
Red shale	39 "	633
Total depth	633 feet	

Gas at 471 and 587 feet.

LOG NO. 75.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
N½ 16	I	Seneca	Haldimand

Dry hole. Completed June 20, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	60 feet	
Lime and shale	150 "	210
Niagara	245 "	455
Shale	37 "	492
Clinton	25 "	517
Red Medina	40 "	557
Blue shale	58 "	615
White Medina	12 "	627
Red shale	1 "	628
Total depth	628 feet	

LOG NO. 76.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Township	County
Part Young Tract	Seneca	Haldimand

Dry hole.

Formation	Thickness of Formation	Total Depth (feet)
Surface	57 feet	
Lime and shale	108 "	165
Niagara	240 "	405
Shale	50 "	455
Clinton	27 "	482
Red Medina	40 "	522
Blue shale	47 "	569
White Medina	15 "	584
Red shale	2 "	586
Total depth	586 feet	

LOG NO. 77.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
N½ 18	I	Seneca	Haldimand

Dry hole. Completed July 11, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	56 feet	
Lime and shale	194 "	250
Niagara	240 "	490
Shale	40 "	530
Clinton	30 "	560
Red Medina	40 "	600
Blue shale	50 "	650
White Medina	12 "	662
Red shale	1 "	663
Total depth	663 feet	

Log No. 78.—Information by Kervin & Co., Merlin

Lot	Concession	Township	County
11	M.R.S.	Tilbury East	Kent

Open flow: 160,000 cubic feet.
Rock pressure: 280 lbs.

Completed May 10, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Drift, clay	150 feet	
Soapstone	52 "	202
White lime	333 "	535
Sharp sand	25 "	560
Grey lime	560 "	1220
Brown lime	135 "	1,355
Total depth	1,355 feet	

Gas at 1,210 and 1,320 feet.

Log No. 79.—Information by Kervin & Co., Merlin

Lot	Concession	Township	County
W½ 9	XI	Tilbury East	Kent

Open flow: 325,000 cubic feet.

Completed April 5, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Drift, clay	150 feet	
Quicksand	15 "	165
Gravel	3 "	168
Soapstone	67 "	235
Grey lime	300 "	535
Sharp sand	200 "	735
Grey lime	265 "	1,000
Dark lime	115 "	1,115
Blue lime	50 "	1,165
Light lime	35 "	1,200
Brown lime	165 "	1,365
Total depth	1,365 feet	

Gas at 1,250 and 1,345 feet.

Log No. 80.—Information by Kervin & Co., Merlin

Lot	Concession	Township	County
11	XIII	Tilbury East	Kent

Open flow: 255,000 cubic feet.
Rock pressure: 342 lbs.

Completed Nov. 25, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Drift, clay	153 feet	
Soap	67 "	220
White lime	70 "	290
Grey lime	100 "	390
White lime	135 "	525
Sharp sand	175 "	700
Water sand	35 "	735
Grey lime	95 "	830
White lime	90 "	920
Blue lime	80 "	1,000
Grey lime	100 "	1,100
Brown lime	105 "	1,205
Grey lime	162 "	1,367
Total depth	1,367 feet	

Gas at 1,250, 1,320 and 1,357 feet.

LOG NO. 81.—INFORMATION BY KERVIN & CO., MERLIN

Lot	Concession	Township	County
W½ 9	XI	Tilbury East	Kent

Open flow: 500,000 cubic feet. Completed Feb. 25, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Drift, clay	149 feet	
Soap	48 "	197
Lime	303 "	500
Sharp sand	150 "	650
Lime	658 "	1,308
Total depth	1,308 feet	

Gas at 1,260, 1,275 and 1,285 feet.

LOG NO. 82.—INFORMATION BY KERVIN & CO., MERLIN

Lot	Concession	Township	County
9	XI	Tilbury East	Kent

Open flow: 400,000 cubic feet. Completed July 29, 1922.
Rock pressure: 432 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Drift, clay	154 feet	
Soapstone	67 "	221
Lime	329 "	550
Sharp sand	100 "	650
Lime	692 "	1,342
Total depth	1,342 feet	

Gas at 1,235 and 1,335 feet.

LOG NO. 83.—INFORMATION BY KERVIN & CO., MERLIN

Lot	Concession	Township	County
W½ 9	XI	Tilbury East	Kent

Open flow: 117,000 cubic feet. Completed Nov. 3, 1922.
Rock pressure:

Formation	Thickness of Formation	Total Depth (feet)
Drift, clay	110 feet	
Quicksand	38 "	148
Gravel	15 "	163
Grey lime	97 "	260
White lime	85 "	345
White lime	75 "	420
Sharp sand	160 "	580
Water sand	135 "	715
Brown lime	148 "	860
Grey lime	162 "	1,022
White lime	146 "	1,168
Brown lime	142 "	1,310
Blue lime	60 "	1,370
Total depth	1,370 feet	

Gas at 1,240, 1,310 and 1,375 feet.

LOG NO. 84.—INFORMATION BY KISER, KISER & LAUER, TILLSONBURG

Lot	Concession	Township	County
5	X	Tilbury West	Essex

Open flow: 65,000 cubic feet. Completed July 8, 1922.
Rock pressure:

Formation	Thickness of Formation	Total Depth (feet)
Surface	98 feet	
Lime	367 "	465
Flint	35 "	500
Lime	100 "	600
Gypsum	445 "	1,045
Hard lime	255 "	1,300
Hard shell and brown lime	10 "	1,310
Salt sand	335 "	1,645
Blue shale	16 "	1,662
Brown lime	24 "	1,686
Red Medina	128 "	1,814
White Medina	36 "	1,850
Red shale	252 "	2,102
Grey shale	470 "	2,572
Trenton	831 "	3,403
Potsdam	20 "	3,423
Top of granite and total depth	3,423 feet	

Gas at 1,064, 1,130, 1,169 and 1,825 feet. Oil at 1,169 feet.

LOG NO. 85.—INFORMATION BY T. J. MCCUTCHEON, DUNNVILLE

Lot	Concession	Township	County
14	I	Wainfleet	Welland

Dry hole. Completed June 13, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Sand	4 feet	
Flint	75 "	79
Brown lime	125 "	204
Lime and shale	246 "	450
Niagara lime	225 "	675
Shale	50 "	725
Clinton rock	30 "	755
Red Medina	45 "	860
Grey shale	55 "	855
White Medina	15 "	870
Red shale	1 "	871
Total depth	871 feet	

LOG NO. 86.—INFORMATION BY T. J. MCCUTCHEON, DUNNVILLE

Lot	Concession	Township	County
13	I	Wainfleet	Welland

Dry hole. Completed April 6, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Sand	13 feet	
Flint	80 "	93
Brown lime	150 "	243
Lime and shale	200 "	443
Niagara lime	230 "	673
Shale	50 "	723
Clinton rock	30 "	753
Red Medina	45 "	798
Grey shale	57 "	855
White Medina	15 "	870
Red shale	7 "	877
Total depth	877 feet	

Log No. 87.—Information by C. W. Featherstone, Dunnville

Lot	Concession	Township	County
19	VII	Walpole	Haldimand

Open flow: 204,000 cubic feet. Completed April 1, 1922.
Rock pressure: 480 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Flint	80 feet	
Lime and shale	260 "	440
Niagara	270 "	710
Shale	59 "	769
Clinton	24 "	793
Red Medina	40 "	833
Shale	55 "	888
White Medina	15 "	903
Red shale	10 "	913
Total depth	913 feet	

Gas at 782 and 800 feet.

Log No. 88.—Information by C. W. Featherstone, Dunnville

Lot	Concession	Township	County
19	VII	Walpole	Haldimand

Open flow: 38,000 cubic feet. Completed Feb. 13, 1922.
Rock pressure: 420 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	27 feet	
Flint	58 "	85
Lime and shale	365 "	450
Niagara	269 "	719
Shale	57 "	776
Clinton	23 "	799
Red Medina	40 "	839
Shale	55 "	894
White Medina	15 "	909
Red shale	6 "	915
Total depth	915 feet	

Gas at 789 and 809 feet.

Log No. 89.—Information by C. W. Featherstone, Dunnville

Lot	Concession	Township	County
20	VII	Walpole	Haldimand

Open flow: 213,000 cubic feet. Completed June 14, 1922.
Rock pressure: 500 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	8 feet	
Flint	82 "	90
Lime and shale	350 "	440
Niagara	272 "	712
Shale	46 "	758
Clinton	27 "	825
Shale	55 "	893
White Medina	13 "	898
Red shale	5 "	
Total depth,	898 feet	

Gas at 785 to 795 feet.

Log No. 90.—Information by C. W. Featherstone, Dunnville

Lot	Concession	Township	County
20	VII	Walpole	Haldimand

Open flow: 350,000 cubic feet. Completed July 12, 1922.
Rock pressure: 500 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	15 feet	
Flint	84 "	99
Lime and shale	358 "	457
Niagara	263 "	720
Shale	49 "	769
Clinton	31 "	800
Red Medina	40 "	840
Shale	55 "	895
White Medina	13 "	908
Red shale	7 "	915
Total depth	915 feet	

Gas at 771, 784 and 803 to 830 feet.

Log No. 91.—Information by Hoover & May, Selkirk

Lot	Concession	Township	County
12	IV	Walpole	Haldimand

Open flow: 20,000 cubic feet. Completed Aug. 19, 1922.
Rock pressure: 280 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Flint	100 feet	
Lime and shale	403 "	503
White Niagara	107 "	610
Brown Niagara	90 "	700
Shale	37 "	737
Guelph lime	23 "	760
Casing shale	40 "	800
Clinton	25 "	825
Red Medina	50 "	875
White shale	53 "	928
White Medina	12 "	940
Red shale	10 "	950
Total depth	950 feet	

Gas at 830 feet.

Log No. 92.—Information by Hoover & May, Selkirk

Lot	Concession	Township	County
13	IV	Walpole	Haldimand

Open flow: 35,000 cubic feet. Completed Oct. 28, 1922.
Rock pressure: 280 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Clay and gravel	15 feet	
Flint	85 "	100
Lime and shale	403 "	503
White Niagara	107 "	610
Brown Niagara	90 "	700
Shale	30 "	730
Guelph lime	30 "	760
Casing shale	40 "	800
Clinton	25 "	825
Red Medina	50 "	875
White shale	53 "	927
White Medina	12 "	940
Red shale	6 "	946
Total depth	946 feet	

Gas at 830 feet.

LOG NO. 93.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
19	VII	Walpole	Haldimand

Open flow: 3,000 cubic feet. Completed May 12, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	7 feet	
Flint	83 "	90
Lime and shale	365 "	455
Niagara	270 "	725
Shale	51 "	776
Clinton	25 "	801
Red Medina	38 "	839
Shale	55 "	894
White Medina	15 "	909
Red shale	4 "	913
Total depth	913 feet	

Gas at 786 and 816 feet.

LOG NO. 94.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
21	VII	Walpole	Haldimand

Open flow: 38,000 cubic feet. Completed Nov. 15, 1922.
Rock pressure: 480 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	18 feet	
Flint	67 "	85
Lime and shale	370 "	455
Niagara	260 "	715
Shale	53 "	768
Clinton	23 "	791
Red Medina	37 "	828
Shale	60 "	888
White Medina	12 "	900
Shale	5 "	905
Total depth	905 feet	

Gas at 778, 801 and 811 feet.

LOG NO. 95.—INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE

Lot	Concession	Township	County
S½ 22	VII	Walpole	Haldimand

Open flow: 497,000 cubic feet. Completed Dec. 15, 1922.
Rock pressure: 500 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	18 feet	
Flint	72 "	90
Lime and shale	370 "	460
Niagara	260 "	720
Shale	52 "	772
Clinton	25 "	797
Red Medina	38 "	835
Shale	60 "	895
White Medina	12 "	907
Shale	5 "	912
Total depth	912 feet	

Gas at 805 feet.

Log No. 96.—Information by C. W. Featherstone, Dunnville

Lot	Concession	Township	County
21	VII	Walpole	Haldimand

Open flow: 25,000 cubic feet. Completed Oct. 3, 1922.
Rock pressure: 480 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	8 feet	
Flint	77 "	85
Lime and shale	360 "	445
Shale	55 "	762
Clinton	22 "	784
Red Medina	40 "	824
Shale	59 "	883
White Medina	15 "	898
Red shale	5 "	903
Total depth	903 feet	

Gas at 794, 799 and 804 feet.

Log No. 97.—Information by C. W. Featherstone, Dunnville

Lot	Concession	Township	County
E½ 20	VII	Walpole	Haldimand

Dry hole. Completed Sept. 1, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Surface	0 feet	
Flint	85 "	
Lime and shale	360 "	445
Niagara	265 "	710
Shale	47 "	757
Clinton	25 "	782
Red Medina	40 "	822
Shale	60 "	882
White Medina	15 "	897
Red shale	7 "	904
Total depth	904 feet	

Log No. 98.—Information by J. J. McLister, Dunnville

Lot	Concession	Township	County
4	III	Walpole	Haldimand

Open flow: 190,000 cubic feet. Completed Oct. 28, 1922.
Rock pressure: 380 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface clay	27 feet	
Shale	10 "	37
Flint	160 "	197
Lime and shale	307 "	504
Niagara	275 "	779
Shale	60 "	839
Clinton	25 "	864
Red Medina	30 "	894
Shale	60 "	951
White Medina	14 "	968
Red shale	40 "	1,008
Total depth	1,008 feet	

Gas at 859, 874 and 964 feet.

Log No. 99.—Information by J. J. McLister, Dunnville

Lot	Concession	Township	County
3	III	Walpole	Haldimand

Open flow: 50,000 cubic feet. Completed Dec. 5, 1922.
Rock pressure: 400 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	33 feet	
Flint	160 "	193
Lime and shale	390 "	583
Niagara	230 "	813
Shale	40 "	853
Clinton	27 "	880
Red Medina	35 "	915
Shale	65 "	980
White Medina	15 "	995
Red shale	11 "	1,006
Total depth	1,006 feet	

Gas at 873 and 890 feet.

Log No. 100.—Information by W. Hamaker, Port Dover

Lot	Concession	Township	County
4 & 5	Broken Front	Woodhouse	Norfolk

Open flow: 198,000 cubic feet. Completed July 4, 1922.
Rock pressure: 635 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	127 feet	
Lime	99 "	226
Flint	80 "	306
Sand	32 "	338
Lime	109 "	447
Lime and shale	82 "	529
Lime	108 "	637
Shale	60 "	697
Niagara lime	273 "	970
Shale	60 "	1,030
Clinton	27 "	1,057
Red Medina	20 "	1,077
Shale	67 "	1,144
White Medina	20 "	1,164
Red shale	50 "	1,214
Total depth	1,214 feet	

Gas at 1,033 and 1,164 feet.

Log No. 101.—Information by W. Hamaker, Port Dover

Lot	Concession	Township	County
4 & 5	Broken Front	Woodhouse	Norfolk

Open flow: 20,000 cubic feet. Completed Sept. 15, 1922.
Rock pressure: 345 lbs.

Formation	Thickness of Formation	Total Depth (feet)
Surface	114 feet	
Lime	98 "	212
Flint	82 "	294
Sand	31 "	325
Lime	102 "	427
Lime and shale	80 "	507
Lime	115 "	622
Shale	60 "	682
Niagara lime	278 "	960
Shale	60 "	1,020
Clinton	25 "	1,045
Red Medina	20 "	1,065
Shale	65 "	1,130
White Medina	20 "	1,150
Red shale	10 "	1,160
Total depth	1,160 feet	

Gas at 1,030 feet.

Log No. 102.—Information by W. Hamaker, Port Dover

Lot	Concession	Township	County
4 & 5	Broken Front	Woodhouse	Norfolk

Open flow: 18,000 cubic feet. Completed Oct. 24, 1922.
Rock pressure:

Formation	Thickness of Formation	Total Depth (feet)
Surface	132 feet	
Lime	113 "	245
Flint	75 "	320
Sand	25 "	345
Lime	95 "	440
Lime and shale	77 "	517
Lime	118 "	635
Shale	60 "	695
Niagara lime	282 "	977
Shale	52 "	1,029
Clinton	22 "	1,051
Red Medina	23 "	1,074
Shale	76 "	1,150
White Medina	20 "	1,170
Red shale	21 "	1,191
Total depth	1,191 feet	

Gas at 1,061 and 1,166 feet.

Log No. 103.—Information by Eric Hussey, Petrolia

Lot	Concession	Township	County
2	I	Dover East	Kent

Dry hole. Completed July 17, 1922.

Formation	Thickness of Formation	Total Depth (feet)
Clay	5 feet	
Gravel	12 "	17
Clay	20 "	37
Quicksand	65 "	102
Soapstone	113 "	215
Big lime	100 "	315
Total depth	315 feet	

Show of gas at 240 feet.

PETROLEUM IN 1922

By

R. B. Harkness

General

The amount of oil produced in Ontario during the year 1922 was 164,732 barrels, valued at $466,587, thus showing a decrease in output of 8,128 barrels from 1921. This quantity of oil was produced by 209 operators. The decrease between 1920 and 1921 was 8,891 barrels. Although it is regrettable that the Ontario fields are falling off, still, the rate of decline is less than last year and the old Oil Springs field, "the first discovered oil field in North America," although in its 64th year has actually shown an increase in production for the past two years.[1] If the rate of decrease remains the same, the present Ontario fields will last another twenty years.

The Mosa field shows a most encouraging gain after a disappointing year in 1921, when its production fell off 13,300 barrels from that of the year 1920. It was allowed to "rest" for a few months, and the increased production shows the wisdom of this. The gains in Plympton and Dutton are doubtless due to shipments held over from 1921, not to increased production. The number of producing wells drilled (5) and the number abandoned (241) will explain at once the main cause of the decreased output. A contributing cause is the fall in the price of oil from $4.00 per barrel in January, 1921 to $2.45 in December, 1922. This decline has driven operators to cut the cost of production in every possible way. Higher wages have attracted experienced men to leave for foreign fields. Small well owners, principally farmers, who previously employed skilled men to run their wells were forced to operate both their wells and farms at the expense of reduced production. The casing in the majority of wells in these old fields is in very poor repair. With the falling price of oil it is not profitable to renew it, and many wells are either abandoned or allowed to lie idle.

[1]In 1830 the presence of oil was noticed in the swamps of Enniskillen township, Lambton county. The first well for the purpose of obtaining and refining oil on the North American continent was dug at Oil Springs, Ontario, in the year 1858 by J. H. Williams, of Hamilton. The depth of this well was about 100 feet. Oil of a lubricating quality was obtained in a gravel bed on top of the limestone. About ten such wells were dug in all. This was really the first oil well in America, and dug a year before Drake's well in Pennsylvania in 1859, although it did not pierce the limestone.

The date that the first well was drilled into the rock in Canada is not so certain. Victor Ross in his book, "Petroleum of Canada," states that James Shaw, a photographer in the vicinity of Oil Springs, "rigged up" a spring-pole drill operated by foot power, and in February, 1862, completed a well to a depth of 165 feet where he encountered petroleum which flowed over a thousand barrels a day, and that other wells in the vicinity drilled later flowed as high as seven thousand barrels. Giving evidence before the Royal Commission on the Mineral Resources of Ontario, 1890, J. H. Fairbanks stated that the first well was drilled at Oil Springs about 1861.

Sir Wm. Logan in his report, Geology of Canada, 1863, page 786, states that "the production of petroleum previous to July 31st, 1861, was 5,529 barrels," and on page 788, "The wells of Enniskillen township continued to yield large supplies of petroleum during a period of eighteen months, but about the commencement of 1863 it was announced that the discharge from the flowing wells had become intermittent."

From the latter quotation it would appear that the flowing wells could not have been drilled later than July, 1861, and if the production previous to that date was 5,529 barrels, it would indicate that the flowing wells were drilled even earlier as the production is very large to be obtained from ten wells in the gravel beds.

Giving due consideration to the above, it is possible that the date given by Victor Ross should be February, 1861. instead of February, 1862.

In the Oil Springs field, out of a total of twenty-seven properties, only three operators have less than ten wells on a single property, and in the Petrolia field, fifty-eight operators have less than ten wells each out of a total of ninety-three properties. Conditions in the scattered fields such as Sarnia, Moore, Mosa and Plympton townships are much the same as in the Petrolia field. In Sarnia township only one property has a total of ten wells on it, and no property in Moore township. These properties vary in size from 50 acres upwards. Considering the above circumstances, it is remarkable that these old fields are kept producing.

Price of Oil

The price paid for Canadian crude oil varies with its specific gravity and the average price for the year was $2.67. The lighter oil containing the most gasoline has the greatest value. The prices quoted below are the average for the year in the several fields and more or less reflect the gravity of the oil in these fields. The price is per barrel of 35 Imperial gallons.

Petrolia	$2.83	Tilbury East	$2.57
Dutton	2.81	Thamesville	2.81
Bothwell	2.81	Inwood	2.70
Onondaga	2.70	Mosa	2.81
Belle River	2.09	Oil Springs	2.90
Raleigh	2.09		

In addition to these prices the Canadian Government pays a bounty of 52½ cents per barrel, or 1½ cents per Imperial gallon.

OIL WELLS AND THEIR PRODUCTION IN 1922

Field	Wells			Production		Gain or Loss in 1922		Wells Drilled	
	Operating	Not operating	Abandoned	bbls.	gals.	Gain bbls.	Loss bbls.	Dry	Producing
Petrolia and Enniskillen	1,541	835	167	64,934	32	....	3,548	2	3
Oil Springs	1,227	36	30	43,213	19	2,247	....	....	....
Moore Twp	120	22	10	7,274	20	....	260	....	....
Sarnia Twp	127	17	20	3,223	26	....	844	....	....
Brooke Twp	1	11	....	....	....	....	....	....	....
Plympton Twp	30	23	2	695	....	210	....	....	....
Bothwell	231	55	4	25,680	34	....	1,196	....	....
Tilbury East	6	....	....	126	32	....	875	....	....
Dover West	7	....	....	5,482	11	....	1,991	....	....
Raleigh Twp	20	....	....	663	14	....	2,657	....	....
Onondaga Twp	21	6	....	489	15	....	76	....	....
Mosa Twp	78	37	8	11,959	14	1,195	....	....	....
Thamesville	7	4	....	383	19	....	936	....	....
Euphemia	....	57	....	....	....	....	....	....	....
Belle River	....	24	....	....	....	....	....	....	....
Dunwich Twp	....	....	....	....	....	....	....	....	2
Dutton	90	....	....	386	27	387	....	....	....
Dawn Twp	....	....	....	216	34	217	....	....	....
	3,506	1,127	241	164,731	17	4,256 Net loss	12,383 8,127	2	5

New Drilling

In the old fields Petrolia is the only one that attracted new drilling; five wells were drilled, two of which were dry.

One new field was opened up in Dunwich township. Two small producing wells were drilled but no oil shipped in 1922.

Exploratory Drilling

Considerable "wild-catting" was done. The well begun by Johnston & Hyatt at Arkona in Lambton county was drilled into the Utica shale, when collapsed casing caused a fishing job which was not completed at the end of the year.

The Central Ontario Petroleum Co. drilled another well near Kerwood with very small production.

In Essex county the Volcanic Oil & Gas Co. drilled a well to the granite near Roslyn, a dry hole. A new location has been made in Romney township.

Mr. Bon Jasperson, in conjunction with the Southern Ontario Gas Co., drilled a well in Gosfield South township. It came in as a very small gas producer, and was later abandoned.

The Eagle Oil & Gas Co., drilled a well to the Trenton at Arner in Colchester South township, but dropped the casing while putting it in. They are at present fishing it out.

The Middlesex Dover Oil Co. commenced a well near Ilderton north of London, but found the surface more difficult than they anticipated and abandoned the attempt.

The Valley Oil & Gas Co. had a similar experience at Copetown west of Hamilton. Here 536 feet of quicksand and gravel was encountered with no sign of rock. Apparently the ancient Dundas valley extended many miles west, and has been partially filled by the great glaciers that spread over Canada and into the northern States.

R. I. Henderson finished a dry hole at Bronte, in Halton county, and began a well in Vaughan township, York county, one mile north of Concord station, which was not completed in 1922. Some gas was found in the Hudson River shales.

Mention has previously been made of the gas wells drilled in Caledon East township, Peel county, near Inglewood.

A strong flow of gas was encountered in the Hudson River shales in a water well drilled on the Gallagher farm north of Perm in Mulmur township, Dufferin county.

The Canadian Oil Fields, Limited, after fishing for eight months, have continued work in their well two miles east of Shelburne.

A well was drilled through the Trenton limestone at Tottenham village, Tecumseh township, Simcoe county—a dry hole.

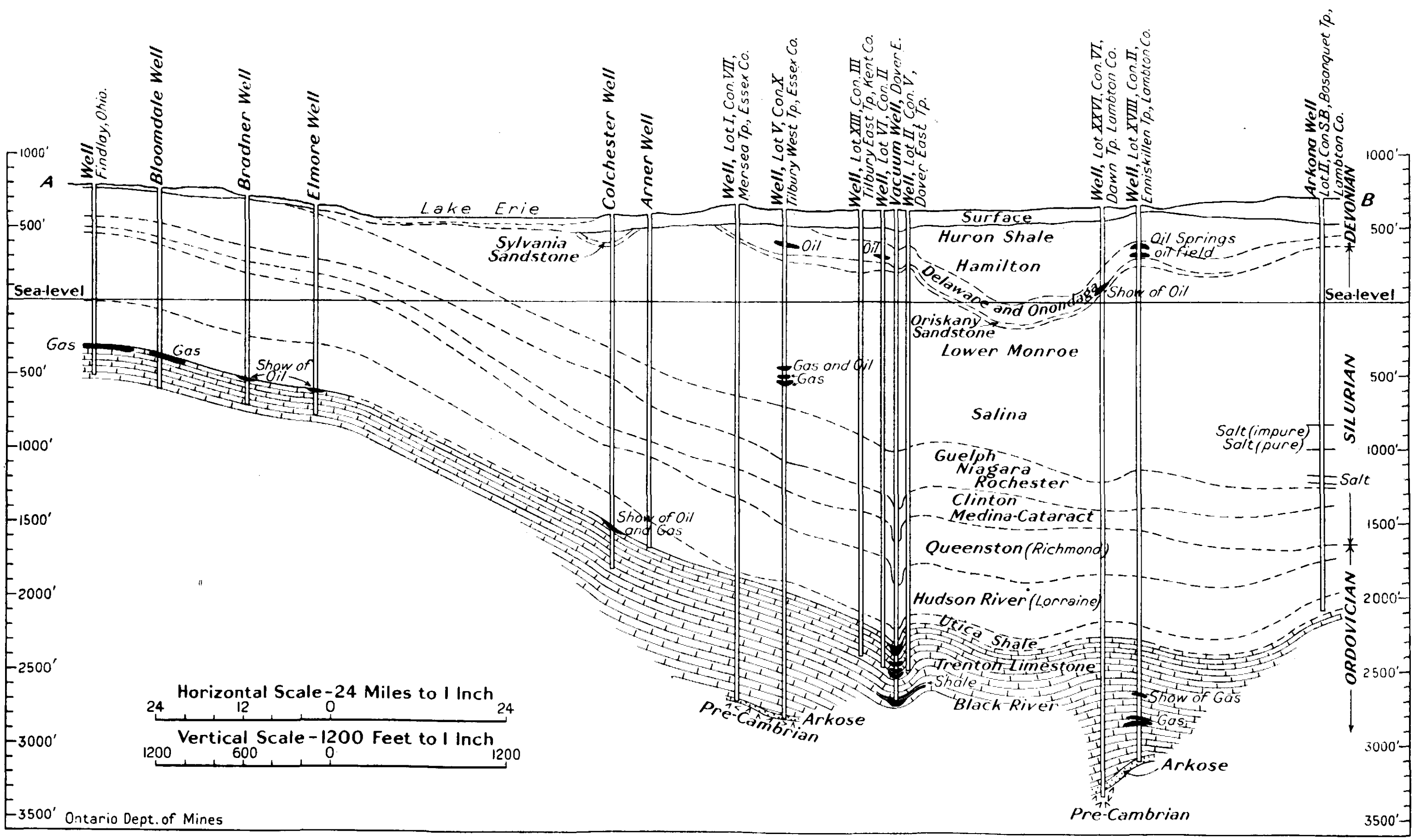
Captain C. M. McCarthy completed the test well on the Mattagami river, northern Ontario, which he set out to drill on December 27th, 1921. This well is located near Grand Rapids, about 75 miles north of the Canadian National Railway. He encountered a flow of gas and a show of oil at shallow depth.

DRILLING FOR OIL ON THE JAMES BAY SLOPE

The illustration shows how Capt. C. M. McCarthy made it possible to drill for oil in the extreme winter weather on the Mattagami river in northern Ontario. To protect the crew and the diamond drill a pit was dug below frost line, roofed with poles and covered with brush. A stove kept the temperature comfortable. It is here shown under construction.

A one-inch Sullivan diamond drill was used. There is no doubt that this is the first well completed where the drilling equipment and casing were transported by dog team. Captain McCarthy deserves great credit for his resourcefulness and for facing the hardships and risks connected with drilling in such extreme temperatures and in an uninhabited country.

Proof that there is gas and oil in northern Ontario, although the quantities are still unknown. The photo is taken looking into the pit (shown above) after a flow of gas and water filled it. The gas bubbles can be seen on the water in the left of the picture. On the right the water can be seen to be agitated. Capt. McCarthy reports a scum of oil on the water.



Section A.B.—Findlay, Ohio, to Arkona, Ontario, through the Ohio, Dover, and Oil Springs oil and gas fields, showing occurrence of oil and gas in the Onondaga and Salina formations. *See* map in pocket for location of section.

Contouring the Trenton

The structure contour map inserted in pocket on inside of back cover is not given as correct in detail, but as showing the major features of the Trenton limestone in the Western Ontario peninsula. Records of the few scattered wells from which the map has been plotted, logs of which have been published from time to time,[1] have been used as pivot points, and the contour lines show the average dip between these wells. The contours extended into Ohio have been added to show the Cincinnati uplift as it passes under Lake Erie, and the Ohio oil and gas field.[2] Since the map was first made two wells recently drilled have been added. These did not change the contour lines to any noticeable extent. The Trenton limestone over large portions of Ontario has a very unbroken slope, and the contour lines may be accepted as fairly accurate with the possible exception of the area in Kent county, north of the Thames river and the southern part of Lambton county. Too little is known of this area to hazard an opinion as to what may be found. The area to the east of Lake Huron has never been prospected. Although some shallow wells have been drilled, mostly salt wells, none penetrated the Trenton. However, there is such unconformity in the salt beds and the Ordovician shales that it is most unsafe to base any opinion on the logs of shallow wells.

The Trenton limestone is the only remaining hope of a large oil and gas field in Ontario. The Devonian limestones have been fairly well tested, a very small area remaining unproven. In the Silurian system, the Guelph and Niagara fields of Kent and Essex and the Medina-Clinton fields of Elgin, Norfolk, Haldimand and Welland have been prospected as far north as the central part of Middlesex and Oxford counties. The Trenton limestone (Ordovician) has not had nearly the attention that these shallower fields have received, mainly because of the greater expense and risk connected with such deep drilling.[3]

The Trenton limestone in Ohio shown in the map has been one of the greatest gas and oil producing fields in North America, but like all other fields the gas was allowed to go to waste and was used for the coarsest of purposes[4] and in a few years' time the supply was exhausted. The gas and oil was found in the upper one hundred feet of the formation under a very hard dense capping of limestone. The limestone was dolomitic (magnesian) with many vugs or cavities, some an inch in diameter[5]. The field proved so uniform that unless oil or gas was discovered within the first two hundred feet the well was abandoned. In late years many of these old wells are being deepened and a further supply is being found at depth[6].

Producing Fields in Ontario

Exactly the same character of rock[7] is found in Ontario, excepting that the oil and gas in the larger Trenton field in West Dover township, Kent county,

[1]Geol. Surv. Can., Summary Report, 1917, 1918, 1919, Part E.
Ont. Dept. of Mines, Volume XXIX, Part V; Volume XXX, Part V; Volume XXXI, Part V.
Can. Dept. Mines, Mines Branch, No. 291, Volume II.

[2]Information taken from logs and elevations in Volume VI, Geological Survey of Ohio, with some more recent logs kindly furnished by Professor J. A. Bownocker, State Geologist.

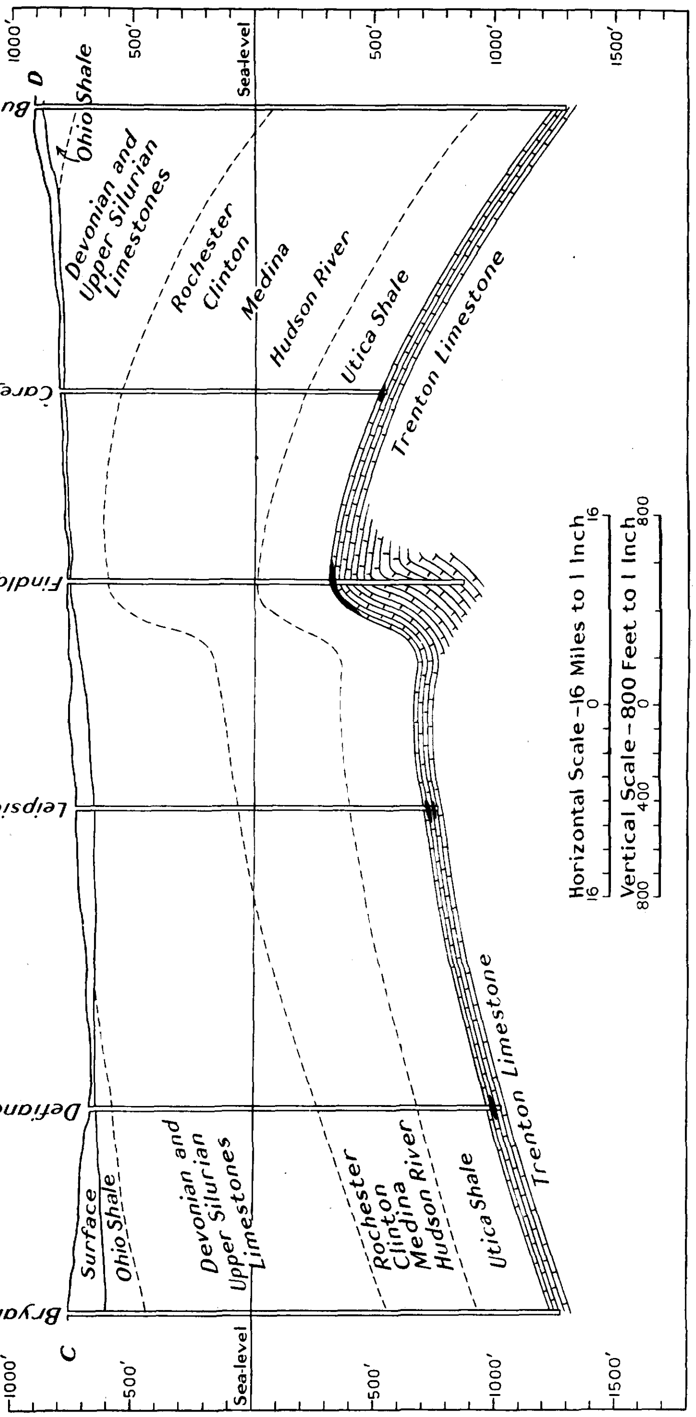
[3]The following extract from Sir Wm. Logan's report, Geology of Canada, 1863, page 788, is interesting: "The possibility of its occurrence (petroleum) in available quantities in some part of the Trenton formation should not be lost sight of, although this has never hitherto furnished any considerable amount of petroleum."

[4]Geological Survey of Ohio—Oil and Gas in 1903.

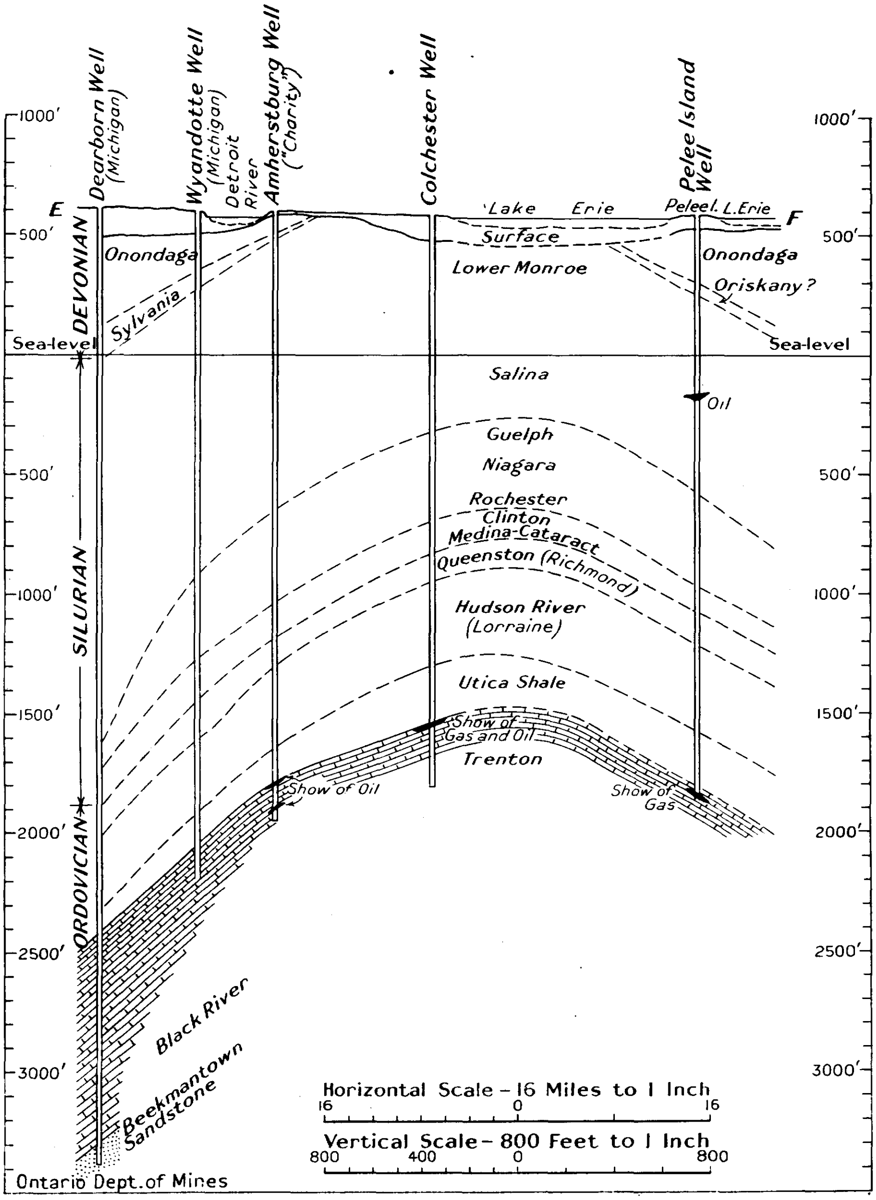
[5]Samples in Ohio State Geologist's possession.

[6]Oil & Gas Journal, July 2 and 9, 1923.

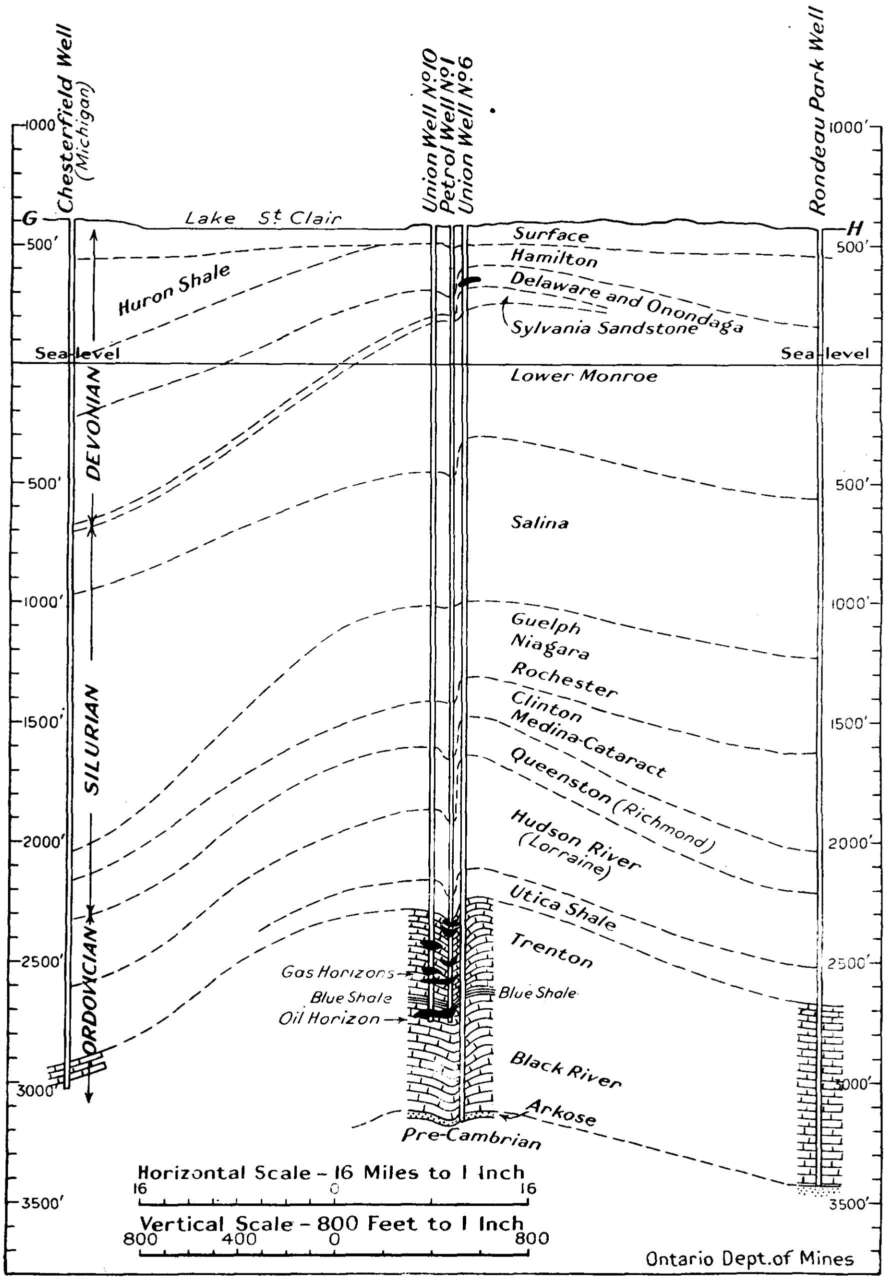
[7]Samples in office of Natural Gas Commissioner, 5 Queen's Park, Toronto. *See* illustration on page 92.



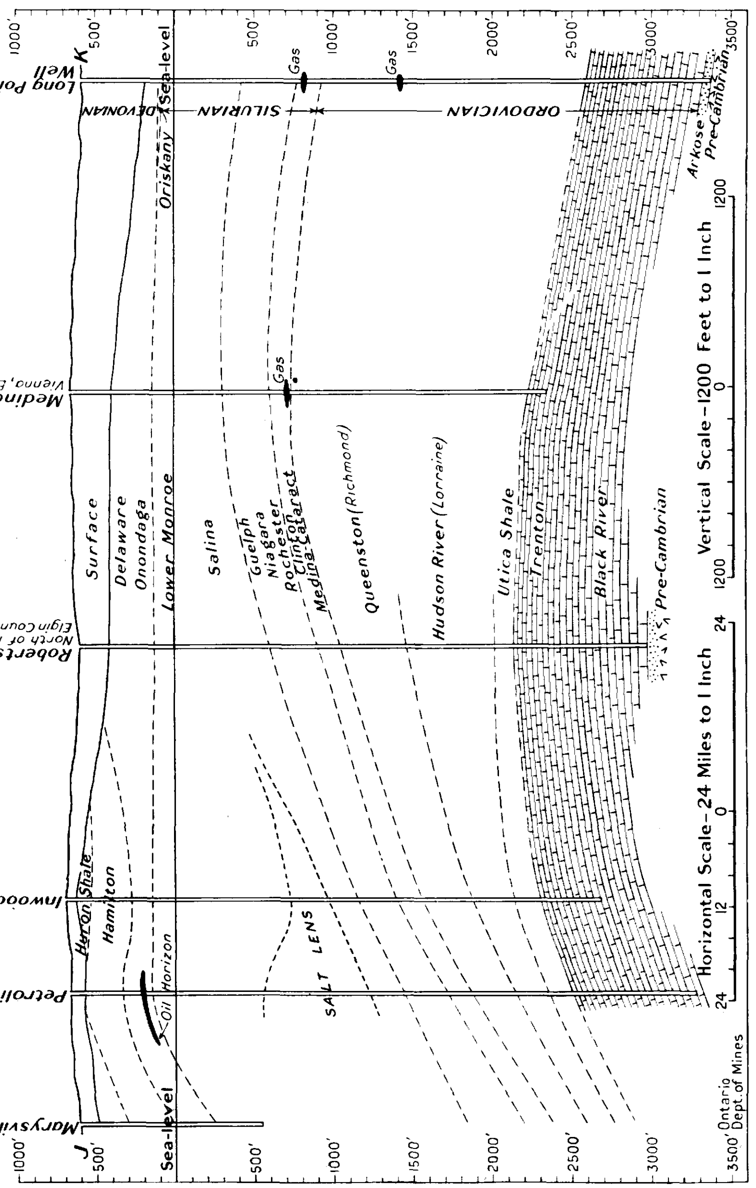
Section C.D.—Bryan to Bucyrus, Ohio. Copied from Ohio Geological Survey, Vol. 8. *See* map in pocket for location of section.



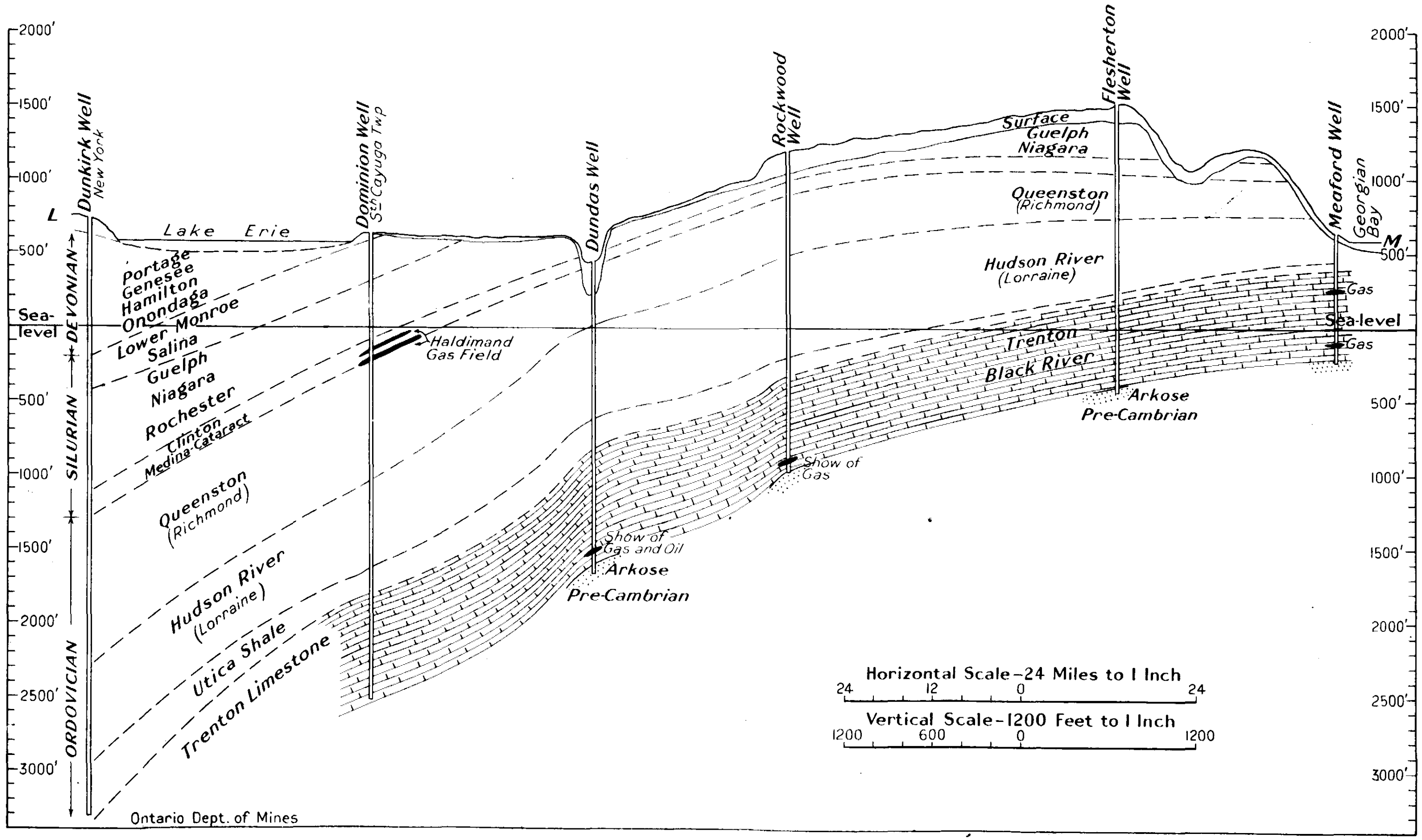
Section E.F.—Dearborn, Michigan, to Pelee Island in Lake Erie. *See* map in pocket for location of section.



Section G.H.—Chesterfield well in Macomb county, Michigan, to Rondeau Park, Ontario, through the Dover oil and gas field. *See* map in pocket for location of section.

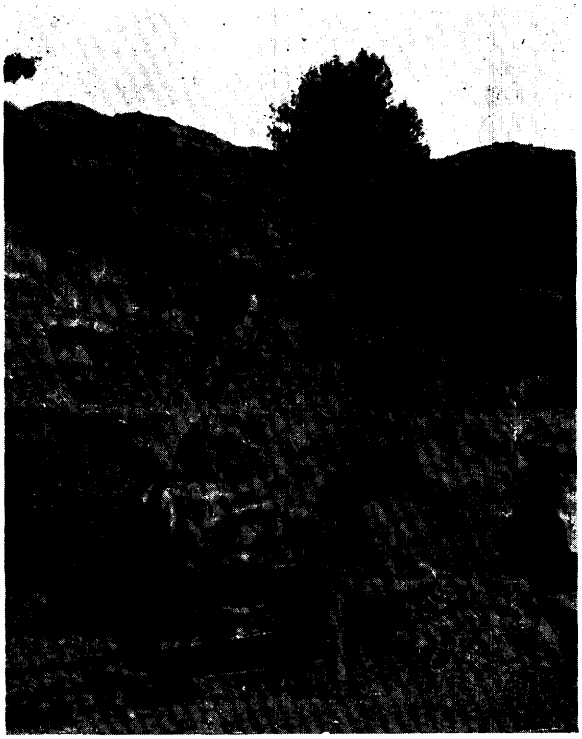


Section J.K.—Marysville, Michigan, to the end of Long Point, Ontario, showing the Petrolia oil field in the Onondaga formation. *See* map in pocket for location of section.



Section L.M.—Dunkirk, New York, to Meaford, Ontario, showing the Haldimand gas field in the Medina-Cataract formation. *See* map in pocket for location of section.

discovered in 1917, has its source at about 400 feet below the top of that formation and immediately underlying a band of shale from five to fifteen feet in thickness. This productive horizon is believed to be the Black River limestone. The original rock pressure was 1,225 lbs. Although the Dover field is in a very small syncline[1] in a saddle at the top of an anticline, its similarity to the Ohio field can be seen in the cross sections: Ontario, G.H.—Chesterfield to Rondeau; and Ohio, C.D.—Bryan to Bucyrus. The sharp, narrow fold in the Dover field would almost indicate a fault.



A view of the massive Black River limestone at Coboconk, Victoria county, where it is used for making lime. It is grey in colour and very dense. The bands of shale are found along the bedding planes.

The Hepworth gas field in Bruce county, discovered in 1900 and still producing gas, is 175 miles northeast of the Dover field. Conditions are very much the same as in the Dover field excepting that instead of a layer of shale covering the gas, there is a layer of cherty limestone. The original rock pressure in this field was 440 pounds.

This same Black River limestone is impregnated with oil at its outcrop in New York state[2].

Oil has been found in the Trenton limestone on Manitoulin island and along the south shore of Georgian bay[3] from Collingwood to Meaford. In the latter area only six wells have been drilled and very little has been proven.

[1]Geol. Surv. Can., Summary Report, Part E, 1919, Oil in a Syncline.
[2]Personal communication from Dr. Rudolph Ruedemann, N.Y. State Geological Survey.
[3]Ont. Dept. of Mines, Vol. VI, Part I, p. 72.

The southeast portion of Welland county has been given considerable attention but with only moderate success. The wells although small have a very long life. One drilled in 1893 is still producing gas. A gas well was recently drilled in Buffalo; the rock pressure was stated to be 1,100 lbs. and the open flow 700M. cubic feet. This gas was found 400 feet in the Trenton, a total depth of 3,200 feet. Welland county has the distinction of having wells that produced gas from the arkose (basal sandy beds) immediately overlying the granite.

Comparing the number of wells drilled in Ontario with those of Ohio, where a thousand wells have been drilled to every one in Ontario and where one per day is still being drilled, Ontario may be considered as unexplored.

An exposure of the Middle Trenton in a road cutting at lot 1, concession XII, Emily township, Victoria county. This is typical of the Trenton throughout Ontario, although the thin-bedded dolomites seen in the upper left hand corner predominate. An exposure similar to this is seen in the quarries of the Ontario Crushed Stone Company, lot 49, Eldon township, Victoria county, three miles northeast of Kirkfield, and in the road cutting at lot 1, between concessions III and IV, Fenelon township, Victoria county. There the limestone is very thinly bedded as in the upper left hand corner of the illustration.

Geology

The western Ontario peninsula presents a most difficult problem to the geologist. The country is very flat and covered with glacial drift to an average depth of 125 feet. The few rock exposure show a dip so small as to be scarcely recognizable and where exposed the thousands of feet of limestone can only be separated by a very careful study of their fossils[1]. The formation under discussion (the Trenton) underlying the region is only exposed north of a line from Collingwood on Georgian bay to Cobourg on Lake Ontario. As will be seen from the photographs it is a thinly bedded, highly fossiliferous, dolomitic limestone having a conchoidal fracture and separated by thin layers of calcareous shale. The lower portion (probably Black River) is massive and is fossiliferous mostly along the bedding planes. As the outcrop is from 50 to 250 miles from the region under discussion it gives very little guidance to the geologist and the only knowledge he can gain is in the history of other fields and the logs of wells already drilled.

[1]Geol. Surv. Can., Memoir No. 91, The Silurian Geology of Ontario, by M. Y. Williams; G.S.C., Memoir No. 70; C.G.S., Summary Report, 1911, p. 253; Ibid., 1913, p. 294.

Location of New Fields

For reasons already mentioned nothing more definite than an opinion can be given as to where new fields may be discovered. Two widely different schools of thought[1] are each successful in finding oil and gas by putting their theories into practice. The follower of the organic and anticlinal theory will find in Essex, Kent and Lambton counties a perfect structure along which to prospect for trapped oil and gas pools. The exponent of the inorganic or volcanic theory will find on the same ground and in the same places typical conditions for fractures that will have allowed oil and gas to enter from below. Those who are experimenting and believe in the accumulation of oil and gas by the circulation of water or hydraulic theory will be interested to know that salt water is found as soon as the rock below the drift is penetrated and that in several places

A closer view of the contact between the thin and heavy-bedded limestones shown in the preceding illustration. These limestones are exceedingly hard. The laminations in the beds are separated by a thin layer of shale or shaley limestone.

along the north shore of Lake Ontario salt springs are found. If there is or has been circulation of water through the Trenton limestone it must have had its point of outflow in Ontario[2] and it would follow that much gas and oil from the Appalachian basin would have moved up the dip towards the region north of Lakes Erie and Ontario in the same way as its accumulation in the Ohio field is explained by that theory.

Combining all theories, no more ideal conditions could be found for any or all than in Essex county along the sharply folded anticline where fracturing is likely to occur, and in the north part of Kent where now there is an oil field in a sharp fold or possible fault. If this uplift was caused by pressure, which is quite possible, there is every possibility of further folds, faults and oil fields to be found in this area to the north and east of the Dover field. Too few

[1]Ont. Dept. of Mines, Volume XIV, Part I, pp. 91-96, Volume XXIV, 1915, Part II.
[2]Economic Geology, Volume XVI, No. 6, p. 365.

wells have been drilled to point out any area immediately north of Lake Erie[1] as a probable place for oil and gas to accumulate, but the fact that oil and gas are present in this area is proven by the producing wells in Welland county.

Acknowledgments

Acknowledgments are due for information and assistance received in compiling the map and sections in this report to Prof. J. A. Bownocker, Ohio State Geologist; Dr. W. I. Robinson of Michigan State Geological Survey; Mr. E. D. Ingall, Geological Survey of Canada, Ottawa; Mr. D. A. Coste, of Niagara Falls; Mr. H. R. Davis, Buffalo; Mr. E. P. Rowe, Toronto; and the many gas companies and drillers who so willingly have offered co-operation and who have painstakingly collected samples of drill cuttings.

Refinery Operations

The refineries operating in Ontario during 1922 are as shown below:—

PETROLEUM REFINERIES, 1922.

Company	Location of Refinery	Days Operated	Head Office Address
British American Oil Co., Ltd.	Foot of Cherry St., Toronto, Ont.	304	Royal Bank Building, Toronto, Ont.
Canadian Oil Co., Ltd.	Petrolia, Ont.	300	Excelsior Life Bldg., Toronto, Ont.
Cities Service Co., Ltd.	Wallaceburg, Ont.	365	Wallaceburg, Ont.
Imperial Oil Co., Ltd.	Sarnia, Ont.	365	Sarnia, Ont.

The following summary gives an interesting comparison of the products from the Ontario oil refineries. It is compiled from the reports of the Ontario Department of Mines and the Dominion Bureau of Statistics and covers a period of five years:

[1]Since this report was written the Southern Ontario Gas Company drilled a producing oil well about two miles west of Port Alma on the shore of Lake Erie, in lot 188, North Talbot road, Romney township. It was brought in on November 1, 1923.

The top of the Trenton limestone was reached at 2,712 feet below the surface. The productive horizon is at the base of the Trenton formation and apparently immediately above the basal sandy beds. It was penetrated one foot, making the depth to the bottom of the well 3,560 feet, or about 3,500 feet below the level of Lake Erie. The production of the well is not definitely known, but is approximately 150 barrels per day; it is about 40 degrees Baumé gravity. The gas production from the Trenton is about 150 M. cubic feet, and from the Guelph 325 M. cubic feet. When this well is drilled through the oil horizon its production will undoubtedly be greatly increased. At present the uncased shales above the Trenton Limestone are caving and shutting off the production.

The location of this well is shown on the map accompanying this report, and it will be seen that the oil is found in a monoclinal fold or possible fault. The northern extension of this structure is uncertain; the log of the well at Fletcher was not carefully kept and there is quite a difference of opinion regarding the depth to the top of the Trenton. Opinions vary by nearly 100 feet. The depth as shown on the map was accepted as most accurate after an exhaustive inquiry. This well was only sunk 387 feet in the Trenton. There is every possibility of a large oil field being developed in this area.

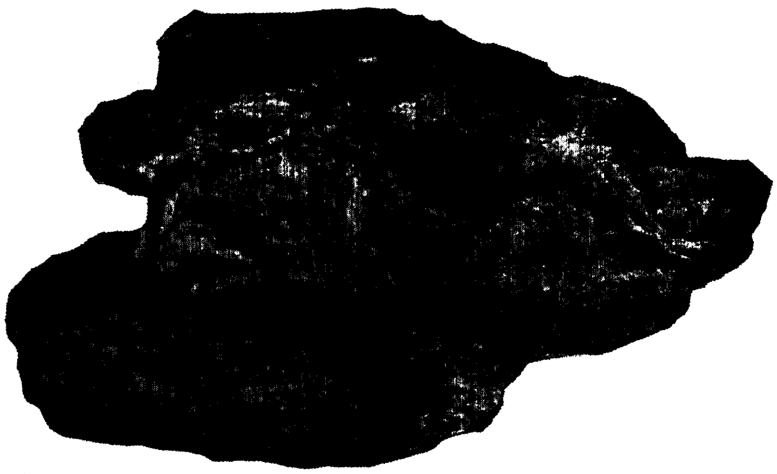
PETROLEUM REFINING OPERATIONS, 1918-1922.

Schedule	Unit of Measure	1918	1919	1920	1921	1922
Canadian crude produced	Imperial gallons	10,106,615	7,703,515	6,361,234	6,050,062	5,756,602
	Value $	781,097	632,789	724,145	466,716	466,587
Imported crude distilled	Imperial gallons	137,065,788	141,157,309	148,540,511	150,692,113	152,888,816
	Value $	12,612,882	12,486,174	20,102,784	14,537,339	13,834,118
Canadian crude distilled	Imperial gallons	9,513,222	7,693,385	6,420,118	5,880,086	5,612,645
	Value $	781,703	661,927	769,775	500,418	462,346
Percentage of total		6.49	5.17	4.13	3.75	3.54
PRODUCTS:						
Illuminating oil	Imperial gallons	36,211,715	34,800,233	33,987,891	29,774,134	36,650,134
	Value $	4,239,816	5,073,647	6,331,706	3,335,200	4,077,350
Lubricating oil	Imperial gallons	12,595,303	12,501,385	13,804,074	13,848,721	14,556,150
	Value $	2,118,002	2,293,640	3,276,569	2,351,975	2,558,278
Benzine, naphtha and gasoline	Imperial gallons	39,156,447	44,625,590	47,418,590	51,033,337	59,223,186
	Value $	10,224,328	11,667,077	14,485,935	12,655,244	13,920,089
Gas and fuel oil	Imperial gallons	40,949,358	40,581,499	45,025,050	44,364,794	34,508,790
	Value $	2,943,504	2,265,457	5,486,636	2,130,685	2,510,427
Paraffin wax and candles	Lbs.	13,650,128	10,903,202	10,398,127	10,777,994	12,063,768
	Value $	1,148,726	1,044,798	973,805	310,267	329,147
Tar and grease	Lbs.	....	....	....	18,971,400	8,186,013
	Value $	....	....	....	142,285	265,150
Acid and Petroleum coke	Short tons	....	....	....	....	38,016
	Value $	....	....	....	....	263,034
Employees	Ave. No.	1,312	1,580	1,736	1,560	1,393
	Wages $	1,486,677	2,045,072	2,695,507	2,176,700	2,018,765

The above table clearly shows the development in the last five years of the "cracking process" by which more gasoline can be taken from a gallon of crude oil. For instance:

	1918	1922
Total gallons crude distilled	146,579,010	157,501,461
Benzine, naphtha, gasoline, gallons	39,156,447	59,223,186
Illuminating, lubricating and other oils, gallons	89,756,378	84,714,074

With the declining supply of high gravity Pennsylvania crude and the greatly increased stocks of heavier "mid-continent" crude it is clear that the improvement shown is not at all due to a better grade of crude having been imported. The table also shows how dependent Ontario is on her neighbour for oil. With the possibilities of finding oil in this Province, shown elsewhere in this report, the price paid for our crude plus government bounty of 52½ cents per barrel makes a most attractive speculation.



A sample of Trenton or Black River limestone in the office of the Natural Gas Commissioner, Toronto. It was recovered from No. 1 well of the Petrol Oil & Gas Co., in lot 1, con. II, Dover West township, Kent county, at about 3,300 feet below the surface. Note the cavernous nature of the sample. The two vugs shown at the top of the photo appear to have been subjected to the action of moving water as the rock is honeycombed.

Photo actual size.

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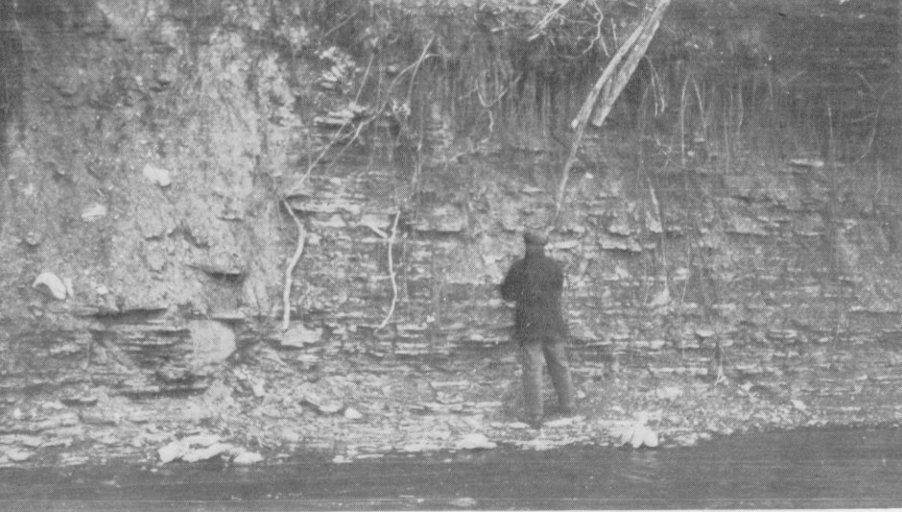

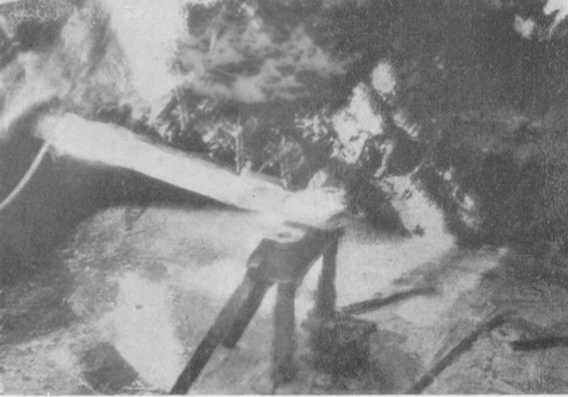

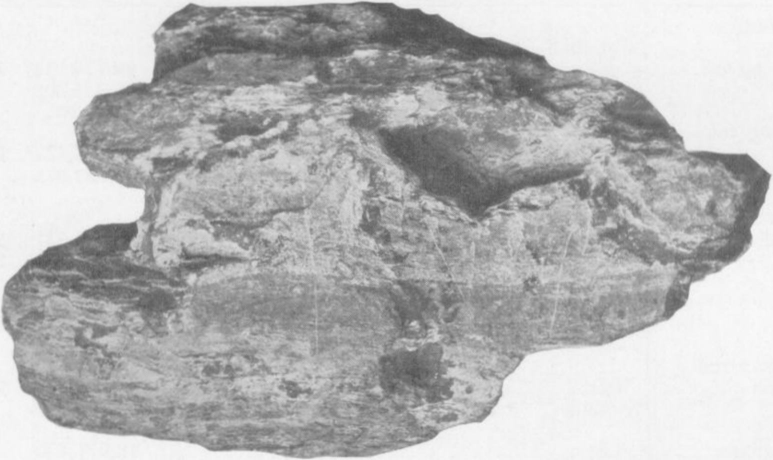

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-SECOND ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXII, PART VI, 1923.

CONTENTS

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1923

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CANADA

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ILLUSTRATIONS AND DIAGRAM

MINING ACCIDENTS IN ONTARIO, 1922

Chief Inspector of Mines, T. F. Sutherland, Toronto; Inspectors, G. E. Cole, Ottawa; James Bartlett, Sudbury; J. G. McMillan, Cobalt; A. R. Webster, Toronto

Accidents during 1922

	Fatal	Non-fatal	Total
Mines underground	13	809	822
Mines, surface	3	214	217
Metallurgical Works	0	193	193
Quarries	3	182	194
Clay Pits	3		
Sand and Gravel Pits	6		
Total	28	1,398	1,426

During the year 1922 at the mines, metallurgical works, quarries, clay, sand and gravel pits regulated by the Mining Act of Ontario there were 1,426 accidents reported to the Department up to January 25, 1923. Twenty-eight of these accidents were fatal, resulting in the death of thirty men.

Table of Fatalities

	1918	1919	1920	1921	1922
Mines underground	11	21	15	11	15
Mines, surface	4	6	6	1	3
Metallurgical works	12	10	3	4	0
Quarries	5	2	5	8	12
Totals	32	39	29	24	30

By months, the fatalities occurred as follows:

	1922
January	5
February	4
March	1
April	1
May	3
June	3
July	0
August	2
September	1
October	4
November	3
December	3
Total	30

Classifying the fatalities according to the industry gives the following:

Nickel mines	2
Talc mines	1
Silver mines	2
Gold mines and mills	13
Quarries	3
Gravel pits	6
Clay pits	3
Total	30

Analysis of Fatalities at Mines

	1918 Per cent.	1919 Per cent.	1920 Per cent.	1921 Per cent.	1922 Per cent.
Falls of ground	20.0	22.2	23.8	33.33	11.11
Shaft accidents	0.0	29.6	9.5	16.66	44.44
Explosives	40.0	7.4	23.8	16.66	11.11
Miscellaneous underground	26.6	18.5	14.3	25.00	16.66
Surface	13.3	22.2	28.6	8.33	16.66

Table of Fatal Accidents in Mines, Metallurgical Works and Quarries, 1901 to 1922

—	Persons killed at metallurgical works and mines.	Persons employed at metallurgical works and producing mines.	Persons employed at non-producing mines (estimated).	Total persons employed.	Fatal accidents per 1,000 employed.
1901	13	4,135	550	4,685	2.77
1902	10	4,426	450	4,876	2.05
1903	7	3,499	400	3,899	1.79
1904	7	3,475	400	3,875	1.80
1905	9	4,415	500	4,915	1.83
1906	11	5,017	750	5,767	1.90
1907	22	6,305	1,140	7,445	2.93
1908	47	7,435	1,750	9,185	5.11
1909	49	8,505	2,000	10,505	4.66
1910	48	10,862	2,000	12,862	3.73
1911	49	12,543	2,000	14,543	3.37
1912	43	13,108	2,000	15,108	2.84
1913	64	14,293	2,000	16,293	3.93
1914	58	14,361	1,500	15,861	3.60
1915	22	13,114	1,500	14,614	1.51
1916	51	14,624	2,000	16,624	3.07
1917	36	16,791	1,000	17,791	2.02
1918	32	14,726	500	15,226	2.10
1919	39	11,926	1,000	12,926	3.00
1920	29	10,486	1,000	11,486	2.61
1921	24	8,436	1,000	9,436	2.54
1922	30	10,143	1,500	11,643	2.58

The occupation and nationality of men killed are set out in the following table:

Occupation.	English Speaking	Russian	Italian	Austrian	Croatian	Swede	Serbian	Total.
Labourer	5	....	1	1	....	....	1	8
Shaftman	1	2	....	....	1	....	....	4
Miner	3	1	....	....	....	....	....	4
Foreman	2	....	....	....	....	....	....	2
Blaster	2	....	....	....	....	....	....	2
Teamster	2	....	....	....	....	....	....	2
Sledger	....	....	1	....	....	....	....	1
Motorman	1	....	....	....	....	....	....	1
Trammer	....	....	....	1	....	1	....	2
Skiptender	....	1	....	....	....	....	....	1
Millman	1	....	....	....	....	....	....	1
Pipefitter	1	....	....	....	....	....	....	1
Repairman	1	....	....	....	....	....	....	1
Totals	19	4	2	2	1	1	1	30

The ages of the men killed were as follows:

Age	17-20	21-25	26-30	31-35	36-40	41-45	51-55	56-60	61-65	Total
No. killed .	2	5	10	3	2	5	1	1	1	30

Prosecutions

At Iroquois Falls, on May 10th, Walter Monahan, of Matheson, was fined $200 and costs by Magistrate Atkinson for undermining in an open-pit working for gravel, on and about February 14th, contrary to Rule 121, Section 164, of the Mining Act.

Before Magistrate Atkinson, at Timmins, on July 20th, Sam Chickman was charged with entering the McIntyre Porcupine mine on July 11th when under the influence of liquor. Through counsel he pleaded guilty and was fined $100 and costs.

Before Magistrate Atkinson, at Timmins, on September 7th, S. Jay was charged with a violation of Rule 31, Section 164, of The Mining Act, in that, while engaged as a deckman at the Hollinger mine on August 25th he failed to close the doors at the 1,100-foot level of the central shaft while dumping a bucket of rock. He was found guilty and fined $50 and costs.

Joseph J. Riddell, a hoistman at the Kingdon Mining, Smelting and Manufacturing Co., Galetta, was fined $25 and costs by Police Magistrate Joynt at Ottawa on October 24th, for violating Rule 219, Section 164, of The Mining Act. Riddell was operating the hoist on October 18th, while under the influence of liquor.

Felix D. Henderson, contractor in charge of the shaft sinking at the Herrick mine, for the Tonopah Mining Company of Nevada, was fined $500 and costs by Police Magistrate D. M. Brodie, of Sudbury, on November 2nd. The charge was that a cross-head not equipped with a safety device was in use in the shaft.

The Tonopah Mining Company of Nevada was fined $500 and costs by Police Magistrate D. M. Brodie, of Sudbury, on November 3rd. The charge was that the Tonopah Mining Company, operating the Herrick mine in Shining Tree, allowed a crosshead to be used which was not equipped with a safety device as required by The Mining Act of Ontario.

Information was laid against the Thames Quarry Company for an infringement of Rule 179, Section 164, of The Mining Act. The case was heard by Magistrate Butcher, of St. Marys, on November 24th and then adjourned till December 8th, on which date the magistrate dismissed the case. An appeal was entered by the Department. The appeal was heard by Judge Barron, County Judge for the County of Perth, on January 4th, 1923, at St. Marys. The appeal was allowed; the company was found guilty of the charge laid and fined $100 and costs.

Table of Fatal Accidents in or

	Date 1922	Name of Mine.	Name of Owner.	Name.	Occupation.
1	Jan. 23.	Dickson Creek......	Dickson Creek (Cobalt) Silver Mines...	Godfrey Wall..	Trammer......
2	Apr. 11.	Dome.............	Dome Mines Co..........	Alex. Budel....	Miner.........
3	May 28.	do	do do	D. Laderoute..	Miner.........
4	Dec. 18.	do	do do	D. McEachern.	Motorman.....
5	Sept. 14.	Henderson.........	Geo. H. Gillespie Co......	J. K. Wager...	Miner.........
6	Oct. 20.	Herrick...........	Herrick Gold Mines.......	J. Alexanderson	Shaftman......
				J. Kulakoff.....	Shaftman......
				M. Cvitko.....	Shaftman......
7	Jan. 27.	Hollinger..........	Hollinger Consol. Gold Mines................	N. Argue......	Miner.........
8	Feb. 20.	do	do do	A. E. Sims.....	Mill man......
9	May 22.	do	do do	V. DiMarco...	Sledger........
10	Aug. 28.	do	do do	F. Martel......	Shaftman......
11	Dec. 21.	Creighton..........	International Nickel Co. of Canada............	A. Shumilak...	Labourer......
12	Oct. 17.	Lake Shore........	Lake Shore Mines.........	K. Englehutt...	Foreman.......
13	Mar. 10.	McIntyre..........	McIntyre-Porcupine Mines	M. Hadenshuck	Skip tender....
14	June 13.	do	do do	S. Skailes......	Labourer......
15	June 26.	Frontier...........	Mining Corp'n. of Canada..	R. E. Miron...	Pipefitter......
16	Aug. 12.	Levack............	Mond Nickel Co..........	K. Rudlavich..	Trammer......

Table of Fatal Accidents at

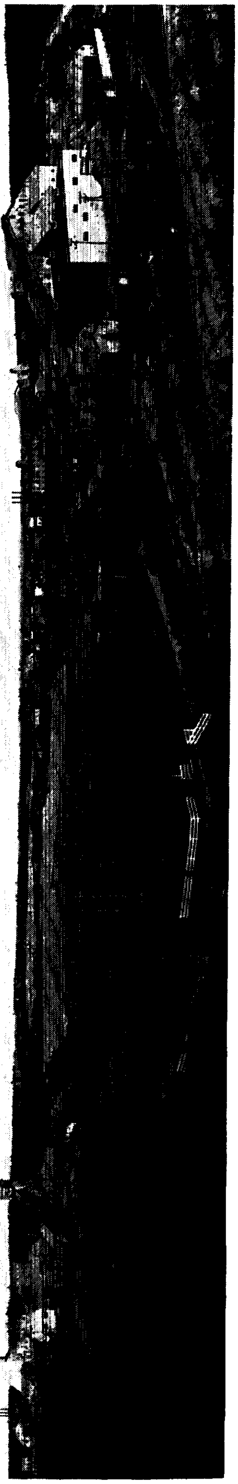
	Date	Name of Works	Name of Owner.	Name.	Occupation.
17	Feb. 14.	Gravel pit.........	J. A. Allan...............	S. D. Gardner..	Labourer......
18	Dec. 25.	Quarry...........	Canada Cement Co........	S. Kollich......	Labourer.......
19	June 14.	Clay pit..........	Can. Pressed Brick Co.....	G. Gerard......	Teamster......
20	May 11.	Clay pit..........	Dominion Sewer Pipe and Clay Industries.........	D. Guistina....	Labourer......
21	Feb. 22.	Gravel pit.........	O. Ethier................	G. Latendresse.	Labourer......
22	Nov. 15.	Quarry...........	Milton Pressed Brick Co..	G. Sheppard...	Blaster........
23	Feb. 10.	Clay pit..........	Price & Smith...........	J. Grady......	Labourer......
24	Jan. 18.	Quarry...........	Queenston Quarry Co.....	F. Brooker.....	Foreman.......
25	Jan. 12.	Gravel pit.........	J. T. Rittinger...........	J. T. Rittinger.	Teamster......
26	Nov. 28.	Gravel pit.........	J. E. Russel Co.	J. A. Agnew....	Repair man....
27	Nov. 23.	Gravel pit.........	E. L. Sackville...........	S. Seeley.......	Labourer......
28	Jan. 12.	Gravel pit.........	Tp. of West Hawkesbury...	C. Joanisse.....	Blaster........

about Mines of Ontario, 1922

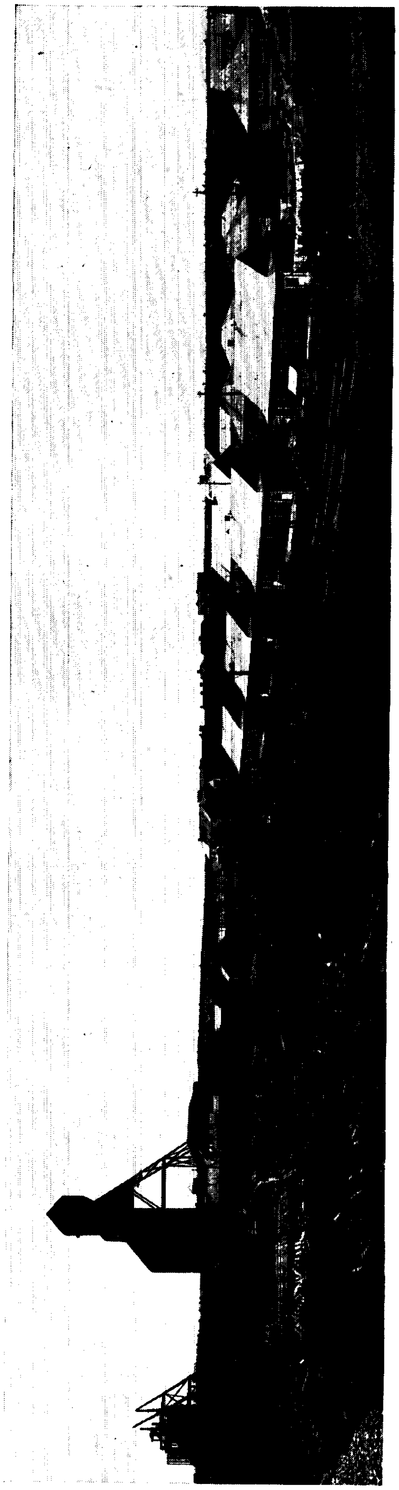
Nationality.	Age	Married or Single	Above Ground	Below Ground	Cause of Accident.
Swede.........	23	S	......	1	Fell from bucket.
Russian........	30	S	......	1	Caught by run of ore in mill hole.
English speaking	20	S	......	1	Fall of ground in stope.
English speaking	28	S	......	1	Fell into ore pass with motor.
English speaking	24	S	......	1	Remained too long lighting fuse in raise.
Russian........	36	S	......	1	
Russian........	30	S	......	1	Struck by falling crosshead.
Croatian.......	30	S	......	1	
				1	
English speaking	30	S	......	......	Fall of ground in stope.
English speaking	32	S	1	1	Clothing caught on shaft in mill.
Italian.........	40	M	......	1	Struck explosive in rock
English speaking	28	S	......	......	Rock fell down shaft,
Austrian.......	19	S	1	1	Crushed while unloading lagging from railroad car.
English speaking	41	M	......	1	Fell from bucket
Russian........	23	S	......	......	Fell down shaft.
English speaking	22	S	1	......	Fell from platform in new mill.
English speaking	26	M	......	1	Crushed by cage.
Austrian.......	35	M	......	1	Crushed between car and loading platform.

Quarries, Clay and Gravel Pits, 1922

Nationality.	Age	Married or Single	Cause of Accident.
English speaking	25	M	Bank undermined and fell.
Serbian.........	29	S	Fell against rock.
English speaking.	27	M	Fall of clay from bank.
Italian..........	45	S	Struck by arm of stump puller.
English speaking.	29	M	Bank undermined and fell.
English speaking.	65	S	Premature explosion.
English speaking.	57	M	Clay fell from bank.
English speaking.	42	M	Caught in shafting.
English speaking.	44	M	Bank undermined and fell.
English speaking.	52	M	Caught by conveyer belt.
English speaking.	34	M	Bank undermined and fell.
English speaking.	43	M	Returned too soon to unexploded charge.



Panoramic view of McIntyre Porcupine mine looking easterly over the bed of Pearl lake.



Shafthouse, mill, office buildings, school and staff residences of Dome Mines, Limited.

MINES OF ONTARIO

By

Chief Inspector of Mines, T. F. Sutherland, Toronto; Inspectors, J. G. McMillan, Cobalt; Jas. Bartlett, Sudbury; Geo. E. Cole, Timmins; A. R. Webster, Toronto.

As an introduction to a description of the mines and metallurgical plants of the Province, it will probably be found advantageous to give a list of the same. The list which follows is alphabetically arranged, both as to the kind of metals or minerals extracted, and also the names of the companies concerned. The inclusion of any given property in this list does not necessarily imply that it is a producing one, or that it is being worked at the present time. The table contains the names of all operating properties and works inspected in 1922.

Lists of the principal stone quarries and clay pits are added at the end.

MINES AND METALLURGICAL WORKS

Mine.	Owner.	Manager.	Address.
	Anthraxolite or Anthracitic Carbon		
....	Balfour Developing Syndicate........	Edgar B. James..	....
....	British-Colonial Mines, Ltd.........	....	62-76 Richmond St. W., Toronto.
....	Ontario Anthracite Mines, Ltd.......	....	95 King St. E., Toronto.
....	Chelmsford Anthracite Coal Co., Ltd.	....	1 Adelaide St. E., Toronto.
	Copper		
Algomont...	Algomont Mines, Ltd..............	Geo. Johnson....	Rydal Bank.
	Dolomite		
Baptiste.....	Burnip Bros. and Co...............	....	2 Darrell Ave., Toronto.
	Feldspar		
Keays......	A. N. Campbell..................	....	Perth.
Richardson..	Feldspars, Limited................	J. Ralph Scott...	R. R. No. 1, Harrington.
Woodcock...	Feldspar Mines Corporation, Ltd.....	R. H. Thompson.	Hybla.
Thompson...	Feldspar Mines Corporation, Ltd.....	R. H. Thompson.	Hybla.
Freeman....	Feldspar Quarries, Limited..........	Ernest H. Tapper	Hartington.
Gardner.....	Gardner Feldspar Company.........	Wm. Gardner....	Hartington.
Macdonald..	Genesee Spar Company............	Peter Macdonald.	Hybla.
McPhee.....	McPhee Bros......................	....	Markstay.
Watson.....	Mount Eagle Feldspar Co., Ltd......	C. C. Birkett....	327 Union Bank Bldg., Cleveland, O.
Burns.......	Orser-Kraft Feldspar, Ltd..........	Sidney H. Orser..	Box 266, Perth.
Kirkham....	Orser-Kraft Feldspar, Ltd..........	Sidney H. Orser..	Box 266, Perth.
Palmer......	Orser-Kraft Feldspar, Ltd..........	Sidney H. Orser..	Box 266, Perth.
Keays......	Rock Products Company............	V. M. Gettins...	R.R. 1, Balderson.
Babcock....	W. G. Treadwell...................	Wm. Gardner....	Hartington.
Vanluven....	Albert Vanluven..................	....	Holleford.
Weisman....	Weisman Feldspar Company.........	Abraham Weisman	Box 363, Sudbury.
Cecebe......	Wheeling Feldspar Co..............	W. Bates Woods..	Burks Falls.
	Garnet		
Bancroft	Bancroft Mines Syndicate, Ltd.......	N. C. Maynard..	Toronto.

MINES AND METALLURGICAL WORKS.—*Continued.*

Mine.	Owner.	Manager.	Address.
	Gold		
Abitibi	The Abitibi Mines, Ltd.	R. S. Manwell	La Reine, Que.
Grace (Michipicoten)	The A-Gold-Ma Syndicate		Goudreau.
Algonquin	Algonquin Mines, Ltd.		Coyne.
Argonaut	Argonaut Gold, Limited	J. W. Morrison	Dane.
Atlas	Atlas Gold Mines, Ltd.	M. P. McDonald	Shining Tree.
Baldwin	Baldwin Gold Mining Co., Ltd.	B. Ashley	Kenogami Lake.
Bidgood	Bidgood Gold Mines, Ltd.	D. H. Angus	Haileybury.
Blue Quartz	The Blue Quartz Gold Mines, Ltd.	J. J. Hollinger	Matheson.
Foley	British Canadian Mines, Ltd.		
Buckingham	The Buckingham Mines, Ltd.	M. P. McDonald	West Shiningtree.
Goldfields	The Canadian Associated Goldfields, Ltd.	T. A. Graves	Dane.
Rochester	The Canadian Gold Mines Corporation	E. M. Loring	Drawer G, Timmins.
Canadian Kirkland	Canadian Kirkland Gold Mining Co., Ltd.	D. H. Angus	Box 86, Kirkland Lake.
Churchill	Churchill Mining and Milling Co., Ltd.	J. A. Knox	Coyne.
Clifton-Porcupine	Clifton-Porcupine Mines, Ltd.	Wm. C. Offer	Box 120, S. Porcupine.
Golden Fleece	The Cobalt-Frontenac Mining Co., Ltd.	D. H. Fletcher	Flinton.
Columbus Kirkland	The Columbus Kirkland Gold Mines, Ltd.	A. W. Grierson	Kirkland Lake.
New Ray	Under option to the Coniagas Mines, Ltd.	John Redington	Schumacher.
West Dome	Consolidated West Dome Lake Mines, Ltd	D. M. McPhail	Box 523, S. Porcupine.
Dome Lake	Consolidated West Dome Lake Mines, Ltd.	D. M. McPhail	Box 523, S. Porcupine.
Bonanza	Contact Bay Mines, Ltd.	E. G. Rognon	Dryden.
Continental	Continental Mines, Ltd.	M. B. Glazier	Kirkland Lake.
Crown Reserve	The Crown Reserve Mining Co., Ltd.	H. J. Stewart	Dane.
Dome	Dome Mines Co., Ltd.	H. P. De Pencier	South Porcupine.
Dominion Kirkland	Dominion Kirkland Mines, Ltd.		
Dryden	Dryden Gold Corporation	E. G. Rognon	Dryden.
Elkstone-Dunkin	The Elstone-Dunkin		Kirkland Lake.
Fenning	Fenning Development Co.	Louis Fenning	Box 28, Schreiber.
Goldale	Goldale Mining Co., Ltd.	H. A. Kee	Box 187, Schumacher.
Golden Rose	Golden Rose Mining Co., Ltd.	Oscar Smith	Sudbury.
Gold Island	The Gold Island Mines, Ltd., under option to Night Hawk Peninsular Mines, Ltd.	A. R. Globe	Connaught.
Gold Nuggett	The Gold Nugget Mining and Development Co., Ltd.	E. J. MacMillan	Haileybury.
Goodfish	The Goodfish Gold Mines, Ltd.	Ernest Martin	Kirkland Lake.
	Gosselin, Aubin, Hebert and Forget	P. Gosselin	Temagami.
Murphy	Goudreau Gold Mines, Ltd.	W. H. Reamsbottom	Goudreau.
Grace (on Eagle Lake)	Grace Mining Co., Ltd.	W. J. Richards	Kenora.

Harvey Kirkland	The Harvey Kirkland Mines, Ltd.	G. G. Thomas	Kirkland Lake.
Hattie	The Hattie Gold Mines, Ltd.	Chas. Mentzel	Matheson.
Hayden	The Hayden Gold Mines, Ltd.	R. P. Teare	Box 439, Timmins.
Highland Kirkland	Highland Kirkland Mines, Ltd.		Kirkland Lake.
Hollinger	The Hollinger Consolidated Gold Mines, Ltd.	A. F. Brigham	Timmins.
Hologden	Hologden Mines, Ltd.	Hart Martin	North Bay.
Holtyrex	Holtyrex Gold Mines Co., Ltd.	C. L. Hershman	Schumacher.
Hunton	Hunton-Kirkland Gold Mines, Ltd	H. M. Porteous	Kirkland Lake.
Jacobs & O'Neill	Jacobs and O'Neill		Matheson.
Jackson	The Jackson Development Co., Ltd.	Wm. S. Jackson	Box 107, Schreiber.
King-Kirkland	The King-Kirkland Gold Mines, Ltd.	Ernest Craig	Kirkland Lake.
Kingston	Kingston Gold Mines	Edward B. deCamps	Shining Tree.
Kirkland-Gateway	The Kirkland Gateway Gold Mines, Ltd.	Robert J. Jowsey	Swastika.
Kirkland Lake	The Kirkland Lake Gold Mining Co., Ltd.	W. M. Sixt	Kirkland Lake.
Kirkland Proprietary	Kirkland Lake Proprietary (1919), Ltd.	W. R. Thomas	Kirkland Lake.
Kirk	Kirk Gold Mines, Ltd.	Richard Sandoe	Havilah.
Kitchener-Kirkland	Kitchener-Kirkland Gold Mines	C. E. Imerson	Kirkland Lake.
Kline			
Lake Shore	The Lake Shore Mines, Ltd.	R. C. Coffey	Kirkland Lake.
McDermott	McDermott Gold Mines, Ltd.		
McEnaney	The McEnaney Gold Mines, Ltd.	E. T. Corkill	Timmins.
McIntyre	McIntyre-Porcupine Mines, Ltd.	R. J. Ennis	Schumacher.
Longworth	McKellar-Longworth	W. L. Longworth	Port Arthur.
Majestic	Majestic Gold Mines, Ltd.	Chas. E. Beckwith	West River.
March	March Gold, Ltd.	W. G. Hawley	South Porcupine.
Mikado	Mikado Consolidated Mines, Ltd.	H. A. C. Machin	Kenora.
Mining Corporation	Mining Corporation of Canada, Ltd.	Russell Cryderman	Cobalt.
Montreal-Ontario	Montreal-Ontario Mines, Ltd.	Chas. Spearman	Kirkland Lake.
Peninsular	The Night Hawk Peninsular Mines, Ltd	A. R. Globe	Connaught.
Northcrown	Northcrown Porcupine Mines, Ltd.	H. J. Stewart	Timmins.
Ore Chimney	Ore Chimney Mining Co., Ltd	A. E. Fletcher	Northbrook.
Ossian	The Ossian Mines, Ltd.	Ralph Hurd	Kirkland Lake.
Porcupine-Crown	The Porcupine Crown Mines, Ltd	H. J. Stewart	Timmins.
Davidson	The Porcupine Davidson Gold Mines, Ltd	Geo. E. Bent	South Porcupine.
Three Nations	The Porcupine Grande Gold Mines, Ltd	Louis Whitman	South Porcupine.
Cavana Veterans	The Porcupine Grande Gold Mines, Ltd	Louis Whitman	South Porcupine.
Paymaster	Porcupine-Paymaster Mines, Ltd	B. L. Eastman	South Porcupine.
Providence	Providence Gold Mines, Ltd.		
Queen Lebel	The Queen Lebel Gold Mines, Ltd.	E. B. Wood	Kirkland Lake.
Wasapika	Ribble Mines, Ltd	Geo. R. Rogers	Coyne.
Shining Tree	Shining Tree Consolidated Mines, Ltd	M. P. McDonald	Toronto.
Skead	Skead Gold Mines	Seymour Stevens	Englehart.
Sylvanite	Sylvanite Gold Mines, Ltd.	Albert L. Wende	Kirkland Lake.
Teck-Hughes	Teck-Hughes Gold Mines, Ltd.	D. L. H. Forbes	Kirkland Lake.
Thesaurus	The Thesaurus Gold Mines, Ltd.	J. C. Nelson	Elk Lake.

MINES AND METALLURGICAL WORKS.—*Continued.*

Mine.	Owner.	Manager.	Address.
	Gold—*Continued.*		
Tomlinson	Chesley Tomlinson		Kenogami Lake.
Herrick	Under option to The Tonopah Mining Co. of Nevada	A. F. Carper	Shining Tree.
Triplex	The Triplex Gold Mines, Ltd	Chas. A. Randall	South Porcupine.
Vickers Porcupine	Vickers Porcupine Mines, Ltd		
V.N.T.	Vipond Consolidated Mines, Ltd	N. J. Evered	Timmins.
Webb-Michael	Under option to Fred W. Sparling and associates		Detroit, Mich.
West Tree	West Tree Gold Mines, Ltd	Wm. D. McKay	Shining Tree.
White Rock	White Rock Mining Co., Ltd	A. E. McVittie	Shining Tree.
Wisconsin-Skead	Wisconsin-Skead Gold Mines, Ltd	C. C. Huffman	Englehart.
Wright-Hargreaves	Wright-Hargreaves Mines, Ltd	A. L. Wende	Kirkland Lake.
	Gypsum		
Caledonia	The Ontario Gypsum Co., Ltd	A. J. Parkhurst	Caledonia.
Lythmore	The Ontario Gypsum Co., Ltd	A. J. Parkhurst	Caledonia.
	Iron		
Leitch	P. A. Leitch		Port Arthur.
Atikokan	Leased to Clement K. Quinn		Duluth, Minn.
	Iron Pyrites		
Northpines	Nichols Chemical Co.	P. Flynn	Northpines.
Sulphide	Nichols Chemical Co.	W. H. De Blois	Sulphide.
	Lead		
Kingdon	The Kingdon Mining Smelting and Manufacturing Co., Ltd	R. R. Rose	Galetta.
	Mica		
Lacey	Loughborough Mining Co	Geo. W. McNaughton	Sydenham.

	Nickel		
Murray	British America Nickel Corporation	E. Hibbert	Mond.
Creighton	International Nickel Co	J. A. Agnew	Levack.
Garson	Mond Nickel Company	A. L. Sharp	Mond.
Lake Hill	Mond Nickel Company	W. J. Mumford	Worthington.
Levack	Mond Nickel Company	F. J. Eager	Nickleton.
Victoria	Mond Nickel Company	Wm. Mumford	Copper Cliff.
Worthington	Mond Nickel Company	A. D. Carmichael	Garson.
	Silver		
Bailey	Bailey Silver Mines, Ltd	G. C. Bateman	Cobalt.
Cane	Cane Silver Mines, Ltd	Duncan McRae	
Castle	The Castle-Trethewey Mines, Ltd	Murray D. Kennedy	Gowganda.
Cobalt A-53	The Cobalt A-53 Silver Mining Co., Ltd	J. J. Byrne	Haileybury.
Coniagas	The Coniagas Mines, Ltd	F. D. Reid	Cobalt.
Ruby	Under option to The Coniagas Mines, Ltd	R. C. Harrison	Cobalt.
Dickson Creek	The Dickson Creek (Cobalt) Silver Mines, Ltd	H. Hollands-Hurst	Haileybury.
Everett	The Everett Mines, Ltd	W. H. Fairburn	Gowganda.
Genesee	The Genesee Mining Co., Ltd	L. F. Steenman	Cobalt.
Silver Islet	Islet Exploration Co., Ltd	D. C. Peacock	5-9 Alworth Bldg., Duluth, Minn.
Keeley	The Keeley Silver Mines, Ltd	J. Mackintosh Bell	Silver Centre.
Little Keeley	The Keeley Silver Mines, Ltd	J. Mackintosh Bell	Silver Centre.
Kerr Lake	Kerr Lake Mining Co., Ltd	H. A. Kee	Cobalt.
Kirkbud	Kirkbud Mining Co., Ltd	C. S. Merriman	Box 771, Cobalt.
La Rose	La Rose Mines, Ltd	G. C. Bateman	Cobalt.
Lawson	La Rose Mines, Ltd	G. C. Bateman	Cobalt.
Princess	La Rose Mines, Ltd	G. C. Bateman	Cobalt.
University	La Rose Mines, Ltd	G. C. Bateman	Cobalt.
Violet	La Rose Mines, Ltd	G. C. Bateman	Cobalt.
McKinley-Darragh-Savage	The McKinley-Darragh-Savage Mines of Cobalt, Ltd	H. C. McCloskey	Cobalt.
Colonial	Menago Mining Co., Ltd	J. P. Hussey	Cobalt.
Miller Lake O'Brien	M. J. O'Brien, Limited	H. G. Kennedy	Gowganda.
Mining Corporation	The Mining Corporation of Canada	M. F. Fairlie	Cobalt.
Frontier	The Mining Corporation of Canada	J. G. Harkness	Haileybury.
Three A	Nipigon Prospecting Co	Wm. Beam	Port Arthur.
Nipissing	Nipissing Mining Co	Hugh Park	Cobalt.
O'Brien	M. J. O'Brien, Ltd	J. G. Dickenson	Cobalt.
Solid Silver	The Ontario Solid Silver Mines, Ltd	J. A. McRae	North Bay.
Oxford	Oxford Cobalt Silver Mines, Ltd	D. R. Russell	Cobalt.
Silverado	Silverado Mining Co., Ltd	W. R. Sweet	Gowganada.
Silver Queen	Leased to J. L. Sweet	J. L. Sweet	Cobalt.
Victory	The Victory Silver Mines, Ltd	J. A. McVichie	Cobalt.
Sanderson	The Wigwam Mining Co., Ltd	Stewart Troop	Gowganada

MINES AND METALLURGICAL WORKS.—*Continued.*

Mine.	Owner.	Manager.	Address.
	Soapstone		
Pidgeon	The Wabigoon Soapstone Co., Ltd.		King Edward Hotel, Toronto.
Wood	The H. H. Wood Talc Co.	H. H. Wood	Toronto.
	Talc		
Connolly	Asbestos Pulp Co.	W. H. Decker	Madoc.
Henderson	Geo. H. Gillespie and Co.	Geo. H. Gillespie	Madoc.
	Metallurgical Works		
Blast Furnaces	Algoma Steel Corporation	Jas. H. Bell	Sault Ste. Marie.
Blast Furnaces	Canadian Furance Co.	G. J. Higgins	Port Colborne.
Blast Furnaces	Steel Company of Canada	H. G. Hilton	Hamilton.
Silver Refinery	Coniagas Alkali and Reduction Co.	D. A. Mutch.	Thorold.
Silver Refinery	Deloro Smelting and Refining Co.	S. B. Wright	Deloro.
Silver Refinery	Dominion Reduction Co., Ltd.	G. W. Perram.	Cobalt.
Nickel Refinery	International Nickel Co.	Donald McCaskill	Copper Cliff.
Nickel Refinery	International Nickel Co.	John More.	Port Colborne.
Cobalt Refinery	Ontario Smelters and Refiners, Ltd.	J. F. Hickling	Welland.
Electric Furnaces	Welland Alloy Steel Corp., Ltd.	W. A. Werrett, Secretary	Toronto.

QUARRIES.

County	Operator	Address	Location	Product
District of Algoma	Dominion Mines & Quarries, Ltd	McLennan	East Neebish Island	Quartzite, coarse and screened.
"	Electro Metals, Ltd.	G. W. Rayner, 410 Crown Office Bldg., Toronto	Killarney	Quartzite for ferro-silicon.
Bruce	Hanover Cement & Stone Co., Ltd	R.R. No. 3, Walkerton	Brant Township	Crushed limestone for cement.
"	Toronto Plaster Co.	Teeswater	S½ lot 14, Con. VI., Culross	Hydrated lime.
Carleton	Brulé & Sons, E. D	Billings Bridge, via Ottawa	Bank of Rideau Canal, Gloucester Township	Crushed and screened limestone for roads and concrete.
"	Farmer-George Construction Co.	23 Lorne Ave., Ottawa	Lot 31, Con. VII., Osgoode	Crushed and screened limestone for roads.
"	Foster & Cram	278 Echo Drive, Ottawa	Bank of Rideau Canal, Gloucester Township	Limestone.
"	Grant Bros.	C. Gosselin, Quarries, via Ottawa	Lot 9, Con. I., Gloucester	Limestone.
"	Grant Bros.	C. Gosselin, Quarries, via Ottawa	Lot 16, Con. II., Nepean	Limestone.
"	Merkley's, Ltd.	Fraser Bldg., Ottawa	Lot 18, Con., Gloucester	Shale.
"	Nepean, Twp. of	Walton Smith, Westboro	At Taylor's Hill on Richmond Rd	Limestone.
"	Ormond, Robt.	Cyrville	Lot 10, Con. II., Gloucester	Limestone.
"	Ottawa Suburban Roads Commission	Thistle Bldg., Wellington St., Ottawa	Kirby Quarry, Lot 3, Con. III., Gloucester	Crushed and screened limestone.
"	Perley, A. G.	155 McLaren St., Ottawa	At Hogs Back on Rideau Canal	Crushed and screened limestone for roads.
Dufferin	Melville Quarry Co.	R.R. No. 6, Orangeville	One mile north of Melville Jct.	Limestone.
"	Wattam, Geo.	Shelburne	Con. I., Amaranth, ½ mile east of Shelburne	Limestone.
Essex	Brunner Mond of Canada, Ltd.	Amherstburg	Lots 6, 7, 8, Con. I., Anerdon Lots 2, 3, Con. II., Anerdon	Limestone for chemical works.
Frontenac	Roddy & Monk	Kingston	Kingston	Building and crushed limestone.
Grenville	Grenville Crushed Stone, Ltd.	J. P. Bains, Oxford Mills	E. ½ Lot 9, Con. IV., Oxford Lot 8, Con. IV., Oxford S. ½ Lot 8, Con. III., Oxford	Crushed and screened limestone for ballast.
"	Woodland & Co., W. J	Cardinal	Lot 10, Con. I., Edwardsburgh	Crushed and screened limestone for roads.

QUARRIES.—*Continued.*

County	Operator	Address	Location	Product
Grey	Keeling, Jas.	1179-16th St., Owen Sound	8th Street, Owen Sound	
"	Lapierre & Checkley	c/o Oliver Rogers Stone Co., Owen Sound	Owen Sound	
"	McKay, Alex. L.	Ed. Rowbottom, Owen Sound	Owen Sound	Limestone for building.
"	McPherson & Hicks	Owen Sound	9th St., East Hill	Limestone for building.
"	Oliver Rogers Stone Co.	Owen Sound	9th St., East Hill	Limestone.
Haldimand	Cayuga Stone Co.	Cayuga	Lot 48, Con. I., Cayuga N.	Limestone.
"	Hagersville Contracting Co.	Hagersville	Lots 13 and 14, Con. XIII., Walpole	Crushed stone for roads and concrete.
"	Hagersville Crushed Stone Co.	Hagersville	S.W. ½, Lot 28, Con. I., Oneida	Crushed stone for roads and concrete.
"	Hagersville Quarries, Ltd.	Hagersville	Lot 13, Con. XIII, Walpole	Crushed stone for roads and concrete.
Halton	Christie Henderson Co., Ltd.	Kelso		Grey lime.
"	Logan, Hugh	Glen Williams	Lot 27, Con. IX., Esquesing	
"	D. Robertson & Co.	Milton		Lime and building stone.
"	F. Rogers & Co.	1193 Queen St., Toronto	Twp. of Esquesing	
"	Toronto Lime Co., Ltd.	Limehouse		Lime and building stone.
Hastings	Canada Cement Co.	Point Anne	Point Anne	Limestone for cement.
"	Patterson Construction Co., Ltd.	Chamber of Commerce Bldg., Belleville	Con. II., Thurlow	Limestone.
"	Routly, H. T.	P. J. McGee, New Queen's Hotel, Belleville	Bush Farm, Con. II., Thurlow	Limestone.
Huron	Brussels, Village of	A. H. McDonald, Clerk, Brussels	East side of village	
District of Kenora	Horne, William	Butler, via Ignace		Granite.
Lanark	Cameron, James	Fallbrook	Lot 4, Con. XI., Drummond	Pegmatite for road metal.
"	King, James	R.R. 1, Balderson	Lot 1, Con. X., Drummond	Granite.
"	County of Lanark	Wm. Walters, Co. Rd. Supt., Perth	Lot 26, Con. I., Bathurst	Granite.
"	McDougall, W. Wellington	R.R. 1, Balderson	Lot 3, Con. X., Drummond	Granite.
Leeds	Campbell & Lattimore	Gananoque	W. ½ Lot 32, Con. IV., Pittsburg	Granite paving blocks, building and monumental stone.
"	Town of Gananoque	John Thompson, Gananoqe	Gananoque	Quartzite for road material.
"	Gordon, David J.	Gananoque	Lot 11, Con. II., Leeds	Red granite.
"	Street & O'Brien	Box 73, Gananoque	Lot 6, Con. II., Leeds	Granite paving blocks
Lennox & Addington	Snider, Reuben C.	R.R. 1, Odessa	Lot 16, Con. V., Ernestown	Lime.
Lincoln	Queenston Quarry Co.	St. Davids	St. Davids	Crushed, monumental, sawn limestone.

Norfolk	McLean, M. L.	Box 560, Simcoe	Lot 19, Con. XIV., Townsend	Limestone.
"	Woodhouse Crushed Stone Co., Ltd.	R.R. 2., Jarvis	Lot 24, Con. I., Woodhouse	Limestone.
Oxford	Beachville White Lime Co.	Beachville		Stone, Lime, Agricultural lime
"	Innerkip, Village of	c/o Vill. Trustees, Innerkip	In the village	
"	Standard White Lime Co.	C. E. Downing, Beachville.	Beachville	High calcium, magnesian and hydrated lime.
Perth	St. Marys Cement Co.	St. Marys		Limestone for cement.
"	Thames Quarry Co.	St. Marys		Limestone.
Peterborough	Ontario Rock Co.	Preneveau	Lot 7, Con. VI., Belmont	Crushed trap.
Prescott	Cloutier & Grenon	Casselman	Lot 20, Con. XVI., S. Plantagenet	Limestone.
"	Counties of Russell and Prescott	F. A. Senecal, Rd. Supt., Plantagenet	Lot 6, Con. II., N. Plantagenet, (Winning Quarry)	Limestone for roads.
Renfrew	Jamieson Lime Co.	Renfrew	on Du Valiquette Farm Lot 5, Con. II., Horton	Crystalline, limestone and lime.
"	Jamieson Lime Co.	Renfrew	Renfrew	Crystalline, limestone and lime.
"	Markus, Wm.	Pembroke		
Russell	Cloutier & Grenon	Casselman	Near Rose's Corners	Limestone.
"	Macdonnell and Dibblee	Rockland	Twp. of Clarence	Limestone.
"	County of Russell	F. A. Senecal, Rd. Supt. Plantagenet	Lot 9, Con. V., Clarence	Crushed and screened limestone for roads.
"	County of Russell	F. A. Senecal, Rd. Supt., Plantagenet	Lot 8, Con. VIII., Russell (Embrun Quarry)	Crushed and screened limestone for roads.
Simcoe	Higginson & Son, Geo.	Coldwater	Lots 19, 20, Con. XII., Medonte.	Crushed limestone.
"	Ontario Stone Corp.	Uhtoff	Lot 10, Con. IV., North Orillia	Crushed limestone.
Stormont	Counties of Stormont, Dundas and Glengarry	c/o Road Supt., Cornwall	Lot 13, Con. VIII., Finch	Crushed limestone for roads.
District of Sudbury	Mond Nickel Co.	Coniston	At Coniston smelter	Quartzite flux for converters.
Thunder Bay District	Chambers, McQuigge & McCaffrey Co., Ltd.	Port Arthur	On Caribou Island, Thunder Bay	Fill for breakwater.
" "	Fort William, City of	Cyril Symmes, City Engineer, Fort William	At foot of Mt. McKay	Road metal.
" "	Henniger, M. G.	Box, 122 Fort William	On Indian Reserve, south of Fort William	Fill for breakwater.
" "	Hewitson, J. F.	Whalen Bldg., Port Arthur	In City of Port Arthur	Trap rock for concrete.
Dist. of Timiskaming.	Abitibi Pulp and Paper Co.	August Johnson, Haileybury	W. ½ Lot 11, Con. III., Bucke	Limestone.
Victoria	Britnell & Co.	Burnt River	Lots A B, Con. VI., Sommerville	Crushed limestone.
"	Canada Lime Co.	Coboconk	Coboconk	Limestone and lime.
"	Crushed Stone, Ltd.	Kirkfield	Lot 49, Con. IX., Eldon	Crushed limestone.
"	Toronto Brick Co.	Coboconk	Coboconk	Lime.

QUARRIES—*Continued.*

County	Operator	Address	Location	Product
Waterloo	Galt, City of	D. F. Black, City Engineer Galt	On Bank of Grand River	Crushed and screened limestone for city streets.
Welland	Bertie, Twp. of	Ridgeway	Bertie Twp	Crushed limestone for road metal.
"	Canada Cement Co	Port Colborne	Port Colborne	Limestone for cement.
"	Law Construction Co	Ridgeway	Baxter Quarry	Limestone.
"	Law Construction Co	Ridgeway	Lot 13, Con. V., Bertie (Standard Quarry)	Limestone for road material.
"	Walker Bros	Thorold	Lots 31, 32, Con. IX., Stamford	Limestone for flux and paper mills, crushed and screened limestone for roads.
Wellington	Alabastine Co. of Paris	Elora	Twp. of Nichol	Hydrated lime and agricultural lime.
"	Christie Henderson & Co	R.R. No. 2, Puslinch	Lots 1, 4, Con. I., Puslinch	Limestone and lime.
"	Harvey & Son, E	Rockwood	Rockwood	Limestone and lime.
"	Gow, James	Fergus	Fergus	Crushed limestone.
"	Maloney, John	R.R. No. 2, Puslinch	Lots 34, 35, Front Gore of Puslinch Twp	Crushed limestone.
"	Ontario Reformatory	Box 1448, Guelph	Guelph	Crushed limestone for roads.
"	Standard White Lime Co	Guelph	Twp. of Wellington	
Wentworth	Brennan Paving Co	Foreman, N. Roung, 195 E. Main St., Galt	Lot 5, Con. VII., Beverley	Crushed and screened limestone.
"	Barton, Twp. of	Mount Hamilton	Lot 13, Con. VI., Barton	Crushed and screened limestone.
"	Canada Crushed Stone Corp., Ltd	Dundas	Dundas	Crushed and screened limestone and building stone.
"	Gallagher Lime & Stone Co., Ltd	R.R. No. 2, Hamilton	Lot 14, Con. VI., Barton	Limestone and lime.
"	Kilmer & Barber	24 Adelaide St. W., Toronto	Lot 18, Con. IV., Beverley	Crushed and screened limestone.
"	Marshall & Sons, Jas	R.R. No. 4, Hamilton	Lot 14, Con. VI., Barton	Limestone and lime.
"	Routly, H. T	877 Hamilton Beach, Hamilton	Twp. of E. Flamboro near Clappison Corners	Limestone.
"	Wentworth, County of	H. A. Carson, Waterdown	Con. II., E. Flamboro	Limestone.
"	Wentworth Quarry Co	Vinemount	Lot 4, Con. V., Saltfleet	Crushed and screened limestone.

CLAY PITS

County	Operator	Address	Location
Bruce	Henry N. Brownscombe	Cargill	Lot 19, Con. A., Culross.
"	Wm. Elliott & Son	Glenannan, R.R. No. 1	Con. I., Culross.
"	John Graf	R.R. No. 1, Cargill	Lot 3, Con. X., Greenock.
Elgin	Deller & Co	Vienna	Con. III., Bayham.
"	James Reid	R.R. No. 3, Belmont	S. ½ Lot 13, Con. IX., Dorchester.
Halton	Atlas Brick Co	Milton Heights	Trafalgar Twp.
"	Halton Brick Co	Terra Cotta	Lot 28, Con. II., Esquesing.
"	Hugh Logan	Glen Williams	Part Lot 28, Con. XI., Esquesing.
"	Milton Pressed Brick Co	Milton	Lot 1, Con. I., Trafalgar.
"	Toronto Brick Co	Milton	Lot 14, Con. I., Trafalgar.
Hastings	D. Rowland	Tweed	Lot 9, Con. VII., Hungerford.
Huron	Chas. Carr	R.R. No. 4, Goderich	Lot 9, Con. III., Colborne.
"	Cruse Bros	R.R. No. 3, Seaforth	Egmondville.
"	Fraser & Leith	Blyth	Con. XIV., Hullett.
"	Wm. Elliott & Son	Glen Annan	Twp. of Turnberry.
"	Thos. Phillips & Son	R.R. No. 2, Lucknow	S. ½ Lot 10, Con. IV., W. Wawanosh.
"	Wm. Sproat	R.R. No. 4, Seaforth	Lot 6, Con. V., Tuckersmith.
Lincoln	Paxton & Bray	230 Queenston St., St. Catharines	Queenston St., St. Catharines.
Middlesex	H. L. Baird & Sons	Parkhill	Parkhill.
"	Wm. H. Deller	R.R. No. 4, Thorndale	Lot 5, Con. V., W. Nissouri.
"	D. A. Janes	R.R. No. 1, Mt. Brydges	Twp. of Delaware.
"	John Jervis	R.R. No. 3, Dorchester	Lot 13, Con. A., N. Dorchester.
"	Chester McCoomb	R.R. No. 2, Denfield	Lot 17, Con. XVI., London.
Norfolk	J. L. Buck	Port Rowan	In Village of Port Rowan.
"	Erie Clay Products Limited	Lt.-Col. D. T. Smith, Man. Dir., Pt. Dover	In Village of Port Dover.
"	Chas. Mason	Simcoe	In Town of Simcoe.
Oxford	Deller Bros	R.R. No. 2, Norwich	Twp. of N. Norwich.
"	L. H. Sinden	Tillsonburg	In Town of Tillsonburg.
Peel	Clarkson Tile Co	Clarkson	Lot 13, Con. I., Toronto.
"	Cooksville Shale Brick Co	Cooksville	Con. III., Toronto.
"	Interprovincial Brick Co	Terra Cotta	Lot 29, Con. V., Chinquacousy.
"	Milton Pressed Brick Co	Streetsville	Streetsville.
"	Shale Products Co., Ltd	Inglewood	Inglewood.
"	Streetsville Pressed Brick Co	Streetsville	Lot 3, Con. V., Toronto.
Thunder Bay District	Piper & Murphy	Victoria Ave., Fort William	In City of Fort William.
Victoria	Frank Curtin	R.R. No. 4, Lindsay	Lot 15, Con. V., Ops.
"	Chas. Wagstaff	R.R. No. 4, Lindsay	Lot 52, Con. IV., Ops.

CLAY PITS—*Continued.*

County	Operator	Address	Location
Wentworth	Bartonville Pressed Brick Co.	Sun Life Bldg., Hamilton	Bartonville.
"	W. H. Cooper	King St. W., Hamilton	Dundas St.
"	Crawford Bros.	King and Macklin Sts., Hamilton	King and Macklin Sts., Hamilton.
"	Dominion Sewer Pipe and Clay Industries Ltd.	Aldershot	Aldershot.
"	Frid Brothers	Macklin St., Hamilton	Dundas Road. and Macklin St., Hamilton.
"	Hamilton Pressed Brick Co.	Kensington Ave., S. Hamilton	Kensington Ave., Hamilton.
"	Edward New	133 George St., Hamilton	Ancaster Road.
"	Ontario Sewer Pipe Co.	Mimico	Aldershot.
York	Richard Butwell	Humber Bay	Humber Bay.
"	Don Valley Brick Works	Don Valley	Don Valley, Toronto.
"	Geo. Pickett Co.	Mt. Dennis	Eglinton Ave. & Weston Rd., Mt. Dennis.
"	John Price, Ltd.	Greenwood Ave., Toronto	Greenwood Ave., Toronto.
"	Price & Cummings	Humber Bay	Humber Bay.
"	Price & Smith	Greenwood Ave., Toronto	Greenwood Ave., Toronto.
"	Standard Brick Co.	Greenwood Ave., Toronto	Greenwood Ave., Toronto.
"	Sun Brick Co.	52 Toronto St., Toronto	Don Valley, Toronto.
"	A. H. Wagstaff Co.	Greenwood Ave., Toronto	Greenwood Ave., Toronto.

I.—NORTHWESTERN ONTARIO

Gold

Contact Bay Mines, Limited.—Contact Bay Mines, Limited, resumed work at the Bonanza mine in the spring, and closed down on September 5, 1922, owing to the stock of fuel becoming exhausted. From this date until the end of the year the work done consisted of repairs and framing timber for a new head-frame.

The Bonanza shaft is now 290 feet deep, and is at an angle of 80 degrees. On the first, or 70-foot, level there is 214 feet of drifting to the east, and 170 feet to the west; on the second, or 170-foot, 278 feet to the east and 287 feet to the west. In the Thirty-first Annual Report the levels were described as the 80-foot and 160-foot; a recent survey showed them to be at 70 feet and 170 feet.

The company again pumped out and sampled the Redeemer mine, but did no other work in it.

Charles W. Riley, the superintendent, resigned at the end of the year, and was succeeded by Donald S. Duncan.

Dryden Gold Corporation.—Dryden Gold Corporation is incorporated under the laws of the state of New Jersey, and is licensed to do business in Ontario. The capitalization is $2,000,000, divided into shares of $1.00 par value; 1,200,000 shares are outstanding, and 800,000 in the treasury. The stock is listed on the New York Curb. The directors are: president, W. M. Evans; secretary and treasurer, J. H. Tucker; H. V. Leonard, all of New York City. The secretary's office is at 42 Broadway, New York. The company owns two properties in Ontario in the District of Kenora.

The first property consists of four mining claims, K.850, K.852, K.853 and K.1060, situated southwest of Trap lake, which is the first lake south of Contact bay, Wabigoon lake. This group of claims runs north and south and extends nearly to the southeast side of Trap lake. Some trenching and test-pitting have been done and a large log cabin, stable and blacksmith shop built.

The second property is mining claim K.951 (originally H.P.387), called the Reliance. It is situated near the west side of Charlton lake, a small lake west of the narrows between Upper Manitou (Anzhekumming) and Manitou lakes. According to the Eighth Annual Report of the Ontario Bureau of Mines, this and three adjoining mining claims were being worked in 1898 by The Manitou Lake Gold Mining Company, Limited, and were known as the Westerfield mine. In the Ninth Annual Report the property is called the Independence. In the Thirteenth Annual Report, covering the year 1903, the following mention is made of the property under the heading, "Reliance Mine"; (see page 66, Part 1).

This property was originally called the Independence mine. It is owned and operated by the Reliance Gold Mining and Milling Company, Limited, of Detroit, Mich., under the superintendence of T. Armstrong with a force of eight. For six months previous to inspection mining had been confined to sinking another, or No. 2 shaft at 300 feet southwest of No. 1 shaft, to 97 feet in depth. First level, depth 80 feet; north drift, 75 feet; south drift, 75 feet. The shaft is timbered and has a good ladderway. . . . The quartz vein extends down the shaft along the north drift. In the south drift it disappears at 10 feet from the shaft.

In the autumn of 1922, the Dryden Gold Corporation had a small crew re-timbering two of the old shafts. It is expected that work will be resumed in the spring of 1923. E. G. Rognon, of Dryden, was in charge of the re-timbering.

Foley.—The Foley Gold Mine, near Mine Centre, has been bought by British Canadian Mines, Limited, a company incorporated in 1922 with an authorized capital of $3,000,000.00 divided into shares of $1.00 par value. In 1919 The Swedish Canadian Mines, Limited, was organized to work this property, but no mining was done, as the flotation was not a success.

British Canadian Mines, Limited, in exchange for 1,500,000 shares of its capital stock, has bought from Foley Gold Mines Company, Limited, the following mining locations: (1) A.L. 74, A.L. 75, A.L. 76, 191 acres; (2) G. 109, G. 110, 160 acres; (3) P. 732, P. 736, P. 737, 230 acres; (4) H.W. 59, H.W. 60, 50 acres; (5) G. 97, G. 98, G. 99, G. 100, G. 101, 200 acres; (6) 13/16 interest in K. 426, 38 acres; (7) three-quarter interest in G. 96, 40 acres; (8) three-quarter interest in G. 150; together with all buildings, machinery, supplies, etc., on the claims mentioned.

The directors of the company are: president, Senator George W. Fowler, Ottawa; vice-president, William D. McKay, Ottawa; secretary-treasurer, Gideon Grant, K.C., Toronto; Clayton S. Corson, Toronto; C. R. Fitch, Fort Frances, Ont.; Frederick McQueen, Toronto; J. M. Aitken, Toronto.

Grace (Eagle Lake).—The Grace gold mine on the west shore of Eagle lake, southwest of Net island, was mentioned in the Thirty-first Annual Report. During the summer of 1922 eight men were employed under the supervision of William J. Richards, of Kenora, in trenching, but no underground work was done as the results obtained during 1921, in the No. 1 shaft workings were not encouraging.

The principal pieces of machinery at this mine are: a 12-inch by 18-inch James Cooper compressor; a small Canadian Rand compressor; a 6-inch by 8-inch Canadian Ingersoll-Rand hoisting engine; an Erie City return tubular boiler of probably 70-horsepower; a Fraser and Chalmer's engine for driving the crusher and other mill machinery; a Fraser and Chalmers Blake crusher; an Allis-Chalmers five-stamp mill; and two Frue vanners.

Laurentian.—On February 10, 1922, Kenbrooke Gold Reserve, Limited, was incorporated under a Dominion charter to work the Laurentian mine, a 216-acre gold property in the Manitou lake area. The directors of the company are: president, Lieut.-Col. H. A. C. Machin, Kenora, Ont.; vice-president, D. O. E. Denault, Sherbrooke, Que.; secretary-treasurer, G. H. St. Pierre, Sherbrooke; Pierre Gauvin, Magog, Que.; J. W. Gregoire, Sherbrooke. The head office is in the Nault Block, Sherbrooke, Que.

Work was carried from March to May, 1922. Some repairs were made to the buildings and to the tramway leading to the mill, and the mine was pumped out to the fourth level; but no mining was done. In May all work was stopped, the sales of stock not having been sufficient.

John A. Johnson was superintendent.

Mikado.—The incorporation of Mikado Consolidated Mines, Limited, and the holdings of the company were mentioned in the Thirty-first Annual Report of the Ontario Department of Mines.

In July, 1922, the pumping-out of the Mikado mine on Shoal lake was begun. When the last inspection was made (January 22, 1923), the workings on No. 1 vein were being kept pumped down to the seventh level, but no drills had been run, the time having been occupied in making repairs, cutting wood, etc. The vertical shaft on No. 1 vein is being repaired.

Neil R. Morrison, of Elk Lake, Ont., was superintendent until September, when he resigned and was succeeded by S. Dryden Smith, of Dryden, Ont.

The head office of the company has been changed from Kenora, Ont., to 202 Imperial Building, Hamilton, Ont. The directors are: president, Lieut.-Col. H. A. C. Machin, Kenora, Ont.; vice-president, George J. Guy, Hamilton, Ont.; secretary and treasurer, Major George H. Marsh, Toronto; J. T. White, K.C., Toronto; W. P. Thomson, Hamilton, Ont.; J. T. Stevenson, Toronto; A. H. Dinning, Detroit, Mich.

Mikado gold mine, Lake of the Woods.

Schreiber Area

Fenning.—Fenning Development Company, a New York syndicate, has options on twelve mining claims, and owns claims T.B. 3833 and T.B. 3870; all these claims are in the Schreiber area, the two purchased having been obtained from William Boswell and L. H. Estelle. T.B. 3833 is the south part of mining location R. 651, and T.B. 3870 is part of mining location R. 653. When inspected on January 18, 1923, camps had been built and a vertical two-compartment shaft was being sunk by hand labour on T.B. 3870; this shaft, which is about a mile and a quarter southwest of the Jackson Development Company's camps, was then 45 feet deep. Louis Fenning, Box 28, Schreiber, Ont., is superintendent.

Jackson.—Jackson Development Company continued to work its property east of Schreiber until August, 1922. On mining claim T.B. 3326, adit No. 1 measures 65 feet, and No. 2 adit, 500 feet from No. 1, 110 feet. On claim T.B. 3783 near its north boundary, and behind the camps a pit has been sunk to a depth of 18 feet. The directors of the company are the same as mentioned in the Thirty-first Annual Report. Wm. S. Jackson, 297 Frederica Street, Fort William, Ont., is superintendent.

McKellar-Longworth.—(Mining Location B.J. 122).—The McKellar-Longworth gold property near Schreiber was not worked from March 16, 1922, until the end of the year. The work done up to the time of shutting down was mentioned in the last Annual Report of this Department.

In January, 1923, William Longworth, one of the owners, began to make preparations to move and ship a carload of ore at the request of George Glendinning and Clement A. Foster, of Toronto, who have an option on the property. This carload weighing 19.774 tons was sent to the Timiskaming Testing Laboratories, the Mines Department plant at Cobalt, where it assayed at the rate of $82.60 per ton.

Iron

Atikokan.—According to newspaper reports in September, Clement K. Quinn, of Duluth, Minn., acting for United States interests, acquired a lease for thirty years on the Atikokan iron mine. Mr. Quinn is a prominent iron-mine operator, and about two years ago held an option on the Atikokan, but allowed it to lapse.

Leitch.—In December the Bethlehem Steel Company began to drill the Leitch group of iron claims east of Poplar Lodge, Lake Nipigon. These claims comprise 2,920 acres, and are owned by P. A. Leitch, of Port Arthur, and associates. Towards the end of March, 1923, the fifth hole was being drilled. Another company did considerable drilling on this property in 1919 and 1920.

Oil

Nipigon Prospecting Company.—During the past two summers the Nipigon Prospecting Company has been drilling for oil in the vicinity of Fort William. The company is really a partnership, consisting of Joseph A. Beam, a bituminous coal-mine owner and operator, of New Bethlehem, Pa., and Job Burton, of Pittsburgh, Pa. A. E. Annis, of Orangeville, Ont., is superintendent.

During the summer of 1921 two holes were drilled on the estate of W. W. Vickers, lot 4, concession III, Paipoonge township, south of the Kaministikwia river. These holes were bored to a depth of 230 and 420 feet, and were abandoned owing to deviation from the vertical. The company then moved the drill to the Indian Reservation, south of Fort William, and started the third hole on the north shore of Squaw bay; this hole was 630 feet deep when work was stopped for the winter on December 1, 1921.

In 1922 Hole No. 3 was continued to a depth of 1,108 feet. Mr. Annis states that this hole is still in the sediments, and that it will be drilled deeper.

Pyrite

Northpines.—The Northpines pyrite mine, owned by The Nichols Chemical Company, Limited, was kept pumped out in 1922, but no mining was done.

Silver

Silver Islet.—Islet Exploration Company, Limited, resumed work at the Silver Islet mine in May with a force of nine men. Part of the ore left in the back of the mine by the early operators was stoped out; the slice taken was from 5 to 20 feet in depth, 4 feet wide, and 60 feet long. Care was taken to still leave sufficient ore to hold back the water of the lake. A drift, 40 feet long, was run on the vein about 26 feet below the lake level, but this showed only calcite, and occasional specks of galena. The mine was abandoned in August, 1922.

D. C. Peacock, 509 Alworth Building, Duluth, was the consulting engineer, and Charles W. Greenlee, superintendent.

Three A Mine.—For a short time in the summer of 1922, the Nipigon Prospecting Company did some work on the Three A silver mine, a 300-acre property in Macgregor township. This company is a partnership, consisting of Joseph A. Beam, a bituminous coal-mine owner and operator, of New Bethlehem, Pa., and Job Burton, of Pittsburgh, Pa.

The Three A mine is thirteen miles east of Port Arthur, and the old shafts are half a mile from Silver Harbour station on the Canadian National Railway. When inspection was made on July 29, 1922, three men under foreman Arthur Ordmark, were engaged in cleaning out an old prospect pit west of the mine workings. This pit is on a vein of quartz and calcite having a strike of 80 degrees. Mr. A. E. Annis, the company's superintendent, states that work was stopped about the end of September, at which time the pit was 25 feet deep and about 20 feet of drifting had been completed.

On page 66 H of E. D. Ingall's "Report on Mines and Mining on Lake Superior," Part H of the Annual Report of the Geological and Natural History Survey of Canada, 1887, there is the following description of the Three A mine:

This vein strikes N. 75 degrees E., and dips slightly away from the vertical. It has a thickness of from eighteen inches to two and a half feet. The gangue is mostly quartz with a little calcite, "through which are irregularly distributed the ores of iron, copper, lead, zinc, nickel and silver, with some cobalt and gold as shown by the assays. The silver is found native and combined with sulphur and nickel, thickly penetrating the vein stone in small and large patches, in some of which it is very heavy." The ore is stated to have been as rich as much of that at Silver Islet. One sample of the ore is said to have assayed 1.4 per cent. of cobalt, and 25 per cent. of nickel.

The enclosing Huronian rocks here consist of grey dolomitic schists, associated with dark green compact diorite, whilst dark greyish red, felistic syenite occurs a short distance to the south. The dip of the strata is nearly vertical.

The discovery of this vein was made in the winter of 1869 and 1870. A considerable amount of work was done on it. The accompanying plan and section of the mine up to March, 1874, taken from Mr. McKellar's paper on "Mining on the North Shore of Lake Superior" shows the underground work. On surface the vein has been traced over half a mile. During the winter of 1871-2, two miners worked on the lode and took out 22 barrels of ore. Towards the fall of 1872 the sinking of the shaft was begun and the work of development carried on for some time. The silver seems to have lasted down but to have been pockety. I have been unable to ascertain when operations were discontinued, but Mr. Courtis, writing in February, 1877, speaks of the mine as closed. He also says that the value of the ore obtained was probably about $2,000.

Soapstone

Pidgeon.—This property consists of Mining Location H.W. 133, in the township of Zealand, district of Kenora.

The Wabigoon Soapstone Company, Limited, whose head office is in the King Edward Hotel Building, Toronto, has been incorporated to work a soapstone deposit on the north shore of Wabigoon lake near Wabigoon station. The property consists of ninety acres, and was bought by the company from E. Pidgeon, of Wabigoon. The capitalization is $500,000 divided into 50,000 shares, having a par value of $10 each. The directors are: president, H. H. Sutherland, Toronto; vice-president, E. Pidgeon, Wabigoon, Ont.; secretary-treasurer, R. E. Evans, Toronto; Robert Fennell, Toronto; F. C. Sutherland, Toronto.

The deposit is described by Hugh S. Spence in Mines Branch Report No. 583, "Talc and Soapstone in Canada," as follows:

An interesting and extensive deposit of so-called soapstone occurs here. The locality was visited in October, 1921, and the following notes on the occurrence were made, but the small amount of development work done on the property precluded full details being secured.

The rock of this deposit may be termed soapstone for want of a better name, though it possesses few of the outward characteristics of normal soapstone. It more nearly resembles the Alberene stone, mined in Virginia, and utilized extensively for many of the purposes usually served by soapstone. Analysis of the two stones shows that they correspond very closely in mineral composition.

The Wabigoon stone is a dark greenish-grey rock, composed largely of talc, with some chlorite and dolomite. It is soft enough to be scratched with the finger nail. The rock is fine to medium-grained, the largest constituents being dolomite crystals that occur as phenocrysts up to $\frac{1}{8}$-inch diameter. There is no approach to schistose structure, the grain being quite uniform and the rock massive and homogeneous. The stone yields a greenish-grey powder. This, screened through 100-mesh, possesses fair slip but is distinctly gritty.

Two well-defined bands of soapstone occur, separated by about 100 feet of hard, greenish rock, resembling an altered diorite. The trend of these bands is northwest, and the dip approximately vertical. The soapstone is well exposed on the summit and west slope of a low ridge that crosses a small peninsula extending from the noith shore of the lake, about one mile west of Wabigoon station on the main line of the Canadian Pacific railway. The actual distance from the track is only 500 yards, and the intervening ground is level and well adapted to the laying of a spur.

The northern band has a proved length of over 500 feet, with an average width of 35 feet. The extent of the southern band has not been determined, but, judging from the visible outcrops, it is probably considerably larger. There is little overburden on the deposit, and only a light stand of second-growth trees.

The northern band has been stripped for a short distance, but no openings have been made on it. No work has been done on the southern band.

The northern band consists of about 35 feet of medium-grained stone, apparently homogeneous throughout its width. Bordering this, along each contact, is about 18 inches of fine-grained, compact, soft soapstone. This soapstone is of very good quality, but its occurrence appears to be confined to the narrow band along the contacts, and there is relatively little of it.

Small veinlets and pockety aggregates of green, foliated talc occur locally in the mass of the main soapstone bodies, but such material does not appear to be present in any quantity.

The deposit is well situated for working, the exposures being on the top of a ridge, thus providing good drainage for quarry operations. The proximity to rail, also, is an important factor.

The following analyses of samples of the stone of the northern body, and of that of the 18-inch band of soft soapstone bordering this deposit, were made in the Mines Branch laboratory. An analysis of a sample of Virginia Alberene stone, such as is used for lining the smelting furnaces of sulphate pulp mills, is shown for comparison. The analyses show that the Wabigoon stone contains considerably less carbonates than the Alberene stone.

	1	2	3
Silica	41.94	51.44	37.10
Ferrous oxide	7.71	7.24	6.58
Ferric oxide	2.05	3.68	4.57
Alumina	7.57	4.79	4.53
Lime	3.42	none	4.20
Magnesia	25.39	26.43	27.37
Carbon dioxide	5.09	0.11	10.45
Water above 105° C.	6.71	6.56	5.46
	99.88	100.25	100.26

1. Wabigoon stone, representative of material of northern body.
2. Wabigoon stone, 18-inch band of soapstone bordering northern body.
3. Virginia Alberene stone.

In addition, the following tests were conducted in the Mines Branch laboratories on material from the northern body:—

Crushing Strength

Tests were made on three samples, 2-inch cubes being used. The results showed:—

(1) 12,140 pounds per square inch.
(2) 10,269 " " " "
(3) 10,755 " " " "

Transverse Strength.—Tests were made on two samples, the test pieces measuring approximately one inch thick and two inches wide. The supports were four inches apart. These tests gave the modulus of rupture as:—

(1) 1,827 pounds per square inch.
(2) 1,920 " " " "

Corrosion Test.—A sample of the stone that had been exposed to ordinary room temperature for three months was weighed and then dried for two weeks at 105° C. On re-weighing there was no loss in weight, indicating no absorbed moisture.

The sample was then immersed in concentrated hydrochloric acid and boiled for 48 hours. After thorough washing, by boiling in water for several days, the sample was dried at 105° C. and weighed. The loss in weight was found to be 9.74 per cent. On immersion in the acid bath, a few small bubbles of gas were given off, indicating the presence of a carbonate. The sample after treatment showed only slight local pitting. A sample of Alberene stone, subjected to the same treatment, effervesced freely when placed in the acid, and exhibited extensive pitting. The loss in weight in this case was 17.95 per cent., or almost twice that of the Wabigoon stone.

Absorption Test.—A sample of the stone was dried at 70° C., for 24 hours, weighed and immersed in cold, distilled water for three days. After air-drying for a short time, the sample was weighed, and found to have gained only 0.12 per cent.—a negligible amount.

Fusion Test.—Two samples were tested for their fusion temperature which was determined in both cases as 1400° C. A sample of Alberene stone, tested at the same time, went down at 1350° C.

It should be noted that all of the above tests on Wabigoon stone were perforce conducted on material taken from within a few inches of the surface of the deposit. This material, as shown by the broken test pieces, is traversed by numerous flaws and cracks showing rusty surfaces, and is likely to be considerably inferior in all respects to fresh, unweathered stone.

The use that suggests itself most strongly for the stone of this deposit is for bricks for the smelting furnaces of sulphate-pulp (kraft) mills. These furnaces require a refractory material that is structurally strong, and that does not spall or crack under the heat to which it is subjected. There are more than a dozen sulphate-pulp mills in Canada, and the aggregate amount of soapstone bricks consumed is considerable. All these bricks are imported from the United States, the principal source being Virginia. If the Wabigoon stone proves suitable, under actual working conditions, for the above purpose, the cost of soapstone to the pulp mills should be materially lessened.

A further suggested use for this stone is for bake oven bricks. Soapstone bricks are superior to ordinary firebricks for bake ovens on account of their greater heat retention, but their use is limited owing to the difficulty of procuring soapstone, and its high cost.

Wabigoon stone might also be suitable for fireless cooker stoves, footwarmers, etc.

The deposit is the most promising, from an economic standpoint, of the soapstone occurrences examined. There is undoubtedly a large tonnage of stone available; the deposit is within a few hundred yards of the railway, and the location is an excellent one for a quarry site.

The work done on the property in 1922 consisted of stripping, sampling, clearing timber, and road-building.

H. H. Wood Talc Company.—The H. H. Wood Talc Company owns two 40-acre mining claims, H.P. 140 and H.P. 141, on the south shore of Turtle lake, and about three-quarters of a mile northwest of Mine Centre station on the Canadian National Railways. These claims were staked for gold during one of the early "booms."

In June, 1922, the company began to work a soapstone deposit on H.P. 141. When inspected in August, a pit, 5 feet by 6 feet, had been sunk near the shore of the lake and was 12 feet deep. In addition to the soapstone obtained during the sinking of the pit, between two and three cubic yards had been channelled with a plugger drill from the deposit nearby. The portion of the soapstone deposit being worked was a band, two feet six inches wide, having a strike of 105 degrees magnetic.

The soapstone is sawed at the property into steel-worker's crayons, ½-inch to ⅜-inch by 4 and 5 inches. Power for the plugger drill and the saw is supplied by a 15-horse-power Clayton air compressor, driven by gasoline. Four men were employed under the supervision of H. H. Wood, 120 Howland Avenue, Toronto. In 1900 and 1901 Mr. Wood was manager of the Golden Star mine near Mine Centre.

II.—THUNDER BAY, MICHIPICOTEN AND SUDBURY

Anthraxolite or Anthracitic Carbon

There was considerable newspaper comment during 1922 regarding the Sudbury "coal" fields, and three companies were incorporated to exploit portions of the Sudbury basin. Unfortunately, but little prospecting was done, and only one concern, a Toronto syndicate, did any diamond drilling.

Balfour Developing Syndicate.—In the autumn, this syndicate of Toronto men—Edgar B. James, a prospector, and three others, sank a vertical diamond drill hole three miles south of Chelmsford to a depth of 850 feet. The hole was drilled on the north bank of Whitson creek on the farm of John Bradley, lot 4, concession I, township of Balfour.

British-Colonial Mines, Limited.—The head office of this company is at 62-76 Richmond Street West, Toronto, and the authorized capital is $500,000, divided into shares of $1 par value. The officers of the company are: president, Stewart Hood; vice-president, J. B. McGraw,; secretary-treasurer William Wheaden. Leases covering the coal rights for 11,000 acres of land in the townships of Rayside, Morgan, Dowling and Balfour have been purchased from Financial Underwriters, Limited, in exchange for 200,000 shares of the company's capital stock.

Ontario Anthracite Mines, Limited.—This company was incorporated in March, 1922, with an authorized capitalization of $500,000, divided into shares of $1 par value each. The directors are: president, R. H. C. Browne; vice-president, F. J. Lightbourn; secretary-treasurer, William S. Milne,; Thos. A. Cain; George D. Reid. The head office is at 95 King Street East, Toronto. The company has acquired leases covering the coal, oil, gas and salt rights to 5,000 acres in the townships of Balfour, Rayside, Dowling, Fairbank, Morgan and Creighton. The leases were sold to the company by Edgar B. James and Joseph N. Mulholland, of Toronto, for $15,000 cash and 200,000 paid-up shares of the company's capital stock.

The Chelmsford Anthracite Coal Company, Limited.—In June, 1922, The Chelmsford Anthracite Coal Company, Limited, was incorporated with a capitalization of $100,000, divided into shares of $10 par value. The company has transferred 1,000 shares of its capital stock to Alfred F. A. Coyne, of Toronto, for the options to purchase the mining rights of certain lands in Balfour and Rayside townships, and has agreed to transfer a further 4,000 shares, when he has transferred to the company options to purchase the mining rights of not less than 6,400 acres. The officers of the company are: president, J. Douglas McNish; vice-president, A. R. B. Richmond, V.S.; director, W. W. Forsyth, V.S.; secretary-treasurer, David A. Robertson, all of Toronto. Head office, 1 Adelaide Street West, Toronto.

Copper

Algomont.—The copper prospect, owned by Algomont Mines, Limited, and situated north of Bruce Mines, was described in the Thirty-first Annual Report of the Ontario Department of Mines.

The company stopped work on December 19, 1921, and did not resume until May, 1922, when a small force was employed for a week, and the shaft was sunk fifteen feet farther. From August 19 to December 23, when all work was discontinued, twenty men were employed; of these five were miners.

At the end of the year the shaft measured 215 feet on the slope (about 72 degrees). At the 100-foot level a station had been cut, and on the 175-foot level 331 feet of drifting had been completed; nearly all of this drifting was to the east of the shaft. George Johnson, Rydal Bank, Ont., is superintendent.

Feldspar

Cecebe Lake.—This property is in Parry Sound district, township of Chapman, concession II, lot 26.

In May, 1922, Wheeling Feldspar Company (Inc.), began to build camps on this property, and carried on work on the vein until October. The vein is a pegmatite striking N. 10 degrees E. and can be traced for over a quarter of a mile; the greatest width seen was 50 feet. As the feldspar is mixed with considerable quartz, the vein matter is crushed to between ⅛-inch and ¼-inch and sold for stucco work.

The machinery used consists of a 10-horse-power Fairbanks-Morse gasoline engine, a 5½-inch by 8-inch Mitchell jaw crusher, a bucket elevator, and a rotary screen, 24 inches by 10 feet, with openings ⅛-inch and ¼-inch square.

When inspected on October 3, 1922, five men were working under the supervision of W. B. Woods, and the fifth carload was being crushed. The product, free from fines, is taken on a scow to Burk's Falls for shipment by rail.

The directors of the company, all residents of Wheeling, West Virginia, are: president, Dr. John McColl; vice-president, Friend Cox; secretary, H. E. H. Caldwell; treasurer and general manager, W. Bates Woods; H. C. Whitaker. The post office for the quarry is Burks Falls, Ont.

McPhee.—Township of Dryden, concessions I and II, lot 9. Since October, 1922, the four McPhee brothers, of Markstay, Ont.; Alexander D., Alexander, Malcolm and Dougald, and Duncan A. McKinnon, of Sudbury, have been working a feldspar deposit, owned by them, one and a half miles south of Wanapitei station. The property consists of six unpatented mining claims of forty acres each.

The owners have built a camp and a stable, and stripped part of the vein. When the writer visited the property on February 2, 1923, two cars of spar had been shipped. It is noteworthy that these are the first carloads of feldspar, so far as is known, that have been shipped from the district of Sudbury. Owing to the snow on the ground at the time of inspection, the extent of the vein could not be seen, but it appeared to be of good width, and the spar of first-class quality. Quartz was seen in two places, but it appeared to be in narrow veins that could be broken separately from the spar. There is as yet only a winter road leading from the vein to Wanapitei station, but it is level.

Weisman Feldspar Company.—Cleland township, concession IV, part of lots 11 and 12. In December, Weisman Feldspar Company built a camp, and began to prospect a feldspar vein on the Canadian National Railways about a mile north of St. Cloud station, and six miles south of Coniston. The mining claims owned by the company are: the southwest quarter of the south half of lot 11, the northeast quarter of the south half of lot 12, and the southeast quarter of the south half of lot 12, all in concession IV, township of Cleland.

Abraham Weisman, Box 363, Sudbury, is manager and Oscar Nygrin is foreman.

Gold

Gold Nugget.—As some attractive specimens of gold-bearing quartz were brought to Sudbury during the summer from the Gold Nugget property southeast of Wanapitei lake, an examination of the discovery was made on June 7 and 8.

The claim is reached by the following route from Crerar station on the Canadian National Railways: east on the railway track a quarter of a mile to Richard Steacy's stopping-place; thence by a trail running northwest for a mile and a quarter to the southeast shore of Ashganing lake (locally called Ess lake); by canoe across the lake to the end of the northwest arm; thence by a one-and-a-half-mile portage northwest to the claim. Another route is from Massey Bay station; in this case a launch may be taken across Wanapitei lake to Southeast bay, and a trail, two miles long, followed southeast to the property.

The Gold Nugget Mining and Development Company, Limited, a prospecting company, owns thirty claims in Davis, Kelly, Rathbun and Scadding townships; the principal discovery was made on mining claim No. S-5110, called the "Red Rock," and being the northeast quarter of the south half of lot 6, concession IV, in the township of Scadding.

The "Red Rock" was the only claim examined by the writer, and the following remarks apply to it only.

The rock on nearly all of the northern half of the claim is quartz-diorite, or quartz-diabase of Keewenawan age, but near the western boundary greywacké is exposed for ten chains south of the No. 4 post, flanking the quartz-diorite, which occupies the high ground. The contact between the diorite and greywacké is covered with drift. The diorite mass is at least fifteen chains in width and runs in a northwesterly direction toward Wanapitei lake. The discovery is near the southeastern edge of this diorite mass. A hundred feet of the most southerly exposure of the lode is an outcrop of greywacké in which one granite boulder, two feet in diameter, was seen; this outcrop shows banding, and has an apparent dip of 50 degrees to the north. About two and a half chains north of this point, the greywacké dips at the same angle, but to the east. Several small outcrops of quartzite can be seen near the south edge of the diorite.

The lode is in a dark-green, schistose rock, that is probably an altered part of the diorite. Stripping and test-pitting have been done along the lode in a direction north 30 degrees east for 350 feet. The altered rock is cut by a stockwork of veins and veinlets consisting of quartz and ferruginous carbonate. At several points in the lode, attractive specimens of native gold have been found. The portion that is more or less impregnated by the quartz and carbonate solutions varies from 15 to 75 feet in width, and may be wider, as there is a depression paralleling and immediately to the east of the lode; this depression has not been trenched. Pyrite is sparingly disseminated through some of the quartz and carbonate, and a little mispickel is said to have been found, but was not seen by the writer.

A piece of the carbonate was sent to the Provincial Assayer, W. K. McNeill, for analysis, and the result obtained was:

	Per cent.
Carbonate of lime	50.82
Carbonate of magnesia	31.50
Carbonate of iron	10.69
Insoluble	2.38
Manganese	trace.

The company is capitalized at $500,000, divided into shares of $1 par value The directors are: president, John G. Henry, Sudbury, Ont.; vice-president, Charles H. Johns, Sudbury; George F. Charsley, Sudbury; Gerald A. Foot; Ewen J. MacMillan, Haileybury, Ont. Arthur A. Jackson, P.O. Drawer 760, Sudbury, is secretary-treasurer. The work on the company's claims is under the supervision of Ewen J. MacMillan.

Since the foregoing was written, a winter road has been cut from the Canadian Northern railway bridge across the Wanapitei river to the Red Rock claim. This road is 4.7 miles long, and runs in a northeasterly direction.

Golden Rose.—The Golden Rose mine was bought in 1922 by Oscar Smith, of Sudbury, Ont., from W. R. Sweeney, of Toronto. The mine is situated on the shore of Emerald lake in the Timagami Forest Reserve and was worked for a short time by the Golden Rose Mining Company, Limited, which went into liquidation in 1919.

Grace Mine (Michipicoten).—The A-Gold-Ma Mining Syndicate was formed early in 1922 by H. H. Lang, of Toronto, to work the Grace gold mine near Wawa, Ont., but up to the end of the year the mine had not been pumped out.

Kirk Gold.—Kirk Gold Mines, Limited, a company which has been mentioned in the last three Annual Reports of this Department, has increased its capital stock from 2,000,000 shares of $1 par value to 4,500,000 shares of the same par value. The directors now are: president, George A. Bull, Brampton, Ont.; vice-president, R. B. Burkell, Toronto; managing director, Robert Kennedy, Toronto; secretary-treasurer, G. B. Macfarlane, Toronto; T. B. Dundas, Toronto; C. L. Messecar, Brantford, Ont.; E. R. Wilson, Peterborough, Ont.

After discontinuing work at the Bass lake property in 1921, the company acquired the Havilah (or Ophir) gold mine, fourteen miles north of Bruce Mines, Ont. The Havilah mine has not been worked since 1912, and comprises the following subdivisions in the third concession of Galbraith township; the north half of lot 11, the north half of lot 12, and the north half of the south half of lot 12, some 393 acres in all. Some repair work was done during the summers of 1921 and 1922. In the autumn of 1922 underground work was begun and continued until the latter part of December, when the employees were paid off. Major E. H. Birkett was mine manager until October 1, when he resigned; he was succeeded by Richard Sandoe, of Port Arthur.

The depth of the vertical two-compartment shaft is not known, as it was not pumped out by the present owners below the 83-foot level; however, it is believed to be about 105 feet deep. The principal level is at 83 feet, and above it are a number of sub-levels, raises and tortuous stopes leading to an open cut on the surface. The Kirk Gold confined its underground work to drifting on the 83-foot level. The drift east of the shaft, which was 105 feet long on resuming work, was driven to a point 183 feet from the shaft. A new drift was started west from the shaft, and was stopped at 102 feet. From fourteen to twenty-three men were employed.

Goudreau Area

Goudreau Gold.—In 1922 Goudreau Gold Mines, Limited, carried on work continuously on the Murphy claim, west of Goudreau station.

The two shafts, which are on mining claim A.C. 408 and 500 feet apart, were sunk to a short distance below the 200-foot (vertical) level. The east, or No. 1, shaft measures 224 feet on the slope and the west, or No. 2, 246 feet. The average dip of the vein has so far proved to be between 70 and 80 degrees to the south. The 200-foot level comes at 224 feet (slope measurement) in the east shaft and 237 feet in the west shaft. At the end of the year the west shaft was being straightened and made ready for use as a working shaft. This work was completed, and sinking was resumed in this shaft on March 12, 1923, with the 400-foot point as objective. On the date mentioned the lateral work completed on the 200-foot level consisted of: a 500-foot drift joining the two shafts, 200 feet of drifting east of the east shaft, 200 feet of drifting west of the west shaft, and 100 feet of crosscutting.

The transmission line from the Steep Hill Falls power plant was completed in the spring of 1922. The mine has been equipped with first-class machinery. In the mine power-house is a 175-horsepower Canadian Westinghouse, Type H.S. constant-speed induction motor, 2,200 volts, 43 amperes per terminal, 3-phase, 60-cycles, 690 r.p.m. at full load; also a Canadian Ingersoll-Rand cross-compound Type P.L.B.-2 air compressor, 18-inch and 11-inch by 16-inch stroke, with a capacity of 1,080 cubic feet of air per minute. At each shaft is a Canadian Ingersoll-Rand "Circo" reversing hoisting engine, 8¼-inch by 10-inch.

The Ontario Government has built a five-mile wagon road from Goudreau station to the mine.

The directors of the company are the same as mentioned in the Thirty-first Annual Report of the Ontario Department of Mines. The mine staff consists of: managing director, Clement A. Foster, Toronto; superintendent, W. H. Reamsbottom; master mechanic, D. J. Rees; mine foreman, up to April 1, Albert Terrill; after that date, Peter Sampson. The number of men employed was from forty-five to fifty.

Webb-Michael.—The Webb-Michael group of claims is situated two miles due south of Lochalsh station on the main line of the Canadian Pacific Railway. The claims are numbered S.S.M. 2469, S.S.M. 2470, S.S.M. 2474, and S.S.M. 2475, and are in townships 47 and 48, range XXVII, three miles south of the north boundary of the townships. The claims were staked in November, 1920, by Joseph and William Webb, of Sault Ste. Marie, Ont., and were bought by Gordon Michael, of Sault Ste. Marie, Ont., and associates in December, 1921. Fred. W. Sparling, of Detroit, Mich., and associates took an option on the property in September, 1922, and built a road from Lochalsh to the claims in the autumn.

Stripping done by Mr. Michael in the summer of 1922 disclosed a sheared zone, several hundred feet long, about 50 feet wide, and having a strike of 105 degrees magnetic. This zone is on the east part of S.S.M. 2469, and probably extends eastward upon S.S.M. 2470. The schist is impregnated with quartz and pyrite, and part of it is said to have given encouraging assays for gold. Enclosed in the schist are some intrusions of porphyry. The rock immediately to the north and south of the schist is a greenstone, showing a well-marked ellipsoidal or pillow-lava structure.

Howry Creek Area

Majestic.—Majestic Gold Mines, Limited, carried on work during all of 1922 at its property near West River on the Algoma Eastern Railway. When last inspection was made (March 22, 1923), the two-compartment vertical shaft was 205 feet deep, and the lateral work completed was as follows: on the 50-foot level, 14 feet of crosscutting; on the 100-foot, 35 feet of crosscutting and 135 feet of drifting; on the 200-foot, 51 feet of crosscutting and 80 feet of drifting. A new 10-inch by 12-inch Canadian Ingersoll-Rand hoisting engine, Type "S.S.R.", has been purchased.

The directors of the company now are: president, Antonio Ricca, Philadelphia, Pa.; vice-president, Saad Lattief, Toronto; secretary-treasurer, Charles Gregory, Antonio Manieri, Frank Gregory, Parry Sound.

Peter Greco was superintendent until February, 1923, when Francis M. Simond, of New York City, became general manager and Charles E. Beckwith, superintendent. The post office address for the mine is West River, via Espanola, Ont.

West Shiningtree

Algonquin.—Algonquin Mines, Limited, with a capitalization of $2,000,000, par value of shares $1, was incorporated in August, 1922. This company owns five mining claims west of the Herrick and Wakenda groups of claims in the Shiningtree area. The officers of the company are: president, Walter R.

Knox, Orillia, Ont.; vice-president, Russell Nesbitt, Toronto; secretary, Israel Singer, Toronto.

No mining was done on the property in 1922.

Atlas.—At the Atlas gold prospect, which had not been worked since early in 1920, some diamond drilling was done in 1922, and eight men were employed in wood-cutting, road-building, etc., for a short time during the summer.

The property is owned by Atlas Gold Mines, Limited, of which the directors are now as follows: president and treasurer, Israel Singer, Toronto; vice-president, Russell Nesbitt, Toronto; secretary, N. R. Davis, 133 Queen Street West, Toronto; A. P. Mathieu, Montreal; M. P. McDonald, Toronto.

Buckingham.—The Buckingham Mines, Limited, was incorporated on March 26, 1918, to work mining claims T.R.S. 3664, 2461, and 2407 in Asquith township, and T.R.S. 2406 in Fawcett township. The company has a capitalization of $1,000,000, divided into shares of $1 par value. The officers are: president, Sumner Cottingham; vice-president, Charles S. Buckley; J. W. Cottingham; Fred. Essex; J. A. Stalter, all of Columbus, Ohio.

Some years ago an 85-foot shaft, inclined at 60 degrees, was sunk on mining claim T.R.S. 2461. For a short time in 1922 some men were employed by the company in cutting wood and building camps. M. P. McDonald, West Shiningtree, Ont., is manager.

Churchill.—Churchill Mining and Milling Company, Limited, was incorporated on March 22, 1918, with an authorized capital of $1,000,000 in shares of $1 each; this capital was increased by supplementary letters patent to $2,000,000. One million shares of the stock was allotted to Walter R. Knox in exchange for four mining claims in Churchill township, T.R.S. 3741, 3773, 3774, 4044.

The directors are: president, Walter R. Knox, Orillia; secretary, James G. Merrick, 117 King Street West, Toronto; M. P. McDonald, Shining Tree, Ont.; A. N. Broadhead, Jamestown, N.Y.; Israel Singer, Toronto.

In 1922 the company built several log camps and did some road-building. Seven men were employed from May 1 until September 1 under the direction of J. A. Knox.

Herrick.—Since August 22, 1922, The Tonopah Mining Company of Nevada has been working the Herrick mine in the West Shining Tree area under an option to purchase. The head office of the company is at 572 Bullitt Building, Philadelphia, Pa., and the officers are: president, J. H. Whiteman; vice-president, Chas. R. Miller; secretary and treasurer, P. S. Bickmore.

On February 15, 1923, the work completed consisted of: the vertical two-compartment shaft sunk from 108 feet to 308 feet; on the 200-foot level, a station and sump cut; on the 300-foot level, 259 feet of crosscuts and 631 feet of drifts. In 1920 the Herrick Gold Mines, Limited, which owns the property, did about 100 feet of lateral work on the 100-foot level, but no work has been done on this level by the present operators.

Armistead F. Carper, Shining Tree, Ont., is superintendent, and Felix D. Henderson, of Timmins, Ont., is contractor.

Hologden.—In the Thirty-first Annual Report particulars were given of Hologden Mines, Limited, and its holdings south of MacDonald lake, Asquith township, were enumerated. No change has been made in the directorate.

During most of the time between March 15 and November 15, 1922, the company had a crew of seven men at work. Considerable stripping was done, and a road was built from the company's claims to the road leading to the Holding mine. Also two prospect shafts were sunk; one on mining claim T.R.S. 4043, near the camp, 35 feet deep; and one on T.R.S. 4229, 27 feet deep. The president, Hart Martin, of North Bay, Ont., supervised the work.

Kingston.—A syndicate called Kingston Gold Mines carried on work during the summer of 1922 on a group of three mining claims, situated east of Wasapika lake and known as the Kingston property. These claims are half a mile north of the southern boundary of MacMurchy township, and their numbers from west to east are T.R.S. 3715, T.R.S. 2508, and T.R.S. 4955.

Work was stopped in the autumn after the following had been completed: A shaft sunk to a depth of 50 feet on the T.R.S. 3715, near its east boundary; about 600 feet west of this shaft a second shaft 17 feet deep; 1459 feet of diamond drilling; 1,000 feet of trenching on claims T.R.S. 3715 and T.R.S. 2508.

Edward B. E. deCamps, Shining Tree, Ont., was in charge.

Shining Tree Consolidated.—Shining Tree Consolidated Mines, Limited, has been incorporated with an authorized capital of $5,000,000, divided into shares of $1 par value each. By contract dated December 7, 1922, the company has agreed to purchase from Walter E. Knox, of Orillia, Ont., 29 mining claims, totalling 1,160 acres, in the West Shining Tree area for 1,600,000 shares of the company's capital stock.

These claims are in four groups: five claims, 200 acres in all, east of the Wakenda property, or about half a mile north of the Wasapika shaft; five claims about 200 acres, a quarter of a mile west of the Herrick property; six claims, about 240 acres, south and southwest of the Churchill; thirteen claims, about 520 acres, south and southeast of the Kingston.

The directors of the company are: president, F. H. Plant, Ottawa, Ont.; vice-president, Russell Nesbitt, Toronto; secretary-treasurer, Israel Singer, 133 Queen Street West, Toronto; managing director, M. P. McDonald, Toronto; George Gallup, Boston, Mass.; Dr. B. J. Bixby, Buffalo, N.Y.; Walter R. Knox, Orillia, Ont.

Wasapika.—Ribble Mines, Limited, particulars of which company were given in the Thirty-first Annual Report, re-opened the Wasapika mine in the spring of 1922 and were still carrying on development work at the end of the year. When last inspection was made on September 26, the underground work completed was: the vertical, two-compartment shaft, 208 feet deep; on the 100-foot level, 60 feet of crosscutting and 80 feet of drifting; on the 200-foot level, 25 feet of crosscutting and 50 feet of drifting. A large camp was built during the year.

George R. Rogers, the president of the company, is also the general manager.

West Tree.—After lying idle since 1919, the West Tree mine (formerly known as the Caswell) was re-opened in August, 1922. There are three shafts on this property. Two of these are on the east side of the southeast bay of Michiwakenda lake, are 55 and 60 feet deep, and were sunk some years ago. The work done in 1922 was in the third shaft, which is on the west shore of the lake; it was deepened from 67 to 117 feet and 46 feet of crosscutting was done at the 100-foot level. As the power plant was inadequate, new machinery was bought in the autumn.

The mine is owned by West Tree Gold Mines, Limited, of which the directors are: president, Senator George W. Fowler, Ottawa; vice-president, Senator B. C. Prowse, Charlottetown, P.E.I.; secretary, K. G. Robertson, 632 Bank of Hamilton Building, Toronto; Gideon Grant, Toronto; managing director, William D. McKay, Ottawa.

White Rock.—White Rock Mining Company, Limited, which has been working on the Saville vein in the West Shining Tree area since 1920, stopped work on September 4, 1922. The underground workings consist of: a two-compartment vertical shaft, 175 feet deep; on the 65-foot level, a crosscut 21 feet long from the shaft to the vein, and 201 feet of drifts to the northwest and 100 feet of drifts to the southeast; at a point 185 feet northwest of the shaft a raise, 75 feet long, extending from the 65-foot level to the surface; on the 170-foot level, 126 feet of crosscuts and 628 feet of drifts.

The directors of the company are the same as mentioned in the Thirty-first Annual Report. A. E. McVittie, Shining Tree, Ont., is manager.

Iron

Moose Mountain.—Moose Mountain, Limited, has not operated the mine and concentrating and agglomerating plant at Sellwood since November, 1920. Early in 1923 it was announced that the company purposed selling all of its machinery.

Nickel and Copper

British America Nickel Corporation.

The directors and officers of the British America Nickel Corporation, Limited, remain the same as mentioned in the Thirty-first Annual Report of the Ontario Department of Mines.

The Nickelton smelter and the Murray mine, owned by this company, were closed down during all of 1922.

International Nickel Company of Canada.

The directors of the International Nickel Company of Canada, Limited, are: president, John L. Agnew, Copper Cliff, Ont.; secretary, Britton Osler, Toronto; treasurer, James L. Ashley, New York City; Robert C. Stanley, New York City; W. B. Lawson, New York City; F. S. Jordan, New York City; Alfred Jaretzki, New York City; A. D. Miles, Toronto.

In 1922 the company's Creighton mine and Copper Cliff smelter remained shut down until the latter part of August, when work was resumed. The average number of men employed during the year was 300.

The International Nickel Company owns all the capital stock of the International Nickel Company of Canada, Limited. The stock of the parent company consists of: common shares (par $25), $50,000,000 authorized, $41,834,600 outstanding; 6 per cent. non-cumulative preferred shares (par $100); $12,000,000 authorized, $8,912,600 outstanding. The executive officers of the parent company are: chairman of the board, Charles Hayden; president, Robert C. Stanley; vice-president,, secretary and treasurer, James. L. Ashley; comptroller, James W. Beard; all of New York City. The directors are: James L. Ashley, William N. Cromwell, William E. Corey, Charles Hayden, Alfred Jaretzki, Seward Prosser, William W. Mein, Robert C. Stanley, Andrew V. Stout, all of New York City; William T. Graham, Greenwich, Conn.; John L. Agnew, Copper Cliff, Ont.; Thomas Morrison, Pittsburgh, Pa.; Britton Osler, Toronto, Ont.

The officers residing in Copper Cliff, in addition to those mentioned elsewhere in this report, are: president, John L. Agnew; general manager, John C.

Nicholls; assistant to the general manager, E. A. Collins; master mechanic of mines, David Butchart; electrical superintendent, J. B. McCarthy; transportation superintendent, G. A. Sprecher; works auditor, F. C. Allgeier; chief engineer, Leslie R. Sheridan; mines engineer, Allan F. Brock; purchasing agent, W. T. Waterbury; chief chemist, Heine Waern.

The following information is extracted from the twenty-first annual report of the company, dated June 4, 1923, and covers the fiscal year ending March 31, 1923:—

For the International Nickel Company the year 1922 was a period of constructive reorganization as the company slowly recovered from the serious depression of the previous year. The remaining war inventories were liquidated, and operations were resumed after a prolonged shut-down. Throughout the fiscal year ending March 31, 1923, improvement in business was steady and continuous. Sales of nickel equalled the pre-war volume of 1910, and sales of monel metal exceeded those of any year since this alloy was introduced in 1906.

Refinery production at Port Colborne, Ont., was currently adjusted to sales' requirements and this plant is now operating at approximately 75 per cent. capacity.

During the past year the electrolytic refining plant was transferred from Bayonne, N.J. to Port Colborne, Ont., and modern equipment of increased capacity was installed. Electrolytic nickel, for which there is an increasing demand, can now be produced at lower cost owing to the use of hydro-electric power. A further saving, resulting from an increased production of electrolytic nickel, is the total recovery of platinum metals from the matte thus refined.

The Orford works, at Bayonne, N.J., has been abandoned and the stocks of metal, fuel and supplies transferred to other plants. By concentrating the nickel-refining at Port Colborne and the monel-metal operations at Huntington, West Virginia, many economies have been effected.

The new monel-metal rolling-mill was completed last July at a total cost of $3,690,000.00. Production was started in August and the mill is now operating satisfactorily. The company is now for the first time equipped to roll pure nickel rods and sheets, although for many years pure malleable nickel ingots have been a standard product.

The net operating income (consolidated) for the year was $847,089.27. After providing $394,727.81 for depreciation and depletion, and $389,191.24 for expense and maintenance of shut-down mines and plants, the profits (consolidated) for the year were $48,170.22. This is in contrast to a loss of $797,746.93 in the previous year. Inventories now amount to $5,657,899.47, as compared with $9,340,598.86 a year ago.

The amount written off property account was $2,404,402.69. The major portion of this amount to cover the dismantling of the Orford works at Bayonne, N.J., was charged against the accumulated plant depreciation reserve.

Four dividends of 1½ per cent. each on the preferred stock of the company were paid during the fiscal year. The net earnings for the year of the International Nickel Company of New Jersey, inclusive of dividends received from its subsidiaries, were in excess of the amount so distributed. No dividends were paid on the common stock.

Foreign sales of nickel improved during the past year and, since the Huntington works were completed, the sales of rolled products have doubled. The substantial rise in the price of copper is advantageous as blister copper is an important by-product from the Port Colborne refinery.

The number of shareholders increased during the fiscal year from 17,714 to 18,478.

Copper Cliff Smelter.—After a shut-down extending over one year the Copper Cliff smelter was put in operation on September 1, 1922, when two furnaces were blown in. A third furnace was blown in on November 23. Up to the end of the year the Wedge and reverberatory furnaces had not been put in commission.

The officers at the smelter are: superintendent, Donald MacCaskill; metallurgist, James W. Rawlins; smelter master mechanic, George R. Craig; blast furnace foreman, Peter McDonald; converter foreman, Frank Taylor; reverberatory and Wedge furnace foreman, Joseph K. Workman.

Creighton.—The Creighton mine was shut down for exactly one year, hoisting being resumed on August 26, 1922. Three stopes are being worked above the fourteenth level, and many of the pillars between the fourteenth and tenth levels are being drawn. Shipments for the year totalled 55,980 tons. The annual report of the company, dated June 4, 1923, states that the Creighton has proven ore reserves sufficient to maintain the present rate of production for more than twelve years. The working force from August 26 to December 31 has averaged 165 men.

The staff at the mine consists of: superintendent, William J. Rolfe; mine foreman, Charles Lively; master mechanic, John Symons; electrician, Alex. McIntyre.

Dill Quarry.—The Dill quartzite quarry at Quartz, Ont., was not worked in 1922.

MOND NICKEL COMPANY.

The board of directors of the Mond Nickel Company has been enlarged and now consists of: Rt. Hon. Sir Alfred Mond, Bart. (chairman); C. V. Corless, LL.D.; Viscount Erleigh, D. Owen Evans, Sir E. J. Griffith, Sir Robert A. Hadfield, Dr. Carl Langer, Carl Langer, Jr., Robert Mathias, Emile S. Mond, Henry Mond, Philip Mond, Robert L. Mond, S. W. A. Noble, Sir Byron Edmund Walker. The secretary is D. Owen Evans, 39 Victoria Street, London, S.W., England.

The following quotation is from the *Engineering and Mining Journal-Press* and is part of a speech made at the eighth annual general meeting of the company, on July 26, 1922, by Robert L. Mond, at that time chairman of the board.

I referred at our last general meeting to nickel coinage in Canada and Italy. The new coins have given great satisfaction, and the coinage has been considerably extended in those countries, and has also been adopted in other countries since we met last year.

Among the important steps we have taken in order to extend the use of nickel, I would mention that we have acquired control of Henry Wiggin and Co., Ltd., in this country in order to promote new outlets for our nickel and to share in the manufacture of nickel products. For the same reasons we have recently participated in the formation of the American Nickel Corporation, of Clearfield, Pa., whose business it is to manufacture malleable nickel in a variety of forms for use by manufacturers of nickel goods.

I need hardly mention to you that the potential consumption in the United States is immense, and we fully expect that the technical skill of the management will enable the corporation to produce material of the highest quality, so that the manufacturers of finished nickel goods in America will be in a position to compete successfully with articles which were in the past imported from Europe, but largely to extend the use of these articles in the biggest market of the world. We have appointed the corporation our representative for the sale of raw nickel in the United States, and we are determined to secure our fair share of the market also in that country.

As regards our other important product, copper sulphate, the market for this has been almost normal as regards tonnage, but the price has been kept on a low level for reasons already stated. The sales of precious metals have been well maintained. The costs of production of our products although much lower than they have been, are still higher than we should like.

The Canadian staff of the company, exclusive of those mentioned under the several properties, is as follows: Dr. C. V. Corless, manager; Oliver Hall, superintendent of mines; John F. Robertson, superintendent of reduction works; W. H. Soule, electrical superintendent; L. J. Ingolfsrud, chief engineer; T. M. Paris, chief chemist; W. A. MacDonell, cashier; Harry M. Stevenson, paymaster; Frank Simms, purchasing agent. All reside at Coniston.

W. L. Dethloff, for many years chief engineer of the company in Canada, has vacated the position to become general manager of the America Nickel Corporation, Clearfield, Pa.

Coniston Quartzite Quarry.—The Mond Nickel Company worked this quarry from April to December 15, 1922, the quartzite being used for converter flux.

Coniston Smelter.—One furnace continued in blast at the Coniston smelter in 1922. A number of improvements in the smelting practice have increased the output considerably. The average number of men employed during the year was 335.

The concentrating plant has been enlarged, and the new machinery is expected to be in operation early in 1923. This plant was built for experimental purposes and was expected to treat 60 tons per day, using concentrating tables and Mineral Separation flotation machines. It proved a decided success, and has been treating from 70 to 80 tons per day. When the new units are in operation, the capacity is expected to be 200 tons.

The smelter officers are: E. T. Austin, superintendent of the smelter; K. S. Clarke, superintendent of the sintering and concentrating plants; John Grigg, master mechanic.

Garson.—In 1922 the shipments from the Garson mine amounted to 57,067 (short) tons. All of this ore came from between the fourth and sixth levels. The only development work done consisted of 266 feet of drifting and 132 feet of raising. About 75 men were employed.

The mine officers are: superintendent, Capt. A. L. Sharp; mine foremen, Alex. Pollock and Chas. Caesar.

Levack.—The Levack mine of the Mond Nickel Company was operated continuously in 1922, but with a small force of workmen. As in the preceding year, practically all of the ore stoped came from between the third and fifth levels, but the large No. 54 stope was carried to some distance above the third level. The development work done during the year consisted of: drifting, 548 feet; raising, 614 feet, and section-cutting 680 square feet. About 80 men were employed.

Frank J. Eager, Levack, Ont., is superintendent; William Shovel, mine foreman; and William J. Serpell, master mechanic.

Victoria.—The ore stoped during 1922 in the Victoria mine of the Mond Nickel Company came from between the eighteenth and seventeenth levels, the fifteenth and fourteenth, the third and second, and from the removal of the sixteenth, fifteenth and fourteenth floor pillars.

In June an inclined raise was started from the fifth (or 367-foot) level and was driven to 148 feet above the level. From the top of this raise a crosscut was run to an old working on No. 4 ore body, which is 950 feet southeast of the main shaft. This old working is 204 feet deep and only the portion above the 60-foot level was stoped when work was carried on in 1913.

During the year ore was shipped from still another deposit on this property—the Lake Hill. This ore body is 2,250 feet southeast of the Victoria main shaft and is beside the siding that connects the Victoria mine with the Algoma Eastern Railway. In 1900 a shaft was sunk to a depth of 40 feet and a little drifting done at the bottom. In June, 1922, stoping was started from this shaft. For the first 50 feet the deposit was about 65 feet long and 22 feet wide. At the end of the year stoping had been carried to a depth of 100 feet. At the bottom was one lens of ore, 45 feet long and 20 feet wide, running east and west; and, east of this lens and separated from it by 12 feet of rock, was a second lens running about N. 15° W. and measuring 40 feet long and 9 feet wide.

The shipments for the year were: from Victoria, 32,737 (short) tons; from Lake Hill, 5,890 (short) tons.

W. J. Mumford, Mond, Ont., is superintendent. The average number of men employed was 78.

Worthington.—In 1922 an average of 68 men was employed at the Worthington mine of the Mond Nickel Company; of these, 30 were underground workmen. Stoping was carried on between the third and fifth levels and a small quantity of ore was extracted from between the second and third. Shipments for the year totalled 22,861 (short) tons.

A drive on the first (or 160-foot) level is being extended N. 78° E. to prospect an ore body that outcrops on the surface 800 feet from the shaft.

Towards the end of the year it was decided to raise a new piece of shaft from the sixth (900 feet, vertical depth) level to a short distance above the second level (263 feet, vertical depth). The new shaft will be raised from the sixth, fifth, fourth and third levels and, like the old one, will consist of three compartments; it will be at an angle of 83 degrees, entirely in the footwall, and will permit of the abandonment of the lower part of the existing shaft and the extraction of the pillars of ore through which the latter passes. The old shaft is at 61 degrees for the first 388 feet (vertical depth); from 388 to 450 feet it is curved; and from 450 to 750 feet it is at 80 degrees.

A. D. Carmichael, Worthington, Ont., is superintendent; William McKerrow, mine foreman; and J. A. Newell, master mechanic.

Zinc

Meehan-Ollier.—In the autumn two diamond-drill holes, each 250 feet deep, were bored on the Meehan-Ollier zinc prospect in the Sudbury basin. This property is in the north half of lot 9, concession VI, Creighton township; it is southwest of Chelmsford, near Platinum post office. Several prospect shafts were sunk here a number of years ago.

III.—DISTRICT OF TIMISKAMING

Gold

Painkiller Lake

Blue Quartz.—The Blue Quartz Gold Mines, Limited, has a capital of $3,000,000 in $1 shares. H. C. Crow is president, and C. H. Taylor, vice-president. The head office of the company is at 414 Confederation Life Building, Toronto. The company operated their property at Painkiller lake in Beatty township during the year.

J. J. Hollinger is manager and twenty men are employed.

The year's development work included sinking the shaft from 100 to 200 feet, and the driving of 400 feet of drifts and crosscuts on the 100-foot level, and 600 feet on the 200-foot level.

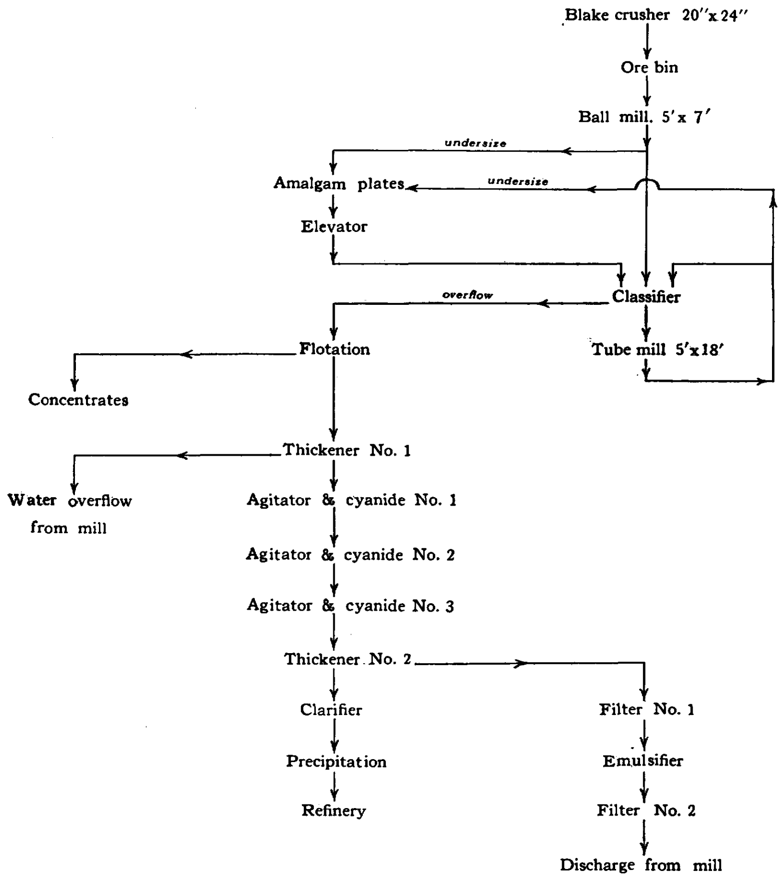
A new compressor house 40 feet by 40 feet was built and a 730 cubic foot Ingersoll-Rand air compressor, and a 10 by 12 hoist are being installed.

Hattie.—The Hattie Gold Mines, Limited, own 200 acres in lots 6 and 7, concession 1, Coulson township, on the north side of Painkiller lake. The company is capitalized at $2,000,000 in shares of $1 par value. The directors are: Dr. W. P. St. Charles, president; John K. Papassimakes, vice-president; A. G. Slaght, secretary; Carlos Warfield, managing director; W. W. Butler, chairman of the board. The president's address is Toronto, and the managing director's, Windsor Hotel, Montreal.

Surface work began about the end of May with a force of five men, which was later increased to fifteen men. The following buildings were erected: a power house, 50 feet by 30 feet; a manager's residence, 30 feet by 30 feet, and a smithy, 15 feet by 20 feet. The bunkhouses were renovated and provide accommodation for 24 men. A plant was installed which consists of a 75-horsepower Fairbanks-Morse semi-Diesel oil engine, a 365-cu. ft. Ingersoll-Rand air compressor and a 6 by 8 hoist.

Commencing in October the prospect shaft on the property was continued from a depth of about 90 feet to a depth of 245 feet in February. The intention is to sink this shaft at least 400 feet.

Late in the year L. T. Herkimer was succeeded as manager by Charles Mentzel, the company's consulting engineer.



Flow Sheet, Argonaut Gold, Limited.

Larder Lake

Argonaut.—Argonaut Gold, Limited, has an authorized capital of $3,000,000 in shares of $1.00 par value, of which nearly 400,000 shares remain in the treasury. The officials of the company are: J. H. Rainville, president and general manager; F. A. LaBelle, vice-president; Louis J. A. Marchand, secretary-treasurer; J. W. Morrison, general superintendent. The head office is at 145 St. James Street, Montreal.

An average of fifty men was employed.

The development work for 1922 consisted of sinking the shaft from the 350 to the 500-foot level, and 310 feet of lateral work on the 200-foot level, 882 feet on the 350-foot level, and 1,000 feet on the 500-foot level. In addition, 1,022 feet of diamond-drilling was done.

A 150-ton mill is in course of erection, the intention being to begin treating 50 tons daily. The crushing capacity is ample for the full tonnage, but a 5 by 7-foot ball mill only will be used at present, though a 5 by 18-foot tube mill is being installed for fine grinding.

The following details of the mill are supplied by the general superintendent:

The ore is first crushed in a jaw crusher of the Blake type, 20 by 24 inch, to pass a 1¼ inch ring. It is then carried by conveyer belt to the storage bin in the mill. From here it is fed to a 5 by 7-foot ball mill (straight line); the undersize, approximately below 12-mesh, goes direct to amalgamating plates, while the oversize is returned to a Dorr classifier. The classifier discharges into a 20 by 5-foot tube mill, and the undersize from the tube mill also goes to amalgamating plates, the oversize being returned to the classifier. The tails from the amalgamating plates are elevated and returned to the classifier.

The overflow from the classifier goes to the flotation machine, a Callow cell, of approximately 100 tons capacity. The sulphides are here recovered and stored for shipment. The discharge from the flotation passes to a 30 by 10 foot Dorr thickener, the overflow of which passes from the mill. The overflow from the thickener goes to the No. 1 agitator where the cyanide is added. After passing through three agitators, 16 by 18 feet, the pulp again enters a Dorr thickener 30 by 10 feet. The overflow from this thickener goes to the Crowe vacuum precipitating plant, while the overflow is carried to two American vacuum filters, the second one acting as a water wash. From the second filter the pulp is discharged.

The distinct feature of the process is that the amalgamation takes place between the grinding mills and the classifier, the separation being made by screens attached to the discharge of the mills.

Associated Goldfields.—The Canadian Associated Goldfields, Limited, has an authorized capital of $30,000,000 in $1 shares, of which 21,141,844 shares have been issued. The officials of the company are Dr. Geo. A. Mackay, president; R. William Mackay, secretary-treasurer. The head office of the company is at 306 C.P.R. Building, Toronto.

W. J. Rolph was succeeded during the year as general superintendent by T. A. Graves. An average force of forty men is employed.

Developments on Block "A" of the company's property, adjoining the Crown Reserve property, continue promising. The work done during 1922 consisted of 160 feet of shaft sinking, and 1,600 feet of drifting and crosscutting, as follows: 800 feet on the 200-foot level, 600 feet on the 300-foot level, 200 feet on the 500-foot level. Upwards of 30 feet of what is claimed to be a good grade of milling ore has been developed on the 300-foot level at the eastern end of the workings adjoining the Crown Reserve property.

Expenditures for the year totalled $191,330, including $12,000 spent in open cut and tunnel excavation in connection with the Wendigo power development. The current assets at the end of the year were $517,679, made up of cash and Victory bonds to the extent of $462,780.

Crown Reserve.—The Crown Reserve Mining Company, Limited, capital $2,000,000 in $1 shares, began surface operations in March on their property at Pancake lake, in McVittie township, with a force of twenty-five men, under Capt. A. S. Crowe.

H. J. Stewart is general manager.

The following buildings were erected: office, 35 by 24 feet; cook camp, 25 by 55 feet; store house, 20 by 21 feet; carpenter shop, 24 by 32 feet; dry, 12 by 20 feet; power house, 30 by 40 feet; smithy, 18 by 30 feet; and shaft house, 16 by 37 feet.

A steam plant was installed which consisted of a 125-h.p. boiler, 480-cu. ft. Allis-Chalmers straight line air compressor, and an 8 by 10 hoist.

Shaft sinking was begun in June and a three-compartment shaft was sunk to the 300-foot level, where 287 feet of crosscutting and 213 feet of drifting was done. This work having confirmed the results of the diamond drilling done the previous year, sinking was resumed in the New Year, the objective being the 550-foot level.

Prospects are very good for the development of a mine of considerable tonnage.

Elstone-Dunkin.—The Elstone-Dunkin property in Gauthier township was held under option by the Thompson-Chadburne interests of New York. Considerable work was done in the way of trenching and the sinking of test pits for examination, but the option was not exercised.

Ossian.—The Ossian Mines, Limited, acquired during the year six of the Fishley-Hurd group of claims in Ossian township. These include 11, 131-2, 11,-185-7-8 and 11,413.

The company has a capital of $2,000,000 in $1 shares. The board of directors is as follows: Anton Eichler, president; A. J. Bolton, vice-president; W. J. Yeoell, treasurer; W. R. Wadsworth, of Bartram and Wadsworth, Solicitors, Toronto, secretary; W. E. Hurd and Frank Fishley.

Discovery was made in June on claims 11,131-2. Two log camps, 16 feet by 18 feet were erected during the summer and in the winter a boiler and a hoist house was completed and a 30-h.p. boiler and a 6 by 8 Jenckes hoist installed.

Ralph Hurd is manager. Seven men were employed. J. C. Lively has the contract for sinking a shaft which was sunk to a depth of 35 feet by hand steel before the steam plant was installed. Lack of water for the boiler held up the work for some time during the winter.

Skead Township

Skead.—Skead Gold Mines has an authorized capital of $5,000,000 in shares of $1 par value. The company holds fifty-five claims in the vicinity of St. Anthony lake in Skead township.

Wood-cutting began in April with a force of eight men, and the building of camps in May. Seymour Stevens was in charge and seventeen men were employed.

No further mining work was done, but an option was taken on four of the company's claims by A. D. Miles and associates, who did considerable diamond drilling during the summer.

Wisconsin-Skead.—Wisconsin-Skead Gold Mines, Limited, operated their property during the month of May with a force of eight men. C. C. Huffman was manager.

Very little work was done underground except some slashing of the walls on the 112-foot level.

The company's office is at Ashland, Wisconsin, and the capitalization is $2,000,000.

Kirkland Lake

Baldwin.—Baldwin Gold Mining Company, Limited, has an authorized capital of $2,500,000 in shares of $1 par value. The officials of the company are: F. W. Tanner, president; F. W. Gates, vice-president; J. H. Cherry, secretary-treasurer; and the head office is at 301-2 Dominion Bank Building, Toronto.

The company owns the north half of lot two, concession six, in Eby township, near Kenogami Lake station, on the T. & N.O. Railway.

Operations were resumed on October 25 with the de-watering of the 200-foot shaft on the property. Between 90 and 100 feet of drifting was done on the 100-foot level in 1922.

B. Ashley is manager and 12 men are employed.

Bidgood.—Bidgood Gold Mines, Limited, has an authorized capital of $3,500,000 in shares of $1 par value. The directors and officials of the company are: George Tough, New Liskeard, president; George Gerrie, Hamilton, vice-president; Edwin W. Kearney, Haileybury, secretary-treasurer; David H. Angus, Haileybury, manager; Thos. B. Tough, R.R. No. 1, Niagara Falls, Ontario; Daniel Hughes, Haileybury.

An average of thirty men is employed.

The work accomplished to date on the company's property in Lebel township comprises a 600-foot shaft and about 3,400 feet of lateral work on the 300-foot, 400-foot and 600-foot levels.

Canadian Kirkland.—Canadian Kirkland Gold Mining Company, Limited, has an authorized capital of $3,500,000 in shares of $1 par value. The directors of the company are: Thos. B. Tough, Niagara Falls, Ontario, president; David H. Angus, Haileybury, vice-president; Edwin W. Kearney, Haileybury, secretary; George Tough, New Liskeard,; Frank J. Carew, Lindsay.

The buildings were remodelled in February and the mine pumped out in April. Sinking began in August, and the shaft was continued from a depth of 150 feet to 400 feet. Including the work previously done on the 100-foot and 150-foot levels, about 800 feet of lateral work has been accomplished to date of end of first quarter of 1923.

Twenty men are employed.

Columbus-Kirkland.—The Columbus Kirkland Gold Mines, Limited, of which Mr. James E. Day is president, and Mr. Mongovan, 26 Adelaide Street West, Toronto, is secretary, own a group of claims situated one mile north of the Teck-Hughes mine at Kirkland lake.

A. W. Grierson is manager, and six men were employed erecting camps and doing surface prospecting from November 16.

Continental Mines.—Continental Mines, Limited, has an authorized capital of $3,500,000 in $5 shares. The board of directors of the company is as follows: R. W. Warriner, president; Thomas Riggs, vice-president; Frederick Bull, treasurer; Frederick D. Faust, A. J. Wadhams, R. Home Smith, Charles McCrea and George Buchanan, directors. W. Schnaufer, Jr., is secretary. The head office of the company is at 43 Exchange Place, New York.

The company has acquired twenty-seven claims in Lebel township, and also through a subsidiary operates the Colonial mine at Cobalt. The group of claims in Lebel township comprises numbers 2450, 2430, 2257, 2452, 2459, 2677, 2808, 2807, 2447-8, 8912, 2790-1, 6477-8, 7798-9, 2676, 3009-10-11, and 8819-20-21-22-23 and 24. The last nine claims were formerly the Kirkland-Munro group.

M. B. Glazier is manager, and forty men on an average were employed for the last seven months of the year.

During the summer months surface prospecting was carried on. The work comprised a total of 21,173 feet of trenching, 11,605 cubic yards of excavation and four test pits, 48 feet in all. During the winter months a two-compartment shaft was sunk with a force of fourteen men, and by April 12 had reached a depth of 134 feet.

Dominion Kirkland.—Dominion Kirkland Mines, Limited, did some work on claims 5939 and 7015 in Teck township, which the company owns.

Goodfish.—The Goodfish Gold Mines, Limited, has a capital of $2,000,000 in shares of $1 par value. Ernest Martin is president of the company; Edward Brennan, vice-president; Harry Oakes, H. L. Slaght, and M. J. McGibney, directors.

The company operated their property at Goodfish lake, in Morrissette township, during most of the year. Ernest Martin is manager, and nine to sixteen men were employed.

A mining plant consisting of a 60-h.p. boiler, 540-cu. ft. Ingersoll-Rand two-stage air compressor and a 6 by 8 Jenckes hoist was installed.

The shaft, which is an incline of 60 to 75 degrees, was continued from 50 feet to a depth of 200 feet during the year, and 100 feet of drifting and cross-cutting was done, mainly on the 200-foot level.

Harvey-Kirkland.—The Harvey-Kirkland Mines, Limited, has an authorized capital of $5,000,000 in $1 shares, of which 2,000,000 shares are issued. The board of directors comprises E. C. Fox, E. W. Backus, B. Neill, D. I. Grant, and C. J. Beilby. J. W. Beilby, 59 Yonge Street, Toronto, is secretary-treasurer.

G. G. Thomas is manager, and twelve men were employed.

The company owns claims in Lebel township, one mile east of the Montreal-Ontario mines. Surface work began June 15, and a shaft was sunk 32 feet, between October 10 and November 7, after which time a plant was installed, a head frame erected and sinking operations resumed on January 16.

The plant consists of a 624-cu. ft. Ingersoll-Rand cross-compound air compressor driven by a 100 h.p. motor, and a 6 by 8 Jenckes hoist. The following buildings were erected: bunk house, 40 by 28 feet; cookery, 26 by 24 feet; office, 16 by 14 feet; a residence, 33 by 18 feet; power house, 26 by 30 feet; smithy, 16 by 18 feet; and stable, 16 by 24 feet.

Highland Kirkland.—Highland Kirkland Mines, Limited, was formed under a Provincial charter to acquire fourteen mining claims in the township of Teck, namely: claims 15750-1-2-3-4, 16550-1-3-4-5-8, 16691, 1356, and 7863. The company has an authorized capital of $100,000 in shares of $1 par value, of which 92,000 shares have been issued, 52,000 shares for properties and organization expenses, and 40,000 shares to a Toronto syndicate for financing the present development. The directors of the company are: T. McCamus, president; M. T. Barney, vice-president and manager; F. L. Hutchinson, secretary-treasurer; A. A. McKelvie and S. D. Eplett, all of New Liskeard, Ont.

Diamond-drilling operations began in March, and two holes were put down on claims 1356 and 15752 to depths of 1,000 feet. About 4,000 feet of surface trenching was done during the summer months, and a test pit sunk 18 feet. A shaft 5 feet by 7 feet was sunk to a depth of 50 feet on claim 16555 by the end of the year.

Two camps, 18 by 20 feet and 18 by 21 feet, were erected. Eight to ten men were employed.

Hunton.—The Hunton-Kirkland Gold Mines began pumping out the shaft on their property in October and resumed sinking operations on November 1. The company has a capitalization of $2,500,000 in $1 shares. The board of directors is composed as follows: Thomas Birt, president; Jacob G. Rosenburg, vice-president; H. M. Porteous, secretary-treasurer; J. T. Willey, Kirkland Lake, and Simon N. Stein, Rochester, N.Y.

H. M. Porteous is manager, and fifteen men are employed.

A station was cut at a depth of 125 feet and the shaft continued to the second level at 250 feet by the end of the year, and to a depth of 375 feet by the end of March.

King-Kirkland.—The King-Kirkland Gold Mines, Limited, has an authorized capital of $2,500,000 in shares of $1 par value. Half of these shares are issued and half remain in the treasury. The directors of the company are: C. F. Jordan, president; G. I. Hambly, vice-president; A. B. Crosby, treasurer; G. A. M. Davison, Unionville, secretary, and N. C. Smith, Burlington.

A mining plant was installed early in the year. This comprises two 80-h.p. boilers, a 740-cu. ft. Ingersoll-Rand cross-compound air compressor, and an 8 by 10 Lidgerwood hoist.

Sinking began in the shaft, which is on a 75-degree incline, in June, and it was continued from 100 feet to a depth of 450 feet during the year.

Ernest Craig is manager, and twenty-five men are employed.

The property was closed during the first quarter of 1923, pending negotiations with the Tonopah Mining Company, and in April it was announced that this company had secured a working option on the property for three years. Continuous work is to be kept up and the Tonopah Company agrees to prove ore deposits to the extent of or in excess of $1,000,000 in value. A company is then to be formed with $1,000,000 capital and shares issued in the ratio of 40: 60 to the King-Kirkland and the Tonopah companies. The Tonopah company also agrees to advance money to build a 100-ton mill, provided developments warrant its erection.

Kirkland Gateway.—The Kirkland Gateway Gold Mines, Limited, began surface work in June on the Lucky Cross property at Swastika, with a force of twenty-five men. Robert J. Jowsey is manager.

The plant and camp buildings were renovated and a new 10 by 12-inch hoist installed. A new head frame was erected and also an office building and store house, 25 feet by 40 feet.

Mining operations began on September 23 and a total of 302 feet was driven on the 224-foot level during the four months. During the winter a shaft which is on a 65 degree incline, was continued from the 224-foot level, and had reached a depth of 305 feet in March.

Kirkland Lake Gold.—The Kirkland Lake Gold Mining Company, Limited, capitalization $2,000,000 in shares of $1 par value, operated continuously during 1922, with the exception of the month of October, when power was off owing to the disastrous bush fire of October 4. This company owns 362½ acres in Kirkland Lake. The officials are: F. L. Culver, president; W. Thos. Mason, vice-president; R. Graham, secretary-treasurer; W. M. Sixt, mine superintendent.

The main central shaft was completed from the 500 to the 1,000-foot level and crosscuts completed to the main break from each level. The most important underground development during the year was on the 800-foot level, where a crosscut driven north from a point 240 feet east of the main shaft encountered an ore shoot which was proven to extend into the lamprophyre. This ore shoot was opened up for 216 feet.

During the 11 months' operations the mill treated 37,489 tons of ore, from which was recovered $224,396.11 in gold bullion. Development during the year included 1,151 feet of drifting, 314 feet of crosscutting, 81 feet of raising, 179 feet of shaft raising and 195 feet of shaft sinking. An average of eighty-five men was employed.

Kline.—Lloyd F. Kline, of North Lima, Ohio, under an option to purchase a seven-eighths interest in five claims in Boston township, owned by E. W. Asselstine, R. P. Graham, and George Brewer, of Cobalt, did some shaft-sinking in August. J. C. Lively was the contractor and three men were employed.

The option was taken in December, 1920, and a log camp 16 by 20 feet was built. In 1921 the shaft was sunk from 10 to 22 feet, and in 1922 this was continued as a two-compartment shaft on a 63-degree incline to a depth of 61 feet.

The plant consists of a 25-h.p. upright boiler, installed in 1922, and a 6 by 8-inch Marsh and Henthorne hoist.

The claims comprise 5316, 5176-7, and 5214-5. Corby and Marshall own a two-fifths interest in the two latter claims.

Lake Shore.—This mine is owned by the Lake Shore Mines, Limited, which has an authorized capital of $2,000,000 in shares of $1.00 par value. The officers of the company are: Harry Oakes, president and managing director; Arthur G. Slaght, vice-president; W. H. Wright, 2nd vice-president; Dr. W. P. St. Charles, treasurer; Kirkland Securities, Limited, secretary; R. C. Coffey, mine manager. The directors are: Harry Oakes, Arthur G. Slaght, Dr. W. P. St. Charles, C. E. Wettlaufer, Albert Wende, J. B. Tyrrell, and Wm. H. Wright.

The manager reports as follows:

During the period December, 1921, to June, 1923, the shaft was enlarged from the surface to the fourth level, 200 feet of sinking completed, steel head-frame erected and double drum electric hoist installed. We now have a well-equipped three compartment shaft in operation to the 800 foot level.

A building 34 feet by 100 feet has been erected accommodating the machine shop, blacksmith shop, electric shop and carpenter shop. Contracts have been awarded for the machinery necessary to increase the milling capacity to 300 tons per 24 hours.

	Feet Advanced	Tons Ore	Tons Waste
Drifting	2,202.69	8,780	1,627
Raising	875.00	2,075	......
Crosscutting	136.92	.....	537
Sinking	197.00	93	2,624
Slashing Shaft	390.00	......	2,490
Box-Holing	8,420 cu. ft.	17	1,502
Stoping	....	24,643	79
Diamond-Drilling	3,145.50	......	......
		35,608	8,859

The mill treated 36,825 tons of ore during the 18-months period, making an average recovery of $22.57 per ton therefrom, and a total production of $831,251.05. Broken ore amounts to 34,700 tons, valued at $801,568.37.

The average number of men employed during the calendar year 1922 was 72, of which number 34 were employed underground and 10 in the mill. The average number of men employed during the six months ending June 30, 1923, was 111, of which number 67 were employed underground and nine in the mill.

Montreal-Ontario.—Montreal-Ontario Mines, Limited, began work on the Ontario Kirkland property on May 6. Crosscuts were driven north on the 300-foot level during the months of May and June. H. G. Young was manager, and fifteen to twenty men were employed.

Charles Spearman became manager in October, and operated with a force of ten men for a month, and continued diamond-drilling until after the New Year. The mining work included a 35-foot raise, 15-foot crosscut, and diamond-drill stations.

W. F. Empey is president of the company, and the directors remain the same as last year. The head office of the company is at 46 Bank of Ottawa Building, Montreal.

Providence.—Providence Gold Mines, Limited, with an authorized capital of $2,000,000 in $1 shares, and 740,000 shares issued, owns five claims north of Goodfish Lake, in Morrissette township. The directors of the company are: A. Archambault, president and manager; C. La Chapelle, vice-president; M. J. McGibney, Edward Brennan and E. Le Mire.

Operations began on claim 2758, which was located in 1912, in April, 1922. The following buildings were erected: a log camp, 20 by 30 feet, two stories high; an office, 18 by 20 feet, and a stable 18 by 20 feet. Shaft sinking began in June and the shaft was continued to a depth of 100 feet on a 45-degree incline by the following March. Two to five men were employed.

The plant, consisting of an upright boiler and a 6 by 8-inch Jenckes hoist, is being moved to claim 2760, and is to be used to open up another vein on the property.

Queen Lebel.—The Queen Lebel Gold Mines, Limited, began trenching on their property in Lebel township at the east end of Gull Lake in the spring of 1921. A 60-foot shaft was sunk in the first quarter of 1922, and in the spring camp buildings and a boiler house were erected.

A mining plant comprising two 50-h.p. boilers, a 420-cu. ft. Ingersoll-Sargent straight line air compressor, and a 7 by 9-inch hoist was installed, but no mining work was done.

E. B. Wood was manager, and nine men were employed during the first half of the year.

Sylvanite.—Sylvanite Gold Mines, Limited, has an authorized capital of $3,000,000 in shares of $1 par value. Edward L. Koons of Buffalo, is president; Albert Wende, of Kirkland Lake, is manager, and twenty-five men are employed.

The No. 2 shaft on the company's property at Kirkland Lake was continued to a depth of 514 feet, and stations established at depths of 129 feet, 260 feet, 393 feet and 500 feet. Crosscuts of 80 feet, 30 feet, 36 feet and 194 feet were driven on the various levels, making a total of 340 feet of crosscutting. In addition, 403 feet of drifting was done on the 500-foot level.

No mining was done between August 28, 1922 and January 26, 1923. During this period a new head frame was erected and the following additions were made to the plant: a new Rand air compressor with a capacity of 1,132 cubic feet, a 100-h.p. motor for driving the same, and a double-drum Ingersoll-Rand hoist.

Teck-Hughes.—Teck-Hughes Gold Mines has a capital of $4,000,000 in shares of $1 par value. The officers and directors are: Charles L. Denison, president; Robert W. Pomeroy, vice-president; George C. Miller, secretary; William C. Himrod, treasurer; Albert W. Johnston and J. F. Thompson.

D. L. H. Forbes is general superintendent, and on an average 105 men are employed.

The following is the report of the general superintendent on the operations for the fiscal year ending August 31, 1922:—

During this period 43,300 dry tons of ore were treated from which bullion amounting to $481,144.02 or $11.11 per ton was recovered. Including exchange premiums and interest, the gross revenue for the year was $501,407.63 or $11.58 per ton. The total *direct* operating cost was $306,912.53 or $7.09 per ton; while *indirect* charges, such as depreciation, new construction, financial charges, extra ordinary expenses, etc., amounted to $82,672.51 or $1.91 per ton, making the total of direct and indirect charges come to $389,585.04 or $9.00 per ton and leaving a net revenue of $111,822.59 or $2.58 per ton. Following is a statement of operating costs in detail.

	Winzing	Raising	Drifting	Cross-cutting	Shaft Sinking	Station Cutting	Total
At August 31, 1921........	512.0	832.5	6,916.5	3,657.8	816	109	12,843.8
Fiscal Year...............	149.5	204.0	1,418.6	447.7	...	...	2,219.8
At August 31, 1922........	661.5	1,036.5	8,335.1	4,105.5	816	109	15,063.6

Development consisted in the opening of the 6th and 7th levels at the 605 and 730 foot depths. On the 6th level, in addition to the expected oreshoots that were found in the No. 3 vein, important orebodies were discovered in two branch veins that strike northeasterly from the No. 3 vein; while, on the 7th level, running parallel to and north of the No. 3 vein, the No. 1 vein was found to have high grade oreshoots of considerable length.

The total ore reserves at August 31, 1922, were estimated to be 79,974 tons with a gross value of $1,183,176.00 of which 19,213 tons are broken.

In December, 1921, the building program of alterations and extensions that had been commenced in July was completed and larger tonnages were treated from that time forward. The maximum tonnage was reached in May, 1922, when 4,846 tons were milled, the ore at that time coming entirely from above the 5th level. With the completion of the sinking work to the 7th level and the sending of high grade ore from the 6th and 7th levels to the mill it was found, however, to be more economical to lower the average daily tonnage to about 110 than to continue to operate the mill at its maximum capacity.

On the whole the year's operations were highly satisfactory, and the finding of important ore bodies in the No. 1 vein at the 7th level is encouraging in relation to the future of the mine at greater depths.

A marked increase has taken place in the grade of the ore from the winze levels as compared with the grade of ore in the first 500 feet. During the last two months of the fiscal year when the treatment of ore from the winze level was again resumed, the average heads were over $23 a ton, and in the month of September the ore treated was of an average grade of $43.79 per ton.

Early in 1923 negotiations were undertaken for the acquisition of the Orr Gold Mines adjoining the Teck-Hughes on the south. A new company, The Teck-Hughes Gold Mines, Limited, was incorporated under a Provincial charter with a capital of $5,000,000 in $1 shares, of which approximately 4,500,000 shares are issued. The new company absorbed the assets of the Teck Hughes Gold Mines, Limited, and of the Orr Gold Mines, Limited, on March 1. The combined acreage of the two properties, comprising 16 claims, is 446.7 acres. Dr. C. E. Wettlaufer and William Reilley, of Buffalo, were added to the directorate.

Tomlinson.—Chesley Tomlinson, of Kenogami Lake, sank a 35-foot shaft while doing assessment work on his claims, Nos. L.9794-5 and 11,082, in Bompas township, at the west end of Kenogami lake. Four men were employed.

Tough-Oakes.—The Kirkland Lake Proprietary (1919) Limited, owners of the Tough-Oakes and Burnside mines in Kirkland Lake, part owners of the Sylvanite mine in Kirkland Lake, and owners of the Aladdin Cobalt Silver Mines in Cobalt, have an authorized capital of £1,000,000 divided into 1,000,000 shares of £1 each, of which 809,129 shares have been issued.

Operations at the Aladdin Cobalt Silver Mine in Cobalt were suspended during the year, and the company's interest in the Sylvanite mine was sold to American interests closely identified with the Wright-Hargreaves mine.

Underground developments on the Tough-Oakes and Burnside properties were encouraging during the latter part of the year. Bullion amounting to £4,105, 14s. and 6d. was produced during the year.

W. R. Thomas, Kirkland Lake, is resident manager.

Wright-Hargreaves.—Wright-Hargreaves Mines, Limited, has an authorized and issued capital of $2,750,000 in $1 shares. The board of directors comprises Oliver Cavana, Jr., president; Edwin Lang Miller, vice-president and secretary; Albert Wende, general manager; Ralph Hochfetter, Charles G. Duffy, and Oliver G. Donaldson, of Buffalo, N.Y., and Harcourt Ferguson, of Toronto, Ont. The head office of the company is at Bridgeburg, Ont., and the executive office, Lafayette Square Building, Buffalo, N.Y.

The company operated its property at Kirkland Lake during the year, except for the thirty days following the big fire of October 4, when power was not available. An average force of 112 men was employed.

The general manager's report on operations for the year ending December 31, 1922, is as follows:—

During the year 66,181 tons of ore were treated and the bullion received therefrom amounted to $762,752.84, with an average value per ton of $11.52. The broken ore on hand December 31, 1922, amounted to 33,200 tons.

The mill operated 88.31 per cent. of its possible running time, being shut down 2.41 per cent. for repairs and 9.28 per cent. for lack of power. The power delay was chiefly due to the forest fires of October last, which made it necessary for us to suspend operations entirely for 30 days.

Analysis of operating costs, reproduced below, shows a total cost per ton milled, including the year's expenditure for exploration and development, of $6.317 per ton.

Development work consisted of sinking No. 3 shaft from 420 ft. to a depth of 865 ft. Stations were cut at the 550 ft., 700 ft. and 850 ft. levels. At the 700 ft. level a sump was cut and a 4 by 6 ft. triplex pump, with a capacity of 60 gallons per minute against a 500 ft. head, was installed. An air receiver was also installed at this level.

Most of the drifting, during the year, was confined to the 400 ft. and 500 ft. levels, over three-fourths of which was in ore.

Stoping was carried on progressively and to date we have opened up 45 box holes and 50 chutes. Below follows a summary of development and exploration to December 31, 1922.

SUMMARY OF DEVELOPMENT AND EXPLORATION TO DECEMBER 31, 1922.

	Drifting	Shaft Sinking	Cross Cutting	Diamond Drilling
	Feet	Feet	Feet	Feet
December 31, 1921..	3,315	1,155	368	....
Fiscal year.........	2,548	445	310	827
December 31, 1922..	5,863	1,600	678	827

A two-story bunk house, 26 by 130 ft., with 40 sleeping rooms, to accommodate 80 men, has been erected to take the place of the mine buildings used at No. 2 shaft. This building has concrete foundation, concrete and hard wood floors. All rooms are plastered and steam heated, the toilet and wash rooms being equipped with best plumbing, and sanitary in every respect. There is a recreation room 26 by 40 ft. which is well patronized. All rooms are ventilated and equipped with suitable furniture.

Five cottages, 20 by 26 ft., with annex 10 by 12 ft. were erected on cement foundations each containing six rooms, bath and pantry. All rooms are lathed and plastered and finished with hard wood floors, plumbing and sewerage disposal. All buildings, including bunk house, are finished outside with asbestos siding. An underground water main was laid to all new buildings. A separate tank and grease trap was built for each house.

Porcupine

Clifton-Porcupine.—Clifton-Porcupine Mines, Limited, capital $2,000,000 in shares of $1 par value, resumed work on its property, claim H.R. 826 in Deloro township on May 1, 1922.

The directors of the company are: F. C. Preston, Midland, Ont., president, Homer L. Gibson, Toronto, vice-president; Ernest Bridger, Toronto, secretary-treasurer; W. E. Preston, Midland; Wm. C. Offer, South Porcupine. The head office is at 703 Bank of Hamilton Building, Toronto.

A mill of thirty tons a day capacity erected to treat the ore, began operations November 15, 1922. Ore is dumped automatically from the skip at the incline shaft (No. 2) into a 10-in. by 15-in. Jenckes crusher, and is then carried 65 feet to the mill on a 16-in. belt conveyor. Here the ore is ground in a 4½ by 4½-foot Denver ball mill and a 4½ by 16-foot Hardinge mill. Then it is passed over plates and amalgamated. A saving of 75-80 per cent. is made. The mill building is 26 by 54 feet with a wing 12 by 20 feet. Ore bins are 12 by 20 feet.

Development work done consisted of 100 feet of drifting and crosscutting on the 100-foot level, and 50 feet of drifting on the second, or 196-foot level. Underground operations were resumed in September, 1922, and two stopes started on the first (100-foot) level.

Twenty-six men were employed. Wm. C. Offer, Box 120, South Porcupine, is manager.

Consolidated West Dome Lake.—In 1922, a company called the Consolidated West Dome Lake Mines, Limited, was incorporated to acquire and operate the properties of the West Dome Consolidated Mines, Limited, and of the Dome Lake Milling and Mining Company, Limited. The consolidation took place in August. The holdings of the new company include five claims of the West Dome group—Nos. 13126, 13127, 13128, 13129, and 13179—three of the Dome Lake group—Nos. 14006, 14114, and 14115—and twenty acres of the west portion of the Ritchie veteran claim, recently purchased. All these claims are situate in the southeast portion of the township of Tisdale.

The Consolidated West Dome Lake Mines, Limited, has a capital of $5,000,000, divided into 5,000,000 shares of the par value of $1 each. The shareholders of the Dome Lake Mining and Milling Company, Limited, and of the West Dome Consolidated Mines, Limited, received one share of the new stock for two of the old.

The officers of the new company are: Sir Henry Pellatt, Toronto, president; Wm. H. Kinch, Buffalo, N.Y., vice-president; C. H. Manaton, Toronto, secretary-treasurer; R. L. Baker, Toronto; F. G. Stevens, Toronto; Major J. A. Murray, Toronto; Angus A. McKelvey, New Liskeard; C. L. Sherrill, Buffalo, N.Y.; directors. F. G. Stevens, 36 Oakmount Road, Toronto, is consulting engineer, F. L. Hutchinson, New Liskeard, assistant secretary-treasurer, and D. M. McPhail, Box 523, South Porcupine, is manager. The head office of the company is 420 Bank of Hamilton Building, Toronto.

No work was done at the West Dome since 1918, and the Dome Lake mine has been closed since July, 1920. Surface work was resumed on September 20, 1922, at the Dome Lake property. Together with the repair of buildings, a 90-horse-power horizontal return tubular boiler was installed. A hoist house, 32 by 36 feet was erected and a double-drum, Flory hoist with 150-horse-power Crocker-Wheeler a.c. motor was installed.

In the compressor plant, an a.c. motor, 150-horse-power was installed to operate the compressor which has been converted from steam driven to electric power. The rating of this compressor was, steam end 18 by 16 inches, and air end 16 by 16 inches, capacity 700 cubic feet per minute.

It is intended to unwater the Dome Lake mine as soon as electric power is available in 1923.

Twenty men were employed.

Dome.—The Dome Mines Company, Limited, have now a capitalization of $4,500,000. The directors of the company are: Jules S. Bache, Frederick G. Corning, Morton F. Stern, of New York; W. S. Edwards, Chicago; Alex. Fasken, Toronto; G. C. Miller, R. W. Pomery, Buffalo; T. R. Finucane, Rochester; Dwight B. Lee, Detroit. The executive officers are: Jules S. Bache, president and treasurer; W. S. Edwards, first vice-president; H. P. De Pencier, second vice-president and general manager; Morton F. Stern, third vice-president; Alex. Fasken, secretary; C. W. Dowsett, general superintendent; E. P. Goetz, assistant treasurer and assistant secretary; John B. Robinson, assistant secretary. The head office at 36 Toronto Street, Toronto, Ont.

The following information is taken from the twelfth annual report of the company, for the year ending March 31, 1923.

During the year a total of 418,177 tons was hoisted. Of this 363,000 tons was ore which was sent to the mill and treated, and 55,177 tons was waste which was dumped on the surface.

The 363,000 tons milled yielded bullion worth $4,278,935.87, the average yield per ton being $11.788. The tonnage treated is only 3,000 tons higher than last year, or 0.83 per cent., while the value of the bullion produced has increased by $1,469,483.49, or 52.3 per cent.

Four dividends, of $238,333.50 each, were paid during the year.

Summary of Development Work for Year 1922-23

Level	Shafts	Drifts	X-Cuts	Raises	Box Holes	Diamond Drilling
3	....	....	....	18	....	....
5	....	109	134	410	18	....
6	....	141	36	221	33	1087.0
7	....	516	360	255	328	994.76
8	....	558	616	1320	582	1124.73
9	....	1439	900	280	1070	3944.49
10	....	488	445	960	275	4019.59
11	11.5	1724	766	515	407	4359.01
12	....	1444	629	199	....	1091.00
13	114	12	....	....	....	....
Totals	125.5	6431	3886	4178	2713	16620.58

Ore Reserves

Stoping operations have disclosed important additions to our ore reserves and the grade of certain stopes, particularly at the 7th, 8th, 9th and 11th levels has exceeded that expected. The large amount of development work accomplished, while not so extensive as it would have been if not hampered by shortage of power, has resulted in opening up a large amount of new ore of good grade. While these ore bodies present the irregularity both as regards outline and distribution of gold characteristic of the Dome, it is believed that no depletion of ore reserves has taken place during the year under review.

Mill

The following are the treatment results from operation of the mill during the year:—

		Per ton	Per cent.
Tons—363,000	....	$12.118	....
Amalgamation Bullion	$2,527,528.38	6.9629	57.4591
Cyanidation Bullion	1,751,407.49	4.8248	39.8153
	$4,278,935.87	$11.7877	97.2744

The total milling cost was $422,504.51, or $1.164 per ton treated. The cost for last year was at the rate of $1.238 per ton. The decreased milling cost was mainly the result of a reduction in the price of some commodities, along with the small increase in the tonnage milled. The grinding has been finer than ever before, and whilst this naturally affects milling costs it has resulted in an extraction of 97.27 per cent. as against 95.13 per cent. for last year. Another factor which was instrumental in improving the extraction was the addition of the two pachuca tanks which came into operation at the beginning of the fiscal year.

To further increase the capacity of the Merrill slime presses, a larger centrifugal pump has been installed to expedite the discharge of these machines. Everything has now been done to get the utmost tonnage through the presses.

The finer crushing has naturally resulted in a slower settlement of slime in the thickeners, and to maintain the capacity of the settling plant it has been necessary to transform one of the disused sand tanks into a primary slime thickener; another old sand tank is being transformed into a secondary slime thickener, and this will be in operation some time in May of this year.

The increased work underground has necessitated additional traming facilities, another storage battery electric locomotive and six cars having been added. A second underground crusher with motor and cables has been installed at the 12th level. No. 3 Bellis and Morcom 2,500 cu. ft. air compressor has been installed at the power house. The other important item of capital expenditure was that for twelve double houses erected for workmen on the Dome Extension ground; in comparison with other places there is a great shortage of houses in Porcupine for married men.

COSTS

Operating costs amount to $5.255 per ton milled, as against $4.558 for the previous year. The increase is due to larger amount of development work, greater tonnage broken in stopes and increased cost of steam power as compared with hydro-electric power combined with lower tonnage milled and general loss of efficiency throughout the whole operation due to power shortage during about five months of the year under review.

Surface plant, Goldale mine.

Goldale.—The Kerr Lake Mining Company, Limited, of Cobalt, have undertaken the development work at the Golddale mine in return for an option on a block of the stock of the Goldale Mining Company, Limited, which owns fifty claims in the Porcupine area formerly held by the Bewick-Moreing interests. These claims are divided into fifteen groups.

The number one group comprises three 40-acre claims, namely, No. 13042, S.E. ¼ of S. ½ lot 8; No. 13043, S.W. ¼ of S. ½ lot 7, and No. 13044, S.E. ¼ of S. ½ lot 7, all in concession III of Tisdale township.

A two-compartment shaft had been sunk by the Bewick-Moreing Company to the 130-foot level on Claim No. 13042 at a location east of Pearl lake, and 475 feet of crosscutting to the north and 225 feet to the south had been done.

The plant at the property consisted of one Canadian Rand straight line compressor, capacity 640 cubic feet, and two 60-horsepower Nagle locomotive boilers. When work was begun by the Kerr Lake Mining Company, Limited, on March 28, 1922, an 80-horse-power return tubular boiler and a 9-in. by 12-in. Jenckes hoist were added to the plant.

In preparation for deepening the shaft, a 44-foot head frame was erected. Work in the shaft was started June 12, 1922. New timbering was done to the 130-foot level below which the shaft was sunk for three compartments (two 5 by 4½ feet, one 5 by 3½ feet) to the 550-foot level. The sump and station were completed on September 25, 1922. An automatic dumping bucket was used in sinking.

At the 550-foot level, development work consisted of 736 feet of drifting to the east and west and 603 feet crosscutting to the north and south.

Buildings constructed included a 20 by 28 feet addition to the compressor and hoist house, a 16 by 18 feet blacksmith shop, a dry and change house, and a water tank of 12,000 gallons capacity.

Forty men were employed. H. A. Kee was manager, and Robert Brown, superintendnent. The mine office address is Box 187, Schumacher, Ont.

Gold Island.—The Gold Island Mines, Limited, own ten claims—9168, 9333, 9334, 12509, 12578, 12579, 12580, 12583 and 12679 in the southeast portion of Cody township, and the southwest portion of Macklem township.

In 1921, 2,755 feet of diamond drilling was done in fifteen holes. In 1922, five holes were drilled for a footage of 1,201.

The claims are under option for purchase by the Night Hawk Peninsular Mines, Limited.

Hayden.—The Hayden Gold Mines, Limited, own five claims in Ogden township and two in Deloro township. During 1922, the shaft was deepened from the 350-foot to the 500-foot level.

At the 400-foot level after the station was cut, there was 180 feet of cross-cutting done to the north of the shaft and 20 feet to the south of the shaft. Forty-five feet of drifting was done to the east and west.

During the year, a 10-in. by 12-in. Canadian Ingersoll Rand hoist and a 60-horsepower locomotive boiler were added to the plant. The boiler capacity was raised to 120-horsepower. Air was supplied by an Ingersoll Sergeant straight line air compressor, steam 12 inches, air 12¼ inches, and capacity 350 cubic feet per minute.

Twelve men were employed.

The officers and directors of the company are: Wm. H. Hayden, president; W. H. Hill, vice-president; Willis S. Spalding, secretary-treasurer; Ed. Phillips and W. S. Pierce; all of Buffalo, N.Y.

R. P. Teare, Box 439, Timmins, Ont., was superintendent. The head office of the company is 509 Brisbane Building, Buffalo, N.Y.

Hollinger.—Hollinger Consolidated Gold Mines, Limited, has an authorized capital of $25,000,000. On January 1, 1923, there were outstanding 4,920,000 shares of $5.00 par value. The directors of the company are: President, Noah A. Timmins, Montreal; vice-president and treasurer, David A. Dunlop, Toronto; secretary, John B. Holden, Toronto; L. H. Timmins, Jules R. Timmins, Dr. Wilfred L. McDougald, all of Montreal. The general manager is A. F. Brigham, Timmins. The general office of the company is 85 Bay Street, Toronto, and the head office is at Timmins, Ontario.

The general manager's report for the year ending December 31, 1922, shows a total income of $12,824,608.25; of this amount the bullion produced yielded $12,274,114.77, and other sources, $550,493.48. Working expenses absorbed $6,346,004.13, taxes $518,223.67, depreciation and donations $813,690.18, leaving a net profit of $5,146,690.27. Thirteen dividends of one per cent. each, amounting in all to $3,198,000, were paid during the year, and the sum of $1,948,690.27 was added to the surplus, which now amounts to $5,909,469.77.

A sufficient supply of satisfactory labour was at all times available. During the year the company secured 100 Cornish miners from England. One hundred additional dwellings for employees were constructed during the year, on the Jerome addition to the town of Timmins, and are occupied by married employees.

Near the central shaft a large crusher station is being constructed for the purpose of effecting finer crushing, which in turn increases the cagacity of the stamps and tube mills and is part of the equipment required to carry out the extended milling capacity. Three sets of rolls, 60-inch diameter, and 24 inches wide, are being installed. Each set of rolls will have a peripheral speed of 1,350 revolutions per minute and will be operated by a 75 H.P. motor. One set of these rolls will be held in reserve. From the rolls the ore will be passed to trommels, 4 feet by 8 feet. A ¾-inch product will be passed from the trommels for further reduction by rod and tube mills. Ore hoisted from the mine will be crushed in gyratory crushers and passed to a 30-inch conveyor belt which will carry the ore to bins in the rolls plant. From the bins the ore will be carried on a 30-inch conveyor belt to the rolls.

During the year, seven Oliver filters, oscillating agitator type, 14 feet by 16 feet, were added to the milling equipment. Each filter has an area of 704 square feet, a speed of 3¾ revolutions per minute and a capacity of 600 tons dry solid every twenty-four hours. All these filters are supplied with 20-inch valves. Two 5-inch Keogh pumps handle the solutions.

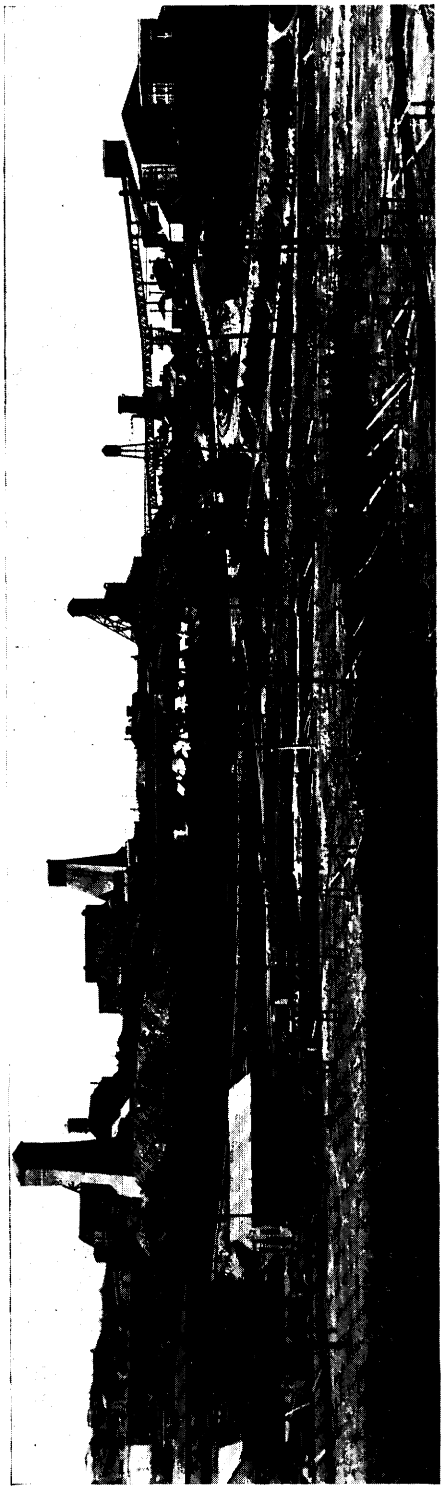
In conjunction with these filters there are two Canadian Ingersoll-Rand vacuum pumps, one of which is held in reserve. The dimensions of each pump are: stroke 14 inches, cylinder 27 inches in diameter. Each operates at 1,700 revolutions per minute and has a capacity of 3,500 cubic feet per minute. With these pumps are installed two 36-inch by 144-inch steel vacuum receivers and two 36-inch by 96-inch steel moisture traps.

An interesting addition to the milling equipment followed experiments to determine the type of grinding machinery to use in the mill extension. A 5-foot by 10-foot (measured inside the liners) rod mill was installed, and operated by an 80 H.P. motor. This, together with one tube mill, 6 by 16 feet, reduced 385 tons per 24 hours to 70 per cent.—200 mesh. The rod mill worked in open circuit and the tube mill in closed circuit with a duplex Dorr classifier, 6 feet by 26 feet. It is intended to replace the stamps entirely with rod mills.

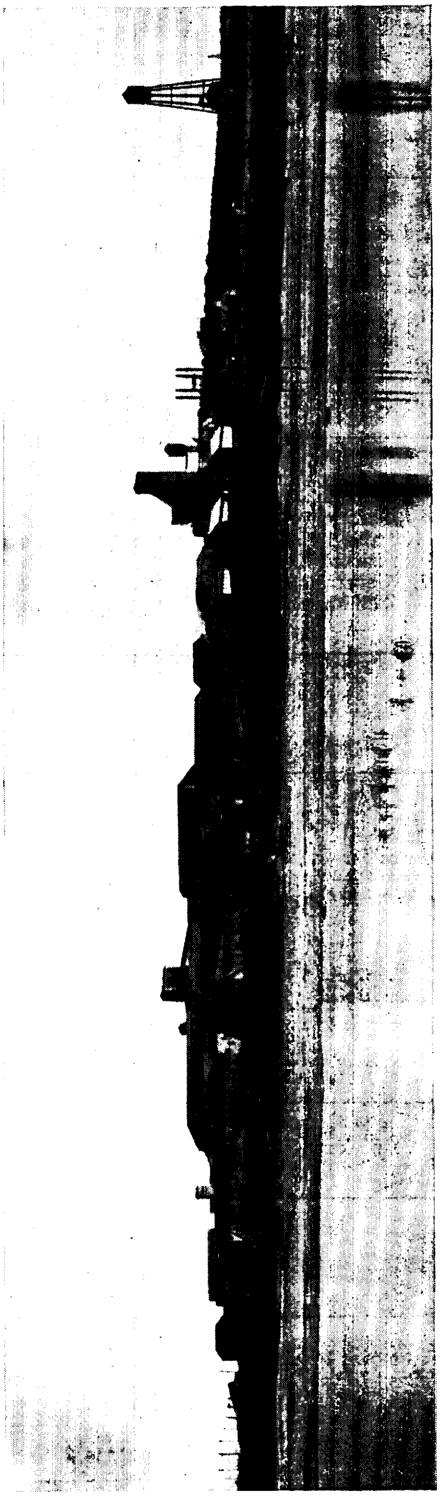
Other additions to the plant include a steel head frame at No. 11 shaft, a 20-inch main to the Mattagami River for mill water, and the surface equipment of the Schumacher Gold Mines, Limited.

One outstanding transaction during the year was the purchase of the Schumacher mine. It has been apparent that the veins on the Acme claim show a distinct tendency to dip to the east and to pass into Schumacher territory at depths between 2,000 and 2,500 feet. To secure the value of the veins to the Hollinger, the purchase was negotiated for $1,671,676.23.

Power shortage again caused considerable curtailment of production. The auxiliary steam plant was operated during the fall and winter months, until



Hollinger Consolidated gold mine, as viewed from dump of McIntyre mine. On the left foreground is part of the McIntyre mill and immediately above is the new blacksmith shop of the Hollinger. The office and mill are shown on the right.



Hollinger mine, looking northeast. Office and mill are on the left of the illustration.

April 9, 1922. The tonnage milled during 1922 was approximately 50 per cent. greater than during 1921.

The following information taken from the annual report of the company summarizes the result of the year's operations:

COST DATA.

Recapitulation	Sundries	Labour	Stores	Total	Per Ton Milled
Total general charges	$131,424 06	$256,633 04	$134,079 23	$522,136 33	$0.3501
Total mining charges	....	2,540,492 86	1,531,090 93	4,071,583 79	2.7301
Total milling changes	....	609,842 01	1,142,442 00	1,752,284 01	1.1749
Grand total......	$131,424 06	$3,406,967 91	$2,807,612 16	$6,346,004 13	$4.2551

DEVELOPMENT AND ORE RESERVES.

Throughout the year development has been highly favourable, particularly on the 950, 1,100 and 1,250 levels as compared with occurrences on the upper horizons.

A notable discovery, south of the present workings, was on the 425-foot level of vein number 97. Several hundred feet of drifting on this disclosed a strong vein with exceptional values.

The important increases, as shown in the statement of ore reserves, are in veins of medium grade tenor:

	Tons	Value per ton	Estimated Gross Value Dec. 31, 1922	Estimated Gross Value Dec. 31, 1921
Total Ore Reserves (developed underground)				
Above 425-foot level..............	1,216,027	$10 70	$12,990,707	....
Above 800-foot level...............	1,496,939	10 74	16,074,718	....
Below 800-foot level...............	677,779	9 85	6,672,448	....
	3,390,745	$10 54	$35,737,873	$36,644,154
Probable Ore:				
Veins under $6.00.................	1,007,797	5 30	5,348,594	4,162,833
Surface outcrops..................	209,681	10 41	2,183,360	1,909,040
Grand Total...................	4,608,223	$9 39	$43,269,827	$42,716,027

Another summary of the ore reserves developed underground shows the same total as above, but with a different basis of classification:

	Tons	Value per ton	Estimated Gross Value Dec. 31, 1922	Estimated Gross Value Dec. 31, 1921
Veins over $10.00.................	1,321,934	$13 10	$17,320,114	$17,554,815
Veins $10 to $8.00................	1,992,192	8 96	17,856,981	18,793,306
Veins $8.00 to $6.00..............	76,619	7 32	560,778	296,033
Totals......................	3,390,745	$10 54	$35,737,873	$36,644,154

The probable ore to add to this is as stated in the first summary.

MINE DEVELOPMENT.

Progress during the year was as follows:

Level	Shafts	Drifts	Cross Cuts	Raises	Diamond Drilling	Timbering		Excavation
						Shafts	Stopes	
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Tons
Surface	....	....	....	....	3,192	....	....	....
100 feet	....	....	....	96	....	....	....	....
200 feet	....	2,860	3,168	182	10,024	....	965	160
300 feet	....	869	952	303	1,769	....	851	....
425 feet	....	1,300	3,470	423	7,117	....	1,241	....
550 feet	....	1,021	995	117	4,799	....	638	....
675 feet	....	2,680	960	9	11,155	....	3,832	415
800 feet	....	3,396	2,733	256	10,655	....	4,616	1,297
950 feet	129	1,669	4,183	24	5,621	106	....	565
1,100 feet	150	1,380	2,891	31	3,208	150	....	75
1,250 feet	252	161	1,330	411	....	292	....	1,435
1,400 feet	146	....	27	....	....	77	....	825
1,550 feet	27	....	....	....	....	8	....	....
Total	704	15,336	20,709	1,852	57,540	633	12,143	4,772

Total, Sinking, Drifting, Cross-Cutting and Raising, 38,601.

MINE PRODUCTION.

Level	Broken Ore in Mines Jan. 1, 1922	Ore Broken During 1922	Ore Removed During 1922	Broken Ore in Mine Dec. 31, 1922
No. 10 Shaft Dump	2,250	....	929	1,321
Above 100 ft. Level	....	4,098	3,901	197
Above 200 ft. Level	61,626	95,325	129,474	27,477
Above 300 ft. Level	36,083	105,609	106,998	34,694
Above 425 ft. Level	128,791	161,934	224,626	66,099
Above 550 ft. Level	142,487	172,537	299,528	15,496
Above 675 ft. Level	71,100	452,381	363,084	160,397
Above 800 ft. Level	87,546	446,103	329,950	203,699
Above 950 ft. Level	....	13,410	13,410	....
Above 1,100 ft. Level	....	10,885	10,885	....
Above 1,250 ft. Level	....	9,623	9,623	....
Total	529,883	1,471,905	1,492,408	509,380

OPERATIONS IN PLANT ACCOUNT.

Expenditures by companies now comprised in Hollinger Consolidated Gold Mines, Limited.

Year	Expended	Written Off
1910-1915	$1,839,910 05	$529,480 89
1916	599,417 16	150,000 00
1917	673,237 52	100,000 00
1918	118,379 14	375,000 00
1919	338,162 32	600,000 00
1920	131,359 78	445,985 08
1921	482,790 79	627,488 50
1922	1,070,076 25	787,999 95
Total	$5,253,333 01	$3,615,954 42

The present valuation of $1,637,378.59 is 31.17 per cent. of the total cost of plant, as compared with $1,355,302.29 and 32.4 per cent. at the end of the year 1921, a net depreciation of 1.23 per cent.

EXPENDITURES FOR PLANT.

	Buildings.	Equipment.	Total
Central Shaft Plant	$58,102 46	$59,424 01	$117,526 47
Compressor Plant	....	25,008 55	25,008 55
No. 11 Shaft Plant	22,524 63	9,661 19	32,185 82
Mill and Cyanide Plant	55,927 31	135,380 71	191,308 02
Mine Equipment	....	12,824 17	12,824 17
Water Main	....	109,763 99	109,763 99
No. 1 Sub-Station	....	8,673 96	8,673 96
New Dwellings	259,795 74	....	259,795 74
New Hospital	2,173 35	135 00	2,308 35
New Store Building	5,963 14	4,270 43	10,233 57
Golf Club	6,990 70	199 95	7,190 65
Miscellaneous	911 30	5,710 43	6,621 73
Schumacher Gold Mines, Ltd	98,921 31	189,213 92	288,135 23
	$511,309 94	$560,266 31	$1,071,576 25
Credit, re Acme Fire Loss	500 00	1,000 00	1,500 00
	$510,809 94	$559,266 31	$1,070,076 25

EMPLOYEES.

Average number of men employed during the year has been 2,183, distributed as follows:

Miners		Mechanics		General		Total	
Exploration	17	Operation	96	Mill & Refinery	249	Miners	1,401
Development	263	Maintenance	180	Engineering Staff	53	Mechanics	308
Production	1,121	Construction	32	Clerical Staff	36	General	474
				Miscellaneous	136		
	1,401		308		474		2,183

MILLING RESULTS.

Tons Ore Milled	1,491,381
Average value per ton	$8 53
Gross value	$12,726,549 77
Deduct Loss in Tailings	$452,435 00
Net Value Recovered	$12,274,114 77

Average tons per day	4,097	Cyanide consumed per ton of ore	0.490 lbs.
Per cent. of possible time run	90.5	Zinc consumed per ton of ore	0.133 lbs.
Tons per 100% running time	4,527	Zinc consumed per ton of solution	0.072 lbs.
Stamp duty per 100% running time, tons	20.12	Lime consumed per ton of ore	2.970 lbs.
Solution precipitated per ton ore	1.85	Lead acetate per ton of ore	0.008 lbs.
Value per ton in tailings	$0.30	Average value pregnant solution	$4.43

Holtyrex.—The Holtyrex Gold Mines, Limited, was incorporated December 20, 1921, with a capitalization of $3,000,000 in shares of $1 par value. The company owns four mining claims in Tisdale township, Nos. 13320 and 13321, formerly known as the Newton claims and Nos. 13340 and 13341, formerly known as the Shillington-Richardson claims. These lie in lot 8, in the third concession.

The head office of the company is 501-2 Bank of Hamilton Building, Toronto; the post office address of the mine is Schumacher, Ont.

The officers are: president, A. J. Young, 1506 Bank of Hamilton Building, Toronto; vice-president and managing director, Weldon C. Young, Toronto; secretary-treasurer, Charles G. Knott, Toronto; directors, A. J. Young, Weldon C. Young and F. R. Varcoe, of Toronto; Ernest A. Schmidt, Montreal, Que., and L. H. Holland, Schumacher, Ont.

The total work done on the claims by this company to date consists of a two compartment shaft (No. 2) sunk 35 feet, (in 1911, a shaft known as No. 1 was sunk 50 feet), 4,500 feet of diamond drilling and the erection of the following buildings: office, 24 by 32 feet, mess house, 20 by 32 feet, men's quarters, 20 by 32 feet, dwelling, 24 by 24 feet, blacksmith shop, 16 by 14 feet, all of frame construction.

Twelve men were employed. L. H. Holland was manager, and C. L. Herschman, superintendent.

March.—The March Gold, Limited, was incorporated under the Ontario Companies' Act on December 19, 1919, with a capitalization of $1,500,000 in shares of ten cents par value, each. The officers are: Bert. C. Conderman, Hornell, N.Y., president; Henry Kobler, Buffalo, N.Y., vice-president; Frank J. C. Bull, Buffalo, N.Y., secretary; J. C. Roche, Buffalo, N.Y., treasurer; Fred. Goellner, Henry Tiedt, Peter Schabacker, Edward T. Bline, all of Buffalo, N.Y., directors; Walter G. Hawley, South Porcupine, manager. The head office of the company is 207 White Building, Buffalo, N.Y.

The company owns claims H.R. 823, H.R. 846 and H.R. 900, located in Deloro township.

The March mine was worked with a force of eighteen men continuously through the year, 1922.

The shaft was deepened from the 100-foot to the 335-foot level, and a station cut at a depth of 321 feet. Development work on the 100-foot level consisted of extending the east drift 82 feet, making it 188 feet east of the crosscut south from the shaft.

At the second (321-foot) level, 193 feet of crosscutting was done to the north of the shaft, and 95 feet to the south of the shaft. From a point 163 feet north of the shaft, 317 feet of drifting was done to the west, and 337 feet of drifting to the east. Near the end of the west drifting, some 30 feet of crosscutting was done. At another point, 47 feet south of the shaft, 78 feet of drifting was done to the east.

During the year, a 70-horsepower locomotive type boiler was added to the plant. In 1923, it is proposed to install a larger hoist and sink the shaft to the 800-foot level.

McEnaney.—The McEnaney Gold Mines, Limited, own three groups of claims in Ogden township, the first comprising six claims of the Hollinger Reserve, M.E. 44, 45 and 46, and H.R. 948, 949 and 1074, the second comprising six claims of the Porcupine Mutual, 8053, 8054, 8292, 8605, 8606 and 8851, and the third comprising three Flynn claims—6040, 6784 and 6785.

Operations at the mine were resumed in October, 1922. The mine workings which consisted of a 200-foot shaft, 200 feet drifting on the first level, 800 feet drifting on the second level and 500 feet drifting on the third level, and a winze 200 feet below the shaft level, were unwatered.

Mining operations were commenced on December 4, 1922. The winze, located 190 feet northeast of the shaft, and sunk on an incline 65 degrees to the north, was straightened out and deepened to 275 feet. It is proposed to continue sinking the winze to 700 feet.

The plant installed at the mine previous to resumption of operations included two 65-horse-power Jenckes Horizontal return tubular boilers, one Canadian-Rand straight line air compressor, capacity 600 cubic feet, and two 8-inch by 10-inch Jenckes hoists.

Twenty-eight men were employed.

The officers and directors of the company are: R. P. Gough, Toronto, Ont., president; Gordon Taylor, Toronto, Ont., secretary-treasurer; Lawrence Solman, J. H. McGregor and R. K. Russell, of Toronto; Chas. McCrea, M.L.A., of Sudbury, Ont.; E. G. Germer, of Erie, Pa.; W. F. Fitzgerald, of Boston, Mass. E. T. Corkill, Timmins was manager, and Hector McQuarrie, mine captain.

McIntyre.—The McIntyre-Porcupine Mines, Limited, has an authorized capitalization of $4,000,000, being divided into 800,000 shares of a par value of $5.00, of which 738,056⅗ shares have been issued. The officers are: J. P. Bickell, president; W. J. Sheppard, vice-president; M. P. Van der Voort, secretary; H. G. Laux, treasurer. The directors are: J. P. Bickell, W. J. Sheppard, J. B. Tudhope, N. J. Miller and Joseph Errington. R. J. Ennis is general manager. The mines and plant are at Schumacher and the head office is in the Standard Bank Building, Toronto.

In addition to the Porcupine holdings the company owns a 50 per cent. interest in the Blue Diamond Coal Company, Limited. Three dividends of five per cent. each were paid during the year.

The following information is taken from the 11th annual report of the company for the year ending June 30, 1923.

PRODUCTION.

In the operating year 240,615 tons of ore were treated of an average value of $9.96 per ton and a gross value of $2,397,303.00. The total bullion recovered amounted to $2,249,741.63, or $9.35 per ton of ore milled, and contained 107,997.36 fine ounces of gold and 26,377.86 fine ounces of silver.

MINING.

In stopes 227,247 tons of ore were broken and development produced 41,389 tons, making a total of 268,636 tons. In the period 242,891 tons were hoisted, leaving a balance of 25,745 to be added to broken ore reserves which are increased from 130,136 tons, the amount at June 30th, 1922, to 155,881 tons at June 30th, 1923.

SUMMARY OF ORE HOISTED.

Level	Tons	Assay	Value
1,000 ft.	119	9.33	$1,111
1,125 ft.	48,594	9.90	481,194
1,250 ft.	21,093	10.75	226,614
1,375 ft.	53,043	11.30	598,936
1,500 ft.	54,533	8.60	470,286
1,625 ft.	6,596	6.25	41,087
1,750 ft.	16,290	9.05	147,834
1,875 ft.	42,058	9.55	401,318
2,125 ft.	565	13.10	7,419
	242,891	9.76	$2,375,789

ESTIMATED ORE RESERVES.

	Tons	Assay	Value
McIntyre Claims	445,043	9.62	$4,283,396 00
McIntyre Extension Claims	182,313	11.31	2,059,528 00
Jupiter Claims	75,267	7.65	574,354 00
Broken Ore in Stopes	155,881	10.24	1,597,522 00
	858,504	9.92	$8,514,800 00

In the above estimate of ore reserves, values have been reduced to allow for barren schist inclusions in the veins and the dilution of broken ore reserves by wall rock.

SUMMARY OF DEVELOPMENT AND EXPLORATION WORK, 1922-1923

Period	Drifts Feet	Cross-cuts Feet	Raises Feet	Winzes Feet	Shafts Feet	Stations cu. feet	Sumps cu. feet	Pockets cu. feet	Total Footage	Total Exca'vns cu. feet	Diamond Drilling
1	753	256	125		23	12,166			1,157	12,166	1,403
2	399	504	160		33	3,420		5,288	1,096	8,708	1,730
3	358	451	159		76	2,800			1,044	2,800	1,200
4	521.5	299	45		89	3,377			954.5	3,377	1,228
5	634	244	97		68	6,367			1,043	6,367	1,339
6	540	223	51		94	4,000			908	4,000	1,217
7	655	495	16		82	1,848			1,248	1,848	1,564
8	608	271	34		48	9,197			961	9,197	786
9	523	134	42		11	2,330			710	2,330	244.9
10	808	85			60		512		953	512	583
11	810	536			35	12,600			1,381	12,600	1,807
12	508	365			88				961		1,707
For year, 22-23	7,117.5	3,863	729		707	58,105	512	5,288	12,416.5	63,905	14,808.9
Previous	45,386.8	18,110.3	7,498.4	579.7	6,963.9	212,827	32,531	58,698	78,539.1	304,056	61,627
Total	52,504.3	21,973.3	8,227.4	579.7	7,670.9	270,932	33,043	63,986	90,955.6	367,961	76,435.9

MILLING.

The new mill addition was ready to operate on November 1st, but due to a shortage of hydro-electric power only half of it was put into commission. There were further reductions in power, with consequent reductions in tons milled, until in April only 250 tons per day were being treated. Full power was available again on May 3rd, and in that month 28,085 tons, and in June 27,925 tons, were handled. The milling costs for the period are $1.11 against $1.03 for the preceding year. The increase of 8 cents per ton is due to the mill not operating to full capacity, the shortage of hydro-electric power, and the generation of power by steam to operate part of the plant.

OPERATING COSTS.

MINING:		
Exploration	$19,288 19	.08
Development	243,183 90	1.01
Breaking and Stoping	525,706 13	2.18
Examination of Prospects	11,696 84	.05
	$799,875 06	3.32
Crushing and Transportation of Ore	48,046 61	.20
Milling	265,911 11	1.11
Heating and Maintenance, Buildings and Camps	34,824 23	.14
Mercantile Store and Welfare Expense	18,987 29	.08
Management and General Expense, Mine Office	59,056 24	.24
Administrative and General Expense, Head Office	80,743 82	.33
Transfer and Registrar Expense	8,849 71	.04
Insurance—General	18,223 29	.08
	$1,334,517 36	5.54

Newray.—In June, 1922, the Coniagas Mines, Limited, of Cobalt, secured an option on the holdings of the Newray Mining Company, Limited, in Tisdale township.

Two diamond drills were operated until the end of November, 1922, and one continued until the end of the year. Seven thousand feet of drilling was done.

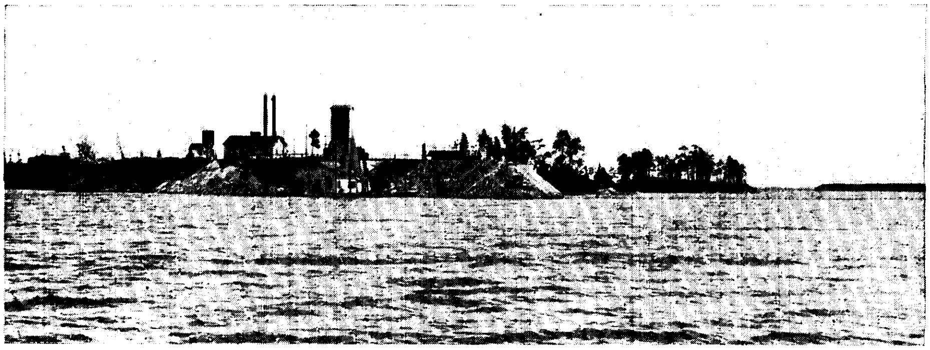
The steam and air plant already installed was used in carrying on operations to pump out the mine. This began on December 23, 1922. It was expected to have the workings cleared of water in January, 1923, when an active campaign of underground development will be carried out.

The work was in charge of John Redington, Schumacher, Ont. Twelve men were employed.

Peninsular.—The Night Hawk Peninsular Mines, Limited, capital $5,000,000, divided into shares of $1 par value is incorporated under the Ontario Companies' Act. Its head office is at 157 Bay Street, Toronto. The executive offices are at 323 Fourth Avenue, Pittsburgh, Pa. The officers are: president, Wm. Thaw, Pittsburgh, Pa.; vice-president, J. Albert McKay, Pittsburgh, Pa.; chairman, Jas. R. Dodsworth, Pittsburgh, Pa.; secretary-treasurer, S. Hollis, Pittsburgh, Pa.; directors: Beno Jansen, Samuel Grenett, Chas. Ward, Thos. McKay, all of Pittsburgh, Pa.; and Geo. A. Grover, Gordon Taylor and John Callinan, of Toronto, Ont.

The holdings of this company consist of four groups of claims in the southeast portion of Cody township and the southwest portion of Macklem township. The first group includes six claims: 9421 (H.R. 914), 9422 (H.R. 915), 9878 (H.R. 919), 10656 (H.R. 916), 15604 (H.R. 918), 15605 (H.R. 917). These claims were formerly held by the Porcupine Night Hawk Mines, Limited, which discontinued work in 1917.

In 1921, the Porcupine Peninsular Gold Mines, Limited, acquired the claims of this group and to it added a second, comprising the McEachen fraction, and claims 7801 and L.O. 931, the two latter being under the waters of Night Hawk



Surface plant, Night Hawk Peninsular Mines, Limited.

lake. The third group of seven claims includes: 565, 1394, 8356, 8357, 12371, 12372 and 12631 (H.R. 4). The fourth group of ten claims: 9168, 9333 (H.R. 3), 9334 (H.R. 2), 12508, 12509, 12578, 12579, 12580, 12583 and 12679, is owned by the Gold Island Mines, Limited. The third and fourth group are held under option to purchase. The four groups are held by the Night Hawk Peninsular Mines, Limited, whose charter was granted March 24, 1922. A. R. Globe, Connaught, Ont., is manager and John Barron, mine captain. Sixty men were employed in 1922.

The mine lies southwest and eleven miles distant from Connaught station, on the Porquis Junction—Timmins branch of the Temiskaming and Northern Ontario Railway. In summer, the trip to the mine is made by a good water route along the Fredickhouse river and Night Hawk lake, from Connaught; in winter, a sleigh road following a land route is used.

In 1917, a shaft was sunk 80 feet on claim 9878 (H.R. 919) in the northwest portion of the claim and on the peninsular shore of the lake, by the Porcupine Night Hawk Mines, Limited. Beyond some drifting and crosscutting, no further work was done until July, 1921, when diamond drilling was carried on by the Porcupine Peninsular Gold Mines, Limited.

In addition to the two log buildings, an office, 20 by 30 feet, and a sleep house, 30 by 40 feet, built in 1917, the following have been constructed of lumber with asbestos covering, a sleep camp, 25 by 40 feet, dining hall and cookery, 25 by 50 feet, three cottages, 18 by 24 feet, an assay office, 25 by 40 feet, and a power house, 30 by 42 feet.

The plant installed in the power-house includes two 100-horse-power boilers h.r.t. type, a 12-inch by 18-inch tandem duplex cross compound Canadian-Rand air compressor, capacity, 1,250 cubic feet per minute. The compressor has been steam driven, but was installed with the intention of using electric power when it is available. In 1922, wood fuel was used.

A head frame, 55 feet in height, was erected and a shaft house, 20 by 30 feet, constructed. On the lake shore and near the shaft house, a blacksmith and machine shop, 22 by 40 feet, was built. These buildings are frame structures covered with "asbestos side." The blacksmith shop includes a Leyner drill sharpener, two furnaces and one forge.

The hoisting engine installed was a 10 by 12-inch Lidgerwood.

In October, 1921, work was started at the 80-foot level in the shaft. In 1922, it was deepened to 440 feet. Stations were cut at the 180, 300 and 425-foot levels. The shaft has two compartments, 4 by 4 feet 6 inches and 4 feet 6 inches by 4 feet 6 inches.

The following is a summary of the exploration and development work done up to the end of 1922:

Level No.	Feet	Drifting, feet	Crosscutting, feet
*First	80	82	70
Second	180	515	364
Third	300	520	277
Fourth	425	80	165
Total	....	1,197	876

(*Done in 1917)
Diamond drilling, 1,655 feet.

A promising ore body, No. 1 vein, was opened on the second and third levels. At these levels, No. 1 vein has an average width of 20 feet. Another vein, known as No. 4, was developed with good results on the third level. No. 4 vein has an average width of 6 feet. The average grade of the ore in the mine at the end of 1922 was said to be $11.50.

The veins have been prospected at several places on the surface, but overburden has been too heavy for continuous trenching. From development underground, the rocks encountered from north to south across the strike are serpentine schist, a highly altered quartz porphyry, gray basalt and andesite. The character of the serpentine schist is so soft as to make its examination difficult. Through it are a number of quartz stringers. The width of this schist has not been determined, but at one place it was found to be 120 feet and no contact was encountered.

The rock, to the south, in contact with the serpentine schist has become completely re-crystallized, and appears to be a schistose equivalent to quartz porphyry. It is a fine-grained rock composed of quartz grains, often in irregular mosaics together with a varying and frequently larger amount of pale green chlorite which gives a grayish-green or greenish-gray colour[1]. It also contains

[1]Ontario Dept. of Mines, Vol. XXX, 1921, Part 2, page 34. Ontario Gold Deposits by P. E. Hopkins.

considerable sericite. In places, the rock has been more thoroughly replaced by iron-bearing carbonates together with a development of a larger number of extremely minute prismatic crystals, which appear yellowish under reflected light, and only distinguishable under a high-power microscope—probably rutile. Together with these are crystals or grains of pyrite scattered or abundant. In places, the porphyry mass has a width of 100 feet.

The third rock in the series is a gray basalt, fairly high in quartz which occurs in nests. The rock itself has a banded appearance due to layers of feldspar and iron-bearing carbonate. It also contains considerable chlorite. This gray basalt has a width of 100 feet.

It is followed by a darker rock, an andesite, which sometimes shows hornblende crystals. There is an absence of quartz. It also contains iron-bearing carbonates and sometimes pyrites. No determination of its width has been made.

No. 1 vein lies along the contact of the serpentine and quartz porphyry. No. 4 vein at its western extremity occurs along the contact of the quartz porphyry and gray basalt. As it extends to the east, it lies along a fracture in the basalt. The general strike of the two veins is north 65 degrees east, and the dip of both veins is almost vertical.

During the year 1923 it is proposed to erect a 200-ton mill to treat the ore by counter-current continuous decantation cyaniding. Foundations have been made for the mill which is expected to be in operation in the fall of 1923.

A second and larger shaft is to be sunk 250 feet east of the first shaft. It is intended to use electric power for the operation of mine and mill machinery. The power will be obtained from the Great Northern Power Company's plant at Indian Chutes on the Montreal river. Current will be transmitted at 66,000 volts to a sub-station at South Porcupine, where it will be transformed to 11,000 volts and then transmitted at this lower voltage to the Peninsular mine. The power line from South Porcupine to the mine will parallel the Timiskaming and Northern Ontario Railway to Hoyle. Thence it will cross the narrows of the Frederickhouse river, below Squaw island. From this point, it will run due south on the peninsula to the mine. The line from South Porcupine to the mine will be fourteen miles long.

Porcupine Crown.—The Porcupine Crown Mines, Limited, controlled by the Crown Reserve Mining Company, Limited, of Cobalt, operated the Porcupine Crown mine from March to November of the year 1922.

Operations were confined to exploration work in the west area of the property. A winze was sunk west of the main shaft to a depth of 105 feet from the 500-foot level. Further exploration and development work consisted of 350 feet of crosscutting, 600 feet of drifting, 90 feet of raising and 600 feet of diamond drilling.

Twenty men were employed. H. J. Stewart, Timmins, Ont., was manager, and C. Mosher, mine captain.

Porcupine Davidson.—The Porcupine Davidson Gold Mines, Limited, was formed in August, 1921, and incorporated under The Ontario Companies' Act. The authorized capital is £1,000,000 divided into 1,500,000 preference shares of 5 shillings each, and 2,500,000 ordinary or common shares of 5 shillings each. The preferred shares carry the right to two-thirds of the profit distributed annually until 100 per cent. in dividends has been paid, thereon and thereafter they are entitled to 20 per cent. non-cumulative dividend in priority to the ordinary share capital.

The company acquired the property and assets of the Davidson Consolidated Gold Mines, Limited, the property comprising ten claims in the townships of Tisdale and Whitney. The officers and directors of the company are: Sir Archibald Mitchelson, London, England, president; R. E. Evans, Toronto, Ont., secretary; H. H. Sutherland, Toronto, Ont., managing director; Robert Fennell, Toronto, Ont.; Colonel Robert Stark, Montreal, Que.; J. J. Davis, London, Ont.; Arthur Wilson Filmer, London, England; Capt. the Honourable Inigo Brassey Freeman-Thomas, London, England; Geo. E. Bent, South Porcupine, Ont., general manager.

The head office of the company is Pinner's Hall, Austin Friars, London, E.C., England. The Toronto office is at Rooms 4 and 5, King Edward Hotel.

The Davidson mine was closed down on January 15, 1922, owing to a shortage of electric power. Exploration with diamond drill was carried on at the surface, and 12,000 feet of drilling was done.

It is proposed to obtain electric power from the Great Northern Power Company, Limited, when the plant is in operation at Indian Chutes on the Montreal river. A new incline (72 degrees) shaft is to be sunk to the 1000-foot level. At the 550-foot level, connection will be made with the old workings of the mine.

Porcupine Paymaster.—Porcupine Paymaster Mines, Limited, continued to operate its property (M.E. 15) in Deloro township throughout 1922.

The directors of the company are: A. S. Fuller, Timmins, president; J. A. Frohoch, Boston, Mass., vice-president; M. P. Van der Voort, Toronto, secretary-treasurer; E. H. Walker, F. G. Wright, D. B. Patterson, Boston, Mass. B. M. Walton, South Porcupine, was manager until August 1, 1922, and was succeeded by B. L. Eastman. R. E. Hearn was assistant-manager, and Chas. H. Richardson, mine captain. The head office is at 312 Temple Building, Toronto, Ont. The Premier Paymaster Mines, Limited, is the holding company of which the secretary-treasurer is F. G. Wright, Suite 402-404, 79 Milk Street, Boston, Mass.

The two-compartment shaft 4 by 4 feet, and 3 feet 6 inches by 4 feet, was deepened from 200 feet to 412 feet and levels were opened at 300 and 400 feet.

A summary of the underground work done since August 1, 1922, follows:

Level feet	Drifting feet	Crosscutting feet
300	435	59
400	332	45
Total.......	767	104

Drifting and crosscutting in 1922 previous to August 1, amounted to 200 feet. Exploratory work with diamond drill consisted of 306 feet underground, and 3,351 feet from the surface.

During the year, several buildings were completed. These comprise a sleep camp and cook house, 26 by 60 feet, an office and store-house, 25 by 50 feet, and one residence, 24 by 50 feet. All these are of lumber covered with asbestos sheeting. Other buildings constructed in 1922, include a blacksmith shop, 18 by 24 feet, a pump house, 10 by 12 feet, and a water tank, capacity, 11,300 gallons.

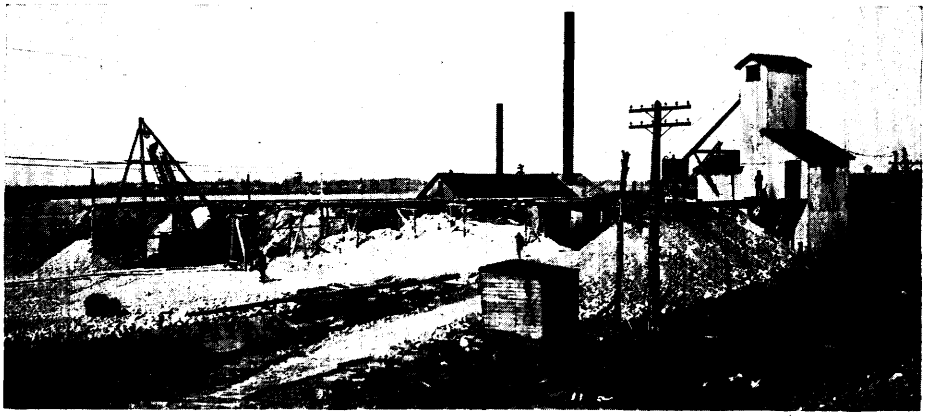
A small test mill was also built and operated in a building, 12 by 20 feet. The plant includes a 4-inch by 6-inch crusher, one set 7-inch Sturtevant rolls, small bucket elevator, bins, amalgamating plates and concentrating table. Power is supplied by a 6-horsepower Canadian Fairbanks-Morse gas engine.

Thirty-five men were employed.

Rochester.—The Canadian Gold Mines Corporation operates under a charter granted by the state of Delaware. It owns a number of claims in the Porcupine area, and also has a number under option. At present as a holding company it will own the Canadel Gold, Limited, which has under option the Rochester veteran claim lying north of the Hollinger.

Operations were begun on the south part of this claim on August 8. The following buildings were erected: power-house, 30 by 44 feet, with additions 14 by 14 feet and 14 by 28 feet; assay office and sample room, 14 by 32 feet; head-frame height, 35 feet. All buildings are of frame construction with galvanized iron covering.

The plant includes one 60-horsepower locomotive boiler, an 8-inch by 10-inch Lidgerwood hoisting engine, two 14-inch high compression oil-burning compressors (Chicago Pneumatic Tool Company). These burn light fuel oil for power, and have a capacity of 309 cubic feet free air per minute. A Brownell 3-inch by 3½-inch gas engine is used in starting the compressors.



Surface plant of the Rochester mine, operated by Canadel Gold, Limited.

Mining operations consisted of sinking, to a depth of 115 feet, a two-compartment shaft, each compartment being 4 feet 6 inches by 4 feet 8 inches. A level was opened at 100 feet, and 482 feet crosscutting was done to the south from the shaft, and 40 feet to the north from the shaft. South of the shaft, two drifts extend, the first, 12 feet east and 25 feet west, the second, 10 feet east and 15 feet west. It is proposed to deepen the shaft early in 1923.

The officers and directors of the company are: Latham Reid, New York, president; Geo. E. Larned, vice-president and treasurer; Theodore Gross, 25 Bond Street, New York, managing director.

The head office of the company is at Timmins, Ont.

The Advisory Board in London, England, consists of Earl of Pembroke and Montgomery, chairman; Sir Harry Brittain, and Sir Park Goff; and representing the English interests in Canada, Chas. A. Sara, 79 St. James Street, Montreal, Que.

Frank C. Loring, 76 Sun Life Building, Toronto, is consulting engineer. Ernest M. Loring, Drawer G. Timmins, is manager and, S. F. Monk is mine captain.

Thirty-five men were employed.

Three Nations.—The Porcupine Grande Gold Mines, Limited, owns outright two claims of 160 acres each, known as the Cavana Veteran claims comprising the south half of lot 4, sixth concession, and the north half of lot 6 in the fifth concession of the township of Whitney, and has an operating lease on eight claims comprising 309 acres known as the "Three Nations" property. These two groups adjoin each other, and are situated in Whitney township.

The company is incorporated under the Ontario Companies' Act, with an authorized capital of $5,000,000, in shares of $1 par value. The Ontario National Development Company is the holding company.

The work of unwatering the Three Nations mine was begun in November, 1922. In addition, trenching was done and test pits sunk on the Cavana Veteran claims.

Fifteen men were employed. Louis Whitman was superintendent.

The head office of the company is 504-505 Confederation Life Building, Toronto, Ont.

The following are the officers and directors of the company: S. A. Harnett, Toronto, Ont., president; A. G. Cavana, Orillia, Ont., vice-president; Dr. W. J. Kirby, Toronto, Ont., secretary-treasurer; D. A. Diehl and W. A. Miner, Toronto, Ont.; Melville B. Tudhope and Clifford Jeremy, Orillia, Ont.

Triplex.—The Triplex Gold Mines, Limited, owns several claims in the southeast corner of Shaw township. The head office of the company is 476 Main Street, Worcester, Mass. The officers are: Chas. B. Post, Worcester, Mass., president; Andrew G. Hildreth and Geo. T. Greenwood, Worcester, Mass., vice-presidents; Matthew Thomas, South Porcupine, secretary-treasurer; Chas. S. Averill, Frank D. Heslor, and Everett W. Durgin, all of Worcester, Mass.; J. I. Thomas, South Porcupine, directors. Duncan B. Harrison, South Porcupine, was construction manager and chief fiscal agent. Chas. A. Randall, South Porcupine, Ont., was superintendent, and J. J. Rutherford mine captain from September 21, 1922, until the work was stopped on January 27, 1923.

A force of twenty-five to fifty men was employed during the year. Considerable trenching work was done. At the 100-foot level of the two-compartment vertical shaft, 150 feet of crosscutting was done together with 100 feet of drifting along what was known as the Tommy Burns' vein[1].

In the latter part of 1922, two 100-horse-power horizontal return tubular boilers, a 12-drill compound duplex Canadian Ingersoll-Rand air compressor, and an 8 by 10-inch Jenckes hoist were added to the plant. Wood fuel was used. It is proposed to obtain electric power from the Great Northern Power Company whose line from Matachewan to Porcupine will pass a quarter of a mile to the west of the shaft house.

Vickers Porcupine.—Vickers Porcupine Mines, Limited, was incorporated in the early part of 1923 to work the two Lindburg mining claims in Tisdale township. These claims have a total area of eighty acres and comprise the northeast and southeast quarters of the south half of lot 6, in the third concession.

The directors of the company are: president, George Vickers, Barrie, Ont.; vice-president, H. Cartwright, Toronto; George A. Brodie, Toronto; Dr. W. A. Mathieson, Toronto; H. A. Henry, Barrie, Ont. Joseph Montgomery, 26 Adelaide Street West, Toronto, is secretary-treasurer, and N. J. Evered, manager of the Vipond mine, consulting engineer.

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[1] Ontario Dept. Mines, Vol. XXX, 1921, Part 2, page 34. Ontario Gold Deposits, by P. E. Hopkins.

Vipond-North Thompson.—The Porcupine V.N.T. Gold Mines, Limited, has been succeeded by the Vipond Consolidated Mines, Limited. The sale of properties was authorized on July 22, 1922. The capitalization of the new company is $2,000,000 divided into shares of $1 par value. The shareholders of the Porcupine V.N.T. Gold Mines, Limited, received one share of the new stock for three shares of the old.

The directors of the re-organized company are: president, Hamilton B. Wills, Toronto; vice-president, W. H. Stafford, Almonte; secretary-treasurer, T. S. H. Giles, Toronto; J. W. Bain and J. H. Black, Toronto; J. Mackintosh Bell, Almonte; R. T. Shillington, Haileybury. The managing director is J. Mackintosh Bell. The head office of the company is Trusts & Guarantee Building, Toronto.

Since July, 1918, no work has been done at the North Thompson mine. Operations were resumed on April 13, 1922, by the Porcupine V.N.T. Gold Mines, Limited, and carried on till August 1, 1922, when the transfer of properties to the Vipond Consolidated Mines, Limited, was carried out.

The main shaft (3-compartment) was sunk from the 600-foot to the 1000-foot level, and to a further depth of 18 feet for a sump. Development work was carried on at the sixth (600 feet), seventh (733 feet), eighth (865 feet), and ninth levels (1000 feet). This consisted of 295.5 feet crosscutting and 678.5 feet drifting.

N. J. Evered, Timmins, was manager, and Alex. Hattie, mine captain. Forty men were employed.

Matachewan

Empire Asbestos.—The Empire Asbestos Company, Limited, own ten claims in the central portion of Bannockburn township. C. G. Rahn is manager, and five men were employed during the fall months.

A shaft was sunk 45 feet on the incline.

Thesaurus.—The Thesaurus Gold Mines, Limited, operated their property in Baden township at the head of Matachewan lake from May 24 to November 21. J. C. Nelson is manager, and sixteen men were employed.

The plant consists of an upright boiler of 20-horsepower, and a 7 by 9-inch Napanee hoist.

The shaft was deepened from 100 to 137 feet, and crosscuts driven 103 feet northeast, and 102 feet southwest on the 100-foot level.

Lightning River

Abitibi.—The Abitibi Mines, Limited, was incorporated in October by the directors of the Canadian Mining Syndicate, and acquired from the latter nine mining claims in Holloway and Harker townships which included the three Seagers claims (10080-1-2), the three Manwell claims, the Muton claim and two other claims.

The Canadian Mining Syndicate entered the region soon after the discovery of gold made by William Seagers in February, 1922, and acquired twenty claims in all. The work carried on during the summer months consisted of trenching, stripping and the sinking of pits, D. S. Paterson is president, and Austen Campbell secretary-treasurer, with offices at 202 Royal Bank Building, Toronto.

The officials of the company are: Geo. H. Campbell, president; Lt.-Col. R. P. Rogers, D.S.O., general manager; E. S. Cunningham, secretary-treasurer. The head office of the company is at 202 Royal Bank Building, Toronto.

The mine is reached during the summer, by boat across Abitibi lake, from La Reine, Quebec, which is the company's post office, to the landing on Lightning river, thence two miles by jumper road to the property. The best winter road is from Ramore on the T. & N. O. Railway, a distance of thirty-two miles.

R. S. Manwell is superintendent, and about twenty men were employed.

In addition to nearly a mile of trenching and the sinking of a 25-foot shaft, commodious camps were erected. These comprise two camps 20 by 30 feet, an office, 18 by 22 feet, an assay office and store, 18 by 22 feet, a stable, a magazine and blacksmith shop.

Jacobs and O'Neill.—C. H. Jacobs, of Iroquois Falls, and Tom O'Neill, of Matheson, have located a group of five claims south of Teddy Bear creek in Holloway township. This group includes claims 11009-10-11-12 and 11386. Stripping to the extent of 500 feet has been done on claims 11009-10, and a shaft 5 by 7 feet has been sunk to a depth of 22 feet on a 5-foot dyke of red porphyry in silicified basalt.

A camp, 16 by 20 feet, and smithy, 12 by 14 feet, have been erected.

McDermott Gold Mines, Limited.—This company with which Messrs. P. A. McDermott and I. W. C. Solloway are connected located a group of eight claims adjoining the Jacobs and O'Neill property in Holloway township in August. Six of the claims have been surveyed and considerable surface trenching has been done on them. A office, 12 by 16 feet, and two log camps, each 16 by 20 feet, have been built. Four men were at work.

Mining Corporation.—The Mining Corporation of Canada have taken up thirty claims in Holloway and Harker townships, and of these eleven have been surveyed. On claim No. 10476 which is one of a group of five claims north of the Abitibi Mines, a shear zone 60 feet wide has been uncovered which shows encouraging values in gold. Two log camps and a stable have been built. Russell Cryderman is in charge, and four or five men have been employed.

Silver

Cobalt Area

Bailey.—The Bailey Silver Mines, Limited, closed down the Bailey mine, in April, after shipping about 2,500 tons of ore to their mill at 104. Development work comprised 350 feet of crosscuts, 50 feet of drift, and a 15-foot raise. Twenty men were employed.

The company operated the Silver Cliff mine under lease for the first four months of the year. From this property about 2,000 tons of ore were sent to the mill from old stopes, and 50 feet of development work was done with a force of five to nine men.

The company's mill at 104 treated, besides the above tonnages, 24,784 tons of ore from La Rose mine, during the first nine months of the year. A force of twenty-five to thirty men was employed. Early in October the mill was sold under the authority of the bondholders to the O'Brien mine.

Cobalt A-53.—The Cobalt A-53 Silver Mining Company, Limited, worked their property in Gillies Limit for a portion of the summer. The winze was sunk 40 feet from the 60-foot level, and a small amount of drifting was done. J. J. Byrne was in charge, and six men were employed.

Colonial.—The property of the Colonial Mining Company, Limited, comprising sixty-eight acres, was leased to the Menago Mining Company, Limited, a subsidiary of the Continental Mines, Limited. The Board of Directors of the operating company comprises: R. C. Warriner, president; Thomas Riggs, vice-president; John L. Agnew, Frederick Bull, treasurer, and Sidney Rossiter, secretary. The head office of the company is 43 Exchange Place, New York.

The sinking of a three-compartment shaft was begun on July 17. This shaft had reached a depth of 644 feet at the end of the year, and was continued to the bottom of the diabase sill at a depth of 962 feet by April 6.

J. P. Hussey is manager, and on an average fifty men are employed.

Coniagas.—The Coniagas Mines, Limited, with a capital of $4,000,000 divided into 800,000 shares of $5 par value, own and operate the Coniagas and Trethewey mines at Cobalt, and the Coniagas Reduction Company's refinery at Thorold. The company also operates under option the Ruby property at Cobalt and the Newray property at Porcupine. The head office of the company is at St. Catharines, and the directors are: R. W. Leonard, C.E., president, St. Catharines; Alex. Longwell, vice-president, Toronto; F. D. Reid, general manager, Cobalt; R. P. Rogers, Woodstock; A. L. Bishop, St. Catharines; H. H. Collier, St. Catharines; R. L. Peek, Deschenes, Que. J. J. Mackan is secretary-treasurer.

The following is taken from the annual report of the company for the year ending October 31, 1922:

The year's production of silver from the mine reached a total of 1,158,882 ounces, as compared with 1,301,515 ounces last year. Of this recovery 1,121,279 ounces were obtained from 123,583.8 tons of ore hoisted having an average value of 9.19 ounces per ton, as compared with 10.7 ounces the previous year, and 37,603 ounces from the re-treatment of sand tailings which had accumulated on the property from former years. The company realized an average price of 70.09 cents per ounce for silver during the year, as compared with 70.88 cents per ounce last year. The output for the year in tons of ore milled averaged 3.77 tons per man per day, exclusive of 30 tons of high-grade ore sacked in the mine, and 24,739 tons of old sand tailings re-treated.

The ore was mined and concentrated during the year at a cost of 32.46 cents per ounce of silver content, as compared with 33.52 cents last year. This cost included all overhead expenses, royalties and other general expenses, but excludes the cost of smelting, refining, shipping and marketing, which amounted to 7.64 cents per ounce, as compared with 6.33 cents last year. The average cost of silver produced during the past fifteen years, including all charges above mentioned, has been 23.87 cents per ounce.

Two dividends of $100,000 each, amounting to 5 per cent., were paid during the year, making a total distribution to October 31, 1922, of $11,040,000. An additional dividend of 2½ per cent. was declared payable November 1, 1922.

The Coniagas Reduction Company, Limited, shipped during the year 380,766.4 ounces of fine silver, resulting from the re-treatment of speiss, slag, etc. No ore was purchased, and the works closed down on January 3, 1922. The average number of men employed was sixteen.

In conjunction with the Niagara Alkali Company and the Electro-Bleaching Gas Company, both of Niagara Falls, New York, a new company was formed under a Dominion charter to take over a portion of the company's property and operate under a different process for the reduction of ores (particularly silver-cobalt ores) and the manufacture of other products. The new company is the Coniagas Alkali and Reduction Company, Limited, in which the old company has acquired a substantial stock interest in exchange for assets and rights.

The Coniagas Reduction Company's plant at Thorold, Ontario, has been a substantial producer of silver bullion, cobalt oxides and metal, white arsenic and nickel oxide and metal, for the past fourteen years. The financial results of its operation have been highly satisfactory, and it has proved a valuable asset to the company.

The average force of men employed at Cobalt during the year was ninety-six on a seven-day basis, or 112 on a six-day basis.

TRETHEWEY

Work performed on the Trethewey property of the Coniagas company consisted of developing known veins and stringers on all levels. Further connections with the main workings were completed, for the purpose of more efficient handling of the ore.

This property produced, during the fiscal year, 23,217 tons of milling ore, with a silver content of approximately 232,000 ounces, or a total of 30,893 tons of milling ore, containing approximately 307,000 ounces of silver, since its purchase by the company.

RUBY

This mining property, located in Bucke township, three miles northeast of Cobalt, was worked under option by the Coniagas company.

Work formerly done on this property disclosed silver values in the Keewatin formation, to which the original workings were confined. The silver, however, was not in sufficient quantity to be profitably mined.

Exploratory work has been confined to diamond drilling to the west of the present workings. This work disclosed a thickness of the Cobalt series, sufficient to warrant further exploration by development work underground.

Construction work commenced on August 30, and was completed at 4 p.m. October 4. At 7 p.m. October 4, the compressor building and store house were destroyed by the fire which prevailed throught the district. On October 9 re-construction started, and the plant is again completed.

The plant consists of a shaft house, power building, powder magazine, dry house and transformer house. The machinery installation includes an Alley McLellan vertical 400 cubic foot air compressor, driven by a 75-horsepower Westinghouse motor, and a Jenckes 9 by 12-inch geared hoisting engine.

The development programme for the immediate future is to sink the shaft, which is now 62 feet, to a depth of 150 feet, and to drive a crosscut on this level, approximately 1,000 feet west, to explore the more favourable Cobalt series.

NEWRAY

On the Newray gold property, situated in the township of Tisdale, Porcupine, several diamond drill holes have been driven, indicating favourable geological formation which warrants further exploration. *See* page 59.

Dickson Creek.—The Dickson Creek (Cobalt) Silver Mines, Limited, operated their mine until June 10 with a force of seven or eight men. About 240 feet of drifting was done on the 300-foot level. The total work to date comprises 325 feet of shaft on a 78½-degree incline, 247 feet of drifts and crosscuts on the 100-foot level, 30 feet on the 250-foot level, and 450 feet on the 300-foot level.

H. Hollands-Hurst is manager, and the directorate remains the same as last year.

Dominion Reduction.—The Dominion Reduction Company, Limited, operated a portion of their mill for four months, beginning July 11, in the re-treatment of Peterson Lake tailings. G. W. Perram is manager, and twenty men were employed.

The tailings re-treated amounted to 21,770 tons of an average value of 3.825 ounces, from which 48,900 ounces of fine silver were recovered. Shipments included 185 tons of flotation concentrates of an average value of 264 ounces per ton.

Genesee.—The Genesee Mining Company, Limited, unwatered their mine, and began drifting on March 8. The development work done during the year comprised 428 feet of drifting on the 350-foot level, 425 feet of crosscutting on the 450-foot level, and a 10-foot raise.

L. F. Steenman, Cobalt, is manager, and six to ten men were employed.

Kirkbud.—The Kirkbud Mining Company, Limited, own claims T-19224-5 and T-19246 in Gillies Limit and began operations on May 18, with a force of six men, which was later increased to fifteen men, under superintendent C. S. Merriman.

Camp buildings, a hoist house, and a head frame were erected, and a 7 by 10-inch Marsh and Henthorn hoist was brought from the Waldman mine and installed. The sinking of a two-compartment shaft began on July 24, and this was down 130 feet at the time of the fire on October 4, when operations ceased.

The company is capitalized at $1,000,000 in shares of $1 par value. S. J. Merriman is president, Cecil Cave, vice-president, and G. L. Buffham, secretary-treasurer. The head office of the company is at 336 Woolworth Building, Watertown, N.Y.

LaRose.—LaRose Mines, Limited, has a capital of $1,500,000 in shares of $1 par value, and operates several mines at Cobalt including the University Mines, Limited. The board of directors is as follows: D. Lorne McGibbon, president; Edwin Hanson, vice-president; Stephen J. Le Huray, secretary-treasurer; G. C. Bateman, general manager; E. W. Nesbitt, W. M. Dobell, David Fasken, K.C., George Parent, K.C., M.P., and Sir Thomas Tait. The head office is at 260 St. James Street, Montreal.

The general manager's report for 1922 gives the production for the year from the combined properties as 469,146 ounces of silver, having a gross value of $322,945, which includes $7,144 for the cobalt in the ore. The output consisted of 70.26 tons of high-grade, containing 153,325 ounces, and 24,784 tons of milling ore, containing 393,809 ounces. From the latter there was recovered 381 tons of concentrates, containing 315,821 ounces of silver. The mill ore averaged 15.89 ounces, the concentrates 827 ounces, and the high-grade 2,180 ounces a ton. Total costs were $302,065, leaving a net operating profit of $20,880. Other income, including exchange amounted to $23,197, making a total net income of $44,078 for the year.

A dividend of 10 per cent., amounting to $150,000, was paid April 20. The net surplus was $450,355 at the end of the year.

Following the big fire, which occurred on October 4 and damaged the transmission lines of the power company, there was a general shut-down for about two weeks. During this interval the Bailey customs mill, which treated LaRose ore, was sold under authority of the bondholders for default in bond interest, to the O'Brien mine, and the LaRose contract was automatically cancelled.

The following information is taken from the annual report of the company:

Work done in 1922 may be summarized as follows:—

	Shafts ft.	Stations cu. yds.	Drifts ft.	Crosscuts ft.	Raises ft.	Stopes cu. yds
La Rose	.....	.....	.....	222.	.....	343
Princess	27.5	.....	357.	119.5	110.5	830
University	.....	.....	712.5	1,719.0	172.5	3,728
Violet	92.5	81	400.	75.5	43.5	1,970
Totals	120.0	81	1,469.5	2,136.0	326.5	6,871

The tonnage of mill rock supplied by each mine was:

La Rose	1,088 dry tons
Princess	2,602 " "
Violet	5,290 " "
University	15,803 " "
Total	24,783 dry tons

New Properties.—In the early part of the year the University workings were approaching the west boundary and in order to protect the company on the extension of any veins which might be found in this section, the Cleopatra and Montreal Syndicate properties adjoining the University were taken over. The Cleopatra property, consisting of 53 acres, was purchased outright for a small sum, and the Montreal Syndicate property of 13 acres was leased for three years on favorable terms. A number of other properties in different parts of Canada were investigated and the company entered into negotiations for a working option on a promising property in the Porcupine district. Terms have been agreed upon, but due to delay in transferring titles the actual agreements have not yet been signed. As soon as this is done, diamond drilling will be started on the property.

La Rose Mine.—There was shipped from this property 2,574 ounces of high grade and 1,088 tons of mill rock, averaging 21.53 ounces a ton, or a total gross output 23,475 ounces. Production came from old workings in which there is still a limited amount available.

Partly as a result of geological work undertaken in Cobalt by the Provincial Geological Department, it was decided to do further work on the La Rose Extension claim, which had been closed down for about seven years. Exploration is being carried on, but has not yet reached the point where it is believed the most favorable territory lies.

Violet Mine.—Production from this property consisted of 25,204 ounces of high grade and 5,290 tons of mill rock, averaging 25.91 ounces a ton, a total of 137,061 ounces, which came from the 530 and 600-foot levels. The winze was continued to the 600-foot level, where the best ore yet encountered in this mine was found, several hundred feet east of the winze. Fifty feet of drifting produced over 25,000 ounces of high grade. The high grade ore did not reach the roof of the drift, and it would appear that the drift is on the apex of an ore body. There is good milling ore in the face, and the roof of the drift and the prospects for further development in this area are considered most promising.

On account of the rake of the ore bodies, it would have been necessary to sink another winze at the point where this new ore was found, which would have necessitated three different hoistings to get the ore to the surface. The new shaft is being sunk immediately over the point where it was proposed to sink the new winze, and if it is continued through to 600 feet will result in considerable economy of operations. The new shaft can, if considered advisable, be connected with the 470-foot workings.

There is considerable ore available in the stope above the 600-foot level, while the undeveloped ground between the 470 and 600 foot levels will also undoubtedly produce ore. The new shoot should give a considerable production below the 600-foot level, in addition to excellent possibilities further to the east. On the Colonial property, adjoining the Violet, a shaft is being sunk a distance of 900 feet to explore the same geological horizon, without the definite assurance of ore which the Violet possesses.

Princess Mine.—Production amounted to 70,759 ounces from 24,782 ounces of high grade and 2,602 tons of mill rock, averaging 17.67 ounces a ton. A new ore bearing section was found, which is the extension of No. 12 vein and while the probable tonnage is not large, the grade of the ore is good. Over 1,200 tons broken in the course of development work and the opening up of the stope is stored underground and the costs have gone against the year's operations. As soon as milling is resumed this ore will be shipped and production will also come from the new stope.

Lawson Mine.—Production from this property was 15,708 ounces of high grade, derived from some old pillars. No underground work was done during the year.

University Mine.—This property contributed the major part of the combined output of the La Rose and University, and produced a total of 275,321 gross ounces, of which 85,056 ounces came from high grade, and 187,265 ounces from 15,803 tons of mill rock, averaging 11.85 ounces a ton. The operation of the property resulted in a profit of $17,948.

During the year the known ore was practically exhausted and while several new discoveries were made, these proved to be small. The westerly workings were extended a short distance into the Cleopatra and Montreal Syndicate properties, but only a small amount of work was done on them, and nothing of importance was found.

Development work is being continued and there is still a large area of slates on both the University and Cleopatra to be prospected. It is in the slates that practically all ore on the University has been found, and the remaining ground offers good possibilities.

On an average, seventy men were employed.

Mining Corporation.—The Mining Corporation of Canada, Limited, has an issued capital of $8,300,250 in shares of $5 par value. The directors and officers of the company are: J. P. Watson, president; W. R. P. Parker, first vice-president; G. M. Clark, second vice-president; E. H. Rose, J. G. Watson, Thomas Plunkett, Capt. C. E. Trafford, directors; Scott Turner, consulting engineer; M. F. Fairlie, mine manager; G. C. Ames, secretary. The head office is at 1512-20 Bank of Hamilton Building, Toronto.

The silver produced from the older mines of the corporation amounted to 338,638 ounces during the year, from the Buffalo mine 965,037 ounces, and from the Cobalt lake tailing plant 158,594 ounces, making a total of 1,462,269 ounces. The profit at the mines amounted to $101,958.15, and the net profit of the company's operations amounted to $41,965.15.

The average number of men employed was, at Cobalt, 225, of whom 145 were engaged in mining, and eighty in the mill of the Cobalt Reduction Company.

The following is taken from the resident manager's report for 1922:

Ore Reserves.—At the end of 1921 our Ore Reserve estimates showed a total of 102,300 tons in Townsite-City-Lake and Buffalo Mines. During 1922 a total of 91,622 tons were treated, and at the end of the year there were 19,585 tons of broken ore in the stopes, while the tonnage of possible ore in place is problematical.

Tailing.—During the year 54,362 tons of old tailing were reclaimed from the bed of Cobalt Lake, and treated at a small profit by oil flotation in the Buffalo plant. The margin of profit on 4 to 5 ounce material is necessarily small and the price of silver will determine whether the treatment of the remaining tonnage of tailing will be resumed during the coming season.

New Properties.—A group of eleven claims in South Lorrain has been taken under the control of the Mining Corporation, by option or purchase in this district. Active exploration during the year was confined to the two claims known as the Frontier and Crompton. High-grade ore has been developed in drifting on three veins, all of which offer encouragement for further exploration. A total of 6,108 feet of drifting and cross-cutting was done during the year, and the main shaft deepened to the fourth level. No attempt has been made to treat milling ore, and this grade of material is being accumulated pending future developments. Owing to the erratic character of the ore-shoots so far encountered and to the fact that development to date has been almost entirely by drifting operations, it is impossible to estimate ore reserves with any degree of accuracy. Work during the coming year will enable the Corporation to place a more accurate value on its holdings in this promising territory. The fact that no road has yet been completed into the district has greatly hampered operations in South Lorrain. Work on this government road is being pushed aggressively, and completion is promised during the coming year.

Farah.—A lease on this property owned by the Nipissing Extension Mines, Limited was taken during the year, and a small force of men has been employed. No ore was shipped from the property during the year.

Peterson Lake.—A lease on the properties of this company was taken late in the year. Unwatering operations are now going on.

Concentrating Plant.—This plant, the Cobalt Reduction Company, Limited, ran 350 days during the year. In addition to holidays, the plant was shut down 11½ days due to damage to the power transmission lines by fire in October. Seventy-five stamps ran 603,406 out of a possible 629,500 stamp hours or 95.85 per cent. of the possible running time. The tonnage of mine ore treated in the low-grade plants was 91,730 against 72,664 tons in 1921. This tonnage was shipped by the following mines:—

The Mining Corporation of Canada, Limited	23,403.33
General Examining and Developing Company, Limited	68,216.00
Sundry	111.27
	91,730.60

Cyanide Plant.—This plant ran 350 days in 1922, treating slimes produced from mine ore.

Flotation Plant.—Treatment of tailing from the bed of Cobalt Lake commenced on May 4th, and was continued until November 7th.

Summary of Milling Operations:

		Extraction Per cent.
Tons of mine ore milled	91,730.60	
Tons of Cobalt Lake tailing milled	54,362.00	
Total tons	146,092.60	
Average assay	12.40	
Ounces contained	1,811,313.90	
Tabled concentrate produced, ounces	1,047,061.60	57.81
Flotation concentrate produced, ounces	158,593.65	8.75
Bullion produced from cyaniding, ounces	349,897.69	19.32
Total ounces produced	1,555,553.17	85.88

High-Grade Plant.—This plant treated 1,499.60 tons, including 851.48 tons of purchased ore and concentrate, against 1,049.86 tons in 1921. The refinery produced 3,181,475.83 ounces of refined bullion, of which 2,831,578.14 ounces were from the high-grade plant and 349,897.69 ounces from the low-grade cyanide plant.

Residues carried over from 1921, and the 1922 production to November 1st, amounting to 2,892 tons, were shipped during the year.

General Costs.—The total cost of operation was $451,770.00 against $322,912.98 in 1921. The tonnage on which costs are figured is the tonnage of mine ore treated in the low-grade plants and does not include purchased ore treated in the high-grade plant or tailing.

Included in the total cost of operation is the cost of tailing treatment amounting to $78,679.91. None of this material was treated in 1921. For comparison with the previous year, this amount should be deducted, leaving a balance of $373,090.09 or $4.06 per ton against $4.44 in 1921.

McKinley - Darragh - Savage.—The McKinley-Darragh-Savage Mines of Cobalt, Limited, capital $2,500,000 in shares of $1 par value, operates the McKinley-Darragh-Savage mines. The company's offices are at The Trusts & Guarantee Building, Toronto, and Cobalt, Ontario. The directors are: J. R. L. Starr, president; Thomas W. Finucane, vice-president; T. R. Finucane, treasurer; J. H. Spence, secretary; H. C. McCloskey, manager; A. G. Beckwith and B. E. Finucane.

The McKinely-Darragh mine and mill employing seventy-five men, were in operation for the last seven months of the year.

Mining operations were confined mostly to known ore bodies and several extensions to these were opened up. The total ore removed from the mine was 25,799 tons, and from dumps 88 tons. There are approximately 20,000 tons of broken ore and a considerable tonnage of unbroken ore still in the mine.

Mining operations are summarized as follows:

Year.	Shafts feet	Drifts feet	Crosscuts feet	Raises feet	Winzes feet	Stoping tons	Stations cu. yds.
1922	....	113.5	94.5	112.5	....	16,752	....
Totals to date.	1,447.5	36,991.5	33,275	7,320	1,265.5	445,860	478

The mill ran 75.84 per cent. of the possible running time, a total of 202,039 stamp hours, and treated 25,848 tons, an average of 120 tons per day. The average mill heads were 12.113 and the average mill tails 1.946 ounces per ton. The percentage of extraction was 84. The ratio of concentration 89.64 to 1. A total of 263,073 ounces of silver was recovered.

The total silver recovered was distributed in the following classes of products:

Classification	Tons of Product	Ounces of Silver	Percentage of Total	Average Ozs. per Ton
Nuggets	.278	6,207	2.09	22,327.3
Below 550 ounces per ton	22.041	3,135	1.06	142.2
550 to 1,000 ounces per ton	25.834	21,830	7.35	845.0
1,000 to 2,000 ounces per ton	24.205	34,358	11.57	1,419.5
Over 2,000 ounces per ton	7.105	16,638	5.60	2,341.7
Sand Concentrates	126.262	142,016	47.81	1,124.8
Flotation Concentrates	121.631	72,849	24.52	598.9
Totals	327.356	297,033	100.00	907.4

Production costs amounted to $131,390.22, that is $5.075 per ton mined, or $0.4424 per ounce of silver recovered, and total costs amounted to $161,940.81, that is $6.255 per ton mined, or $0.5452 per ounce of silver recovered. The cost per ounce of silver produced was the lowest since 1916, and the selling price averaged 65 cents per ounce.

The year's operations yielded a profit of $65,086.64, and the company's surplus stands at $108,959.20.

Nipissing.—The Nipissing Mines Company, Limited, has an authorized and issued capital of 1,200,000 shares of a par value of $5. The officers of the company are: E. P. Earle, president; Alexander Fasken, secretary; P. C. Pfeiffer, treasurer. The directors are: W. H. Brouse, John H. Black, and David Fasken, of Toronto; Richard T. Greene, E. P. Earle, August Heckscher and R. B. Watson, of New York. The head and corporate office is in the Excelsior Life Building, Toronto, and the New York office is at 165 Broadway.

The operating company is the Nipissing Mining Company, Limited, with an authorized and issued capital of 2,500 shares of a par value of $100. The officers are: David Fasken, president; E. P. Earle, vice-president; Alexander Fasken, secretary; P. C. Pfeiffer, treasurer. The directors are: John H. Black and David Fasken, of Toronto; E. P. Earle, Richard T. Greene and R. B. Watson, of New York. The operating officials are: R. B. Watson, general manager; Hugh Park, manager; James J. Denny, manager research department. The head office is in the Excelsior Life Building, Toronto.

The following information is taken from the eleventh annual report of the company, covering the year 1922.

	Fine Ounces Silver	Gross Value	Net Value
Shipments in 1922	3,845,011.83	$2,904,335.62	$2,884,391.29
On hand at Mine, Dec. 31, 1922	868,447.11	648,456.33	639,949.65
	4,713,458.94	$3,552,791.95	$3,524,340.94
On hand at Mine, Dec. 31, 1921	1,290,344.14	1,020,438.31	1,013,870.01
Nipissing production	3,423,114.80	$2,532,353.64	$2,510,470.93

This silver was produced at a cost of 32.938 cents an ounce or $13.746 a ton of ore. The total production of silver by this mine to December 31, 1922, amounts to 65,700,579.22 ounces.

High-Grade Ore Treatment:

The various products treated in the high-grade plant were:

	Tons	Assay, Ozs.	Contents, Ozs.
Nipissing Concentrate	1,971	1,214	2,393,207
Custom Ore	25	1,081	26,517
By-products	26	2,458	63,904
	2,022	1,228	2,483,628

There were no important changes made in the high-grade ore treatment. The number of ounces treated was about the same as in the previous year. The cost per ton was materially decreased.

Shipments of residue amounted to 2,961 tons. This did not include any of the 1922 production which was 2,385 tons, containing 55 ounces silver and 7 per cent. cobalt per ton.

The refinery treated precipitate containing 3,139,945 ounces.

Shipments of 3,682,817 fine ounces of bullion were made during the year.

Low-Grade Mill:

	Tons	Assay	Ounces
Ore treated	82,025	44.01	3,609,757
Recovered in Products:			
Precipitate	35	24,683	866,358
Coarse Concentrate	1,796	1,338	2,403,030
Fine Concentrate	261	450	117,452
Total recovery			3,386,840

Average tailing, 2.77 ounces. Recovery, 93.82 per cent.

Forty stamps ran 290 days, 19 hours, or 79.67 per cent. of possible running time, and crushed 282.1 tons per day, or 7.053 tons per stamp per day.

The tons and ounces treated were more than in any previous year.

The cost per ton was 41 cents lower than in 1921, notwithstanding there were no material decreases in the market cost of supplies.

Summary of Underground Work, 1922:

Shaft No.	Drifting feet	Crosscutting feet	Raising feet	Sinking feet	Total feet	Stoping cubic yds.
19	152.0	32.0	192.0	....	376.0	2,601.61
26	191.5	31.0	.....	....	222.5	....
63	999.0	2,246.5	234.5	44.5	3,524.5	5,212.20
64	60.5	41.0	576.5	....	678.0	3,745.36
73	938.5	2,010.0	599.0	20.0	3,567.5	7,686.93
128	217.0	1,688.0	57.5	....	1,962.5	....
Totals	2,558.5	6,048.5	1,659.5	64.5	10,331.0	19,246.10

DEVELOPMENT.

All mining operations were considerably increased during the year. Work was carried on at six shafts, all widely separated. The total underground advance was the largest in several years; it was 63 per cent. more than in 1921. The number of faces worked was 170, exclusive of stopes, of which there were 20. Several new veins of moderate importance were discovered. The greatest increases of known ore, however, were obtained in the stopes of the older veins, particularly 64 and 490, and in the satisfactory development of vein 251, found a year ago.

Shaft 19. A large tonnage of mill rock was mined from No. 6 open cut. The stope is increasing in length, and there is still a considerable area to be broken.

Vein 130 will also be mined through this shaft. It is smaller than No. 6, but the vein contains more high grade ore.

Stoping operations were confined to the summer months, as the broken rock freezes during the winter.

Shaft 26. A large production was obtained from this shaft during the early period of the property, but it has not been worked in recent years. The vein was extremely high grade and was mined to a depth of 200 feet. It was one of the few veins of the district that produced any considerable amount of silver from the keewatin formation.

The shaft was pumped out and repaired during the latter part of the year, and a large amount of exploration and development will be done. Particular attention will be given to an area near the lower contact of the diabase sill and the keewatin.

Shaft 26 was worked before the company had a mill for the treatment of low grade material; only high grade ore was sought. It is probable that the old stopes contain unbroken low grade ore which can now be recovered and treated at a profit.

Shaft 63. All mining work was increased during the year. A few small veins were found, but the most important result of the year's woık was the favourable development of Vein 251.

A new level was started just above the keewatin contact, 55 feet below the discovery level. A drift at the lower level shows a continuous ore shoot 265 feet in length. The vein is two inches wide and has an average assay of 2,900 ounces. The present estimated ore reserves in Vein 251 will probably be materially increased by vertical development, now under way.

After producing a large tonnage during the year, the ore reserves at shaft 63 show practically no decrease, and are about one-half of the total reserves at all shafts.

Shaft 64. Stoping was actively carried on throughout the year. Notwithstanding a large production, the ore reserves show only a small decrease.

There is still an area to be mined which contains high grade ore and which will also produce a large amount of mill rock.

Shaft 73. As in former years, this shaft produced most of the tonnage treated. After sending 42,000 tons to the mill, the reserves show an increase in tons and only a slight decrease in silver ounces.

Several new veins of fair importance were found. Faulted portions of a number of others were favourably developed, and will produce a considerable tonnage in the future.

An important development was made on vein 490. While stoping a low grade section of the vein, a high grade shoot was encountered which more than compensated for withdrawals made during the year. The vein is six to eight inches in width and assays several thousand ounces over a length of 60 feet.

Vein 490 has been a consistently large producer for several years and the present reserves show an increase over the previous year.

Shaft 80. No work was done during the year.

Shaft 128. No favourable developments were encountered and the shaft was closed late in the year, the equipment being transferred to shaft 26.

Ore reserves, comprising developed and partly developed ore, were placed as follows, December 31, 1922:—

Shaft	High-Grade Ore		Low-Grade Ore		
	Tons	Ounces	Tons	Assay	Ounces
63	366	612,560	14,582	17	254,205
64	206	168,780	5,793	15	104,274
73	221	318,570	11,247	17	193,040
80	64	109,120	2,392	25	59,800
96	83	166,700	10,866	15	162,990
490	265	216,270	12,458	20	249,160
	1,205	1,592,000	57,338	18	1,023,469

O'Brien.—The O'Brien Mine is owned by M. J. O'Brien, Limited, of which the officers are: president, M. J. O'Brien, Renfrew; vice-president, J. A. O'Brien, Ottawa; mine manager, J. G. Dickenson, Cobalt.

The O'Brien mill was completely destroyed by fire on September 4, 1922. This mill had been treating ore since 1909 and during that time over 600,000 tons were milled. It was a combined concentrating mill and cyanide plant, the ore being stamped in cyanide and all tailings from concentration being reground and cyanided. It was the first mill in Cobalt, in which all the milling ore was treated with cyanide.

One month after the mill-fire, the Bailey mill, which was formerly operated as a custom plant at Mileage 104, was purchased by the O'Brien. Milling was commenced in November. The narrow gauge railway at the O'Brien was extended one-half mile to the Bailey mill, the ore being handled in five-ton cars by a gasoline locomotive.

The development during the year amounted to 1,580 feet of drifting and crosscutting, 65 feet of sinking and 214 feet of raising. The total tonnage milled amounted to 46,112, from which was recovered 916,000 ounces. An average of 150 men was employed.

Oxford.—Oxford Cobalt Silver Mines, Limited, resumed work on their property in Gillies Limit in August and continued until October 15. A total of 280 feet was driven on the 75-foot level in No. 3 shaft.

D. R. Russell is manager, and six men were employed.

Silver Queen.—The Silver Queen property was leased to J. L. Sweet in July, 1922. About 30 bags of ore was taken out from a pillar beside the winze in the first level. This ore, together with some obtained from picking over the dump, yielded 5,664 ounces of silver.

Victory.—The Victory Silver Mines, Limited, continued the shaft on their property in southeast Coleman from 185 feet to a depth of 464 feet, and cut a station at 450 feet. The lateral work comprised 101 feet of drilling and 378 feet of crosscutting on the 450-foot level. A 10 by 12-inch hoist was installed.

J. A. McVichie is manager, and the directorate remains the same as last year. Twelve men were employed.

South Lorrain

Frontier.—The Mining Corporation of Canada, under a subsidiary the Lorrain Operating Company, has acquired by option or purchase a group of eleven claims in South Lorrain. These comprise the Haileybury Frontier, and the Crompton, H.R. 20, H.R. 68, H.S. 39, H.R. 17, H.R. 167; also the Forneri, H.R. 39, G.F. 10, and G.F. 11.

Active exploration during the year was confined to the Frontier and Crompton claim. The Frontier main shaft was deepened from 300 to 400 feet, and a total of 6,108 feet of drifts and crosscuts were driven. High-grade ore was developed on three veins, and about the end of the year a very fine shoot of high-grade ore about 100 feet long was developed on the Crompton in the continuation of the Woods vein.

On an average eighty men were employed.

Keeley.—The Keeley Silver Mines, Limited, operated their property in South Lorrain during the year and also opened up the Little Keeley mine as a prospect in April, but closed it down in June. An average of ninety men is employed. Dr. J. Mackintosh Bell is manager, and Mr. H. Whittingham resident superintendent.

The general manager's report summarizes the operations as follows:

The year's operations, both in mine and mill, were highly satisfactory. In spite of a total production of 815,265 ounces, the ore reserves at the end of the year were estimated to contain 1,639,234 ounces of silver, and 330,713 pounds of cobalt; an increase over last year's figures of 784,234 ounces of silver and 24,913 pounds of cobalt. The physical condition of the mine is excellent. The milling has shown steady and marked improvement—both as regards tonnage and extraction—and, although at the end of the year considerable trouble was being experienced with the refractory ore from the south end of the lower levels, it is confidently anticipated that the mill will continue to give a high recovery without recourse to chemical methods.

During 1922 the No. 3 or main shaft was deepened from 418 to 495 feet. A new level, No. 7, was opened up at a depth of 480 feet.

At a depth of 101 feet in the old Beaver Lake shaft a new drift, No. 131a, was driven north, partly to facilitate operations in D3 stope and partly to provide an alternative exit from the mine workings. This drift demonstrated a lateral extension of the D ore body, the drift having encountered high grade ore, 40 feet south of D3 stope.

With the above exception, mining operations were limited to No. 3 shaft, in which the following work was carried out at the levels indicated.

	No. 3 ft.	No. 4 ft.	No. 5 ft.	No. 6 ft.	No. 7 ft.
Drifting	480	39.5	648.0	950.5	1214.5
Crosscutting	....	....	....	31.0	49.0
Side slashing	18	21.0	21.0	57.0	72.0
Raising	....	57.0	....	10.0	....
Sinking	....	....	....	77.0	....
Station Cutting	....	....	....	....	35.0

On the 5th level the most important development was the opening up of shoot D5 which extended to a length of 60 feet, averaging 108 ounces over 33 inches. Except for this shoot, the northern development of Woods vein on this level did not produce any new ore, though the vein continued strong. The work on No. 16 vein on this level was not productive of any ore, although the vein was strong and encouraging.

On the 6th level the further development of Woods vein produced most satisfactory results. To the north shoot D6 was developed for a length of 140 feet, averaging 247 ounces over 18 inches. To the south shoot N6 was entered and was developed for a length of 135 feet averaging 524 ounces over 20 inches. No. 16 vein was drifted on for a distance of 313 feet with encouraging results. Shoots of ore being encountered at 80 feet and 188 feet west of Woods vein. Q shoot averaged 21 ounces over 17 inches for a distance of 20 feet, and R shoot averaged 295 ounces over 17 inches for a distance of 73 feet.

The outstanding feature of the year's developments was the extremely gratifying results obtained on the 7th level. These did more than merely demonstrate the continuance of silver values well below the diabase-keewatin contact. They developed the richest ore yet found in the mine. The north drift on Woods vein encountered ore of excellent grade at a distance of 95 feet from the main crosscut. This body of ore (believed to be the downward continuation of shoot F) was proven for a total length of 175 feet, with average values of 530 ounces over 14 inches, whilst for a distance of 40 feet the values were spectacular. In one place a central band 8 inches wide assayed 14,800 ounces per ton, and for the whole 40 feet the vein averaged 2,550 ounces over 10 inches. North of this shoot on Woods vein no further ore was encountered at the end of the year.

The south drift on Woods vein encountered good ore—in part secondary—at a distance of 240 feet from the main crosscut. This shoot, believed to be the downward continuation of shoot N, had up to the end of the year shown a total length of 104 feet with an average value of 406 ounces over 17 inches.

About the middle of December a new vein of considerable importance was discovered branching northwest from Woods vein south at a point 300 feet south of the main crosscut. This vein, No. 26, contains a shoot of ore 74 feet in length with an average value of 2,500 ounces over a width of 15 inches.

Of the ore broken during the year, by far the greater portion came from new stopes. Stopes F3, N3, N4, O5, D5, F6, N6 and DL6 were timbered for a total length of 584 feet and leading stopes (untimbered) were removed in shoots R6 and Q6.

Ore was broken principally in the following stopes. The letters indicate the shoot and the figures the level immediately below.

D. 3	5,031 tons
N. 3	3,196 "
F. 3	1,989 "
N. 4	142 "
F. 4	178 "
B. 5	566 "
D. 5	1,466 "
F. 5	1,426 "
O. 5	1,078 "
F. 6	3,320 "
D. 6	3,288 "
R. 6	370 "
Q. 6	65 "
B. 6	515 "
R. 7	137 "
	22,767 tons

In addition to the above, 62 tons were removed from a cut in the floor of the drift under shoot R6, and 5,249 tons were produced from development.

During the year the mill treated 24,596 tons of ore. Of this amount 18,698 tons were from the stopes, 5,249 tons from development and 649 tons from the dumps; 300,115 pounds of high grade ore containing 335,373 ounces of silver and 29,691 pounds of cobalt were picked from the bumping table and shipped direct to the smelter; 827 tons of waste were removed from the mill-feed. The quantity actually milled was 23,619 tons, producing 1,635,985 pounds of concentrates, containing 479,892 ounces of silver and 141,154 pounds of cobalt. The total production for the year was therefore 815,265 ounces of silver and 170,845 pounds of cobalt.

The mill ran 145,607 stamp hours, or 83.11 per cent. of possible running time. The average recovery for the year, based on smelter figures, was 87.68 per cent. as compared with 80.5 per cent. in 1921. The concentrates produced—all grades—averaged 586 ounces per ton. The average ratio of concentration was approximately 29 to 1, and the tons milled per 480 stamp hours averaged 77.86 as against 64.8 in 1921. The average assay of the picked ore was 2,235 ounces per ton.

The principal additions to plant during the year consisted of a new pumping unit with a capacity of 150 imperial gallons per minute against a head of 375 feet installed at Beaver Lake, and a new Sullivan drill sharpener of the latest type. The new pumping unit consists of two Bawden centrifugal pumps direct connected with a 40-h.p. Westinghouse motor. A 15,000 gallon tank was also erected near No. 3 shaft. After the closing down of the operations at the Little Keeley prospect, a 380 cubic foot air compressor driven by a 75-h.p. motor was added to the plant.

Housing conditions for the workmen were improved early in the year by building one new bunkhouse, and by considerably increasing the accommodation available at the old Keeley bunk-houses by means of a central annex which served to convert the two buildings into one. The whole was thoroughly renovated and put in good order.

Septic tanks were constructed; water closets and shower baths were installed at each bunk-house. A new house for the resident superintendent was completed in June. Two additional ore bins were built as an assurance against the stoppage of mill operations through shortage of ore. Towards the close of the year a start was made on a comprehensive building and re-building programme which will greatly facilitate operations.

Elk Lake and Gowganda

Cane.—Cane Silver Mines, Limited, has an authorized capital of $1,500,000 in $1 shares. R. S. Potter is president; W. A. Taylor, vice-president; F. L. Hutchinson, New Liskeard, Ont., secretary.

Work was resumed on the property in lot 2, concession 2, Cane township, in November, by Duncan McRae and three men. A shaft was sunk to a depth of 35 feet during the winter.

Castle.—The Castle-Trethewey Mines, Limited, resumed mining operations March 1st, with a force of fifty men. Murray D. Kennedy is manager, and there are no changes in the company officials.

A 10 by 12-inch hoist and a six-drill air compressor were installed. New buildings erected included a boiler house, 30 by 30 feet, a compressor house, 20 by 26 feet, a blacksmith shop, 25 by 25 feet, seven dwellings and a new camp to accommodate 30 men. An ice house and a store house were moved from the old Castle shaft.

The following is a summary of the underground development:—

Sinking	124	feet
Drifting	1,216	"
Crosscutting	314	"
Raising	85	"
Stoping	988	tons
Slashing	608	"

Production consisted of 11 tons of high grade, containing 40,400 ounces, and 1,530 pounds of cobalt; 5,159 tons of mill ore were hoisted and placed on the dumps.

Everett.—The Everett Mines, Limited, capital $1,500,000 in $1 shares, own claims adjoining the Castle-Trethewey mines at Everett lake, near Gowganda. The officials of the company are: Sir Henry M. Pellatt, president; C. H. Manaton, secretary. The head office of the company is 420 Bank of Hamilton Building, Toronto.

W. H. Fairburn is manager, and twenty-seven men are employed.

The construction of camps began August 15, and mining operations on November 1. The buildings comprise a cook camp, 20 by 40 feet, a sleep camp, 30 by 30 feet, power house, 30 by 40 feet, smithy, 16 by 16 feet, and a stable, 20 by 30 feet.

The Castle No. 1 shaft was leased and the north drift on the 150-foot level continued into the Everett mines property for a distance of 120 feet, in 1922. Thirty feet of crosscut was also driven.

Miller Lake O'Brien.—This mine is owned and operated by M. J. O'Brien, Limited. J. G. Dickenson, Cobalt, is general manager, and H. G. Kennedy, resident superintendent. An average of sixty-two men is employed.

Development work during 1922 comprised 1,220 feet of drifts and 1,236 feet of crosscuts.

A total of 8,918 tons of ore was sent to the mill; sorters' waste amounted to 1,998 tons, and waste hoisted to 618 tons, making 17,435 tons hoisted in all.

The Bonsall group of claims, comprising 318 acres, adjoining the Miller Lake O'Brien property, on the west, was acquired during the year. This brings the company's acreage at the west end of Miller lake to a total of 513 acres.

Sanderson.—The Wigwam Mining Company, Limited, began surface prospecting and the erection of camps on the Sanderson claims near Wigwam, in April. The company has an authorized capital of $2,000,000, of which 1,000,000 shares are issued. The officials are: Col. Robert Stark, president; A. Cleghorn, vice-president; P. K. Brown, 128 Bleury Street, Montreal, secretary-treasurer.

Stuart Troop was manager, and eight men were employed previous to commencing the adit on September 8, and an average of twenty-four men thereafter.

Two boilers of 30 and 40-horsepower were installed, also an 150-cubic foot Alley and McLellan air compressor.

Development work comprised the driving of an adit 272 feet in length and three crosscuts totalling about 90 feet, previous to the suspension of mining operations in March, 1923.

A shipment of 23 bags of medium grade ore was made to Cobalt. This ore had a value of $650.00.

Solid Silver.—The Ontario Solid Silver Mines, Limited, Col. D. Shepp, owner, continued the shaft on their property in Cane township from 50 to 100 feet.

J. A. McRae, North Bay, was manager, and Roy Sullivan, contractor. Four men were employed during part of the year.

IV.—SOUTHERN AND EASTERN ONTARIO

Dolomite

Baptiste Lake.—In the Thirty-first Annual Report of this Department mention was made of a large deposit of dolomite, on the southwest shore of Baptiste lake and about 30 chains west of Baptiste station, on the Irondale, Bancroft and Ottawa branch of the Canadian National railways. In 1921 the deposit was being tested by Ontario Dolomite Manufacturing Company, Limited. This company was reorganized and absorbed by Crystalline Milling Company, Limited. As difficulty was again experienced in financing the enterprise, a partnership, Burnip Bros. and Company, was formed to work the quarry and to grind and sell the dolomite.

A small grinding plant has been erected at 4-10 Darrell Avenue, Toronto, and Burnip Bros. and Company are now selling crushed dolomite for the manufacture of artificial stone, cleansing powders, stucco, etc., and are also supplying dolomite, ground so that 98 per cent. will pass through 300-mesh, to certain industries as a substitute for whiting, asbestos, clay, talc, etc.

Burnip Bros. and Company's office is at 2 Darrell Avenue, Toronto.

Feldspar

Feldspars, Limited.—Bedford township, concession 2, lot 1. Feldspars, Limited, owner of the Richardson feldspar mine, continued to sort the dump in 1922, but did not pump out the pit. J. Ralph Scott, R.R. No. 1, Harrington, Ont., is manager.

Feldspar Mines Corporation, Limited.—This company, a subsidiary of the Pennsylvania Pulverizing Company, of Lewistown, Pa., is working two feldspar properties near Hybla, Ont.,—the Woodcock and the Thompson. S. S. Woods, Lewistown, Pa., is general manager; Wm. J. Woods, Lewistown, Pa., assistant general manager; and Robert H. Thompson, Hybla, Ont., superintendent of the two quarries mentioned.

The Woodcock deposit is in Monteagle township, concession 8, lot 17. This vein was first opened by this company in September, 1921, and has since been worked continuously. In 1922, from 10 to 20 men were employed. The machinery includes a locomotive-type boiler and a Napanee Iron Works double-drum derrick hoisting engine.

The Thompson property is also in Monteagle township, concession 7, lot 11. In November, 1922, the company began work on a new vein, which is on the farm of James Thompson, and is said to be very promising. Several carloads were shipped before the end of the year.

Feldspar Quarries, Limited.—Loughborough township, concession 12, lot 1. Feldspar Quarries, Limited, have shipped feldspar from a number of veins near Verona in past years, but discontinued mining in the spring of 1921. On October 1, 1922, the company began to work the Freeman Feldspar mine, which was operated in 1902 and 1903 by the Pennsylvania Feldspar Company. When inspection was made on November 13, twenty-seven men were employed and the pit measured 114 feet in length, 60 feet in width, and from 8 to 15 feet in depth. The machinery consists of an 8-inch by 12-inch Beatty derrick hoist, and a vertical boiler. In December all work was stopped for the winter.

The directors of the company now are: W. H. Despard, president; James Langskill, vice-president; Thos. A. Chisholm; D. A. Cameron, J. Roy Langskill, all of Toronto. Ernest H. Tapper, Hartington, Ont., is manager.

Gardner Feldspar Company.—Loughborough township, concession 12, east half of lot 3. For a short time in the early part of the year, the Gardner Feldspar Company shipped spar from a deposit on this lot, of which Sylvanus Deyo owns the surface rights and Messrs. Tovell and Lacey, of Sydenham, the mineral rights. The vein is on the west side of Mud Lake, and was opened during the war by L. E. Austin. When inspected on January 26, 1922, the pit was 43 feet long, 20 feet wide, and 15 feet deep.

William Gardner, Hartington, Ont., was manager and Charles H. Hughes, foreman.

Harry Keays.—Bathurst township, concession 9, west half of lot 20. In July, A. M. Campbell, of Perth, started a small crew of men stripping a pegmatite vein on the farm of Harry Keays, near Fallbrook, Lanark county. When inspection was made in August, seven men were engaged in stripping and test-pitting the vein and in building 200 yards of road. The dike is an unusually wide one, but in a considerable part of it the feldspar is discoloured with iron rust. The property has been named the Gleeson-Campbell. It is the intention to ship the feldspar from Glen Tay station, which is five and a half miles distant. M. P. Powers, of Perth, is the foreman.

Macdonald.—Monteagle township, concession 7, lots 18 and 19. The Verona Mining Company, a subsidiary of the Pennsylvania Feldspar Company and operator of the Peter Macdonald feldspar deposit near Hybla, has gone into liquidation. The pit was worked by the receiver from May until September, when all the assets of the company were sold at sherriff's sale.

On November 20, the Genesee Spar Company began to work the vein, and were still shipping at the end of the year. The officers of this company are: president, Samuel R. Parry, Rochester, N.Y.; secretary and treasurer, William C. Fredericks, Rochester, N.Y.; manager, George E. Worth, Rochester, N.Y.; superintendent, Peter Macdonald, Hybla, Ont.

Mount Eagle Feldspar Company, Limited.—Monteagle township, concession 6, lot 22. This company resumed work for a few months in 1922 and went into liquidation in June.

The present owners of the property, who shipped a few cars of spar during the latter part of the year, are represented by C. C. Birkett, 327 Union Buildings, Cleveland, Ohio.

Orser-Kraft Feldspar, Limited.—In 1922 this company did work at the Burns, Kirkham, and Alex. Palmer mines. Sidney H. Orser, Box 266, Perth, Ont., is manager.

The Burns property is in Bathurst township, concession 3, lot 2.

This property was worked on a small scale during the summer. Crushed feldspar for stucco and quartz were shipped. A small plant for crushing the feldspar was erected during the summer; this consists of a 20-horsepower Cleveland tractor, a 7-inch by 11-inch Mitchell jaw crusher, and a small pair of rolls.

The Kirkham deposit is also in Bathurst township, concession 7, lot 3.

The pit was formerly worked by Rinaldo McConnell and Son, but has been idle since August, 1921. It was operated for two weeks in November, 1922, by Orser-Kraft Feldspar, Limited, who shipped four carloads of spar from it.

The Alex. Palmer property is another deposit in Bathurst township, being on lot 5, concession 3, near Christie lake.

Orser-Kraft Feldspar, Limited, owns the mineral rights and Alex. Palmer the surface rights. The company worked here intermittently in 1922 and shipped quartz, but no feldspar, from two pits.

Rock Products Company.—This company, which has been mining feldspar north of Perth for several years, continued to work the vein on the James Keays' farm (west half of lot 21, concession 9, Bathurst township) until February, 1922. The machinery was then moved to the next farm to the west, which belongs to William Keays, and is lot 20, concession 9, Bathurst. The vein on the latter property was worked for a short time in 1921 by Rinaldo McConnell and Son, of Perth. When the last inspection was made, April 3, 1923, the pit on the William Keays' farm was about 90 feet long, from 20 to 40 feet wide, and 65 feet deep. Feldspar of good quality was being produced.

V. M. Gettins, R.R. No. 1, Balderson, Ont., is superintendent and James Benton is foreman.

W. G. Treadwell.—Loughborough township, concession 11, lot 1. During the latter part of the year, W. G. Treadwell, of Ottawa, mined feldspar from several pits on the W. J. Babcock farm, the mineral rights of which are owned by Tovell and Lacey, of Sydenham, Ont. In November a small crushing and screening plant was erected to crush the low-grade material from the veins for the manufacture of stucco fragments and chicken grit.

William Gardner, of Hartington, Ont., is manager for Mr. Treadwell, and George N. Paddock is foreman.

Garnet

Bancroft Mines Syndicate, Limited.—Township of Ashby, concession 15, lot 3. Bancroft Mines Syndicate, Limited, a company capitalized at $250,000, was incorporated in 1922 to mine and concentrate garnet for abrasive purposes.

Those interested in the company, after testing several prospects, finally decided that the one located in Ashby township, in the county of Lennox and Addington, was the most suitable for yielding a grade of garnet acceptable to the abrasive trade.

Camps were built in 1921, later followed by a fully equipped mill, bunk houses, cook and eating houses, stables, blacksmith and tool shops, after which production commenced.

The property was inspected on February 7, 1923. A band of quartzite in gneiss was being worked, and showed a high garnet content. This product has stood the severe tests which have to be made upon garnet mineral before it is acceptable to an abrasive manufacturer, and its quality now appears to be established. While the market for the finished concentrates is somewhat limited, the company has been successful in securing some business.

The directors of Bancroft Mines Syndicate, Limited, are: president, Norman C. Maynard, Toronto; vice-president, H. Ormsby Symmes, M.D., Niagara Falls, N.Y.; secretary-treasurer, Robin Boyle, Toronto. No stock has yet been issued or sold to the public.

Gold

Golden Fleece.—The Golden Fleece mine, owned by The Cobalt-Frontenac Mining Company, Limited, is in lots 24 and 25, concession 6, Kaladar township, about seven and a half miles from Kaladar station, on the Canadian Pacific railway.

All work was stopped in both mine and mill about July 1, 1922, as the company's money was exhausted. However, at the end of the year more money was being raised, and it was expected that work would be resumed in a few months.

The capital stock of the company consists of 3,000,000 shares of $1 par value each. The directors are: president, Noah Dyment, Smithville, Ont.; vice-president, M. E. Fletcher, Hamilton, Ont.; secretary-treasurer and managing director, D. H. Fletcher, Toronto; A. S. Glover, Hamilton; T. H. Matthews, Stirling, Ont.; W. J. Guyatt, Glanford, Ont.; Andrew Dodds, Belmont, Ont.; John McFarlan, Thorndale, Ont.; G. W. Millen, Stoney Creek, Ont. The mine office is at Flinton, Ont., and the general office at 43 Victoria Street, Toronto.

A pamphlet issued by the company toward the end of 1922 contains extracts from a report made by James G. Ross, consulting mining engineer, Montreal, after examining the workings and plant of the Golden Fleece mine on September 8 and 9, 1922. The following notes are summarized from Mr. Ross's report as quoted in the said pamphlet:—

The main shaft, 6 feet by 11 feet, divided into a ladderway and a hoisting compartment, has been sunk to a depth of 100 feet with a 10-foot sump; it is at a slope of 63 degrees to the horizontal.

At the 100-foot level the following development work has been done:

	Feet
South drift	200
South crosscuts	140
" "	22
Centre crosscut, easterly	130
South drift from centre crosscut	35
North drift	115
North crosscut	110

North stope, 20 feet wide, 50 feet long.
South stope, 30 feet wide, 106 feet long.
Winze from centre crosscut, 66 feet deep.

Development work at the 100-foot level has disclosed three principal veins composed of quartz and sericite schist., all of which are well mineralized.

No. 1 vein, in which the main shaft is sunk, has a width of over 20 feet.

No. 2 vein is parallel to and a few feet easterly from No. 1 vein; it has an average width of about 30 feet.

No. 3 vein is about 50 feet easterly from No. 2 vein and is from 12 to 15 feet wide.

From 40 to 50 feet farther east a number of quartz stringers occur; at this point work was stopped.

A number of test pits have been sunk along the strike of the mineralized zone for a distance of about a mile, and in each case a vein was exposed which is probably the continuation to the north and south of that now being developed.

The strike of the zone is east of north and the dip 63 degrees. The hanging wall does not appear to have been encountered in either the surface or underground workings.

The mill is so laid out that the ore can be treated by amalgamation or by cyanidation, the crushing units being the same for either process.

The flow sheet is as follows:

Ore bins, 200 tons capacity.
Grizzly with by-pass for waste.
Crusher of the jaw type, 14 inches by 24 inches.
Ore bin, 60 tons capacity.
Two batteries of stamps, each stamp weighing 1,250 lbs.
Dorr classifier.
Tube mill, 5 feet by 16 feet.

After being ground in the tube mill the ore may be passed over amalgam plates or sent to the cyanide treatment tanks, which are laid out on the Dorr system.

3 agitator tanks, 20 feet by 14 feet.
2 thickener tanks, 30 feet by 12 feet.
2 thickener tanks, 33 feet by 12 feet.
2 gold tanks.
1 solution tank.
Clarifier.

Zinc feeder.
Filter press.
4 diaphragm pumps, McIntyre type.
1 vacuum pump.
3 storage tanks.
3 triplex pumps.
1 air compressor.
1 auxiliary gas engine.

After some minor additions and adjustments are made, the mill equipment will be ample to treat ten tons of ore per hour.

Mr. Ross states that the indications are favourable for the opening up of a large body of ore.

Gypsum

Ontario Gypsum Company.—The Ontario Gypsum Company, Limited, which is the only producer of gypsum in Ontario, operates two mines in Haldimand county, at Caledonia and Lythmore. At Caledonia the company owns 300 acres outright, and has the mining rights on an additional 50 acres. The location is on lots 9 and 10, range I, Seneca township, and lies on both sides of the Hamilton-Port Dover highway. The Lythmore mine is on lot 29, concessions 3 and 4, Oneida township.

At Caledonia the mining has been confined almost exclusively to one bed of gypsum, which is the most suitable for the different products. This bed lies in a horizontal plane about 80 feet below the surface and has a uniform thickness of about 7½ feet. An area of 50 acres had been mined previous to the beginning of 1922, and an additional four acres was mined during that year. The maximum distance of the working faces is 1,500 feet from the shaft.

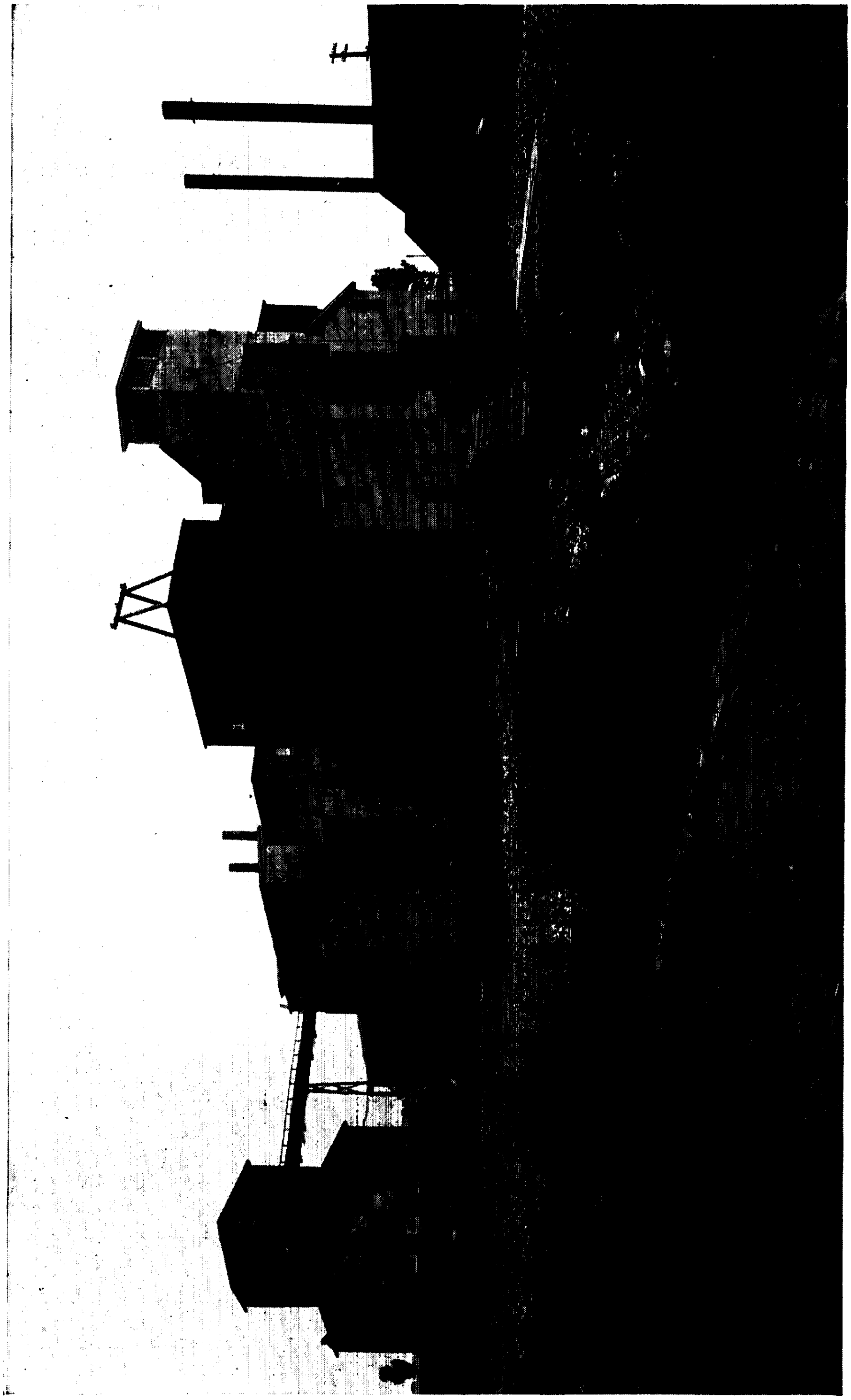
The mining is done by the room and pillar system. The rooms are 20 feet wide with 12-foot pillars. Every 200 feet an opening is cut through the pillars between the rooms for ventilating purposes.

Electric drills are used which average about 120 feet in nine hours. The face of each room is 6 feet by 20 feet, into which 12 holes are drilled about 8 feet deep and blasted with a low grade of dynamite. The rock is trammed by mules to the shaft in three-and-a-third-ton cars. Eleven mules are used in the mine for this work, and are brought to the surface after each shift.

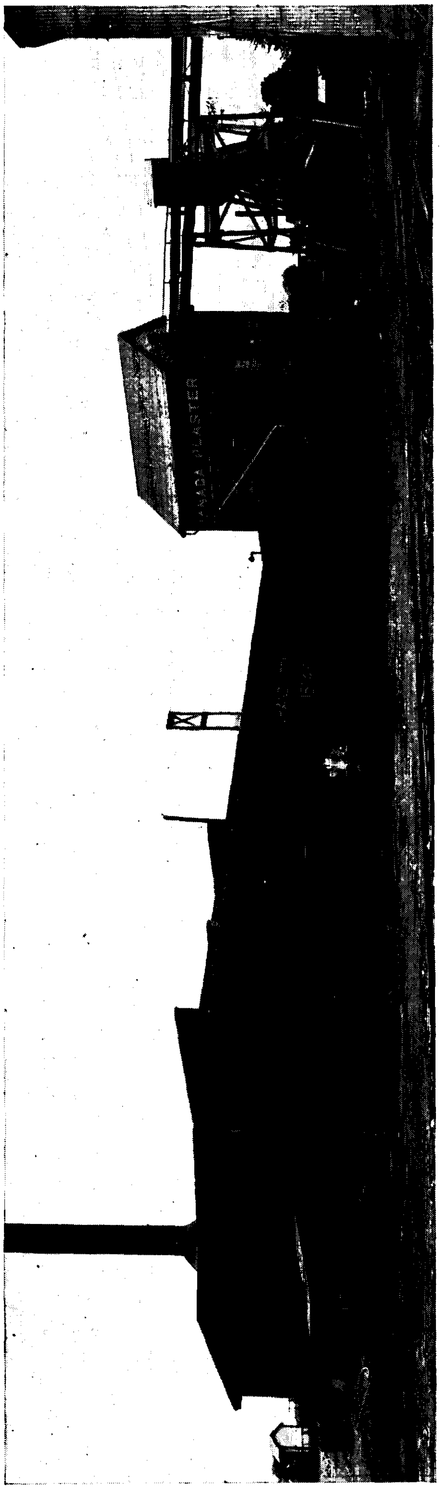
The mine cars are hoisted to the mill up an incline shaft which has a grade of about 20 per cent. for the first hundred feet and 10 per cent. grade for the balance of the distance.

The rock is dumped from the cars into a jaw crusher and afterward passes through rotary crushers and mill stone grinders, and is ground until 98 per cent. passes through 20-mesh. This material, known as land plaster, is then conveyed to the kettles and is calcined to produce plaster of Paris. The material which goes to make up the other gypsum products is then conveyed to other stone and tube mills for further grinding.

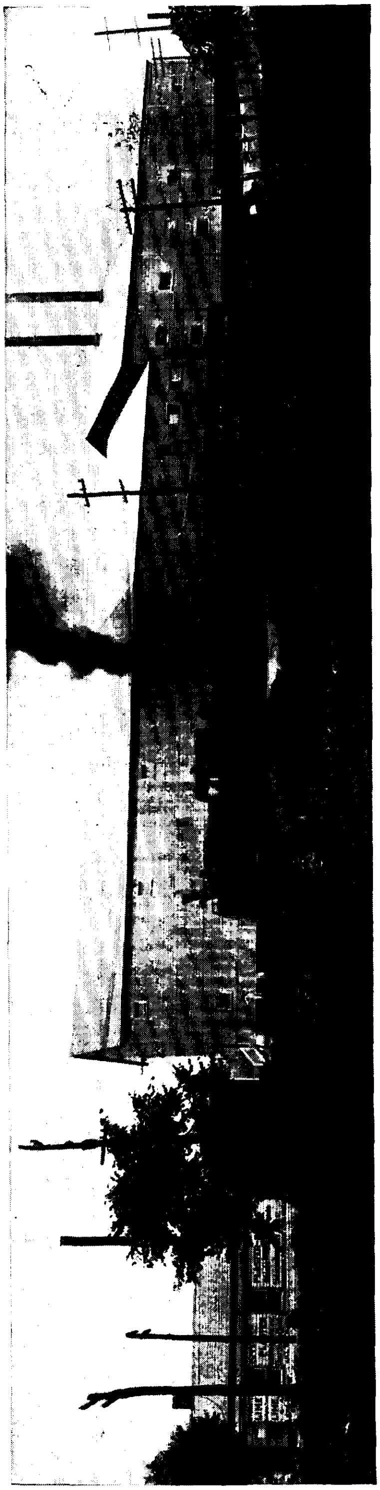
The gypsum wall board is manufactured in a separate plant on the property. The plaster of Paris is conveyed to this plant by a belt and mixed with a small amount of sawdust to give toughness and lightness. It is then fed on to a large belt and passes under a fluted roller and through a water-pan, where the gypsum takes up sufficient water for proper mixing. It is deposited from the first belt on a sheet of paper which is carried along by a belt to a compressing roller, where the top layer of paper is applied, and then passes between the rollers to give the required thickness. The lower paper is scored near each end by a small emery wheel and, passing a folder, is turned over so as to give the board a square edge. The width is regulated by two guides between which the



Lythmore mill of the Ontario Gypsum Company, Limited.



Plaster Board mill of the Ontario Gypsum Company at Caledonia.



Caledonia mill of the Ontario Gypsum Company, Limited.

board passes and is then carried by a belt in four sections with a total length of 650 feet. The gypsum, in travelling this distance, has had sufficient time to set and adhere to the paper and is cut into the required lengths by a large knife. The boards are taken from the belt, loaded on trucks and passed through a drying kiln 400 feet in length, into which hot air is forced.

During the year 1922 the mine at Caledonia produced 98,000 tons of gypsum rock, which was marketed as follows: 43,000 tons of crushed gypsum rock to cement companies of Canada; 7,000 tons to the manufacturers of partition tile; 24,000 tons of prepared wall plaster; 3,000 tons of plaster of Paris and calcined plaster.

The mine at Lythmore has a vertical double compartment shaft to a depth of 115 feet. Levels have been opened up at the ore bodies at 85 and 115 feet, and a small amount of gypsum taken from the upper level, where the vein is five and one-half feet thick.

The mining at present is confined to the lower level where the grade of rock is most suitable for the manufacturing of prepared plasters. The gypsum on this level is 40 inches thick and lies in a horizontal plane. The mining is done on a double entry system with three main entries in each system, off which the rooms are extended. The main entries are 18 feet wide and separated by pillars 17 feet thick, and have been worked for a distance of 250 feet. Cross-cuts are run through the pillars at intervals and filled with waste material. The mill has a capacity of 75 tons per day of the different prepared plasters.

The mine and mill at Caledonia are operated with an average of one hundred men, and at Lythmore with an average of forty men.

The officers are: W. G. Case, Buffalo, president; R. E. Haire, Paris, secretary-treasurer; A. J. Parkhurst, Caledonia, general superintendent; L. V. Robinson, Caledonia, assistant general superintendent; J. C. F. McPherson, superintendent at Lythmore.

Lead

Kingdon.—The Kingdon Mining, Smelting and Manufacturing Company, Limited, operated the mine, concentrator and smelter at Galetta throughout 1922.

Ore was mined in the stopes above the fourth and fifth levels.

The winze west of the main shaft at the fourth level was continued to a depth of 525 feet, from which point 240 feet of drifting was done to the east. Connection with the main shaft was completed after raising from the fifth to the fourth level. The drift on this fifth level was extended easterly 30 feet beyond the main shaft. To the west, the drift was extended 500 feet beyond the winze, making the total distance of 740 feet west of the main shaft. On the fourth level, the drift was continued 659 feet to the west, making it at the end of the year, 1,163 feet from the main shaft. No drifting was done to the east on this level during 1922.

A 36 by 72-inch blast furnace with all necessary feeding equipment, built by the Traylor Engineering Works, Allentown, Pa., was installed in the smelting department. A galvanized iron-covered frame building houses the blast furnace, as well as the 30-ton refining kettle which was moved from the Scotch (or St. Louis Mechanical) hearth department. High grade concentrates will be treated in the Scotch hearth, and the blast furnace will handle the other concentrates as well as the grey slag from the Scotch hearth.

Power installation for the blast furnace department includes a 60-horsepower motor for the blower and a 5-horsepower motor for the ventilator.

Charge mixing bins, 20 by 125 feet, were built. Charges are weighed on multiple-beam scales and hoisted in a 2-ton automatic dumping skip to the feed floor of the blast furnace by a Marsh hoist, operated by a 10-horsepower motor.

Power obtained from the Galetta Electric Power and Milling Company, Limited, is transmitted a mile and a half at 2,200 volts and transformed at the mine to 550 volts.

During the year, a complete analytical laboratory was installed.

The officers of the company are: Chas. M. Robertson, Montreal, Que., president ; John J. Milne, Montreal, Que., secretary-treasurer; A. G. Munich, Montreal, Que., managing-director; R. R. Rose, Galetta, Ont., superintendent; F. A. Warren, Galetta, Ont., smelter superintendent; Robt. E. Vear, Galetta, Ont., mine captain. The head office of the company is at 314 Beaver Hall Hill, Montreal, Que.

The employees numbered 87 in the mine, 23 in the smelter and 24 in mill and on the surface.

Iron Pyrites

Nichols Chemical Company.—The mine and plant of the Nichols Chemical Company at Sulphide were operated during the year 1922 at reduced capacity.

The greater part of the ore mined during the year came from the stopes on the north and south veins of the fifth level. About 11,000 tons of ore were broken during the year in those stopes, which are each about 80 feet long and 8 feet wide.

A total of 16,000 tons was taken from the mine and treated in the plant which produced sulphuric, muriatic, nitric and battery acids.

W. H. De Blois, Sulphide, is manager.

Talc

Asbestos Pulp Company.—The Asbestos Pulp Company operated the talc mine at Madoc from March 1 to the end of the year, and the mill for about six months.

The ore was taken from the stopes on the east and west sides of the shaft, between the second and third levels.

Two crosscuts, each about 200 feet in length, were run on the third level, north and south from the shaft. One drift of about 100 feet in length was run east from the south crosscut and other short drifts were run making a total of about 600 feet in drifts and crosscuts completed during the year.

The new ventilation shaft was completed to the drift on the sub-level between the second and third levels.

An additional storey was built on part of the mill and the capacity increased by installing one more Griffin mill and two Lammer screens.

During the year about 3,000 tons of talc were produced. An average of thirty men was employed.

The officers of the company are: H. B. Hungerford, Belleville, president; Henry Taylor, Belleville, managing director; A. D. Harper, Belleville, treasurer; P. McNiven Bennie, Madoc, secretary; W. H. Decker, Madoc, manager.

George H. Gillespie and Company.—The company's talc mill at Madoc was operated during the greater part of the year on ore from the Henderson mine. The production was curtailed, especially during the latter part of the year, owing to the difficulties of freight transportation on the railways in the eastern States. Deliveries were delayed to places where the greater part of the product was marketed.

About 10,000 tons of ground talc was produced, the greater part of which was used in the manufacturing of paper, paints and cloth.

An average of twenty men was employed.

George H. Gillespie is manager, and L. A. Ashley is mill superintendent.

Henderson Talc Mine.—The Henderson talc mine near Madoc was operated continuously during the year and produced about 10,000 tons of talc, which was hauled to the George H. Gillespie mill by trucks and horses.

The greater part of the ore was obtained from the stope between the third and fourth levels. This stope is 60 feet long and 35 feet wide, and has been worked to a height of about 60 feet.

The new shaft, which is about 160 feet west of the old shaft, was completed to the 200-foot level and connected with the workings on that level.

An average of twelve men was employed.

George H. Gillespie is manager, and Edward Philips superintendent.

METALLURGICAL WORKS

Algoma Steel Corporation, Limited.—Algoma Steel Corporation, Limited, owns the blast furnaces and steel plant at Sault Ste. Marie, Ont., and mines in the Michipicoten area. The directors are: W. C. Franz, president and manager, Sault Ste. Marie, Ont.; Herbert Coppell, vice-president, New York City; James Howson, vice-president, Sault Ste. Marie; Sidney Mason, vice-president, Philadelphia, Pa.; Alex. Taylor, secretary, Toronto; Joseph S. Dale, New York City; W. H. Cunningham, Philadelphia, Pa.; F. McOwen, Philadelphia, Pa.; H. C. Coleman, Philadelphia, Pa.; H. I. Underhill, South Orange, N.J.; R. Home Smith, Toronto; Thos. D. Wood, Philadelphia, Pa.; T. Gibson, Toronto; C. M. Brown, Philadelphia, Pa. E. W. Shell is treasurer, and E. Carey controller.

The Lake Superior Corporation controls Algoma Steel Corporation, Limited, and has the following directorate: Wilfred H. Cunningham, president, Philadelphia, Pa.; W. C. Franz, vice-president, Sault Ste. Marie, Ont.; Herbert Coppell, vice-president, New York City; James Hawson, vice-president, Sault Ste. Marie; Alex. Taylor, secretary, Toronto; Joseph H. Dale, New York; Fred. McOwen, Philadelphia, Pa.; Harvey I. Underhill, South Orange, N.J.; Sidney Mason, Philadelphia, Pa.; H. C. Coleman, Philadelphia, Pa.; R. Home Smith, Toronto; Thos. D. Wood, Philadelphia, Pa.; Thos. Gibson, Toronto; C. M. Brown, Philadelphia, Pa. A. A. Pinkney is controller and treasurer.

During 1922 blast furnaces of the Algoma Steel Corporation at Sault Ste. Marie, Ont., ran as follows: No. 1 furnace, 307 days; No. 2 furnace, idle; No. 3 furnace, 247 days; No. 4 furnace, idle.

The staff at the furnaces consists of: James H. Bell, blast furnace superintendent; James Dale, assistant blast furnace superintendent; and Harry Hitchens, blast furnace master mechanic.

Coniagas Alkali and Reduction Company.—The Coniagas Alkali and Reduction Company was organized on May 1, 1922, and for the remainder of the year operated the plant owned by the Coniagas Reduction Company at Thorold.

A treatment of ores by chlorination was used to replace the blast furnace smelting, and part of the installations of the plant was changed to place this system of reduction of ores on a commercial basis. These experiments were carried on with the ores from stock and 2,100 tons of residues from the Cobalt mines, from which arsenic and cobalt were produced.

An average of about sixty men was employed after May 1.

The officers of the company are: E. D. Kingsley, president; R. W. Leonard, vice-president; A. L. Bishop, treasurer; J. J. Mackan, secretary; J. T. Manson, T. N. Hicks, and A. Longwell, directors; F. S. Low, director and works manager; D. A. Mutch, superintendent.

Deloro Smelting and Refining Company.—The Deloro Smelting and Refining Company, at Deloro, operated the silver and arsenic departments throughout the year, and the oxide plant during the last six months. The plants were operated at reduced capacity during the early part of the year and production rapidly increased during the last six months to meet the increased demands for the products. The arsenic plant was operating at full capacity at the end of the year.

The cobalt and nickel metals and the stellite departments were operated continuously, but considerably below full capacity. The demand for stellite high-speed tool metal increased slightly during the latter part of the year.

Advantage was taken of the dull period to complete the alterations in the oxide plant to increase efficiency and production.

The insecticide plant, which is operated by the Deloro Chemical Company, a subsidiary company, was started during the latter part of the year and manufactured arsenate of lead, arsenate of lime, paris green and a special line of G. E. Sander's dusts.

The smelting and refining company employed 85 men during the early part of the year and the number gradually increased to 260.

The officers of the company are: M. J. O'Brien, president; J. A. O'Brien, vice-president; Thomas Southworth, managing director; S. B. Wright, general manager; S. F. Kirkpatrick, consulting metallurgist; F. A. Bapty, secretary-treasurer; R. A. Elliott, superintendent. The head office is at Deloro.

International Nickel Company of Canada.—The following notes have been supplied by the Company:

The refinery of The International Nickel Company of Canada, Limited, Port Colborne, Ontario, after a shut-down of nine months, resumed operations in May, 1922, operating at approximately half of its capacity. Throughout the remaining months of the year improvement in business was steady and continuous, and by November the plant had reached its maximum capacity as originally designed. During this period an extensive enlargement plan was developed and construction work started that has since doubled the plant output.

The electrolytic refining plant was moved from Bayonne, N.J., U.S.A., to Port Colborne, and modern equipment of increased capacity installed The building, 390 feet long by 92 feet wide, has in the tank room on the main floor six parallel units of tanks of which four are completed and in operation Overhead cranes facilitate handling of anodes and cathodes. Beneath the main floor is a light cellar, 9 feet high, with acid-proof floor, which is drained through gutters to a sump. One end of the building contains stripping benches, looping machine, shears, scales, storage and shipping room. The other end consists of storage tanks, filter presses and the "precious metal" department.

Electrolytic nickel, of a quality produced by this company, for which there is an increasing demand, can now be produced at lower costs, due to the use of hydro-electric power.

Since resuming operations some months ago many changes have been made throughout the plant. Increasing the plant capacity necessitated the immediate installment of new and larger water-jacketed cupolas of modern design. Two new electrically driven Connersville blowers have been installed to meet the increased requirements of the new cupolas. They are situated in a new annex to the main building where good light, accessibility, and cleanliness are easily obtained.

A change in the process eliminated the reverberatory furnaces, resulting in a considerable saving of labour and fuel. A Pierce-Smith basic lined converter was installed, the cupola matte being charged directly to this furnace, which gives a more uniform product for the acid converters.

Many changes and improvements had to be made in the leaching and roasting department to facilitate the handling of the increased production, another Krupp-ball mill, two large lead-lined solution tanks, and a filter press and pump being added. Due to an improved method of leaching, it was not found necessary to increase the number of leaching tanks All the hand operated and mechanical roasting furnaces have been changed to the double hearth type, which is a new type recently developed here. This has greatly increased the capacity of the roasting plant, without necessitating enlargement of the building, although a new furnace had to be built before remodeling was started.

A 96-foot extension has been added to the refinery building, and another refining furnace has been installed, identical with those in present use except that the waste gases pass through a 600 B.H.P., 6 drum, rust water tube boiler with super-heater built by Babcock & Wilcox Company.

The track facilities throughout the yard have been improved and extended, and with the additional locomotive and cars recently acquired, handling of materials has been greatly simplified. Since November, 1922, the entire electrical power load has been carried by hydro-electric power; the company's generating plant acts as a stand-by and is called into service only when the "hydro" supply is cut off. Two new motor generator sets have been installed in the sub-station of the new Electro Nickel Refinery, which are taking care of the direct current requirements. The present indications are that a gradual change from direct to alternating current will be made, the latter being employed in all new equipment.

The company's policy of catering to the comfort and health of the employees has been rigidly carried out. Last year a fund of $100,000 was set aside for a housing scheme, enabling employees to obtain loans for building and to own their own homes. Insurance policies are taken out and paid for by the company for all men who have been in their employ one year, and the amounts are further increased with each additional year's service.

The conversion of a part of the plant property on the shore of Lake Erie into a public park, under the control of the town of Port Colborne, with a splendid bathing beach and picnic grounds, has greatly improved recreation facilities and has filled a long felt want of the townspeople.

All new buildings and extensions have been built to conform with the same general design and permanency as the original plant, steel and brick construction being used exclusively, and the capacity of the plant will be over 4,000,000 lbs. of nickel per month shortly.

Steel Company of Canada.—The Steel Company of Canada, Limited, operated "B" furnace from January 1 to July 13, and "A" furnace from September 15 to December 31.

During the year "B" furnace was completely rebuilt and its capacity increased from 375 to 450 tons per day.

As in previous years, the ore was obtained from the Lake Superior region, U.S. One thousand tons of briquettes for experimental work were received from Moose Mountain, Ontario. The production of the blast furnaces was 87,570 tons of pig iron.

An average force of ninety men was employed.

The officers of the company were: Robert T. Hobson, president; R. G. Wells, works manager; H. H. Champ, secretary-treasurer; H. G. Hilton, blast furnace superintendent; all of Hamilton.

Welland Alloy Steel Corporation, Limited.—This company was incorporated 7th December, 1922, with a capitalization of $5,000,000.00, divided into shares of $10.00 par value. The company has bought the property and equipment of Electric Steel and Metals, Limited. This plant, which has been idle for two years, is situated at Welland, on the bank of the Ship Canal. The equipment includes two seven-ton Heroult electric furnaces. It is the intention of the company to manufacture nickel alloy steel direct from Sudbury nickel-copper ore by a patented process that utilizes both the nickel and the iron in the ore.

The company owns about 700 acres of patented mining claims on the north side of the Sudbury nickel basin and has options on others, which, when exercised, will make a total of 3,000 acres. On the north half of lot 5, concession 3, township of Levack, considerable test-pitting has been done, and in 1922 three diamond-drill holes, totalling 956 feet, were sunk; this property is one and one-eighth miles northeast of the Levack mine of the Mond Nickel Company.

The directors of the company are: President, W. H. Devlin, Sharon, Pa.; first vice-president, F. G. Allerdice, who is also first vice-president of the Brier Hill Steel Company, Youngstown, Ohio; second vice-president, George B. Nisbet, Welland, Ont ; treasurer, J. Ferguson Black, Sudbury, Ont.; W. F. Pattengel, Youngstown, Ohio; H. E. Timmerman, Welland; William Mitchell, Washington, D.C.; Anson Mack, Indiana Harbor, Ill. W. A. Werrett, 77 Victoria Street, Toronto, Ont., is secretary.

CLASSES FOR PROSPECTORS, 1922-23

By

W. L. Goodwin, Instructor

During the season of 1922-1923 classes were held in nineteen places, covering a period from November 7th to May 2nd. The time spent in each place was cut down to seven working days instead of the nine days used formerly. The attendance at most of the places visited was satisfactory, but in a few it was evident that the ground had been well covered and that it will not be necessary to hold classes again in those places, at least in the immediate future. The attendance at the places visited is given later in a tabular statement. In some places evening lectures on geology were not given. This was the case at Swastika and South Porcupine, because classes were being held at a second place, Kirkland Lake in the first case and Dome Mines in the second, during the same days. At Connaught Station no electric light current was available to run the lantern, and it was not considered advisable to attempt the lectures without the lantern illustrations. At Perth Road and Bancroft it was not found possible to organize day classes for the study of minerals, but at Bancroft one practical lesson was given by request to a class of high school students. In places where classes had been held in former years, an advanced class was organized for practice in spotting minerals and rocks. For this purpose a collection of about two hundred specimens had been prepared, of a much larger size than the small pieces distributed to beginners. These specimens had been markéd with a permanent number and the collection was increased during the season by many specimens given by members of the classes. The spotting classes were very popular, and many of the men became expert in the identification of minerals and rocks.

In the tabular statement of attendance, the classes for the practical identification of minerals and rocks are distinguished as *Beginners* and *Advanced*. *Beginners* were the day classes in which small specimens of minerals and rocks were distributed, identified by the members of the class, and placed by them in small envelopes that had printed descriptions on them. In this way each member of a class got a set of about seventy mineral and rock specimens. *Advanced* refers to the classes for spotting the marked specimens of minerals and rocks in the collection already referred to. In preparing this collection, the variability in the appearance of a mineral was taken into account. In order to accustom the members of the advanced classes to this, many varieties of a mineral were put before them to practise on. For example, some eight or ten different specimens of hematite were used. This kind of work can be usefully extended. Many experienced prospectors were glad to enlarge and refine their acquaintance with minerals in this way. *Geology* covers the evening lectures on the elements of geology. *Registration* gives the total numbers registered for the day classes. It was not practicable to register those attending the evening lectures.

At Perth Road the lectures were given in the United Church by kind permission of the trustees.

Community Hall was again the comfortable place of meeting at Bancroft. For its use thanks are due to the township council.

The Sault Ste. Marie Board of Education was kind enough to provide a room in the new technical school for the day classes. The evening lectures were held in the lecture room of the school. This fine audience hall is a good example of the provision being made in Ontario for a side of education not the least in importance. I wish to express my appreciation of the assistance rendered by the principal, Mr. J. F. Ross, and the science master, Mr. A. R. Clary.

The Sudbury Technical and Mining School is another good example of such a building. By permission of the Board of Education the day classes were held in one of its classrooms, and the evening lectures in the assembly room of the adjoining Collegiate Institute building.

The classes in Cobalt were held in the town hall. All arrangements were made by Mr. M. F. Fairlie, manager of the Mining Corporation of Canada, Limited. I wish to thank him, also Mr. H. C. Tomney, accountant for the Mining Corporation, and Mr. Richard Pearce, editor of *The Northern Miner*, for their assistance and courtesies.

The classes at Schreiber were held in the Community Hall of that place. Mr. Wm. Longworth made all the arrangements for this and also for our comfortable rooms in the C.P.Ry. Young Men's Christian Association building.

At Port Arthur the classes were held as formerly in the Chamber of Commerce and in the Council Chamber, Whalen building. Mr. Bruce L. Morrison and the Mining Recorder, Mr. J. W. Morgan, were unsparing of their time and energy in getting the classes started.

The Fort William classes were again carried on in the Technical School and Collegiate Institute, through the kindness of the Board of Education and Principal E. E. Wood.

At Dryden, Mayor Alfred Pitt arranged for the classes to be held in the Council Chamber, and this arrangement was found to be comfortable and convenient.

At Kenora the Council Chamber was put at our disposal for both day and evening classes. The arrangements were made by Mr. H. E. Holland, Mining Recorder.

The classes for South Lorrain were held at the Frontier mine, and thanks are due to Mr. M. F. Fairlie and the officials of the mine for their pleasant reception and their hospitality. I wish also to express my appreciation of the kind invitation of Major J. M. Bell to be the guest of the Keeley mine while the class was being held in South Lorrain.

The classes at Elk Lake were held as formerly in the Council Chamber. The Mining Recorder, Mr. M. R. Morgan, made the arrangements.

The classes at Swastika and Kirkland Lake were carried on at different hours of the same day. The Prospectors' Association made suitable arrangements for Swastika, and Mr. John Gillan secured the Miners' Union Hall in Kirkland Lake. The Mining Recorder at Swastika, Mr. H. Geo. Ginn, looked after the advertising and other preparations.

At Connaught the class was held in the station of the T. & N. O. Railway. Mr. D. O'Connor is to be thanked for much assistance. On the invitation of Mr. A. R. Globe, Manager of the Night Hawk Peninsular gold mine, I spent a day at the mine.

South Porcupine and Dome Mines being only two miles apart, it was possible to carry on classes at the two places on the same days, but the evening lectures were given only at Dome Mines. I wish to thank Mr. W. A. Donaghue, Mining Recorder at South Porcupine, and Mr. H. P. DePencier, Manager of Dome Mines, for making the necessary preparations; and the management of Dome Mines for much appreciated hospitality.

Dr. J. A. McInnis, mayor of Timmins, secured the use of the basement of the Presbyterian church for the classes in that place.

At Iroquois Falls the classes were held in the Mill class room. Mr. A. M. Dewar and other members of the staff of the Abitibi Power and Paper Company contributed much to the success of the classes there.

AVERAGE ATTENDANCE AT CLASSES FOR PROSPECTORS, 1922-23.

Place	Date	Beginners	Advanced	Geology	Registration
Perth Road	Nov. 7–13	..	..	30	..
Bancroft	Nov. 15–22	12	..	17	12
Sault Ste. Marie	Nov. 25–Dec. 4	19	9	46	26
Sudbury	Dec. 6–13	21	14	16	38
Cobalt	Dec. 15–22	14	10	39	28
Schreiber	Jan. 11–18	21	..	35	32
Port Arthur	Jan. 20–27	12	14	24	24
Fort William	Jan. 29–Feb. 5	8	6	17	21
Dryden	Feb. 7–14	36	..	42	45
Kenora	Feb. 16–23	7	3	21	12
South Lorrain	Feb. 28–Mar. 7	21	..	56	30
Elk Lake	Mar. 10–17	8	8	44	10
Swastika	Mar. 21–28	6	7	..	17
Kirkland Lake	Mar. 21–28	12	10	53	22
Connaught	Mar. 29–Apr. 5	5	4	..	10
South Porcupine	Apr. 7–14	6	7	..	12
Dome Mines	Apr. 7–14	9	9	24	18
Timmins	Apr. 16–23	25	17	34	46
Iroquois Falls	Apr. 25–May 2	54	..	40	74
	Total	296	118	538	477

Throughout the season of 1922-1923, I was accompanied by Mr. L. E. Hamilton as assistant, in which capacity, as in former years, I found him capable and efficient.

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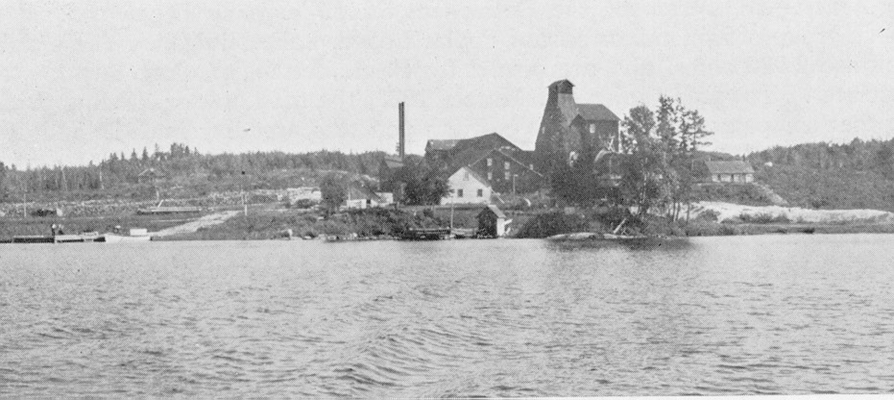

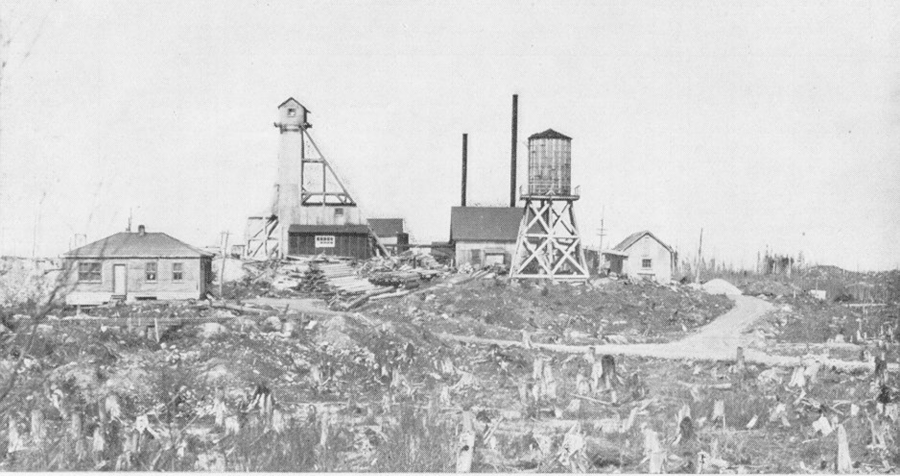

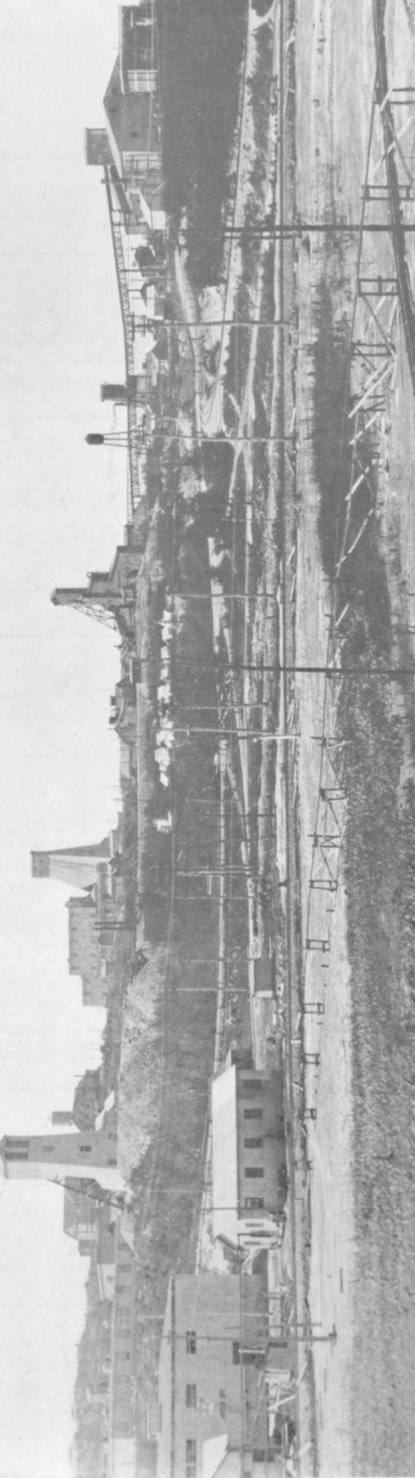

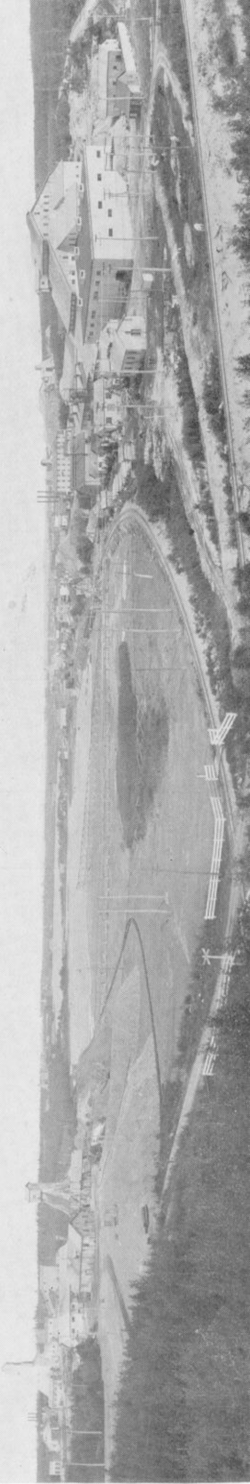

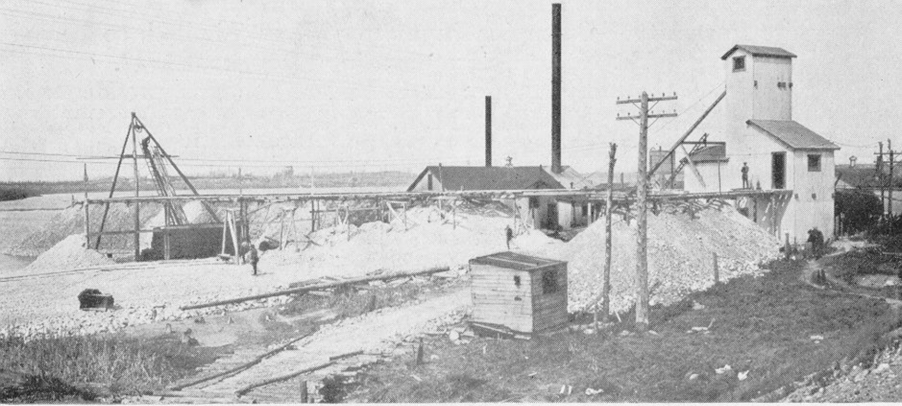

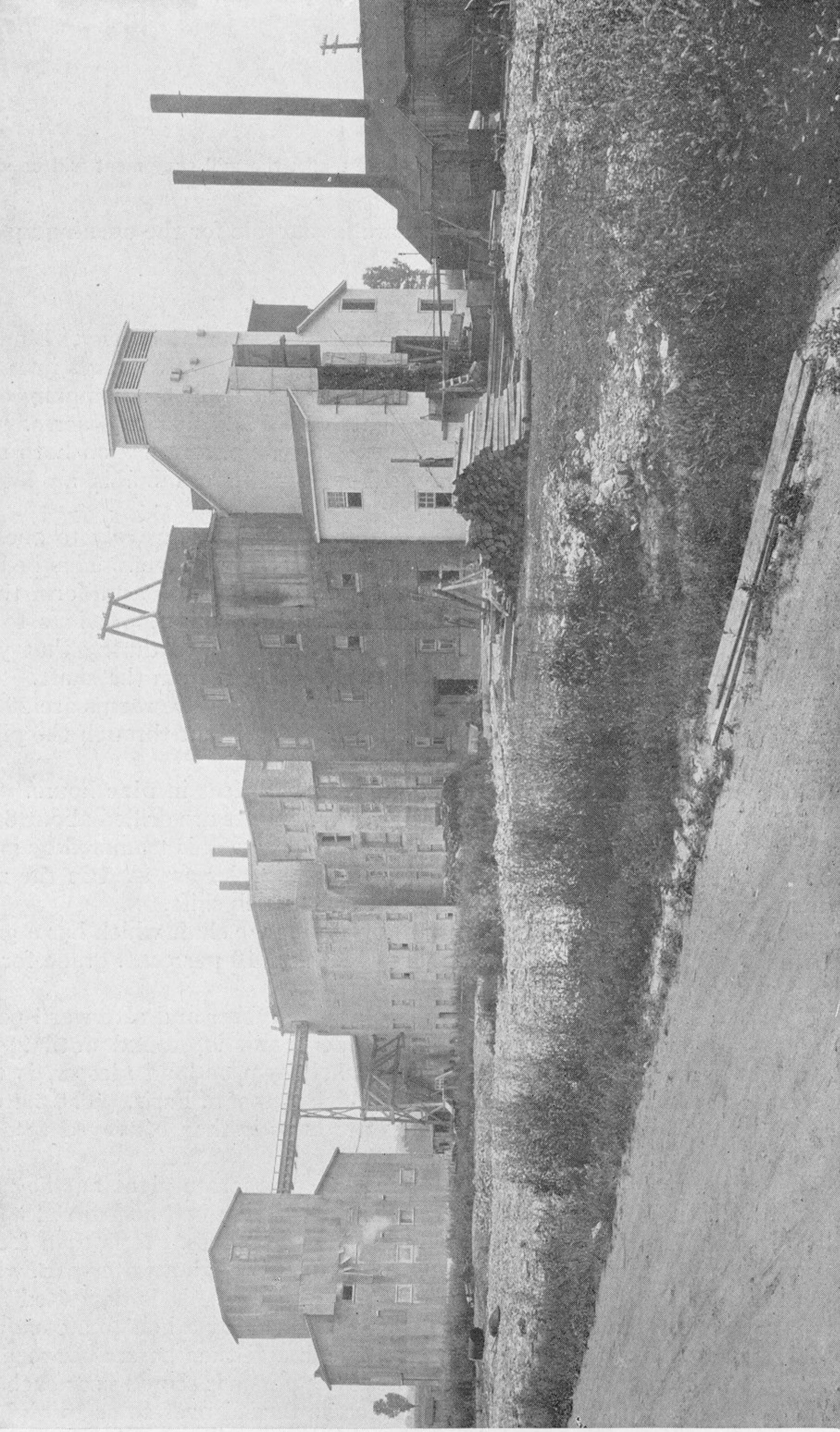


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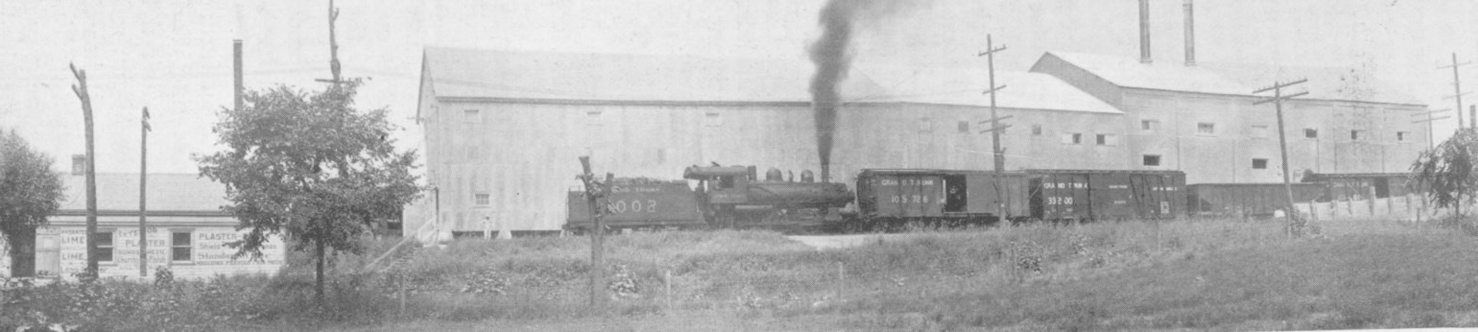
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PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. CHAS. MCCREA, *Minister of Mines* THOS. W. GIBSON, *Deputy Minister*

THIRTY-SECOND ANNUAL REPORT
OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXII, PART VII, 1923

The Stratigraphy and Paleontology
OF
Toronto and Vicinity

Accompanied by five figures in text, eleven plates, and insert of section facing page 118

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THE STRATIGRAPHY AND PALEONTOLOGY
of
TORONTO AND VICINITY

Part IV.—Hydrozoa, Echinodermata, Trilobita, Markings

By

Madeleine A. Fritz

Introduction

Three parts of this series have already been issued in the 29th, 30th, and 31st Annual Reports of the Ontario Department of Mines; these dealt successively with (1) *Pelecypoda*, (2) *Molluscoidea*, and (3) *Cephalopoda*, *Gastropoda*, and *Vermes*.

The present part contains descriptions of all the fossil organisms, other than the above, which are known at present to occur in the strata at Toronto.

The fossils herein described are considered without reference to their exact stratigraphic position. This subject will be dealt with in the sixth or final part of this series.

The fossils undescribed in the previous parts will be considered as follows:—

HYDROZOA
- Stromatoporoidea
- Graptolitoidea

ECHINODERMATA
- Crinoidea
- Asteroidea

TRILOBITA

MARKINGS (fucoids, tracks, rill marks, etc.)

Of the *Stromatoporoidea* only one species has been determined while the *Graptolitoidea* are represented by seven species. The *Crinoidea* are represented by six species, but of these, two are known only by stems. The *Asteroidea* have only one representative, which has been determined as a new species. The *Trilobita*, while few, are very characteristic, but only three species are known. A great number of more or less distinct impressions or markings are found in our strata. Some of these are considered to be due to plant life, while others are regarded either as the tracks of animals or as due to inorganic causes. In all, nine fairly constant types of these markings are observed.

The investigation of the fossil groups enumerated above was carried on in the Department of Geology of the University of Toronto during the tenure of a bursary granted by the Canadian Honorary Advisory Council for Scientific and Industrial Research. The problem was suggested by Dr. W. A. Parks, to whom I wish to express my indebtedness for constant help and encouragement during the progress of the work.

The drawings accompanying this article were prepared by the author, Miss Emily Logier, and Mr. Theo. Logier. In a few instances it was found necessary to reproduce figures already published.

Description of Species

Phylum **COELENTERATA**

Subphylum **CNIDARIA**

Class HYDROZOA

Order **STROMATOPOROIDEA**

Family **LABECHIIDAE**

Genus DERMATOSTROMA, *Parks*

DERMATOSTROMA, *Parks*. Univ. Toronto Studies, Geol. Series, 7, 1910, p. 29.
DERMATOSTROMA, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 401.

The genus is described as follows:—

The forms included in this genus present a papillose surface exactly resembling that of *Lophiostroma* (*Chalazodes*) but they differ from that genus in the thinner coenosteum and the almost complete obliteration of the pillars as distinct elements.

The coenosteum consists of a thin, continuous sheet of calcareous matter, usually investing a foreign body. It is covered with minute, close-set papillae giving the whole surface a hail-like aspect as in *Lophiostroma* (*Chalazodes*) and in many species of *Labechia*. The internal structure of the coenosteum is not well revealed; it does not show, however, the structure either of *Labechia* or of *Lophiostroma*, but in *Dermatostroma* there is no distinct development of pillars at all, the growth being arrested with the completion of the basal expansion. In some forms, however, there is a repetition of these sheet-like growths with irregular cavernous interspaces between.

Many of the forms here included have previously been ascribed to *Labechia*, but the complete absence of vesicular tissue and distinct pillars renders necessary their removal to a new genus.

DERMATOSTROMA SCABRUM (*James*)

Plate I, Figure 1

STROMATOPORA SCABRA, *James*. Paleontologist 3, 1879, p. 18.
LABECHIA SCABRA, *Harper and Bassler*. Cat. Fossils, Trenton and Cincinnati Periods Vicinity Cincinnati, 1896, p. 3.
DERMATOSTROMA SCABRUM, *Parks*. Univ. Toronto Studies, Geol. Series, 7, 1910, p. 31, pl. 2A, figs. 1–3.
DERMATOSTROMA SCABRUM, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 402.

The species is described by James in the following terms:—

Coenosteum a thin crust on foreign bodies (shells or corals) one line or less thick, made up, apparently, of very thin laminae; surface marked with prominent, conical or elongated monticules, one-half line to a line high, and from one to two lines apart; entire surface covered with closely set papillae, generally with small circular openings at the apex; varying in size from one to two inches square.

In the Toronto district this form is frequently found encrusting *Endoceras proteiforme*. The general external features of these specimens are in accord with the above description and vertical sections show a similar structure to that mentioned by Parks.

Locality.—Humber river (?), Toronto.
No. 821 H.R., Royal Ontario Museum of Paleontology.

Class GRAPTOLITOIDEA

Order **DENDROIDEA**

Family **DENDROGRAPTIDAE**

Genus DENDROGRAPTUS, *Hall*

DENDROGRAPTUS, *Hall.* Geol. Surv. Canada, Dec. 2, p. 126, 127, figs. a, b, c.
DENDROGRAPTUS, *Ruedemann.* Mem. New York State Mus., 7, pt. 1, 1904, pp. 578, 579.
DENDROGRAPTUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915 (see for full synonymy).

Ruedemann describes the genus in the following terms:—

The genus *Dendrograptus* was erected by Hall for forms with a strong main stem and a broad, spreading, shrub-like, variously ramifying frond. The thecae are described as quite distinct and angular in some, of obscure form in others, while in still others they are shown only as round or elliptical pits or pustules.

Dendrograptus has been made the receptacle of all arboriform graptolites; and the fact of the great difference of the thecal apertures mentioned by Hall indicates already its heterogeneous character. There is no doubt that eventually the internal structure will furnish safer criteria for recognizing the phylogenetic relations.

DENDROGRAPTUS, *sp. indet.*

Plate I, Figure 2

There is only one specimen in our collections which may be referred to the genus *Dendrograptus;* this is a mere fragment not justifying a specific determination.

The specimen consists of a single branch 17 mm. in length and 1.5 mm. in width, showing about 14 round to elliptical pits as represented in Plate I, Figure 2.

Locality.—15-foot level, Don Valley quarry, Toronto.
No. 1243 H.R., Royal Ontario Museum of Paleontology.

Genus INOCAULIS, *Hall*

INOCAULIS, *Hall.* Amer. Jour. Sci. Arts, 2d. Ser., 11, 1851, p. 401.
INOCAULIS, *Hall.* Pal. New York, 2, 1852, p. 176.
INOCAULIS, *Nicholson.* Mon. British Grapt., 1872, p. 131.
INOCAULIS, *Ruedemann.* Mem. New York State Mus., 11, 1908, p. 185.
INOCAULIS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 665.

Hall's description of the genus follows:—

A plant-like, corneous coral, with numerous bifurcating branches; structure fibrous or plumose.

The texture of this coral is similar to the graptolites, a black scaly crust or film being all that remains of the substance. From the specimens examined, it appears to have grown in groups, with rounded or flattened stems, which are dichotomous above and more or less spreading. The structure is too peculiar to be mistaken or to be referred to any established genus.

INOCAULIS YORKENSIS, *sp. nov.*

Plate I, Figure 9

Text Figure 1

The Museum collections contain a single specimen which seems to be referable to the genus *Inocaulis.* This form is regarded as a new species, the description of which is given herewith. The rhabdosome consists of a single flattened stipe of about five millimetres in width, which divides distally into two branches; from these branches are given off dichotomously rather numerous spreading branchlets, the average width of which is three millimetres. The branchlets are, as a rule, of a uniform width throughout and they terminate in more or less rounded extremities. The angle at which the branches and branchlets are given off varies from 45° to 60°. The material of the stem, branches, and branchlets seems to have been corneous as the residue preserved is black and graphitic. The surface is irregularly striated, with a few small oval impressions quite indiscriminately disposed. Irregular tube-like structures are observed extending from a half millimetre to one millimetre beyond the margins of the stem, branches, and branchlets; these are outwardly and upwardly

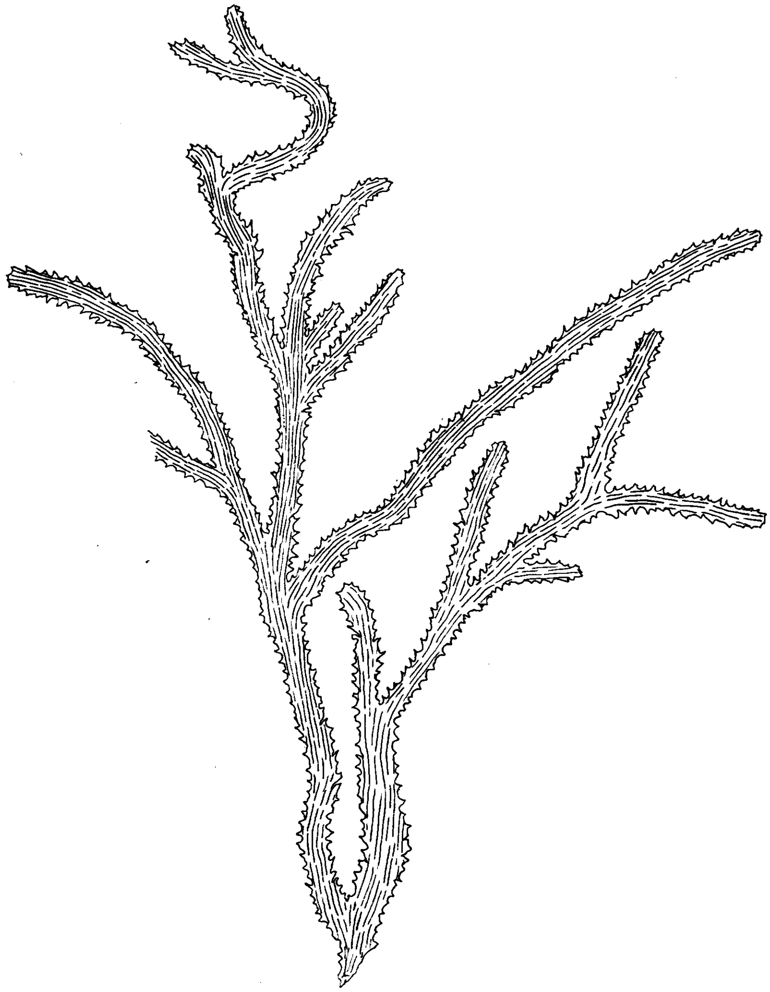


Fig. 1—Inocaulis yorkensis, *sp. nov.*

directed and give the margins an irregularly serrated appearance. There appear to be from seven to eight of these structures in a space of 10 mm. These denticulations resemble thecae, but, owing to the imperfection of the specimen, it is not possible to make a definite statement concerning them. The striations mentioned above give the general surface of the rhabdosome a scaly or fibrous appearance.

The present species is very similar to *I. plumulosus*, which Hall described from the Niagara shale at Lockport and Rochester. It differs, however, from

Hall's types in possessing fewer scale-like structures and a less definite arrangement of the same. Judging by Ruedemann's observations on *I. plumulosus*, *I. yorkensis* differs from that species in the following ways: (1) there are fewer tube-like processes (Ruedemann states that there are 14 in 10 mm.), (2) the branchlets are not observed to terminate in bundles or tufts of these tube-like structures, and (3) the main stipe is not smooth but resembles the branches and branchlets in structure.

These differences, in addition to the fact that *Inocaulis* is not recorded from a horizon lower than the Clinton, seem to justify the establishment of a new species for the reception of this form.

The entire specimen measures 13 cm. in length and 11 cm. in width.

Locality.—Don Valley quarry, Toronto.
No. 889 H.R., Royal Ontario Museum of Paleontology.

Genus MASTIGOGRAPTUS, *Ruedemann*

Mastigograptus, *Ruedemann.* Mem. New York State Mus., 11, pt. 2, 1908, pp. 210-216.
Mastigograptus, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 788.

Ruedemann's description follows:—

Hall described his genus *Dendrograptus* as characterized by "a broad spreading shrub-like frond" and by cellules, that appear "sometimes as simple indentations on the surface and sometimes distinctly angular, with the denticles conspicuous"; adding that "in some specimens the cellules are indicated by prominent postule-like elevations, arranged along the centre or in subalternate order on one face of the branch." Corresponding to the wide compass of this description a great variety of forms have, in the course of time, been brought under *Dendrograptus.* We have already in Memoir 7 pointed out that it has become the receptacle of all arboriform graptolites and that the fact of the great difference of the thecal apertures mentioned by Hall, indicates its heterogeneous character.

We have now before us a form (*M. tenuiramosus*) from the upper graptoliferous beds which, while originally described as *Dendrograptus* and also properly referable to that genus as originally diagnosed, shows a structure totally different from that of the genotype of *Dendrograptus* (*D. hallianus*, Prout) and at the same time is representative in its general habitus of a large group of the forms brought under *Dendrograptus.*

Dendrograptus hallianus has distinct "denticles", *i.e.*, projecting thecae of the appearance of those of *Dictyonema*, and Wiman has shown that also the internal structure of similar denticulate Swedish forms is as complex as that of *Dictyonema.* *D. tenuiramosus*, however, while arborescent in its habit, has smooth whiplike branches, which as Walcott has correctly observed, in the great number of specimens found in the Utica shale of Holland Patent, N.Y., exhibit nothing but a row of obscure pits, apparently the thecal apertures. The same is the case with the associated *D. simplex* and with other species of *Dendrograptus.* Dr. Ulrich, however, has obtained material of a *Dendrograptus* in the Eden shale in Kentucky which he has, as I believe, correctly referred to *D. tenuiramosus* and which in beautiful preservation exhibits additional features (*vide postea*) thereby revealing a structure entirely different from that of *D. hallianus* and the forms investigated by Wiman. We believe, therefore, in the necessity of separating these forms generically from *Dendrograptus* and in restricting the latter genus to species with distinct denticles.

The specimens here referred to are preserved in an extremely fine-grained, greenish gray shale in which the jet-black branches of the graptolites become very distinct by colour contrast. To these branches are attached in great number brown elongate triangular appendages which clearly were conical in shape originally. Their lighter colour is obviously due to greater thinness of the perisark and from the fashion in which the black branches are at their broken ends continued into brown shreds of like brown colour, it would appear that the conical bodies are formed by but one or few of the perisarcal layers. They exhibit distinct transverse lines of the appearance of growth lines and a very dark outline except at the distal margin where the supposed aperture is situated. The proximal end is distinctly contracted into a narrow tube with thicker wall. This in the best preserved specimens possesses two opposite lateral notches for the insertion of smaller conical bodies which sometimes are also preserved, consist of like brown substance and bear like growth lines. The larger conical bodies were in such numbers attached to the branches that in some places they form closely arranged series. From the great number of such bodies found loose on the Covington slabs and the fact that they are missing altogether on the numerous large rhabdosomes from the shales at Holland Patent, it is to be inferred that they were very easily detached and lost. The explanation for this is found in their extremely small base of attachment and the probable presence of a joint at the latter; for not only do they always detach at this point, but it is also quite evident that the basal tubes were attached directly over the pores observable in the branches from which the appendages have been stripped and that the walls of these pores do not appear rough but smooth.

MASTIGOGRAPTUS GRACILLIMUS (*Lesquereux*)

Plate I, Figures 3 and 14

PSILOPHYTUM GRACILLIMUM, *Lesquereux*. Proc. Amer. Phil. Soc. 17, 1877, p. 164, pl. 1, fig. 2.
DENDROGRAPTUS GRACILLIMUS, *Ulrich*. Cat. Foss. Cincinnati group, 1880.
MASTIGOGRAPTUS GRACILLIMUS, *Ruedemann*. Mem. New York State Mus., 11, pt. 2, 1908, pp. 219-221, figs. 116-118.
MASTIGOGRAPTUS GRACILLIMUS, *Bassler*. U.S. Nat Mus., Bull. 92, 1915, p. 789 (see for full synonymy).

Ruedemann describes the species as follows:—

Stem very slender, dichotomously branching, smooth or naked, half round, slightly channelled in the length, branches numerous, of various lengths, filiform.

The stem is scarcely 1 mm. thick at the base; the upper branches curved as from a spiral unfolding, are slender, gradually attentuated and capilliform, or of the thickness of thin thread at their extremities.

This small branching form is very common in the lower two feet of the Don Valley quarry but it has not been found at any other level or at any other locality in this district.

Specimens have been submitted to Dr. Ruedemann and he has ascribed them to the *Mastigograptus tenuiramosus-gracillimus* group, adding that, with present usage, he would refer the form to *M. gracillimus*. Specimens, however, which show the mode of branching indicate that the branches are given off monopodially and alternately rather than dichotomously; this feature seems to be more characteristic of *M. tenuiramosus*.

The branches are extremely slender; the greatest width observed is scarcely one millimetre, while in the majority of cases it is very much less.

Locality.—Lower 2 feet, Don Valley quarry, Toronto.
No. 1244 H.R., Royal Ontario Museum of Paleontology.

MASTIGOGRAPTUS (?) QUADRIBRACHIATUS, *sp. nov.*

In this species, the rhabdosome consists of four long, unequal stipes springing from a common centre. A sicula can not be observed nor can the exact manner of origin of the stipes be ascertained. There seems to be one main stipe, proximally 0.5 mm. wide, but reaching a width of 1.25 mm. towards the distal end; its observed length is 38 mm., but the end is broken. In line with this stipe, on the opposite side of the centre, is a smaller stipe, unfortunately broken off at 4 mm. from the centre. Laterally, there arise two stipes, one on each side; these curve in such manner that they lie nearer to the main stipe than to the short opposite stipe. The length is at least 27 mm., and the maximum width 0.75 mm.

The structure of the branches is very like that of *Mastigograptus*, in that the periderm is continuous, has continuous raised margins, and shows only obscure and uncertain pitting. In places the branches show indistinctly the segmented structure characteristic of *Phycograptus*, but as this genus is not regarded as valid by Ruedemann, the nearest relationship still remains with *Mastigograptus*.

The four-rayed branching of the rhabdosome does not indicate the genus *Mastigograptus* nor does it suggest *Dendrograptus*, as in both these genera the rhabdosome is described as bush-like. As the species is founded on a single specimen, collected by Mr. J. Satterly in the Don Valley quarry, and as this specimen is, for the most part, an impression only, it seems advisable to ascribe the species provisionally to *Mastigograptus* rather than to erect a new genus for its reception.

This species may be distinguished from *M. gracillimus* by the greater width of the branches.

Locality.—Don Valley quarry, Toronto.
No. 1304 H.R., Royal Ontario Museum of Paleontology.

Order GRAPTOLOIDEA

Suborder AXONOPHORA

Family DIPLOGRAPTIDAE

Genus CLIMACOGRAPTUS, *Hall*

CLIMACOGRAPTUS, *Hall.* Geol. Surv. Canada, Dec. 2, 1865, p. 111.
CLIMACOGRAPTUS, *James.* Jour. Cincinnati Soc. Nat. Hist., 14, pt. 2, 1892, p. 158.
CLIMACOGRAPTUS, *Ruedemann.* Mem. New York State Mus., 11, pt. 2, 1908, pp. 400-406.
CLIMACOGRAPTUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 234 (see for full bibliography).

Ruedemann quotes Hall's description as follows:—

Simple stipes with subparallel margins, having a range of cellules on each side; axis filiform; cellules short and square; apertures apparently excavated in the margin of the stipe, and transversely oval or subquadrate; cell denticles or appendages, if present, usually on the upper side of the aperture.

CLIMACOGRAPTUS *cf.* TYPICALIS, *Hall*

Plate I, Figure 6

CLIMACOGRAPTUS TYPICALIS, *Hall.* Geol. Surv. Canada, Org. Rem., Dec. 2, 1865, p. 27, pl. A, figs. 1-9.
CLIMACOGRAPTUS TYPICALIS, *Ruedemann.* Mem. New York State Mus., 11, pt. 2, 1908, pp. 407-411, pl. 28, figs. 6, 7; figs. 354-362.

The species is described as follows:—

Synrhabdosome not observed. Rhabdosome long (66 mm.), narrow, with extremely narrow whip-shaped sicular end (.3-.4 mm.) which in the space of about 16 mm. attains the mature width (2-2.4 mm.). The latter is maintained to the growing end. Lateral sides convex, smooth, broad. Sutural grooves so faint that they are observed only in exceptional cases. Sicula short (1.2 mm.), aperture possessing two short mucros. Thecae closely arranged (11-15 in 10 mm.), overlapping one third in mature part, one fourth and less at sicular end; twice bent; in the proximal half parallel to axis of rhabdosome, then abruptly turning outward at nearly right angle and finally again becoming parallel to axis. Aperture horizontal to slightly everted, apertural excavation short (one fourth of ventral margin) and deep (one fourth of width of rhabdosome). Nemacaulus very thin and short and hence rarely observed.

In the Museum collections there is a single specimen which may be referred to *Climacograptus typicalis*. The fragment is six millimetres in length and two millimetres wide and contains eight thecae.

Locality.—8 feet below uppermost beds in Don Valley quarry, Toronto.
No. 1245 H.R., Royal Ontario Museum of Paleontology.

CLIMACOGRAPTUS (MESOGRAPTUS) PUTILLUS (*Hall*)

Plate I, Figure 4

GRAPTOLITHUS PUTILLUS, *Hall.* Geol. Surv. Canada, Org. Rem., Dec. 2, 1865, pp. 27, 44, pl. A, figs. 10-12a.
DIPLOGRAPTUS PUTILLUS, *Nicholson.* Quart. Jour. Geol. Soc., London, 24, 1868, p. 527, pl. 19, figs. 17, 18.
CLIMACOGRAPTUS PUTILLUS, *Ruedemann.* Mem. New York State Mus., 11, pt. 2, 1908, pp. 415-419, pl. 28, figs. 14, 15, text figs. 368-374, 376, 377.
CLIMACOGRAPTUS PUTILLUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 237 (see for full bibliography).
CLIMACOGRAPTUS PUTILLUS, *Foerste.* Geol. Surv. Canada, Mem. 83, 1916, p. 74.

Ruedemann's description of this species follows:—

Rhabdosome very small (9 mm. mostly less) and slender (1–1.3 mm. wide), elliptic in section, widening gradually, possessing a gently wavy median furrow on each lateral face. Sicula small (1.3 mm.) and very slender, provided with a short aperture spine; its slender virgella protruding from the rhabdosome. Thecae tubular, little inclined to the axis of the rhabdosome in the proximal half and subparallel to it in the distal free half; closely arranged (12–14 in the space of 10 mm. or 32 in 1 inch); apertures straight, at right angles to longer axes of thecae. Nemacaulus thin.

Climacograptus (*Mesograptus*) *putillus* has been identified by Dr. Ruedemann (Foerste, *op. cit.*) from the Don Valley quarry, Toronto, but as yet our collections contain no specimen referable to this species.

The plate herewith is copied from Ruedemann's monograph (Text Figure 368).

Genus DIPLOGRAPTUS, *McCoy*

DIPLOGRAPTUS, *McCoy*. Ann. Mag. Nat. Hist., 6, 1850, p. 270.
DIPLOGRAPTUS, *Nicholson*. Quart. Jour. Geol. Soc. London, 24, 1868, pp. 9, 137.
DIPLOGRAPTUS, *Dana*. Amer. Jour. Sci. Arts, 2d. ser., 14, 1852, p. 128.
DIPLOGRAPTUS, *Wiman*. Jour. Geol., 2, 1894, p. 267.
DIPLOGRAPTUS, *Ruedemann*. Mem. New York State Mus., 11, pt. 2, 1908, pp. 339-341.
DIPLOGRAPTUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 450 (see for full bibliography).

Ruedemann describes the genus in the following terms:—

The genus *Diplograptus* makes its first appearance in the uppermost of the graptolite beds of the Deepkill and does not attain the acme of its development till the Trenton period.

The genus was originally proposed by McCoy in place of Barrande's *Diprion*, a name which was preoccupied. Like Barrande's term, it was intended to include all forms with two series of thecae. By the separation of several groups of biserrate forms as genera, as *Climacograptus* and *Glossograptus*, the genus has been restricted to diprionid forms with a straight virgula, inclined thecae, and normal, mucronate or nonmucronate apertures. The various forms comprised by this definition have since been subdivided by Lapworth (1873), and Frech (1897) has proposed a division into two groups according to the presence or absence of apertural spines.

It has been demonstrated by the present writer that the rhabdosomes of *Diplograptus* are parts of a person of a higher order (synrhabdosome), they being united in the centre by a funicle and a central disk, and that from the latter originate the gonangia in which new siculae are produced; and Wiman has shown that the apparent biserial arrangement of the thecae is produced by one series, the thecae budding alternately on opposite sides.

DIPLOGRAPTUS FOLIACEUS VESPERTINUS, *Ruedemann*

Plate I, Figures 8 and 13

DIPLOGRAPTUS HUDSONICUS (*Nicholson*). Rep. on Pal. of Prov. of Ont., 1875, p. 38.
DIPLOGRAPTUS PRISTIS, *Coleman*. Nat. Hist. Toronto Region, 1913, p. 60.
DIPLOGRAPTUS FOLIACEUS VESPERTINUS, *Ruedemann*. Mem. New York State Mus., 11, pt. 2, 1908, pp. 352-354, pl. 25, figs. 4, 5, 18; text figs. 296-298.
DIPLOGRAPTUS VESPERTINUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 455.

Ruedemann describes this variety as follows:—

Synrhabdosome not observed. Rhabdosomes as a rule short (15 mm. greatest length observed 42 mm.), widening gradually from an initial width of 1 mm. to a maximum width of 2.5, which is attained in a distance of 15 mm. from the sicular extremity and then maintained. Sicula not observed. Sicular extremity furnished with a short blunt virgella (about .4 mm. long) and two equally short straight lateral spines. Thecae numbering 11 to 13 in 10 mm. (30-32 in 1 inch), inclined at an angle of 30°–40°, overlapping a little more than one third, the outer margin distinctly convex with the proximal part frequently slightly concave. The aperture horizontal, concave, the interthecal excavation about one fourth the width. Nemacaulus very thin and inconspicuous within the rhabdosome and not seen protruding beyond the antisicular end.

This graptolite is fairly common at various localities on the Humber river and is also known from the Don. The fragments, for the most part, are mature portions of the rhabdosomes, the sicular end being of less frequent occurrence.

One of the latter, figured herewith (Plate I, Figure 8) shows the virgella and one lateral spine. This rhabdosome measures one millimetre in width at the sicular end. The average width of the mature rhabdosome is two millimetres and from 12 to 14 thecae occur in a length of ten millimetres.

Locality.—Exposure at end of Bloor Street on Humber river, Toronto.
No. 1246 H.R., Royal Ontario Museum of Paleontology.

Family GLOSSOGRAPTIDAE

Genus GLOSSOGRAPTUS, *Emmons*

GLOSSOGRAPTUS, *Emmons*. Amer. Geol., 1, pt. 2, 1855, p. 108.
GLOSSOGRAPTUS, *Ruedemann*. Mem. New York State Mus., 7, 1904, p. 724.
GLOSSOGRAPTUS, *Ruedemann*. Mem. New York State Mus., 11, pt. 2, 1908, pp. 375-379.
GLOSSOGRAPTUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 549 (see for full synonymy).

The history and description of the genus are given by Ruedemann as follows:—

The author of the genus saw its distinctive character in the ligulate outline and rounded extremities, but not in the presence of the long spines, for he described in the same paper an equally spinous form under *Diplograptus*. Hall (1865, p. 43) did not recognize the genus, as, in his opinion, it is based on a species of *Diplograptus* with ciliate appendages on the cell margins "and no characters are given to show its generic distinction"; and Frech (1897, p. 631) concurs with Hall in this view, stating that, as these appendages show all gradations in the diprionid graptolites and in *Pristiograptus*, they are not suited for generic distinctions. On the other hand, the same author divides the species of the genus *Diplograptus* into two sections, one without and one with thecal spines, considering the latter section as coinciding with the genus *Glossograptus*, as defined by Lapworth. The latter author (1873, p. 504), however, has proposed to restrict the term to forms in which, as in Emmon's type, not only is each theca furnished with two long spines or fibres, extending outward from the angles of the aperture, but the polypary itself is ornamented in addition with two opposite, longitudinal rows of gigantic isolated spurs, developed along the median line of the periderm at right angles with the thecae. Elles (1898, p. 521 ff) unites under *Glossograptus* all diprionid species with long thecal spines, which, indeed, seem to form a characteristic group. We give the genus here with the same compass.

GLOSSOGRAPTUS, *sp. indet.*

Plate I, Figure 10

Our collections contain a single specimen of a type of graptolite differing from all others observed in the possession of remarkably long apertural spines. These spines are plainly shown by the specimen itself and also by the cast; in the actual spine the margin seems to be quite smooth, but certain of the casts indicate a serrated margin.

The species suggests the genus *Glossograptus*, but the single specimen is too much crushed and otherwise too imperfect to justify a specific name.

The fragment of stipe itself is about 14 millimetres long and two millimetres wide. The spines are as much as three millimetres in length and occur to the number of 11 in the total length of the fragment. Their disposition with regard to the axis of the rhabdosome cannot be determined with certainty as some variation is evident. It would appear, however, that they are inclined at about 75° to the axis of the rhabdosome. The thecae are quite indistinguishable.

The present species bears some resemblance to *Glossograptus quadrimucronatus approximatus*, Ruedemann, from the Utica shales. The spines, however, seem to be longer, but in view of the condition of the specimen little or no dependence can be placed on this single feature.

Locality.—15-foot level, Don Valley quarry.
No. 1243 H.R., Royal Ontario Museum of Paleontology.

Phylum ECHINODERMATA

Subphylum PELMATOZOA

Class CRINOIDEA

Subclass MONOCYCLICA

Order INADUNATA

Family HETEROCRINIDAE

Genus HETEROCRINUS, *Hall*

HETEROCRINUS, *Hall.* Pal. New York, 1, 1847, p. 278.
HETEROCRINUS, *Billings.* Geol. Surv. Canada, Dec. 4, 1859, p. 48, fig. 16.
HETEROCRINUS, *Bather* (*Lankester*). Treatise on Zool., pt. 3, Echinoderma, London, 1900, p. 146, fig. 58, 2.
HETEROCRINUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 610 (see for full bibliography).

A description of the cup of this genus, founded on the work of Bather and of Wachsmuth and Springer, follows:

Calyx small; subcylindrical; tapering but slightly from the column upwards. Basals five. Radials irregular, the right and left anterior radials and the right posterior radial are divided transversely into two segments. The proximal plate of the anal tube rests partly on the left posterior radial, though more intimately connected with the right posterior superradial. The two remaining radials have only one segment; this, however, is nearly as large as the two in the divided radials.

HETEROCRINUS JUVENIS, *Hall*

Plate I, Figures 7, 11, and 12

Text Figures 2 and 3

HETEROCRINUS JUVENIS, *Hall.* 24th Rep. New York State Cab. Nat. Hist., 1872, p. 212, pl. 5, figs. 9, 10.
HETEROCRINUS JUVENIS, *Meek.* Geol. Surv. Ohio, Pal., 1, 1873, p. 10, pl. 1, figs. 3a-c.
STENOCRINUS JUVENIS, *Wachsmuth and Springer.* Proc. Acad. Nat. Sci., Philadelphia, 1886, p. 132.
STENOCRINUS JUVENIS, *Wachsmuth and Springer.* Rev. Pal., pt. 3, sec. 2, p. 208.
HETEROCRINUS JUVENIS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 611 (see for full bibliography).

The following description of the species is modernized from Meek:—

Body very small, less than one and a half times as long as wide, with breadth nearly the same above as below, being slightly constricted above at the point where the rays become free. Basals comparatively large, a little wider than high, with a general pentagonal outline, their lower lateral angles being minutely truncated.

Anterior radial longer than wide; first primibrach shorter and upward-tapering; second, third, and fourth primibrachs wider than long, the fourth one being axillary and supporting two branches.

Antero-lateral rays have their inferradials wider than long. These support one superradial and four primibrachs, the last one of which is axillary and supports two branches.

Left posterior radial is a little longer than wide, hexagonal or sub-heptagonal in shape; first primibrach smaller and upward-tapering.

The inferradial of the right posterior ray is about as long as wide and pentagonal. The superradial is pentagonal and smaller, the left superior sloping side connecting with the first anal, the right superior sloping side supporting the first primibrach. Nothing further is known with regard to the plates of the arms.

The first anal rests as usual on the left sloping side of the right posterior superradial and partly on the short sloping side of the left posterior radial; it is irregularly pentagonal in form and bears above two smaller plates that taper rapidly upward. Surface smooth or obscurely granulated.

The column is proportionately very large, equalling the diameter of the widest part of the cup, sub-pentagonal in form, and composed of moderately thin discs.

In the strata at Toronto there is a small form which resembles *Heterocrinus juvenis* very closely, but which constantly differs in certain characteristics. Meek in describing this species makes no distinction between the right and left antero-lateral rays. In the Toronto specimens the left antero-lateral radial is divided into an inferior and superior portion but the right antero-lateral radial, if compound, is not divided in the same proportions as are either of the other compound radials; the suture is much higher in position, thus making the inferior plate much larger. On the other hand, the right antero-lateral radial resembles very closely the anterior radial, from which it would appear that the right antero-lateral radial is not compound. It may be that the right antero-lateral radial is divided in similar proportions to the other compound

Fig. 2

Fig. 3

Fig. 2—Heterocrinus juvenis, *Hall* (Toronto specimen).
Fig. 3—Heterocrinus juvenis, *Hall* (Cincinnati specimen).

radials and that the suture is not perceptible. But, since this feature is observed in all our specimens, it would seem more probable that the right antero-lateral radial is not divided and that the first plate distal to it is a primibrach. This same feature has been observed, to a less marked degree, in specimens of *H. juvenis* from Ohio. Text Figures 2 and 3 illustrate the points mentioned above.

The basals of the specimens from Toronto are slightly higher than wide, instead of wider than high as in the type; similarly the left antero-lateral inferradial is longer than wide, whereas the opposite condition holds in the type. In this ray, also, there are five primibrachs instead of four; in the right antero-lateral ray, assuming that the radial is not divided (*vide ante*) we have, unfortunately, no evidence of the number of primibrachs.

The left posterior radial is essentially the same as in the type and bears similarly an upward-tapering first primibrach. Our specimens, however, furnish the additional information that there are in this ray five primibrachs in all, the last axillary and bearing two branches, one of which shows eight secundibrachs.

The right posterior radial is divided and similar in shape and proportions to that of the type. The additional information is afforded that there are five primibrachs in this ray, the last axillary.

The column is relatively smaller than that described by Meek. Near the body it is composed of alternately thick and thin plates. At the angles prominent nodes are developed as shown by Plate I, Figure 12.

Several of our specimens show the attempts at recuperation mentioned by Springer.[1] The break between the arms and the cup appears to have been partially repaired leaving the surfaces smoothly rounded and the old stumps appear to have turned inwards in order to protect the tegmen.

The measurements of the figured specimen are:—

Length of cup	6 mm.
Breadth of cup	5 mm.
Breadth of column	3 mm.

Locality.—Don Valley quarry, Toronto.
Nos. 1247 H.R., 1251 H.R., Royal Ontario Museum of Paleontology.

Family HETEROCRINIDAE

Genus IOCRINUS, *Hall*

IOCRINUS, *Hall.* 24th Rep. New York State Cab. Nat. Hist., 1872, p. 210 (extract 1866, p. 5).
IOCRINUS, *Wachsmuth and Springer.* Rev. Pal., pt. 1, 1879, pp. 62-67; pt. 3, 1886, pp. 209, 210.
IOCRINUS, *Bather.* Treatise on Zool., pt. 3, Echinoderma, London, 1900, p. 145, fig. 26, 1; 28; 58, 1.
IOCRINUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 667 (see for full bibliography).

A description of the genus, founded on the work of Bather and of Wachsmuth and Springer, follows:—

Dorsal cup broadly spreading. Basals small and nearly equal. Radials five, four of them undivided, of equal form and height, comparatively large, strong, and pentagonal; their upper sides truncated throughout their entire width for the reception of the brachials. The remaining radial, *i.e.*, the right posterior radial, is divided. The upper portion, in shape like an axillare, is separated by a horizontal suture; it bears an arm on its right shoulder, and on its left shoulder a line of ossicles supporting the anal tube. The radials in all five rays are followed by five to six brachials, the upper one is axillary and pentagonal, the others quadrangular, all wider than long.

The anal tube consists of a single row of rather large, strong plates resembling the arm plates, although somewhat higher and not as wide.

Column strong, sharply pentagonal, its angles in a line with the radial plates.

IOCRINUS SUBCRASSUS, *Meek* and *Worthen*

Plate I, Figure 5

ACTINOCRINUS SUBCRASSUS, *Meek and Worthen.* Proc. Acad. Nat. Sci., Philadelphia, (1), 17, 1865, p. 148.
HETEROCRINUS SUBCRASSUS, *Meek and Worthen.* Geol. Surv. Illinois, 3, 1868, p. 325, pl. 4, figs. 5a-d.
HETEROCRINUS (IOCRINUS) SUBCRASSUS, *Meek and Worthen.* Geol. Surv. Ohio, Pal. 1, pt. 2, p. 15, pl. 1, figs. 9a, b.
IOCRINUS SUBCRASSUS, *Wachsmuth and Springer.* Rev. Pal., 1879, pt. 1, p. 72.
IOCRINUS SUBCRASSUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 667, 668 (see for full bibliography).

An amended description of the species founded on Meek and Worthen's definition follows:—

Body presenting the form of a short, truncated, and inverted pentagonal pyramid, with the five sides deeply concave, excepting at the top; here the breadth is nearly double the height, but it decreases abruptly to the column below. Sub-basals undeveloped. Basals of moderate size, about twice as wide as high, pentagonal in form, the superior sloping margins and lower side

[1]Crinoidea, Flexibilia, 1920, p. 403.

being comparatively long and the lateral very short, all deeply concave up the middle of the outer surface and very prominent on each side.

Radials comparatively large and strong, wider than high, pentagonal in form, and truncated nearly their entire breadth above for the reception of the primibrachs; each very profoundly excavated on its external surface at the inferior lateral angles, so as to leave the central region standing out in the form of a very prominent vertical ridge coincident with that formed by the prominent lateral margins of the basals, while a somewhat similar but less prominent ridge extends horizontally across the upper margins on each side, so as to connect with each other on contiguous plates.

The right posterior radial is transversely divided into superradial and inferradial. The superradial is twice as wide as long and irregularly quadrangular or sub-pentagonal in form, the left superior sloping side supporting the anal, the right sloping side three primibrachs, of which the third is axillary. Either this assertion is a mistake or the generic description given on page 12 must be amended.

Other rays bifurcate on the third, fourth, or fifth primibrach. All the primibrachs are scarcely half as long as wide and are rounded on the outer side.

The anal series consists of a direct vertical range of pieces presenting much the appearance of an arm. The plates are very convex, smooth, and rounded on the outer side.

Column stout, distinctly pentagonal, the angles coinciding with those of the body, composed near the body of alternately thick and thin pieces.

This species has not been identified from the Toronto rocks, except in the variety which follows:

IOCRINUS SUBCRASSUS TORONTONENSIS, *var. nov.*

Plate I, Figure 5

In the Museum collections there are a number of specimens, which resemble *Iocrinus subcrassus* very closely. Only two of the specimens, however, expose the posterior side and both of these differ from Meek and Worthen's types in that the arm borne on the right shoulder of the right posterior superradial bifurcates on the fifth and not on the third primibrach. The same feature is observed in the left posterior ray and in the right antero-lateral ray. In the right posterior and left posterior rays there are seven secundibrachs in the right branch and six in the left branch. In the right antero-lateral ray there are only five secundibrachs in the left branch.

The columns associated with this species are pentagonal with concave sides, acute angles, and a generally less nodose appearance than those of *Heterocrinus juvenis*.

The constant number of primibrachs displayed by our specimens seems to justify the making of a new variety for this form. Plate I, Figure 5, illustrates the variety.

The specimen figured measures:—

Height of cup	6 mm.
Breadth of cup at top	11 mm.
Thickness of column at connection with base	6 mm.

Locality.—Don Valley quarry, Toronto.
No. 245 H.R., Royal Ontario Museum of Paleontology.

Order CAMERATA

Suborder MELOCRINOIDEA

Family GLYPTOCRINIDAE

Genus GLYPTOCRINUS, *Hall*

GLYPTOCRINUS, *Hall.* Pal. New York, 1, 1847, p. 281.
GLYPTOCRINUS, *Meek.* Geol. Surv. Ohio, Pal. 1, 1873, p. 30.
GLYPTOCRINUS, *Wachsmuth and Springer.* Rev. Pal., pt. 2, pp. 182-188.
GLYPTOCRINUS, *Cumings.* 32d. Ann. Rep. Dep. Geol. Nat. Res., Indiana, 1908, p. 712.
GLYPTOCRINUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 553.

An amended description of the genus *Glyptocrinus* founded on Wachsmuth and Springer's definition follows:—

Cup obconical to subglobose, the surface ornamented by elevated ridges radiating from the centres of the plates and thus dividing the surface into triangular impressed areas. On the brachials, the vertically disposed ridges are rounded and nearly as wide as the plates themselves, emphasizing the camerate appearance, in that the actual arms appear to be soldered into the cup.

Infrabasals five, rudimentary—perhaps sometimes obsolete—entirely hidden from view by the column and filling only a small portion of the basal concavity. Basals five, of uniform size, small, scarcely extending to the sides of the cup and slightly concave for the attachment of the column. Radials five, somewhat larger than basals but similar in form, each one bearing two primibrachs, first hexagonal and second pentagonal in outline and axillary supporting on its upper sloping sides in each division the secundibrachs, which vary in number according to the species. As a general rule, however, in species in which there are tertibrachs in the cup, there are only two secundibrachs, while in species in which the tertibrachs are outside the cup, their number is much greater. Species of the latter kind sometimes have six, eight, or more secundibrachs, and these are succeeded to the last bifurcation by three, four, or more free plates. The tertibrachs, where they exist, are as variable in number as the secundibrachs. There may be within the same species, three or more of these soldered into the cup, or they may all be outside, according to the age of the individual. The tertibrachs are somewhat wedge-shaped plates, of which each one supports at its larger end a pinnule. Pinnules very closely arranged.

Interbrachial areas occupied by a large number of plates, arranged in four or more series, with one plate in the first, two in the second, and generally three in each succeeding series. The plates of the posterior or anal interray differ from those of the other interrays in being a trifle wider and having three plates instead of two in the second and all succeeding series. The median row generally consists of larger plates, and these are elevated above the level of the others. The first anal, like the first interbrachial, rests upon the upper sloping side of the radials and between the first primibrachs. Intersecundibrachs from one to ten, with a less number in species in which the last bifurcation takes place within the cup.

Vault scarcely elevated above the zone of origin of the free arms, the interradial regions somewhat depressed; composed of numerous very small, convex plates. The apical dome plates not well defined; anal aperture directly through the vault, excentric.

Column round, of medium size; central canal small, distinctly pentagonal.

According to the above the genus *Glyptocrinus* is characterized by the possession of infrabasals and ought, therefore, to be included in the subclass *Dicyclica*. Bather, however, describes the family *Glyptocrinidae* as without infrabasals, and, accordingly, places it in the subclass *Monocyclica*. In view of the fact that our specimens do not show cups sufficiently well preserved to determine either the presence or absence of these plates and since Bather's classification has been followed in this report, the genus *Glyptocrinus* will here be considered as belonging to the subclass *Monocyclica*.

GLYPTOCRINUS DECADACTYLUS, *Hall*

Plate II, Figures 1, 2, 3, 4, and 5

GLYPTOCRINUS DECADACTYLUS, *Hall.* Pal. New York, 1, 1847, p. 281, pl. 77, figs. 1a-f; pl. 78, figs. 1a-u.
GLYPTOCRINUS DECADACTYLUS, *Meek.* Geol. Surv. Ohio, Pal., 1, 1875, p. 30, pl. 2, figs. 5a-b.
GLYPTOCRINUS DECADACTYLUS, *Bather.* Treatise on Zool., pt. 3, Echinoderma, London, 1900, p. 119, fig. 25.
GLYPTOCRINUS DECADACTYLUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 553, 554 (see for full synonomy).

Meek's description in modern terms follows:—

Cup obconical, somewhat higher than wide, and tapering to the column below, with areas occupied by supplemental elements a little flattened, so as to present a slightly pentagonal outline as seen from below. Basals small, pentagonal in form, wider at the top than high. Radials five, larger than basals, as wide as long and heptagonal in form. Each radial bears two primibrachs, first one smaller than radial and hexagonal or heptagonal in outline, second primibrach about same size as first, heptagonal in outline and axillary, supporting on its upper sloping sides, in each division, two secundibrachs about same size as primibrachs, second one axillary and supporting the tertibrachs; the proximal two or three tertibrachs are included in the cup, the distal ones bear alternate, slender and very closely arranged pinnules. The interbrachial areas are somewhat flattened giving the cup a pentagonal aspect as viewed from below. A similar but less extensive flattening is observed in the areas of the intersecundibrachs.

There are several ranges of interbrachial plates. The first is a single plate, the first interbrachial, resting between the superior sloping sides of the radials; the second range contains two plates; the third range consists of three plates; and the fourth of two or three plates. In adult specimens there are ten or twelve smaller plates above the fourth range. Of intersecundibrachs there are usually three small pieces, while of intertertibrachs there may be two or more very small pieces.

In the posterior interray the proximal plate, the anal, is single. The ranges above consist of three plates each, the middle plate of each range lying directly above the middle plate of the range below.

The plates of this species are elegantly ornamented with elevated ridges running from the centre to the middle points of the sides of each plate. The ridges of contiguous plates, therefore, unite to outline sub-triangular areas, the centre of which corresponds to the point of junction of three contiguous plates.

The column is of moderate size, round near the base where it is composed of alternately thick and thin plates, the former of which are also a little wider so as to project somewhat beyond the others; perforation distinctly pentagonal.

Glyptocrinus decadactylus has long been recorded from the rocks at Toronto, but we have not in our possession a single cup sufficiently perfect to justify absolute determination. On the other hand, vast numbers of columns, presumably belonging to this species, are found in our rocks. In recording the species, therefore, it will be understood that the actual identification is based on the works of earlier writers. The columns referred to *G. decadactylus* present minor variations chiefly in the degree to which the alternate character of the columnals is developed. As the round shape of the columnals and the pentalobate form of the lumen is constant in all our specimens, it is a reasonable assumption that the variations observed are due to different parts of the stem being in question.

Plate II, Figure 2, indicates the alternating thick and thin columnals, whereas Plate II, Figure 5, shows the absence of this feature. The character of the lumen is shown by Plate II, Figures 3 and 4.

Columnals figured range from 3.25 to 4.25 mm. in diameter.

Locality.—Don Valley quarry, Toronto.
No. 1248 H.R., Royal Ontario Museum of Paleontology.

Subclass DICYCLICA

Order INADUNATA

Suborder DENDROCRINOIDEA

Family DENDROCRINIDAE

Genus DENDROCRINUS, *Hall*

DENDROCRINUS, *Hall*. Pal. New York, 2, 1852, p. 193.
DENDROCRINUS, *Meek*. Geol. Surv. Ohio, Pal. 1, 1873, p. 20.
DENDROCRINUS, *Wachsmuth and Springer*. Rev. Pal., pt. 1, pp. 62, 66, 75.
DENDROCRINUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 375 (see for full bibliography).

According to Wachsmuth and Springer the genus is described as follows:—

General form of the crinoid elongate and slender. Cup obconical, higher than wide, unsymmetrical. Underbasals five, similar in form, scarcely of medium size, but extending beyond the column. Basals five, the largest plates in the cup; four of them equal, hexagonal, the fifth or posterior one heptagonal, truncate above for the support of the large anal plate. Radials alternating with basals all round, simple in four of the rays, pentagonal and of about equal size; right posterior radial compound, divided by a horizontal suture into two halves, which taken together, have about the form of the simple plates, only slightly longer. Primibrachs two to five, some long and narrow, and others short and wide. Anals one, subquadrangular. Arms long and branching. Pinnulae wanting. Ventral sac strongly developed. composed of numerous small, hexagonal alternating plates of equal size, strengthened by little transverse or slightly oblique costae, and so arranged as to present an ascending zigzag appearance.

Column pentagonal, or exceptionally round.

DENDROCRINUS *cf.* DYERI (*Meek*)

Plate II, Figures 7 and 18

POSTERIOCRINITES (DENDROCRINUS) DYERI, *Meek*. Geol. Surv. Ohio, Pal. 1, 1873, p. 24, pl. 3 bis., figs. 3a, b.
DENDROCRINUS DYERI, *Wachsmuth and Springer*. Proc. Acad. Nat. Sci., Philadelphia, 1879, p. 299.
DENDROCRINUS DYERI, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 396 (see for full bibliography).

Meek's description modernized follows:—

Cup small, obconical or tapering regularly to the column from above. Infrabasals pentagonal, longer than wide, the greatest breadth being between the superior lateral angles. Basals a little larger than infrabasals, longer than wide and, excepting the one in the posterior interray (which is largest and heptagonal), all hexagonal. Radials about the same size as basals, but proportionately broader; the right posterior radial transversely divided into superradial and inferradial. All the radials have a general pentagonal outline but the superior lateral angles are slightly truncated (the superradial in the right posterior ray). Primibrachs in all the rays are narrower than radials, about as long as wide, or slightly longer, and from five to seven in number. Free arms remarkably long and slender, laterally compressed, more or less angular on the dorsal side. The arms divide dichotomously on the axillary primibrachs, but above this bifurcation branches arise alternately, at distant intervals, on opposite sides. These branches are slightly more slender than the main stem from which they spring and from which they diverge but little; they are composed of pieces about as long as wide. These secondary branches sometimes bifurcate once or even twice.

First anal nearly as large as one of the smaller basals, resting on the superior truncated edge of the largest heptagonal basal. It lies between the radial on the left and the inferradial and superradial on the right. The anal supports other plates above that form the base of the ventral extension.

The lower interradial plates of the tegmen occur laterally between the truncated superior lateral angles of the radials, thus giving the impression of interradials.

Ventral extension very long, nearly or quite as long as the free arms, and as wide as the body below, composed of the usual hexagonal plates, apparently without costae and separated by punctured sutures.

Column slender, slightly tapering downward from the base of the cup, near which it is more or less pentagonal, and composed of short, alternately thick and exceedingly thin segments. Farther down it becomes nearly or quite cylindrical and composed of more uniform, very short pieces, with a very small, nearly round lumen.

Our collections show a single specimen which may be referred to this species. It consists of a slender, branching arm and the distal part of the anal tube. The specimen shows the two distal primibrachs, the last one of which is axillary; it supports two branches, each branch being composed of six secundibrachs (Meek's figure shows seven). The half-rays divide on the sixth secundibrach, the two internal divisions being long (with 12 to 13 segments) and the two external divisions being short (with seven segments). The internal divisions divide into an external long (with 18 segments) and an internal short (with 10 segments). The primary external division similarly divides into an internal long (with 17 segments) and an external short subdivision (with 10 segments). Three of these subdivisions again divide, and probably the fourth does also; all divisions diverge but little as in the type. This system of arm division is quite similar to that described for the species except for the fact that there is no constant difference in the strength of the alternating divisions.

The anal tube just about equals the free arms in length but its exact boundaries are not clearly defined. It is presumably made up of a series of slightly concave plates, the sutures of which are not perceptible. The portion of the tube exposed is 12 mm. in length and shows 13 costae, which are downwardly and inwardly inclined on both sides but appear horizontal for a short distance in the centre. These costae are 3 mm. wide in the proximal part and 1.5 mm. in the distal part.

The specimen is much too incomplete to justify a satisfactory determination. The general form of the arm and the system of arm division seem to suggest the species *Dendrocrinus dyeri*. Meek, however, states that no costae are apparent in the anal tube of his types. On the other hand costae are required under the definition of the genus which tends to confirm the generic position of our specimen, although it makes the specific identification more doubtful.

Locality.—Garrison Common, Toronto.
No. 715 H.R., Royal Ontario Museum of Paleontology.

CRINOIDEA, *incertae sedis*

Plate II, Figures 11, 12, 13, 14

The Museum collections show numerous examples of a crinoid column, which has never been found in association with a cup. The fragments, which have not yet been identified, are round and fairly stout. Some specimens are made up of alternately thick and thin discs, whereas others are composed of discs of a more uniform size; this is doubtless due to different portions of the stem being in question. Frequently, flattened specimens with a pronounced small, central, longitudinal depression are found. Although these variations appear externally, all the specimens show a large circular lumen with radiating structures extending from the outside of the lumen to the outer circumference. One of the figured specimens is 6.25 mm. in diameter and its lumen 4.1 mm.

Locality.—Don Valley quarry, Toronto.
No. 1250 H.R., Royal Ontario Museum of Paleontology.

PELMATOZOA, *incertae sedis*

Plate II, Figures 8 and 9

In the local strata there are a great many examples of small columns, which in some cases attain a considerable length (56+mm.). They have never been observed in association with a cup or root; for this reason, therefore, it has not been possible to ascribe them with certainty to any genus or species.

The column is sub-pentagonal in shape and is composed of five ranges of more or less regularly alternating plates which interlock. At the point of junction of three contiguous plates, there is a slight depression. The lumen is of medium size and distinctly pentagonal as shown in Plate II, Figure 9.

The systematic position of these columns is very doubtful. I have been unable to find any figures or descriptions of similar forms in the literature dealing with definite Ordovician crinoids. The nearest approach to the structure here shown is in the genus *Lichenocrinus*. Provisionally, therefore, the present species may be referred to *Lichenocrinus*, the systematic position of which is itself in doubt.

Hall describes the genus *Lichenocrinus as* follows:—[1]

> Bodies parasitic on shells and other foreign substances. Form discoid or depressed convex, with a proboscidiform appendage rising from the centre. Disc composed of an indefinite number of polygonal plates, and apparently having no distinct mode of arrangement. Proboscis perforate, and in the known species, formed of five ranges of short plates alternating and interlocking at their margins.

Since Hall's time it has been considered that the parasitic bodies are roots and not cups and, therefore, that the so-called proboscidiform appendage is a stem. It would appear that the cup has never been observed.

The horizon of these forms is similar to that of the Toronto specimens. This fact tends to strengthen the conclusion as to the affinity of our species to *Lichenocrinus*, based, as it is, only on a comparison of the columns.

Locality.—Humbervale, Ontario.
No. 1249 H.R., Royal Ontario Museum of Paleontology.

Class STELLEROIDEA

Subclass ASTEROIDEA

Family **PROMOPALAEASTERIDAE**

[1]24th Rep. New York State Cab. Nat. Hist., 1872, p. 216.

Genus PROMOPALAEASTER, *Schuchert*

PALAEASTER (part) of authors.
PROMOPALAEASTER, *Schuchert.* Frech, Foss. Cat. 1, Anim. pt. 3, 1914, p. 33.
PROMOPALAEASTER, *Schuchert.* Bull. U.S. Nat. Mus., 88, 1915, p. 102.
PROMOPALAEASTER, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 1041.

Schuchert describes the genus in the following terms:—

Disk about medium size, with distinct and angular interbrachial arcs. Rays five, slender to stout, more or less long, and tapering. Some species attain a large growth. Abactinal area of rays with numerous columns of small, more or less tumid, closely adjoining or reticulated, spine-bearing plates. A medial radial and two lateral or supramarginal columns of plates are usually more conspicuous than the accessory columns; however, the radial plates may be also inconspicuous. The longitudinal arrangement in columns is usually most pronounced, but sometimes the plates on each side of the radial column may have a decided diagonal arrangement. Small accessory plates are usually inserted between the columns of ossicles or between the individual pieces both distally and proximally. Disk with numerous small accessory plates like those of the rays, with no apparent definite arrangement except the supramarginal columns, which continue over the disk and unite angularly in the axillary areas. The larger plates bear several short articulating spines of which the one on the apex is the largest.

Ambital areas well developed, there being one or more columns of small plates like the radial accessory columns both in form and arrangement.

Madreporite usually conspicuous, radially striated, and situated near the margin of the disk between the adjoining columns of supramarginal plates.

Inframarginal plates small and numerous distally like the adambulacrals, but proximally they usually increase rapidly in width and assist in forming the small interbrachial arcs. Each ossicle has numerous small granules which probably bore short, smooth, articulating, blunt spines.

Adambulacral plates distally like the inframarginals, increasing in width proximally and continuing around the plates of the interbrachial areas. The two proximal plates of adjoining columns are the pairs of plates in the oral armature. Each adambulacral plate has a more or less well-developed narrow ambulacral extension which unites with the carina of the ambulacral plates. These extensions belong to the adambulacral plates, apparently always so distally, but proximally they are often separated from the adambulacral plates by sutures; throughout the greater portion of the rays they are situated medially, but in the proximal region they are either on the distal or proximal edge, each alternate plate having the extension from the same corner a little longer. Each plate has more or less numerous spine-bearing granules in addition to the three larger articulating spines which are inserted one on the ambulacral and two on the lateral edge.

Ambulacral furrows generally very wide and regularly tapering. In each ray there are two columns of these plates which are slightly alternating or opposite. The plates are as numerous as those of the adambulacral columns, highly carinated, about as wide as long in the extreme distal portion of a ray, increasing rapidly in width proximally and at the base of the rays may be four times as wide as long. The podial openings, one to each plate and in single ranges, are at the extreme lateral edges excavated between the sutures of adjoining plates and beneath the adambulacrals. Proximally, however, every other podial opening progresses inwardly with the joined carinae and issues where these begin to fork. Here there are, therefore, four columns of podial openings in each ambulacral furrow. This change is indicated by the changed position of the adambulacral plate extensions and also by the pairs of forked carinae of the ambulacral plates. Throughout the greater portion of a ray the carinae are regular and alike on each plate, but toward the mouth they change rapidly in direction and soon they are arranged in forked pairs, one curving distally, the other proximally, with the lateral portions of each pair in contact and uniting with the extensions of the adambulacral plates. The most proximal plate of each ambulacral column is usually considerably modified, longer than wide, and more or less triangular in outline, between which there is sometimes inserted a small quadrangular ossicle. These pieces belong to the oral armature.

Interbrachial areas of medium size, with the interbrachial marginal plates usually arranged in pairs but in some forms the series may be terminated by single ossicles. The number of these plates in an area varies in different species, there being two, three, or five inside the marginal inframarginals, and all seem to be derived from the inframarginal series by inward crowding.

PROMOPALAEASTER SOLITARIUS, *sp. nov.*

Plate II, Figure 19

Text Figures 3 and 4

PALASTERINA RUGOSA, *Billings.* Geol. Surv. Canada, Rep. Progress for 1857, p. 291.
PALASTERINA RUGOSA, *Billings.* Geol. Surv. Canada, Dec. III, 1858, p. 77.
PALASTERINA RUGOSA, *Coleman.* Ont. Bur. Mines, Toronto, Ont., Guide Book No. 6, 1913, p. 9.

Complete starfish remains are exceedingly rare in the strata of the Toronto district; there are only two specimens in the Museum collections which are sufficiently well preserved to justify determination. Isolated fragments, however, are not uncommon. Of the two more complete specimens, the smaller one exposes the abactinal side; the larger, better preserved specimen shows the actinal side. It is chiefly upon the evidence furnished by the latter that both generic and specific determinations have been based.

The literature contains frequent references to the occurrence at Toronto of *Palasterina rugosa*, Billings. It is, of course, impossible to say that this species does not occur, but we have no material to substantiate its presence. As this species was originally described from Anticosti, it seems rather unlikely that the Toronto material is co-specific. It is a more reasonable assumption that the forms ascribed to *P. rugosa* by the earlier writers are really examples of the present species, which is herewith described:—

Form of medium size, five-rayed with differentiation into bivium and trivium but slight; length of ray, measured from centre of disc to apex, about three times as great as its breadth at junction with disc; rays tapering regularly to more or less pointed apices.

The abactinal areas of the rays are covered with numerous slightly tuberculated plates of various sizes; apart from a fairly distinct column of medium-sized supramarginals (six in space of five millimetres at distal end), the plates are quite irregularly disposed. The disc is composed of numerous small irregular plates, of which the arrangement is not clear.

Actinally the rays are bounded by a column of sub-quadrangular inframarginals, which gradually decrease in size distally. In a space of 10 mm. at the proximal end of a ray eight inframarginals are observed, while at the distal end 13 appear in the same distance.

The adambulacrals are very similar in shape to the inframarginals but are somewhat smaller, there being 11 in a space of 10 mm. proximally and 15 in a similar space distally. Proximally the adambulacrals increase in width and decrease in length, but the innermost plate is elongated and pointed orally; it is closely appressed to its fellow of the contiguous ray, the two plates together forming a quite conspicuous "mouth angle point".

The ambulacral furrows are wide (3.75 mm. where ray is 8.75 wide) and fairly deep, tapering very gradually to the apices of the rays; the ambulacral channel is prominent in the centre of each furrow. The ambulacrals are as numerous as the adambulacrals, twice as wide as long in the proximal part and about as wide as long in the distal part. Each ambulacral has a well-defined transverse, median ridge, which increases in height towards the adambulacrals (Plate II, Figure 19).

The ambulacrals on one side of a ray do not indicate any definite arrangement, either alternate or opposite, with respect to the ambulacrals of the other side. The exact position of the podial opening is not observed.

In the axils of the rays, the proximal inframarginals of adjoining rays rest against each other; just orad of these is a pair of wedge-shaped interbrachials, and still farther orad a pair of adambulacrals followed by the inwardly directed triangular plates. All the plates on the actinal surface are strongly tuberculated.

The present species resembles *P. exculptus* (Miller), but differs in the character of the interbrachial areas. *P. exculptus* possesses a single sub-quadrate ossicle orad to the pair of wedge-shaped interbrachials, and external to the contiguous adambulacrals of adjacent rays. *P. solitarius* has no single plate, the pair of wedge-shaped interbrachials being followed immediately by the pair of adambulacrals.

Text Figure 4 represents the abactinal side of the smaller specimen, the measurements of which are:—

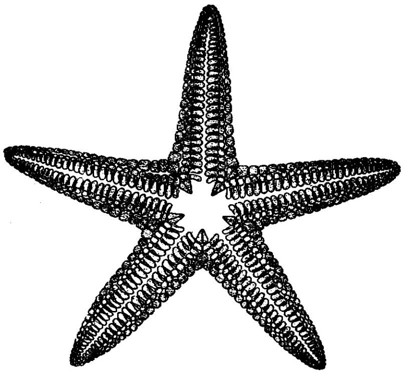
Length from centre of disc to apex of ray	17 mm.
Length from centre of disc to the interbrachial angle	5 mm.
Breadth of ray where it joins the disc	5 mm.

Text Figure 5 represents the actinal side of the larger specimen, the measurements of which are:—

Length from centre of disc to apex of ray	27 mm.
Length from centre of disc to the interbrachial angle	9 mm.
Breadth of ray where it joins the disc	9 mm.

Locality.—Humber river, Toronto.
Nos. 193 H.R., 204 G.S., Royal Ontario Museum of Paleontology.

Fig. 5



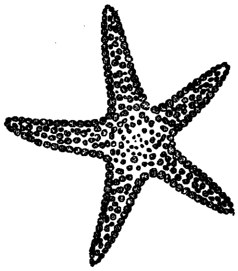


Fig. 4

Fig. 4—Promopalaeaster solitarius, *sp. nov.* (Abactinal view, nat. size).
Fig. 5—Promopalaeaster solitarius, *sp. nov.* (Actinal view, nat. size).

Phylum **ARTHROPODA**

Class CRUSTACEA

Subclass TRILOBITA

Order **HYPOPARIA**

Family **TRINUCLEIDAE**

Genus CRYPTOLITHUS, *Green*

CRYPTOLITHUS, *Green*. Mon. Tril. N. Amer., 1832, p. 72.
NUTTAINIA, *Eaton*. Geol. Textb., 2d ed., 1832, p. 33.
TRINUCLEUS, *Murchison*. Sil. Syst., 1839, p. 659.
TRINUCLEUS, *Grabau and Shimer*. N.A. Index Fossils 2, 1910, p. 258.
CRYPTOLITHUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 294 (see for full synonymy).

The genus is described thus by Grabau and Shimer:—

Cephalon very broad proportionately, with long genal spines and broad, regularly pitted border. Glabella inflated, pear-shaped, smooth or with distinct furrows. Eyes generally absent. Thorax of six segments which are nearly straight at their extremities; axis, narrow. Pygidium with margin entire.

In the Bulletin of Denison University, 1910, Foerste discusses, in detail, "the case of *Cryptolithus versus Trinucleus*". He comes to the conclusion that possibly the term *Trinucleus* is not justified. *Trinucleus* dates back to Lhlwydd in 1698, but this early description was very inadequate. Murchison was the first to describe *Trinucleus* in the true generic sense in 1839. In 1832 two names were given to the trilobite previously considered to be *Trinucleus;* these were *Cryptolithus*, Green, and *Nuttainia*, Eaton. It is not certain which name appeared first, but the evidence favours Green. In consequence *Cryptolithus* is now generally used.

CRYPTOLITHUS TESSELLATUS, *Green*

Plate II, Figure 16

CRYPTOLITHUS TESSELLATUS, *Green*. Mon. Tril. N. Amer., 1832, p. 73, cast 38, pl. 1, fig. 4.
NUTTAINIA CONCENTRICA, *Eaton*. Geol. Textb., 2d ed., 1832, p. 34, pl. 1, fig. 2.
TRINUCLEUS CONCENTRICUS, *Billings*. Geol. Surv. Canada, 1863, p. 190, fig. 191a, b.
TRINUCLEUS CONCENTRICUS, *Cumings*. 32nd Ann. Rep. Nat. Res., Indiana, 1907, p. 1064.
CRYPTOLITHUS TESSELLATUS, *Foerste*. Bull. Sci. Lab., Denison Univ., 14, 1910, p. 78.
TRINUCLEUS CONCENTRICUS, *Coleman*. Ont. Bur. Mines, Toronto, Ont., Guide Book 6, 1913, p. 11.
CRYPTOLITHUS TESSELLATUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 295 (see for full synonymy).

The species is described by Cumings in the following terms:—

Fillet in the form of a semi-ellipse cut in the direction of its transverse diameter, and truncated so as to present the two ends of the fillet in the line of the same diameter; puntures of the fillet in about 4 or 5 concentric arcs, separated by alternating arcs of fine elevated ridges; middle lobe of the head narrower than the side lobes, more prominent, and tapering posteriorly; whole animal short-ovate; side lobes wing-like, flat, with very narrow joints.

Foerste regards *Cryptolithus tessellatus*, Green, and *Trinucleus concentricus*, Eaton, as one and the same thing. He further remarks that if *Cryptolithus* has priority, the specific name *C. tessellatus* also has priority. The name *C. concentricus* is inadmissable on any grounds.

Cryptolithus tessellatus is not an uncommon fossil in this district, although really good specimens are of comparatively rare occurrence. The specimens usually consist of fragments of the cephalon, *e.g.*, portions of the pitted border, the pear-shaped glabella, and genal spines. All these specimens appear to be from the Don quarry. Foerste considers this form to be *C. bellulus*, Ulrich, restricting *C. tessellatus* to the Trenton.

Plate II, Figure 16, is copied from Scott's Introduction to Geology, Plate 7, Figure 4.

Order **OPISTHOPARIA**

Family **ASAPHIDAE**

Genus ISOTELUS, *DeKay*

ISOTELUS, *DeKay*. Ann. Lyceum Nat. Hist., New York, 1, p. 174.
ISOTELUS, *Clarke*. Geol. Minnesota, 3, pt. 2, 1894, p. 700.
ISOTELUS, *Cumings*. 32d Ann. Rep. Dept. Geol. Nat. Res., Indiana, 1908, p. 1052.
ISOTELUS, *Grabau and Shimer*. N. A. Index Fossils, Vol. 11, 1910, p. 291.
ISOTELUS, *Raymond*. Trans. and Proc. Roy. Soc. Canada, 5, 3rd ser., sec. 4, 1912, p. 115.
ISOTELUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 675 (see for full synonymy).

According to Grabau and Shimer, the genus *Isotelus* differs from the genus *Asaphus* only in "its broad axis and obsolete segmentation, at maturity, of glabella and pygidium".

The definition of the genus *Asaphus* given by Grabau and Shimer follows:—

Body oval. Cephalon and pygidium large and nearly equal in size, with broad, infolded margin. Glabella expanded, nearly smooth. Free cheeks large. Eyes large and prominent. Hypostoma deeply forked posteriorly. Thorax of eight segments. Pleura grooved, with rounded extremities. Axis rather narrow. Pygidium trilobed, its axis distinctly segmented, side lobes slightly segmented.

Isotelus maximus, *Locke*

Plate II, Figure 17

Isotelus maximus, *Locke*. 2d Ann. Rep., Geol. Surv. Ohio, 1838, p. 246, figs. 8, 9.
Asaphus megistos, *Billings*. Geol. Surv. Canada, 1866, pp. 26, 60.
Asaphus (Isotelus) megistos, *Meek*. Pal. Ohio, Vol. 1, 1873, p. 159-160.
Asaphus (Isotelus) maximus, *Whiteaves*. Pal. Foss,. Geol. Surv. Canada, 3, pt. 3, 1897, p. 233.
Isotelus maximus, *Coleman*. Ont. Bur. Mines, Toronto, 1913, p. 11.
Isotelus maximus, *Raymond*. Bull. Victoria Memorial Mus., 1, 1913, p. 46, pl. 4, fig. 8.
Isotelus maximus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 678, 679 (see for full synonymy).

The following specific description is given by Meek:—

Entire outline subelliptic, the breadth being nearly two-thirds the length, in a specimen apparently a little contracted by the drawing together of the thoracic segments, rather depressed convex; extremities elliptically and subequally rounded.

Cephalic shield forming about one-third the entire length, exclusive of the posterior lateral spines, nearly semi-circular, the anterior margin being rounded, and the posterior broadly and moderately sinuous, with the posterior lateral angles produced backward in the form of mucronate spines, that nearly or quite equal the length of the thorax. Lateral borders each provided with more or less defined marginal furrows, that extend from the anterior ends of the lateral spines forward, becoming very narrow or obsolete around the anterior end of the glabella. Glabella not rising above the general convexity of the cephalic shield, and but very faintly defined; anterior lobe or division transversely subelliptic, being nearly twice as wide as its anterior-posterior diameter back to the eyes, at which point the narrowest part, or neck of the glabella, is only about two-thirds as wide as its anterior lobe. Facial sutures extending forward and outward in advance of the eyes, then curving and converging to the middle of the front margin; posteriorly, extending at first obliquely outward and backward, and then curving backward so as to intersect the posterior margin at points less than halfway out from the anterior ends of the furrows between the thoracic lobes. Neck furrow entirely obsolete. Eyes lunate, or forming about a semi-circle, of moderate size, and situated a little less than their direct length in advance of the posterior margin of the shield.

Thorax slightly less than the length of the cephalic shield, at its middle, composed of eight narrow segments. Lobes moderately well defined; mesial one depressed-convex, about one-fifth of its breadth wider than the lateral ones, and having its segments flattened; lateral lobes also depressed or flattened within, and rounding or sloping gently from near the middle to the lateral margins; pleurae curving a little backward near the middle, furrowed for about halfway out, rather obtuse at the ends, and each distinctly levelled along its anterior outer-half, so as readily to slip under the next one in advance of it, in rolling up.

Pygidium a little longer and slightly narrower than the cephalic shield, as well as rather more narrowly rounded at its middle, behind, with a more or less flattened margin; lobes and segments undefined, or only very obscurely visible.

Entire surface apparently smooth.

Isotelus maximus, Locke, is one of the most common and best preserved fossils of this district. It occurs on both the Humber and the Don rivers. The smallest specimen known to occur in our strata is only 10 mm. in length, while the largest measures 255 mm. The specimen figured measures 190 mm.

The young individual mentioned above is a mould of the exterior; it illustrates very well some of the earlier stages of the life history, *e.g.*, segmentation of the pygidium and its general semi-circular shape. The genal spines are relatively very long, extending as far as the sixth or seventh thoracic segment. In the larger specimens the spines do not reach farther than the fourth or fifth thoracic segment.

Clarke[1] has pointed out that the sole distinction between this species and *Isotelus gigas*, DeKay, is in the presence of genal spines. The specimens from this region are undoubtedly of the spinous type. It is also stated that the spinous individuals from New York and Minnesota are smaller than the aspinous ones. This statement does not hold for our specimens, as spines are present on the largest as well as on the smallest individuals.

[1]Pal. Minnesota, 3, pt. 2, 1894, p. 701.

The measurements of the figured specimen are:—

Length..190 mm.
Length of pygidium............................ 70 mm.
Length of thorax.............................. 56 mm.
Length of cephalon............................ 64 mm.

Locality.—Don Valley quarry, Toronto.
No. 855 H.R., Royal Ontario Museum of Paleontology.

Order PROPARIA

Family CALYMENIDAE

Genus CALYMENE, *Brongniart*

CALYMENE, *Brongniart.* Hist. Nat. Crust. Foss., 1822, p. 11.
CALYMENE, *Conrad.* 5th Ann. Rep. New York Geol. Surv., 1841, p. 38.
CALYMENE, *Hall and Clarke.* Pal. New York, 7, 1888, p. XXI.
CALYMENE, *Grabau and Shimer.* N. A. Index Fossils, Vol. II, 1910, p. 314.
CALYMENE, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 165 (see for full synonymy).

The genus is described thus by Grabau and Shimer:—

Cephalon with a thickened margin. Glabella conical, broadest behind, very convex, divided by three pairs of deep lateral furrows, forming three globular lobes on each side. Eyes small. Facial sutures curving strongly outward, and cutting the lateral margin. Thorax of thirteen segments; axial furrows deep. Pygidium of six to eleven segments, usually not distinctly marked off from the thorax. This genus possessed very prominently the power of enrolment.

CALYMENE MEEKI, *Foerste*

Plate II, Figure 6

CALYMENE BLUMENBACHII, *Billings.* Geol. Surv. Canada, 1863, p. 952.
CALYMENE SENARIA, *Meek.* Geol. Surv. Ohio, Pal. 1, 1873, p. 173, pl. 14, figs. 14a-f.
CALYMENE BLUMENBACHII, *Nicholson.* Rep. Pal. Prov. Ont., 1875, p. 37.
CALYMENE MEEKI, *Foerste.* Bull. Sci. Lab., Denison Univ., 16, 1910, p. 84, pl. 3, fig. 18.
CALYMENE CALLICEPHALA, *Coleman.* Nat. Hist. Toronto Region, 1913, p. 61.
CALYMENE MEEKI, *Raymond.* Zittel-Eastman Textb. Pal., 1913, p. 724.
CALYMENE MEEKI, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 167.

In the Bulletin of Denison University for 1910, Foerste proposed the new name *Calymene meeki* for the trilobite so well described by Meek from the Cincinnatian rocks of Ohio as *C. senaria.* As types, the large specimens from the Fairmount beds, with rather an extended posterior outline of the cephalon, resulting in acute genal angles, were chosen.

The original description given by Meek of these Ohio trilobites and by him ascribed to *C. senaria*, Conrad, follows:—

General form subovate, the length being usually about one and a half to one and three-fourths the breadth; convexity rather more than one-third the breadth.

Cephalic shield, as seen in a direct view from above, sub-semicircular, approaching sublunate, the anterior outline being more or less nearly regularly rounded, and the posterior broadly sinuous, with the posterior lateral extremities bluntly sub-angular, or abruptly rounded. Glabella more prominent than the cheeks or eyes, about as wide behind as its length, including the neck segment, very strongly defined from the cheeks and the front margin (which latter is very prominent, and strongly recurved and arched upward in the middle) by profound furrows; lateral lobes, particularly the posterior two pairs, distinctly defined by deep lateral furrows that curve a little backward, the posterior pair being transversely, or obliquely, a little oval, and about three times as large as those of the next pair, which are as much larger than the third pair, all being nearly round; neck furrow well defined; neck segment about of the same size as the first thoracic segment, often slightly thickened at each end, arched a little forward, and nearly or quite as high as the most prominent part of the glabella in front. Eyes rather prominent, small, nearly surrounded, excepting on the inner side, by a shallow concavity, and situated opposite the furrows between the anterior and middle lateral lobes of the glabella; visual surfaces very small, about twice as long as high, a little arcuate, and directed nearly laterally; palpebral lobes small, rather prominent, and capping, as it were, the visual surfaces. Movable cheeks, with thick, rounded, lateral margins, defined by a distinct, rounded marginal furrow, continuous with that separating the anterior end of the glabella from the prominent, arched middle of the anterior margin. Fixed cheeks, provided with a very deep, broad furrow along their posterior margins. Facial sutures directed forward anteriorly, so as to intersect the margins somewhat nearer together than the breadth across between the eyes; posteriorly, sometimes slightly furrowed, and directed at first a little obliquely backward and outward from the eyes, for less than half their length, then curving somewhat abruptly, and extending more obliquely backward, nearly straight to, or very slightly in front of, the posterior angles of the cheeks; rostral shield strongly arched, about twice and a half as long, measuring directly across from its lateral extremities, as the height from its upper to its lower margin, at the middle. Labrum or hypostome longitudinally oblong, with sinuous lateral margins; anterior end a little wider than any other part, with a convex outline; anterior margin prominent, rather deeply notched in the middle, with a projecting point on each side of the notch. Internal surface concave; external convex and smooth.

Thorax about twice the length of the middle of the cephalic shield, narrowing backward, and very strongly trilobate; mesial lobe as wide as the lateral, and distinctly more convex, rounded or somewhat depressed on top, and having its thirteen segments usually a little thickened at their ends, but without nodes. Lateral lobes separated from the middle one by distinct furrows, somewhat flattened on the inner third, and rounding off more or less strongly to the lateral margins; pleurae extending straight outward for about one-fourth to one-third of their length, and then slightly deflected and curved backward to their outer ends, which are rounded, compressed, somewhat expanded, and provided with a thickened marginal ridge (not seen externally), while the anterior faces of their outer halves are strongly flattened or bevelled for sliding upon each other in rolling up; each with its longitudinal furrow well defined, and placed so as to divide off, as it were, its anterior third, though this is not seen more than half way out from their inner ends, when the thorax is folded together.

Pygidium one-half to two-thirds the length of the middle of the cephalic shield, wider than long, with a more or less nearly sub-trigonal outline, the anterior margin, however, generally being so rounded as to impart a nearly transversely suboval form to the general outline; mesial lobe well defined, depressed convex, and extending very nearly to the posterior margin, showing five or six segments, the last two being very faintly defined, while behind those there is space enough for two or three more. Lateral lobes sloping or curving off more or less rapidly, each with about five segments, only the anterior one of which has a furrow like that of each of the pleurae.

Entire surface finely and evenly granular.

The form of *Calymene* so frequently met with in the Toronto rocks has been referred to various species, *e.g.*, *C. blumenbachii*, *C. callicephala*, and *C. senaria*. Of these, *C. blumenbachii* and *C. callicephala* are no longer recognized as distinct species in North America. *C. senaria* is regarded, more particularly, as a Trenton form. Raymond has further pointed out that *C. meeki* differs from *C. senaria* in that the ribs on the pygidium do not bifurcate but show only the trace of an impressed line.[1] This feature is well shown by our specimens and is regarded as additional evidence in favour of ascribing them to *C. meeki*.

Length	34 mm.
Breadth (maximum)	20 mm.
Length of cephalon	9 mm.
Length of thorax	20 mm.
Length of pygidium	5 mm.

Locality.—Don Valley quarry, Toronto.
No. 855 H.R., Royal Ontario Museum of Paleontology.

Fucoids

Genus ARTHRARIA, *Billings*

ARTHRARIA, *Billings*. Canadian Nat., n.s., 6, 1872, p. 467.
ARTHRARIA, *Billings*. Pal. Foss., Geol. Surv. Canada, 2, pt. 1, 1874, p. 66.
ARTHRARIA, *Miller*. N.A. Geol. Pal., 1889, p. 107.
ARTHRARIA, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 69 (see for full synonymy).

[1]Bull. Mus. Comp. Zoology, Harvard College, Vol. LX, No. 1, p. 27.

Miller describes the genus in the following terms:—

Cylindrical stems with an expansion at each end in the form of a dumb-bell.

ARTHRARIA BICLAVATA, *Miller*[1]

Plate III, Figure 7

ARTHRARIA BICLAVATA, *Miller*. Cincinnati Quart. Jour. Sci., 2, 1875, p. 354, fig. 26.
ARTHRARIA BICLAVATA, *James*. Jour. Cincinnati Soc. Nat. Hist., 7, 1884, p. 131.
ARTHRARIA BICLAVATA, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 69.
ARTHRARIA BICLAVATA, *Foerste*. Geol. Surv. Canada, Mem. 83, 1916, p. 121.

According to James, Miller's *Arthraria biclavata* consists of a wonderfully symmetrical stem with a perfectly round ball at either end. James states that, as early as 1852, Hall figured a dumb-bell fossil which he regarded as part of a marine plant but to which he did not give a name.[2] James further states that Billings figured a similar form under the name *Arthraria antiquata*,[3] and that Miller described *Arthraria biclavata* in 1875.

With regard to the nature and affinities of this structure James is of the opinion that it is of inorganic rather than of organic origin. He bases this opinion on the absence of any signs of structure as indicated either by the figures or by the descriptions. He is also of the opinion that *A. antiquata*, Billings, is a synonym for *A. biclavata*, Miller.

Arthraria biclavata is one of the most common markings found at Toronto. The stems vary in length from 35 mm. to 85 mm.; they are widest in the middle and taper to the point of attachment of the balls. These bulbous expansions are inclined to be ellipsoidal rather than spherical in shape.

As far as I have been able to ascertain, the inorganic origin of *Arthraria* rests entirely on the conclusions of James. Lacking the evidence of structure, it is obvious that the nature of this marking must remain in doubt. Opposed to James' conclusions is the remarkable constancy in shape and the fact that the object is apparently confined to a more or less limited vertical extent. I feel, in view of the above, that *Arthraria* is probably of organic origin and that a fucoidal rather than an animal origin best explains its existence.

The specimen figured has a maximum stem diameter of six millimetres at the middle and a minimum diameter of four millimetres at the point of attachment of the "balls" which are 21 mm. long and 18 mm. wide.

Locality.—Humber river, Bloor Street, Toronto.
No. 1252 H.R., Royal Ontario Museum of Paleontology.

Genus BUTHOTREPHIS, *Hall*

BUTHOTREPHIS, *Hall*. Pal. New York, 1, 1847, p. 8.
BUTHOTREPHIS, *Billings*. Pal. Foss., 1, Geol. Surv. Canada, 1865, p. 99.
BUTHOTREPHIS, *Whiteaves*. Pal. Foss., 3, pt. 3, 1897, p. 139.
BUTHOTREPHIS, *James*. Jour. Cincinnati Soc. Nat. Hist., 7, 1885, p. 159.
BUTHOTREPHIS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 143 (see for full synonymy).

Hall describes the genus in the following terms:—

Stems sub-cylindrical or compressed, branched; branches numerous, divaricating, leaf-like; structure vesicular.

[1]Since going to press Foerste has established a variety *Arthraria biclavata westonensis*. See Geol. Surv. Can., Mem. 138, 1924.
[2]Paleontology of New York, Vol. II.
[3]Geol. Surv. Canada, Pal. Fossils, Vol. II.

Although most of the species of *Buthotrephis*, Hall, have been regarded as plants, authors have differed as to the nature of certain forms, *e.g.*, Bassler; Grabau;[1] Clarke and Ruedemann;[2] and Williams[3] have listed *B. gracilis*, Hall, and its several varieties as plants. James, on the other hand, is inclined to regard these forms as species of *Dendrograptus*. Ruedemann has definitely assigned *B. lesquereuxi*, Grote and Pitt, from the Bertie Waterlime to the dendroid graptolites.[4]

Buthotrephis subnodosa, *Hall*

Plate III, Figure 6

Buthotrephis subnodosa, *Hall*. Pal. New York, 1, p. 262, pl. 68, figs. 3a-b.
Buthotrephis subnodosa, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 145.

Hall describes the species as follows:—

Frond compressed, branched; branches opposite or alternate, subnodulose or vesicular, obtuse at extremities.

The species of *Buthotrephis* found in the Toronto strata resembles very closely *B. subnodosa*, which Hall described from the Lorraine of New York State. It might also be referred to *B. gracilis crassa*, Hall, from the Clinton. There seems to be very little difference between the species and the variety mentioned above. *B. gracilis crassa* is slightly smaller and rather less nodose than *B. subnodosa* although the latter feature does not appear to be very strongly developed in the illustrations of Hall's types of *B. subnodosa*. On account of the horizon, however, there seems to be more justification for calling the present species *B. subnodosa*. The specimens show no indications of the structure of graptolites, the branches are smooth and always of the same colour as the rock in which they are embedded. From their general appearance and mode of branching, it seems reasonable to assume that they are the remains of plants.

Locality.—Don Valley quarry, Toronto.
No. 1258 H.R., Royal Ontario Museum of Paleontology.

Genus LICROPHYCUS, *Billings*

Licrophycus, *Billings*. Pal. Foss., 1, Geol. Surv. Canada, 1865, p. 99 (adv. sheets, 1862).
Licrophycus, *Miller*. N.A. Geol. Pal., 1889, p. 125.
Licrophycus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 722.

Billings gives the following description of the genus:—

Composed of numerous elongated sub-cylindrical stems springing from a common root, the stems either remaining single or sending off branches at an acute angle.

Licrophycus flabellum, *Miller and Dyer*

Plate III, Figure 1

Licrophycus flabellum, *Miller and Dyer*. Jour. Cincinnati Soc. Nat. Hist., 1, 1878, p. 25, pl. 2, fig. 4.
Licrophycus flabellum, *Harper and Bassler*. Cat. of fossils of Trenton and Cincinnati Periods, 1896, p. 33.
Inocaulis flabellum, *Ruedemann*. Mem. New York State Mus., 11, pt. 2, 1908, p. 191.
Licrophycus flabellum, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 722 (see for full synonymy).

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[1]New York State Museum, Bull. 45, 1901, p. 130.
[2]New York State Museum, Bull. 65, 1903, p. 6.
[3]Geol. Surv. Canada, Mem. 110, p. 55.
[4]New York State Museum, Bull. 45, 1901, p. 131.

The species is described in the following terms by Miller and Dyer:—

This species consists of numerous very long slender branches, springing from a common root or stem. Sometimes the branches appear to be lying together in a bundle, and at other times they are spread out like a fan. All of these little branches are transversely wrinkled. In one instance, where the root appeared to be about quarter of an inch in diameter, these little branches, about a line or a little less in diameter, radiated off, so completely covering the surface that at a distance of about three inches from the point of radiation, sixty-eight were counted in a quadrant. Sometimes they radiate from the root or stem in every direction so as to almost cover a circular space. After the branches leave the root they remain single, and seem to fade away in the slab at the distance of two, three or four inches, though there is little apparent diminution in size until at the point of disappearance.

Markings resembling *L. flabellum*, Miller and Dyer, are frequently found in the Toronto strata. I am inclined to think, however, that the structures which Miller and Dyer regard as separate branches, do not constitute individual branches in the Toronto specimens. It would appear that two of the smaller divisions of Miller and Dyer go to make up one branch (the average width of which is three millimetres), and that a longitudinal groove runs through the centre of each branch. On either side of this groove, the branch is transversely wrinkled. The specimen figured shows the suggestion of a root or stem, from which the branches spring, but, as a rule, the specimens consist merely of a number of branches lying together in bundles or spread out like a fan.

Various authors, including Billings, Miller, Dyer, Harper and Bassler, have regarded *Licrophycus* as a plant. James, however, is not inclined to regard it as such; he suggests that it might represent the impression made by the outstretched arms of a crinoid or the impression of the remains of a graptolite, *e.g.*, of some species of *Inocaulis*. As opposed to the latter suggestion, Ruedemann states definitely that the form is not a graptolite.

Lacking any definite structure, this fossil cannot be placed with certainty in any group. Its general appearance, however, seems to justify the assumption of its being due to plant life.

Locality.—Cut on west side Humber river, one mile below Lambton.
No. 1257 H.R., Royal Ontario Museum of Paleontology.

PALAEOPHYCUS, *sp. indet.*

Plate III, Figure 2

PALAEOPHYCUS SP. INDET., *Hall*. Pal. New York, 1, 1847, p. 264, pl. 70, fig. 2.

Hall gives the following description of an indeterminable species:—

This species occurs in short, small fragments, often quite covering the shaly laminae in some parts of this group. It appears to have been a succulent plant; but no definite character can be assigned to it in the present state of our knowledge. The specimens figured are in a fragment of slate, presenting the usual aspect of the species. It is often found in smaller and in larger fragments, both covering the surfaces and penetrating the thin arenaceous layers.

Slabs covered with confused masses of these short, small fragments are very common in the rocks at Toronto. The average length of our specimens is from 20 mm. to 30 mm. and the average width is about 4 mm. The fragments all appear to have a sharply defined ridge. This sharpness of outline, the interwoven manner of occurrence, and the horizon—similar to that of Hall's specimens—suggest an organic rather than an inorganic origin for these markings. As there is not any trace of structure, it is impossible to state whether the marks are due to animal or vegetable life. In deference to Hall's opinion, they are here placed under the fucoids.

Locality.—Don Valley quarry, Toronto.
No. 1256 H.R., Royal Ontario Museum of Paleontology.

Crustacean Trail (?)

Genus RUSOPHYCUS, *Hall*

RUSOPHYCUS, *Hall*. Pal. New York, 2, 1852, p. 23.
RUSOPHYCUS, *James*. Jour. Cincinnati Soc. Nat. Hist., 7, 1885, pp. 153-155.
RUSOPHYCUS, *Miller*. N.A. Geol. Pal., 1889, p. 138.
RUSICHNITES, *Dawson*. Can. Nat. Geol., 1, 1861, p. 363.
RUSOPHYCUS, *Bassler*. N.S. Nat. Mus., Bull. 92, 1915, p. 1132.

The following account of the genus is founded chiefly upon James' observations:—

In 1852, Hall described the genus *Rusophycus* as a plant consisting of simple or branched stems, which are transversely rugose or wrinkled. He described two species from the Clinton, namely, *R. bilobatus* and *R. pudicus*. In the species *R. bilobatus* the outline is elliptical; the surface is sometimes nearly smooth and sometimes very rugose; the specimens vary from one inch long and a half inch wide to four inches long and three inches wide. A longitudinal groove runs the whole length of the fossil dividing it into two distinct lobes. Occasionally what appears to be a stem is found attached to the central depressed groove but, as a rule, this structure is absent. *R. pudicus* is also elliptical and generally much smaller, smooth, and with the groove deep in the centre but disappearing before the extremity is reached. Hall described two other species from the Clinton, namely, *R. clavatum* and *R. subangulatum*, but as these are quite different in appearance they will not be dealt with here.

In 1865, Billings described *R. grenvillensis* from the Chazy of Grenville, Quebec. This species is very similar to *R. bilobatus*, Hall, but differs specifically in being a proportionately shorter form with the longitudinal furrow running through only a part of the length.

After Hall had described and figured his species, it was found that D'Orbigny had in 1842 described similar forms under the genus *Cruziana*. According to Bassler, however, the species from the Ordovician and Silurian which now stand as *Cruziana* are all European forms; the species which have been dealt with above are still considered as belonging to the genus *Rusophycus*.

In 1890, Dawson was able to show that *R. grenvillensis*, Billings, was in reality the burrow or track of some marine animal, probably a crustacean. He arrived at this conclusion by a careful study of the impression made by the recent *Limulus polyphemus* on muddy and sandy bottoms. In view of these facts Dawson proposed to substitute the generic name *Rusichnites* for *Rusophycus*.

The fossils considered under *Rusophycus* and *Cruziana* have been regarded by Hall, Billings, White, Miller, and recently by Clarke and Ruedemann,[1] as belonging to the *Algae*; other authors, including Dana, James, and Dawson, regard them as the trails or impressions of the trails of crustaceans.

RUSOPHYCUS, *sp. indet.*

RUSOPHYCUS BILOBATUS, *Nicholson*. Rep. on the Pal. of Prov. of Ont., 1875, p. 38, fig. 14.

In the Toronto strata, markings referable to the genus *Rusophycus* are not uncommon. The specimens are all small, the largest one does not exceed

[1]New York State Museum, Bull. 65, 1903.

50 mm. in length and 25 mm. in width, while the majority are much smaller. There is also considerable variation in the general form of these specimens, *e.g.*, some taper rapidly to one end, whereas others show scarcely any tapering; some show a clearly defined longitudinal groove throughout the whole length, while in others the groove fades away toward one end. The surface is in some cases smooth and in other decidedly rugose. The stem mentioned by Hall has not been observed in the Toronto specimens.

This form has long been referred to the Clinton species *R. bilobatus*, Hall, but it appears to resemble quite as closely the Chazy form *R. grenvillensis*, Billings. Both these species, however, are larger than the Toronto form. If this fossil is the trail or the impression of the trail of a crustacean, its different age would indicate a different species from either of the two mentioned above which it so closely resembles. In view of the imperfections of the present material, however, a specific determination does not seem to be justified.

Locality.—Don Valley quarry, Toronto.
No. 1254 H.R., Royal Ontario Museum of Paleontology.

Inorganic Markings

Genus TRICHOPHYCUS, *Miller and Dyer*

TRICHOPHYCUS, *Miller and Dyer.* Jour. Cincinnati Soc. Nat. Hist., 1, 1878, p. 24.
TRICHOPHYCUS, *James.* Jour. Cincinnati Soc. Nat. Hist., 7, 1884, p. 130, 158.
TRICHOPHYCUS, *Miller.* N.A. Geol. Pal., 1889, p. 147.
TRICHOPHYCUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 1288.

The genus is described thus by Miller and Dyer:—

This genus of plants consists of simple branches or stems having diagonal or longitudinal markings, as if made by the folding down of hair-like filaments. The markings readily distinguish it from all other genera of Silurian plants.

TRICHOPHYCUS VENOSUM, *Miller*

Plate III, Figure 4

TRICHOPHYCUS VENOSUM, *Miller.* Jour. Cincinnati Soc. Nat. Hist., 2, 1879, p. 112, pl. 9, figs. 5, 5a.
TRICHOPHYCUS VENOSUM, *James.* Jour. Cincinnati Soc. Nat. Hist., 7, 1884, p. 131.
TRICHOPHYCUS VENOSUM, *James.* Jour. Cincinnati Soc. Nat. Hist., 14, 1891, p. 46.
TRICHOPHYCUS VENOSUM, *Harper and Bassler.* Cat. of Fossils of Trenton and Cincinnati Periods, 1896, p. 34.
TRICHOPHYCUS VENOSUM, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 1289.

The original description of the species follows:—

This plant consists of a half cylindrical stem covered upon the cylindrical surface with irregular and inconstant elevated lines, varying in their course from longitudinal with the stem, to diagonally radiating from a central line. If the stem was originally cylindrical, one half of it seems to have been invariably destroyed in the rock, so as to leave a flat undersurface. The greater diameter is generally about an inch. No bifurcation has been observed.

James is opposed to the theory of the organic origin of this species; he believes that it is merely the cast of a depression made in mud by running water and he adds that it greatly resembles certain recent mud marks. Harper and Bassler, however, at a later date still list this fossil under the fucoids.

Half-cylindrical, stem-like objects, with or without the surface characteristics of *Trichophycus*, are of very common occurrence in our rocks. In some cases the diameter is as much as six inches. Those with surface markings are usually smaller, seldom exceeding one inch in diameter; these are herein ascribed to *Trichophycus*. Most of these stems, however, are smooth, differing from *Trichophycus* only in this respect and in the greater size sometimes reached. The smooth forms are described later under *Palaeophycus*.

Since none of our specimens show any evidence of structure, it is impossible to definitely regard them as having an organic origin. On the other hand, it is not difficult to imagine such structures as being the casts of the courses made by small streams and rills. The fact that these objects vary considerably in size tends to confirm the idea that they were caused by streams of water of various sizes.

The specimen figured is about a half inch in diameter, but specimens as large as one inch in diameter are known to occur in this district.

Locality.—Cut on west side of Humber river, 1 mile below Lambton.
No. 1253 H.R., Royal Ontario Museum of Paleontology.

Rill Marks

Plate II, Figure 10

Certain peculiar markings from the Maysville strata of Cincinnati, Ohio, consisting of a main stem with many minor, sometimes anastomosing branches were described by Miller and Dyer as a fucoid under the name of *Aristophycus ramosus*.[1] Later, however, both the genus and the species were abandoned by the authors, who finally regarded the marks as inorganic or, if fucoidal, of too indefinite a character to be named.

James in his description of these objects[2] states that they were in all probability caused by the heavy dashing of rain on the surface of mud, which, he states will make irregular elevations and depressions, with a little channel to carry away the superfluous water. The casts of such impressions, according to James, look very much like plants in general appearance.

Examples of markings very similar to those described by James are frequently found in our rocks at Toronto. It is quite probable that they were formed in a manner similar to that described by James. The specimen figured consists of one main stem-like portion which divides into several smaller ones; these smaller divisions give rise to an irregular network of vein-like structures. The smallest of these divisions become more and more indistinct until they are finally lost in the rock. It is not difficult to imagine such a network as representing the cast of the courses made by tiny rills which were making their way through the mud. In the absence, therefore, of any definite structure these markings are considered to be of inorganic origin and are regarded as fossil rill marks.

Locality.—First Ravine, Rosedale, Toronto.
No. 1259 H.R., Royal Ontario Museum of Paleontology.

Genus PALAEOPHYCUS, *Hall*

PALAEOPHYCUS, *Hall*. Pal. New York, 1, 1847, p. 7.
PALAEOPHYCUS, *James*. Jour. Cincinnati Soc. Nat. Hist., 7, 1885, p. 157.
PALAEOPHYCUS, *Miller*. N.A. Geol. Pal., 1889, p. 130.
PALAEOPHYCUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 939 (see for full synonymy).

Hall gives the following generic description:—

Stem terete, simple or branched, cylindric or sub-cylindric, surface nearly smooth, without transverse ridges, and apparently hollow.

[1]Contr. Pal., No. 2, 1878, p. 4, fig. 2.
[2]Cincinnati Soc. Nat. Hist., p. 130, pl. 6, fig. 2.

PALAEOPHYCUS VIRGATUS, *Hall*

Plate III, Figure 3

PALAEOPHYCUS VIRGATUS, *Hall.* Pal. N.Y., Vol. 1, p. 263, pl. 70, fig. 1.
PALAEOPHYCUS VIRGATUS, *Nicholson.* Pal. of Province of Ontario, 1875, p. 37, fig. 13.
PALAEOPHYCUS VIRGATUS, *James.* Jour. Cincinnati Soc. Nat. Hist., 7, 1885, p. 158.

Hall describes the species as follows:—

This species is only seen in fragments of long, rigid stems, of nearly equal diameter. It appears to have been succulent or tubular, and is always compressed in the stone. Fractured or weathered surfaces of the arenaceous shales often present great numbers of these fragments, imbedded in great confusion.

James considers that a great many of Hall's species of *Palaeophycus* are not plants, but represent, rather, the casts of the burrows of animals or fossil mud-marks. He regards *P. rugosus*, Hall, as the burrow of some annelid, the rugose surface being caused by the irregularly thrown up mud. *P. virgatus*, Hall, and *P. simplex*, Hall, are also considered by James to represent the casts of annelid burrows. *P. flexuosus*, James, is now regarded by its author as a fossil mud-mark. Clarke and Ruedemann have listed certain species of *Palaeophycus*, namely, *P. rugosus*, Hall, and *P. tubulare*, Hall, under *Plantae*.[1]

Flattened, cylindrical, stem-like objects resembling *P. virgatus*, Hall, are very common in the rocks at Toronto. They are very similar to *Trichophycus venosum*, Miller, but differ from that species in having smooth surfaces and in occasionally attaining a much greater size. The majority of our specimens are fragments about four or five inches long and from a half inch to one inch wide; specimens, however, six inches in diameter are known to occur in this district. Owing to their strong resemblance to *T. venosum*, it is natural to assume that they were formed in a similar manner, in which case they will be regarded as of inorganic origin.

Locality.—Humber river, Toronto.
No. 1255 H.R., Royal Ontario Museum of Paleontology.

Other Markings

Of very frequent occurrence on the surfaces of slabs from the strata of this district are isolated patches consisting of fine parallel ridges and depressions, which are quite uniform in size in any given specimen but which present some variation in spacing when the specimens are compared with one another. After measuring a number of these impressions it has been found that the average number of ridges in a space of 10 mm. is nine, although as many as fifteen and as few as seven are observed in a similar space.

Besides these numerous isolated patches there is a single example of a more definite shape, which, owing to the presence of similar transverse ridges and depressions, suggests a like origin. This specimen which is made up of rock matter, consists of a stem-like portion which begins to widen gradually towards one end and finally flattens and spreads out in a somewhat fan-shaped fashion. The other end terminates in an irregular bulbous expansion.

The so-called stem-like portion shows numerous, inconstant, transverse ridges and depressions, which vary in size from extremely fine to very coarse. The coarser ridges, which are five or six millimetres wide, indicate indistinctly that they are made up of curved laminae of rock matter which are transverse to the ridge, *i.e.*, longitudinal to the "stem." The expanded fan-like part is

[1]New York State Museum, Bull, 65, 1903, p. 8.

undoubtedly the same as the flat patches first referred to, and must be due to the same cause. Toward the left side of this portion, the fine transverse ridges and depressions (nine in a space of 10 mm.) are very constant but show no distinct boundary, being lost finally in the matrix. On the right side, these characteristic markings are interrupted in three or four places by slight longitudinal depressions which appear to run through the whole length of the expanded portion. These depressions cause a slight downward and backward deflection of the ridges on the left side of the depression.

On this single specimen it has not been possible to come to any definite conclusion as to the origin of this more or less definite form. As the specimen was not found *in situ* we do not know whether it represents an upper or a lower surface of the stratum containing it. Assuming that the impression is on a lower surface it has been suggested that the object may represent the cast of an impression formed by a crinoid waving back and forth on the sea floor, the stem-like portion representing the case of the depression worked out in the mud by the crinoid column and the flattened expanded portion being the impressions made by the pinnulae. The fact that there appears to be a crinoid column embedded in the stem-like portion may serve to substantiate this suggestion. It is also quite possible that these fine markings represent the impressions made in mud by the appendages of trilobites. This suggestion might explain the isolated patches so common in our rocks but does not appear to be sufficient explanation for the cause of the single specimen just described. A fucoidal origin is of course possible, but it cannot be said that there is any greater support for this hypothesis than for the others. At present, therefore, it does not seem possible to definitely account for these peculiar markings, although the supposition of an organic rather than an inorganic origin seems more justifiable.

The specimen illustrated in Plate III, Figure 5, has the following measurements:—

Total length	150 mm.
Length of stem-like portion proper	105 mm.
Minimum width of stem	40 mm.
Maximum width of stem	70 mm.
Width of fan-shape portion	90 mm.

Locality.—Humber river, Toronto.
No. 1265 H.R., Royal Ontario Museum of Paleontology.

In addition to the more or less constant markings which have already been described and referred to plants, trails, or to inorganic causes, our strata show certain other markings, the origin of which is still more uncertain. The most clearly defined type of these markings resembles the trail or track of some animal. One of the best examples of this kind is an impression about 16 cm. long and 7 mm. wide, with a depression about 4 mm. wide running the whole length of the specimen and with a prominent ridge standing up on either side. There is no variation in size or shape throughout the entire length, a condition which would indicate that the marking represents the impression made by the onward movement of some creature, possibly a pelecypod.

Another type of marking which is very often found consists of a long, sub-cylindrical, stem-like structure (one example is 20 cm. long and 5 or 6 mm. wide, although smaller examples are very common), with well defined edges. This object would strongly suggest the stem of a succulent plant similar to the genus *Palaeophycus*, but owing to the imperfection of the material a specific determination is not justified.

Fragments of forms of a still more indefinite nature are found in great abundance on typical slabs from this district. They would indicate the roots and stems of low forms of plant life, but in view of our present knowledge no definite statement can be made concerning their exact identity.

ADDENDA ET CORRIGENDA

(Parts I to IV)

By W. A. Parks

Since the appearance of the earlier numbers of this series, additional collecting and further study have rendered necessary a few additions and corrections as below:—

HALLOPORA ONEALLI DANFORTHENSIS, *var. nov.*

HALLOPORA *cf.* SUBPLANA, *Parks and Dyer.* Part II, p. 19.

The common, smooth, ramose bryozoan, so characteristic of the strata on the Don river, was provisionally ascribed to *H. subplana*, but the importance of this species demands a more exact determination. We were led to compare it with *H. subplana* chiefly on account of the apparent occurrence of maculae. An examination of more sections fails to reveal maculae, and a close inspection of the form figured shows that the apparent maculae are possibly due to the state of preservation, the spots being filled with clear calcite while the rest of the zooecia are filled with clay. The actual photograph (Pt. II, Pl. IV, Fig. 14) seems to show the maculae, but in the drawing from the same section (Pt. II, Pl. III, Fig. 13) they are scarcely to be observed.

This form is more likely a member of the extremely variable species *Hallopora onealli* and not far from the variety *sigillarioides.* It differs, however, in the size of the zoarium and in having an almost smooth surface. In view of some undoubted differences and of its stratigraphic importance at Toronto, it seems advisable to consider it as a new variety as above.[1]

HALLOPORA ONEALLI (*James*)

Plate IV, Figure 7

CHAETETES (?) ONEALLI, *James.* Introduc., Cat. Low. Sil. Foss., 1875, p. 2.
MONTICULIPORA ONEALLI, *James and James.* Jour. Cin. Soc. Nat. Hist., X, 1888, p. 174.
CALLOPORA ONEALLI, *Bassler.* Proc. U.S. Nat. Mus., XXX, 1906, p. 23, pl. VI, figs. 1, 2.
HALLOPORA ONEALLI, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 581.

The description of this species as given by James and James follows:—

Corallum dendroid, branching dichotomously, branches varying from less than one line to two lines in diameter. Surface smooth, calices generally oval, long axis corresponding to the long axis of the branches; of two kinds, the larger separated by a considerable number of interstitial tubes. Walls thickened at cell mouths. Operculae often closing apertures of cells.

This species is characterized by the peculiar habit of growth, branching in a very irregular manner at almost every possible angle and anastomosing so as to form various shaped figures; by the presence of a considerable number of interstitial corallites between the larger ones, and a generally smooth surface.

Plentifully on the Humber and sparingly on the Don, there occurs a ramose bryozoan intermediate in size between *Bythopora arctipora* and *Hallopora onealli danforthensis.* Well-preserved specimens are rare, and in consequence the form was omitted when Part II was prepared. Since that time better examples have been found and submitted to Dr. Bassler who identifies the form as *H. onealli*, "*as that variable species is now understood*".

[1]HALLOPORA ONEALLI SIGILLARIOIDES. Proc. U.S. Nat. Mus., Vol. XXX, Pl. VI, figs. 3, 4.

MESOTRYPA DISTINCTA, *sp. nov.*

Plate IV, Figures 4, 5

MESOTRYPA (?), *Parks and Dyer.* Part II, p. 5.

Numerous and better specimens of this discoidal bryozoan have been found since Part II appeared. The description therein is accurate and needs little addition. Good vertical sections show a most distinct pinching-out of the mesopores towards the surface. In some cases, however, the mesopores continue to the surface with no diminution in diameter. Shallow tangential sections show only occasional mesopores, the point at which a mesopore might be expected to appear being occupied by an acanthopore. The species is found at various levels on the Humber and abundantly at the Prison Farm quarry.

Locality.—Humber river, Toronto.
No. 1200 H.R., Royal Ontario Museum of Paleontology.

STIGMATELLA INTERMEDIA, *Fritz*

Plate IV, Figure 1

A species of *Stigmatella* found in abundance on Workman's brook is being described by Miss Fritz as *S. intermedia.* This form is intermediate in character between *S. personata*, *S. crenulata*, and *S. catenulata.* The zoarium is ramose with stout branches growing from a clump.

A single specimen of this species was found at the point where Queen street crosses Mimico creek.

MODIODESMA MODIOLARE (*Conrad*)

MODIOLOPSIS MODIOLARIS, *Stewart.* Part I, p. 34, Pl. III, Fig. 1.

This form becomes *Modiodesma modiolare* in view of recent studies by Dr. E. O. Ulrich who has kindly allowed me to make use of his manuscript in advance of its publication. Dr. Ulrich finds that the species and also the genus requires revision and has divided the so-called *Modiolopsis* into two genera, *Modiolopsis* and *Modiodesma.* The latter genus is defined by Ulrich as follows:—

More or less elongate modiolopsid shells with the hinge nearly straight and the mesial depression and marginal sinus so little developed that the ventral edge remains more or less convexly curved throughout. Anterior fourth or third of surface with distinct rounded, closely and regularly disposed concentric ribs. Posteriorly these die out or pass into more obscure and wider-spaced concentric growth lines and varices that commonly increase in strength again on the cardinal slope. Shell thin, umbones very moderately prominent, depressed convex, and passing diagonally backward into barely distinguishable umbonal ridges; beaks usually farther removed from the anterior end than in *Modiolopsis.* Cardinal slopes of clean and sharply preserved casts of the interior nearly flat with a variable number of raised lines or bands. These converge towards the incurved beaks and outline the wide progressive track of the posterior adductor scar. Anterior adductor scar large, moderately to deeply impressed, vertically furrowed, situated entirely in front of the beaks. Hinge plate very thin, edentulous, the valves held together by linear inner and outer ligaments, the former lying in a narrow channel partly defined on its inner side by a thin longitudinal rib which leaves a corresponding slit-like depression on interior casts. The outer ligament extends to the posterior extremity of the hinge, seems longer than the inner, and differs from it in having a black epidermis.

In the description of the species (Part I, page 34), the words "Basal margin usually contracted or slightly arched upwards" should be deleted. Dr. Ulrich thinks that the form represented (Part I, Pl. III, Fig. 1) is a true *Modiodesma modiolare*, but that the ligament as shown is too short.

Genus MODIOLOPSIS

MODIOLOPSIS, *Stewart*. Part I, p. 34.

The emended description of this genus as given in Ulrich's manuscript, which we are permitted to use, is as follows:—

Shells with a black epidermis, subovate, widest posteriorly, the dorsal edge very gently convex, the ventral side slightly sinuate. Umbones though small and rather low, projecting distinctly above the hinge line, situated near the anterior end and over the inner third of the deeply impressed anterior adductor scar; umbonal ridge rounded, low, notable mainly because of an undefined but wide depression over the antero-ventral slope; cardinal slope gently concave. Surface usually with concentric lines and narrow ribs, the latter strongest, rounded, and most regularly spaced on the posterior half. Hinge plate thin, with a single undefined subrostral tooth and socket in each valve; ligament external but lying partly in a very narrow area. Pallial line simple; posterior adductor scar large but very faintly outlined. Genotype *Modiolopsis ovata* (Conrad), upper part of Pulaski shale, New York; Fairmount limestone of the Maysville group, Cincinnati, Ohio, and vicinity.

MODIOLOPSIS OVATA (*Conrad*)

Plate IV, Figures 2, 6, 9

Modiolopsis ovata was described by Conrad as *Cypricardites ovata* in the Fifth Annual Report of the New York Geological Survey, 1841. It was included by Hall in *Modiolopsis modiolaris* and figured as such.[1] In Dr. Ulrich's manuscript this form is selected as the genotype of *Modiolopsis*, as indicated above.

The species is characterized by the great height of the shell posteriorly and the narrowness anteriorly.

The abundant modiolopsid shell from the Prison Farm quarry has been identified by Dr. Ulrich as *M. ovata*. He is of the opinion, also, that certain somewhat larger forms, showing a less difference between the anterior and posterior heights, approach *Modiolopsis valida*, Ulrich (Pl. IV, Fig. 6).

Locality.—Prison Farm quarry, Toronto.
No. 1274 H.R., Royal Ontario Museum of Paleontology.

MODIOLOPSIS STRIATA, *sp. nov.*

Plate IV, Figure 3

The collection contains a single example of a small modiolopsid shell consisting of a mould of the exterior, unfortunately broken anteriorly. In form it is not unlike *M. ovata*, being high posteriorly and having a well marked ventral sinus. As far as can be ascertained, however, the anterior end is less attentuated than in *M. ovata* and the shell is much smaller. Concentric wrinklings are well marked on the posterior part of the mould, but the most characteristic feature is the distinct radiating striae extending from the region of the beak to the posterior and postero-ventral margin. Length 16 mm., height posteriorly 11 mm.

Locality.—Humber river at road bridge, Weston.
No. 1275 H.R., Royal Ontario Museum of Paleontology.

MODIOLOPSIS BOREALIS, *Foerste*

Plate IV, Figure 8

MODIOLOPSIS BOREALIS, *Foerste*. Geol. Surv. Can., Mem. 138, 1924, p. 178, Pl. XXIV, Figs 4a-f; Pl. XXIII, Fig. 5.

The collections from the Credit member of the Credit River section contain a single right valve of a species of *Modiolopsis*, the description of which has

[1]Pal. New York, I, Pl. 81, Fig. 1e.

not heretofore been published. The specimen was referred to Dr. Foerste, who immediately recognized it as one which he had described in an unpublished manuscript.

Dr. Dyer describes his specimen as follows:—

Shell with a black epidermis, elongate-ovate in outline, widest posteriorly; umbones rather prominent for the genus, extending slightly above the hinge line; umbonal ridge prominent extending almost to the ventral margin before being lost in the general convexity of the shell, followed in front by a wide shallow depression; ventral margin slightly sinuate; shell marked by very distinct concentric ribs, almost equally strong on all parts of the shell, but becoming faint on the postero-ventral slope; a few indistinct radiating undulations observable just behind the umbonal ridge. The shell measures 31 mm. in length by 11 mm. in height.

The species differs from other members of the genus in the prominent umbonal ridge and in the very strong concentric ribs. In this latter feature it somewhat resembles *Cuneamya scapha brevior*, Foerste, of the Toronto rocks.

Locality.—Credit river, Erindale.
No. 1278 H.R., Royal Ontario Museum of Paleontology.

Figures in Text

Plate I

Unless otherwise stated the figures are of natural size.

		Number	Locality	Page
Fig. 1.	*Dermatostroma scabrum*................	821 H.R.	Humber river (?)	2
Fig. 2.	*Dendrograptus*, sp. indet., × 2.........	1243 H.R.	15-foot level, Don Valley quarry	3
Fig. 3.	*Mastigograptus gracillimus*, × 4........	1244 H.R.	Lower 2 feet, Don Valley quarry	6
Fig. 4.	*Climacograptus putillus*, × 5...........	After Ruedemann	....	7
Fig. 5.	*Iocrinus subcrassus torontonensis*.........	245 H.R.	Don Valley quarry	13
Fig. 6.	*Climacograptus* cf. *typicalis*, × 4.......	1245 H.R.	8 feet below uppermost beds in Don Valley quarry	7
Fig. 7.	*Heterocrinus juvenis*. Showing cup and arms, × 2......................	1247 H.R.	Don Valley quarry	10
Fig. 8.	*Diplograptus foliaceus vespertinus*. Showing sicular end, × 4............	1246 H.R.	Exposure at end of Bloor Street on the Humber river	8
Fig. 9.	*Inocaulis yorkensis*. Composite drawing, showing surface, × 4........	889 H.R.	Don Valley quarry	3
Fig. 10.	*Glossograptus*, sp. indet. Fragment showing thecal spines, × 2...........	1243 H.R.	15-foot level, Don Valley quarry	9
Fig. 11.	*Heterocrinus juvenis*. Showing cross-section of column..................	1251 H.R.	Don Valley quarry	10
Fig. 12.	*Heterocrinus juvenis*. Showing portion of column..........................	1251 H.R.	Don Valley quarry	10
Fig. 13.	*Diplograptus foliaceus vespertinus*, × 4 ..	1246 H.R.	Exposure at end of Bloor Street on Humber river	8
Fig. 14.	*Mastigograptus gracillimus*.............	1244 H.R.	Lower 2 feet, Don Valley quarry	6

Plate I

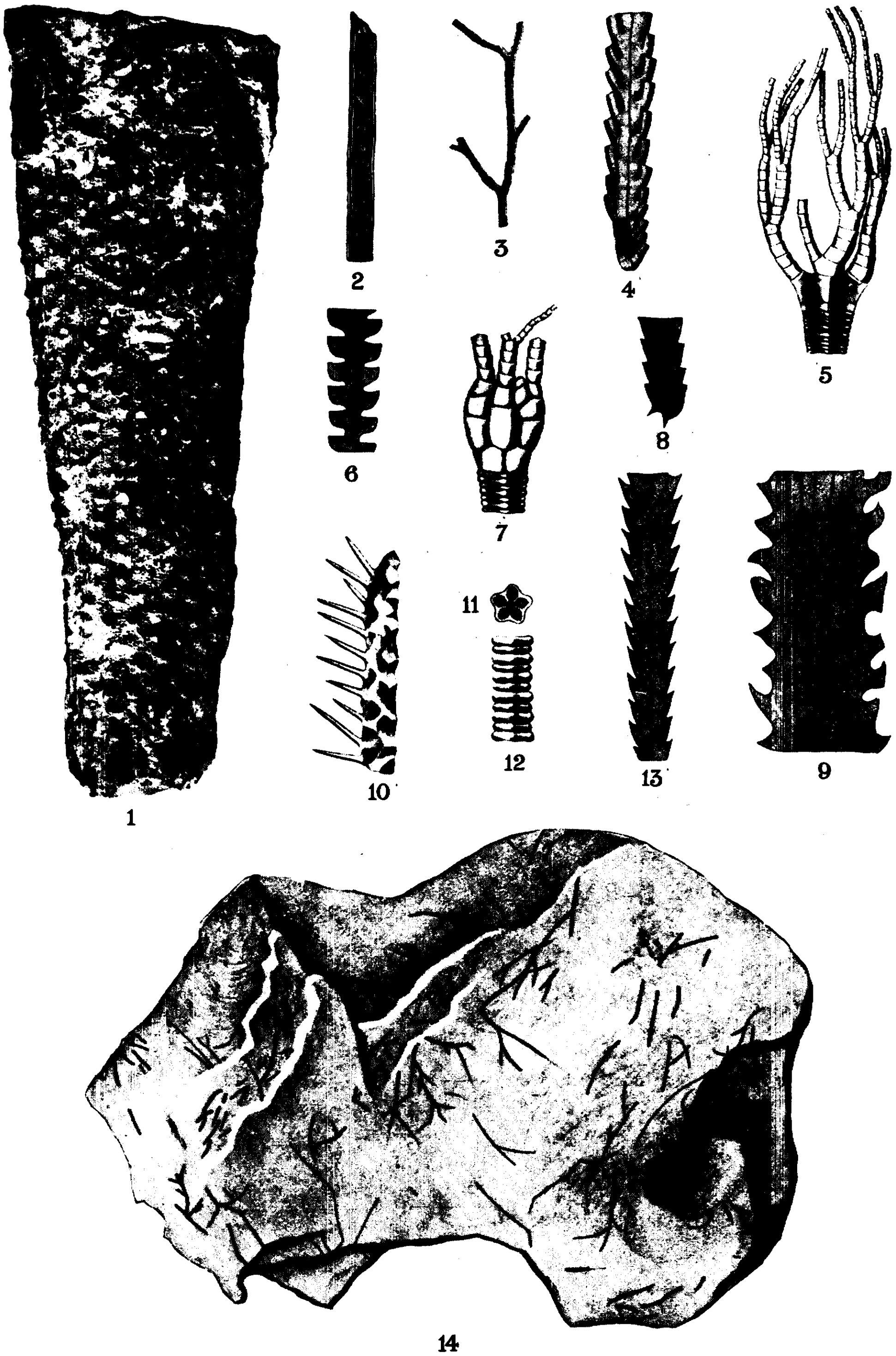

Plate II

Unless otherwise stated the figures are of natural size.

		Number	Locality	Page
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Fig. 2.	*Glyptocrinus decadactylus.* Portion of column made up of thick and thin discs	1248 H.R.	Don Valley quarry	15
Fig. 3.	*Glyptocrinus decadactylus.* Cross-section of column	1248 H.R.	Don Valley quarry	15
Fig. 4.	*Glyptocrinus decadactylus.* Cross-section of column	1248 H.R.	Don Valley quarry	15
Fig. 5.	*Glyptocrinus decadactylus.* Portion of column composed of discs of uniform size	1248 H.R.	Don Valley quarry	15
Fig. 6.	*Calymene meeki*	183 H.R.	Don Valley quarry	24
Fig. 7.	*Dendrocrinus dyeri.* Showing arms and anal tube	715 H.R.	Garrison, Toronto	16
Fig. 8.	cf. *Lichenocrinus*, sp. indet. Showing portion of column, × 2	1249 H.R.	Humbervale	18
Fig. 9.	cf. *Lichenocrinus*, sp. indet. Showing cross-section of column, × 2	1249 H.R.	Humbervale	18
Fig. 10.	Rill mark	1259 H.R.	First Ravine, Rosedale Toronto	31
Fig. 11.	Indeterminable crinoid column. Cross-section	1250 H.R.	Don Valley quarry	18
Fig. 12.	Indeterminable crinoid column. Composed of alternately thick and thin discs	1250 H.R.	Don Valley quarry	18
Fig. 13.	Indeterminable crinoid column. Cross-section	1250 H.R.	Don Valley quarry	18
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Plate II

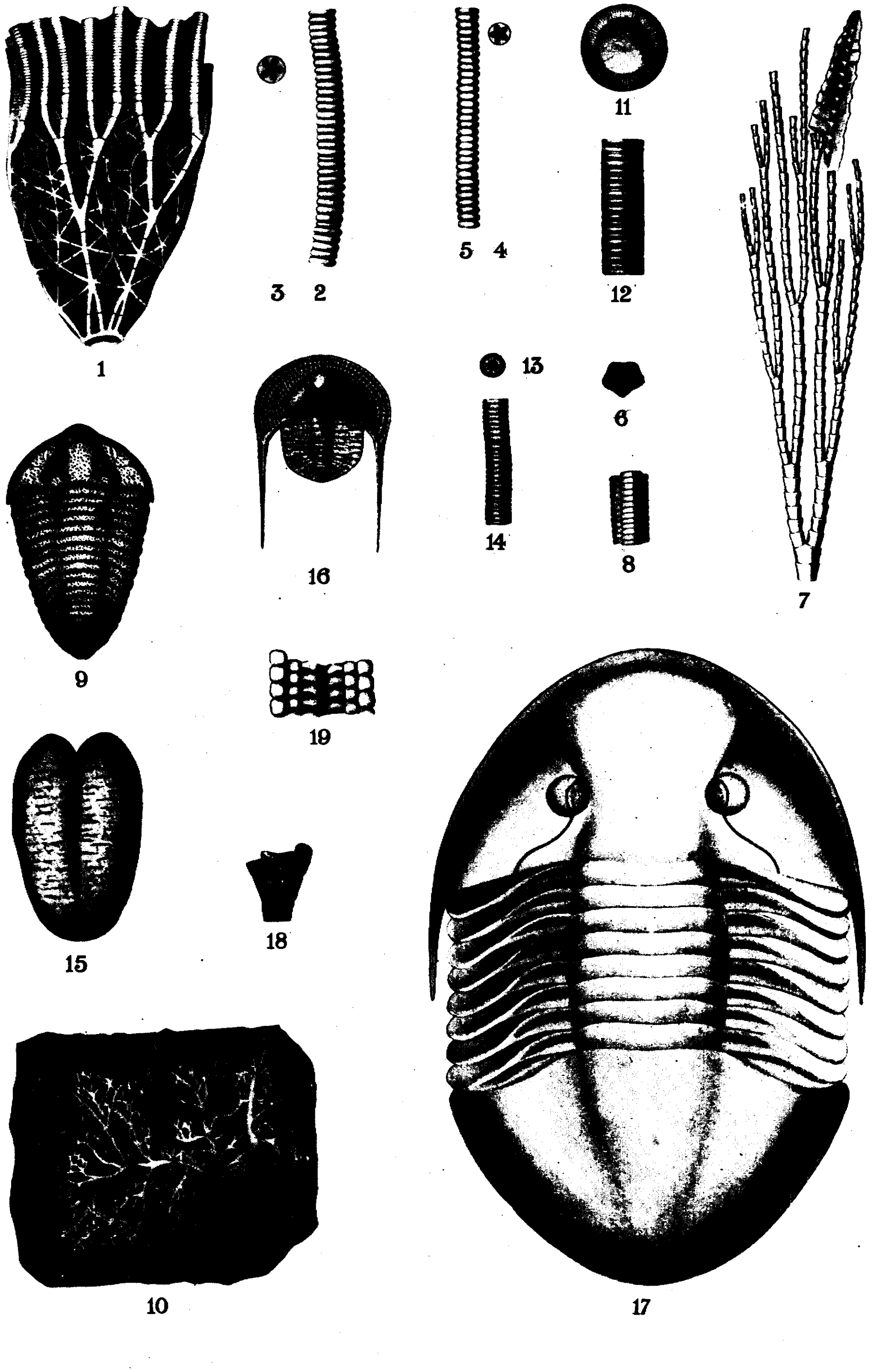

PLATE III

Unless otherwise stated the figures are of natural size.

		Number	Locality	Page
Fig. 1.	*Licrophycus flabellum*	1257 H.R.	Cut on west side of Humber river, 1 mile below Lambton.	27
Fig. 2.	*Palaeophycus*, sp. indet	1256 H.R.	Don Valley quarry	28
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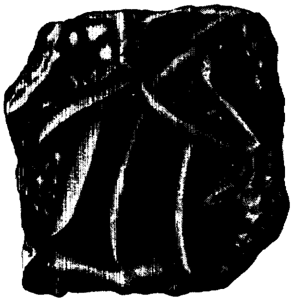
Plate III



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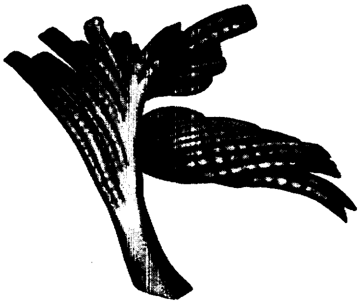

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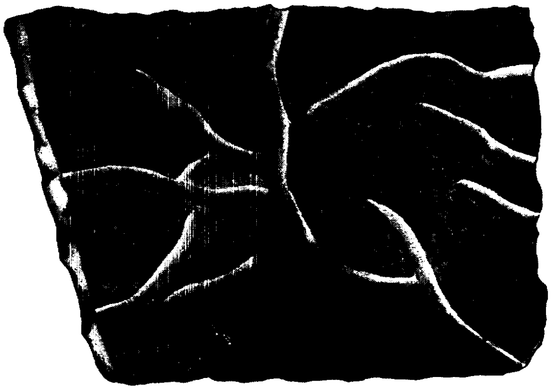

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Plate IV

Unless otherwise stated figures are of natural size.

		Number	Locality	Page
Fig. 1.	*Stigmatella intermedia*..................	1276 H.R.	Meaford	36
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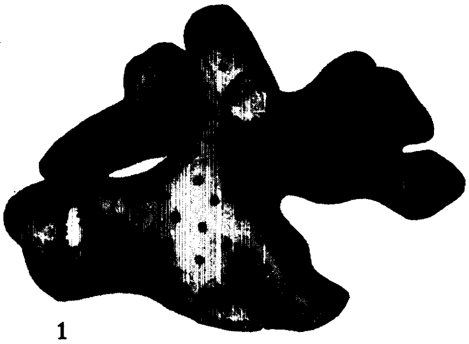
Fig. 8.	*Modiolopsis borealis*, × 2...............	1277 H.R.	Credit river	37
Fig. 9.	*Modiolopsis ovata*......................	1274 H.R.	Prison Farm quarry	37

Plate IV



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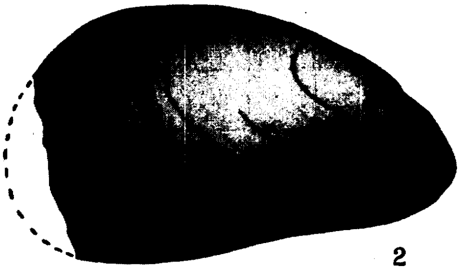

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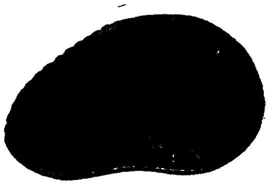

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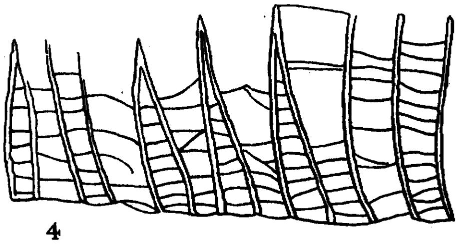

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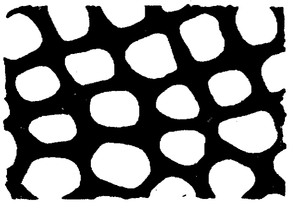

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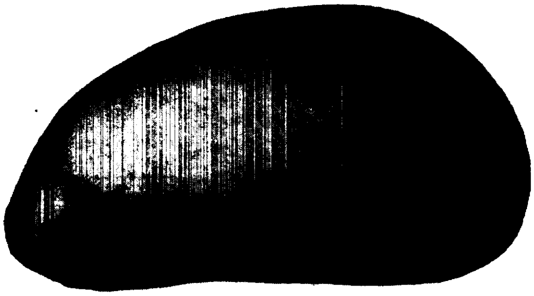

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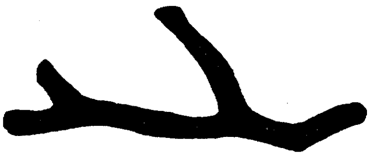

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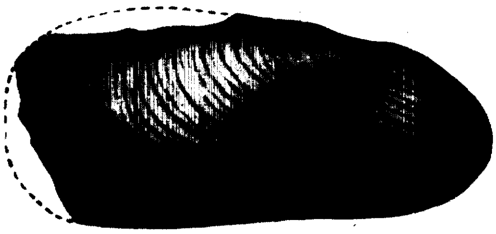

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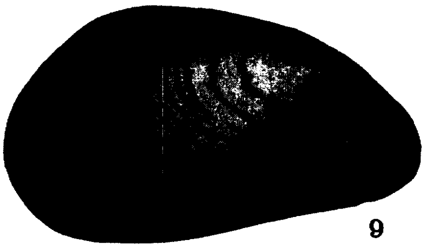

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Part V.—The Paleontology of the Credit River Section

By

W. S. Dyer

INTRODUCTION

The source of the Credit river is on the western side of the Niagara cuesta near the village of Coningsby. From this point the river flows in a south-easterly direction and empties into Lake Ontario at the village of Port Credit, seven miles west of the city of Toronto. In its upper reaches, at Credit Forks and Cataract, it cuts through the cuesta and exposes the Cataract and Lockport divisions of the Silurian, and the Queenston red shales. Between Credit Forks and Meadowvale, it winds slowly over the flat-lying drift which covers the Queenston shales. Two miles south of Meadowvale, the grey fossiliferous beds of the Richmond are first exposed, and from here to its mouth, a distance of about eight miles, the river cuts through these rocks in many places and in addition, exposes the upper part of the underlying formation herein called "Dundas".

The present study deals only with the paleontology of that part of the section below the Queenston red shales and is based on field work performed during the summers of 1921 and 1922. The method of treatment departs somewhat from that used in the former numbers of this series. As the exposures on the Credit are farther from Toronto than the others referred to in this report, only those fossils which are new to science are treated in detail. This subject forms the second section of this number, the first being devoted to faunal lists, comments on important features, and the stratigraphic range of the species. The succession of strata and the correlation of the faunas is reserved for Part VI, but the necessary stratigraphic introduction precedes the paleontology in this number.

Acknowledgments.—The work in the field as well as in the laboratory has been under the supervision of Dr. W. A. Parks of the University of Toronto, to whom the author is greatly indebted for advice and assistance on innumerable occasions. Thanks are also due Dr. A. F. Foerste of Dayton, Ohio, for valuable advice concerning the identification of certain brachiopods; Prof. W. H. Shideler of Oxford, Ohio, for supplying lists of Richmond fossils of Ohio with the exact range of each; and Dr. E. O. Ulrich of Washington for advice regarding certain specimens and microscopic sections. The drawings have been made by Miss Emily and Mr. Theo. Logier and the photomicrographs by the author.

Previous Work.—It is a surprising fact that a very small amount of work has been done in former years on the lower part of the Credit river, although the district is readily accessible and situated close to Toronto. The first reference in geological literature to the Credit river is found in the Report of Progress of the Geological Survey of Canada for the year 1843. In this report, A. Murray, assistant geologist to Sir William Logan, classes all the rock underlying the country between the Rouge river in the township of Pickering on the east and the Credit river on the west with his "bluish shales and sandstones", which he defines as including all the rocks between the bituminous Utica shales below and the Queenston shales above. In the same report he correlates the "red and green sandstones, shales and marls," which have since become the Queenston, with the Medina of the New York geologists. In the report of the Geological Survey of Canada for 1863, the Credit river is again mentioned. The rocks outcropping in its bed are referred to the Hudson River group, and on the authority of Billings the names of two or three fossils, including the abundant species *Favositella stellata* (*Columnaria alveolata*), are given. In the report upon the "Palaeontology of Ontario," which appeared in the years 1874 and 1875, Nicholson describes certain species of fossils from the Credit River rocks, which he includes in the Hudson River group.

Dr. W. A. Parks next described the Ordovician section on the Credit river in a short article in Guide Book No. 5, issued by the Geological Survey of Canada at the time of the Geological Congress in Toronto in 1913. He refers the rocks in part to the Richmond and in part to the Lorraine, listing a few species from each formation. The first mention of the prominent coral reef at Streetsville is made in this article, although corals were among the fossils from the Credit river listed by Billings and Nicholson.

The only other work of importance appeared in Memoir No. 83 of the Geological Survey of Canada. In this memoir, Dr. A. F. Foerste gives an account of the stratigraphy and paleontology of the rocks at Streetsville, naming the fossils which he found and giving their position and range in the section. He did not find any distinctive species in the coral reef, but it was his opinion that these rocks are contemporaneous with the Gore Bay reef on Manitoulin island, which is referred with greater certainty to the Whitewater or Saluda of Ohio and Indiana. He found *Strophomena varsensis* which he listed as *Strophomena sulcata*, *Strophomena planumbona erindalensis* listed as *Strophomena planumbona*, and *Catazyga headi* at the base of the cliff northeast of the home of William Crozier, and he correlates this part of the section with the Waynesville of Ohio, a conclusion which finds support in this paper. Between this level and the coral reef, he found other species, chiefly pelecypods, which are also suggestive of the Waynesville. Below the former level he found nothing diagnostic. He did not find any indication of the Liberty, which is not surprising, for the establishment of the Streetsville member (*vide postea*) with relationship to the Liberty is based entirely on bryozoan remains, and Foerste records only two species of bryozoans from the whole Credit River section.

Outline of Stratigraphy.—The classification given below of the Cincinnatian strata in the vicinity of Toronto is founded on observations by Professor Parks at Toronto and by the writer on the Credit river.

CLASSIFICATION OF CINCINNATIAN STRATA OF TORONTO DISTRICT

Series	Time Scale	Formation	Member
Cincinnatian	Richmond	Richmond	Queenston Meadowvale Streetsville Erindale
	Maysville-Lorraine	Dundas	Credit Humber Danforth Rosedale
	Utica	Utica	Utica

The strata on the Credit river between Meadowvale and the lake show exposures in descending order of the lower part of the Queenston member, the whole of the Meadowvale, Streetsville, Erindale, and Credit members, and the upper part of the Humber member.

With the exception of the overlying red Queenston shale, the rocks consist largely of greyish shale showing in many places harder beds of impure arenaceous shale and argillaceous sandstones on which ripple marks are frequently seen and even mud cracks at some levels. At intervals, more or less defined, are layers of fossiliferous limestone. All these rocks indicate a deposition near a shoreline as attested by the markings mentioned and by the manner in which the fossiliferous limestone layers rapidly wedge out into unfossiliferous shales and sandstones.

The following table indicates the detailed subdivisions of the rocks on the Credit river, with an approximate correlation with those of the Ohio valley.

STRATIGRAPHY AND CORRELATION OF THE CREDIT RIVER ROCKS[1]

Credit River				Ohio Valley	
Formation	Member	Zone	Thickness	Foerste	Shideler
Richmond	Queenston		feet ?	Whitewater-Saluda	Upper Whitewater
	Meadowvale	Upper Meadowvale *Columnaria* reef	30		Saluda
	Streetsville	*Bythopora meeki* *Stromatocerium* reef *Homotrypa streetsvillensis* *Ischyrodonta miseneri*	20	Liberty	Lower Whitewater Liberty
	Erindale	Upper Erindale *Strophomena varsensis*	65	Waynesville	Waynesville
Dundas	Credit	*Stigmatella sessilis crassa*	50	Maysville	Maysville
	Humber	Unfossiliferous	100		
		Fossiliferous	26		

PALEONTOLOGY

Under this heading will be found a complete list of the species occurring on the Credit river, together with notes on important features and the strati-

[1]Since this table was printed, a new classification has been published by Dr. Foerste. See Mem. 138, Geol. Surv. Can, 1924.

graphic range of each, both in the Credit Valley basin and at points outside of it.

The total fauna consists of 101 species or varieties, of which 46 are *Bryozoa.* This feature constitutes one of the strongest peculiarities of the fauna. Next to the *Bryozoa*, the *Pelecypoda* are most abundant, with 22 species. The remaining fossils are in order of importance as follows: *Brachiopoda*, 12 species; *Gastropoda*, 8 species; *Anthozoa*, 5 species; *Nautiloidea*, 2 species; *Trilobita*, 2 species; *Hydrozoa*, 1 species; *Echinodermata*, fragments of 2 genera; *Incertae sedis*, 1 species. At least three-quarters of the total fauna is from the Richmond.

Of the above 101 species or varieties, 23 are described as new; of the *Bryozoa*, 13 species and 7 varieties; and of the *Brachiopoda*, 1 species and 2 varieties.

Hydrozoa

Stromatocerium huronense (Billings).—This species is very abundant in the *Stromatocerium* reef of the Streetsville member and in the *Columnaria* reef of the Meadowvale member. In some cases it forms masses as great as eight inches in diameter. As this species is known to occur at different horizons in the Richmond, it is of no particular formational significance.

Anthozoa

Calapoecia huronensis, Billings.—Foerste[1] in reference to this species, states that *C. cribriformis*, Nicholson, appears to be identical and that Nicholson's name should be abandoned, an opinion endorsed at a later date by that author himself.

Foerste records this species from a locality on the Credit river which seems to accord with the section in the Meadowvale member just above Castler's bridge. A fine specimen from Streetsville is in the collections of the University, but its exact stratigraphic level is not indicated. No further examples were found.

Columnaria alveolata, Goldfuss.—This coral occurs abundantly in the *Columnaria* reef of the Meadowvale member, and sparingly in the upper part of the Streetsville. The range of the species is long but it is most abundant elsewhere in the Saluda division.

Columnaria calicina, Nicholson.—On the Credit this species is found in the *Columnaria* reef and sparingly in the *Stromatocerium* reef. In other parts of Ontario, it is most abundant in strata correlated with the Whitewater, only one occurrence being recorded from rocks below this horizon (Waynesville of Manitoulin island). According to Foerste the species occurs in the Cincinnati basin at the base of the Liberty.

Streptelasma rusticum, Billings.—Foerste records the occasional occurrence of small examples of this species (one-quarter inch long) on the Credit at an outcrop above Castler's bridge (Meadowvale member). The species is common in all the divisions of the Richmond in Ohio and Indiana, and on Manitoulin island.

Tetradium approximatum, Ulrich.—Abundant in the *Columnaria* reef and in the *Stromatocerium* reef. Coralla as great as 18 inches in diameter are sometimes found. This fossil has frequently been ascribed to *T. minus* described by Safford from the Trenton of Tennessee, but it agrees more closely with *T. approximatum*, the common species of the Ohio, Indiana, and Ontario localities.

[1]Bull. Sci. Lab. Denison Univ., 14, 1909, p. 310, pl. 11, fig. 4.

Echinodermata

Glyptocrinus sp.—A portion of a column, apparently referable to this genus, was collected by Joseph Townsend at Streetsville, and is now in the possession of the University. Similar columnals are not uncommon in the Humber member in the quarry at Port Credit.

Lichenocrinus sp.—Stems possibly referable to this genus are found in the Humber member in the quarry at Port Credit.

Bryozoa

Amplexopora solitaria, sp. nov.—See page 61.

Atactopora sp.—A single example of a thin, frondescent, unilaminar bryozoan with elevated, sub-solid monticules was found in the Erindale member. It is herein referred to the genus *Atactopora*, but it is not sufficiently well preserved to admit of specific identification. In the spacing of the monticules, it appears to differ from other members of the genus from the Cincinnatian series. See Plate V, Figure 10.

Atactoporella densa, sp. nov.—See page 62.

Arthropora shafferi (Meek).—A single example of this species was found among the collections of the Royal Ontario Museum of Paleontology, labelled "Richmond, Credit River". It probably came from the Erindale member, since it is on the same piece of rock as a specimen of *Hallopora aequalis*, a new species from this member. It is identical in form and structure with the specimen described and figured by Parks and Dyer from the Humber River section.

Batostoma cf. *varians* (James).—A small fragment of a bryozoan was found in the *Bythopora meeki* zone of the Streetsville member, which is herein referred to the genus *Batostoma*. The character of its growth could not be ascertained, but the vertical section prepared from it seems to show that its relationships are with the species *B. varians* of the Waynesville rather than with *B. variabile* of the Liberty and Whitewater.

Bythopora meeki, James.—This species is comparatively abundant in the uppermost five feet of strata of the Streetsville member (zone of *Bythopora meeki*). The following remarks in reference to it are made by Bassler.[1]

> The various species of *Bythopora* are so much alike in internal structure that it is not strange that Nicholson considered the species under discussion only a variety of his *Monticulipora gracilis*. However, the fact that it occupies and is characteristic of a different geological horizon and always forms a considerably larger zoarium seems to me reason enough for its rank as a distinct species.
>
> *Bythopora gracilis* forms long, slender stems seldom over three millimetres in diameter and characterizes the Fairview and McMillan formations while the branches of *Bythopora meeki* are seldom less than six or seven millimetres in diameter and occur only in the Waynesville.

The forms from the Streetsville member vary in diameter from one and a half to six millimetres, the average being four millimetres. Thus, in size, they are intermediate between the two species mentioned above. They are referred in this paper to *B. meeki* on account of their occurrence in rocks which are even higher stratigraphically than those of the Waynesville. See Plate V, Figures 4 and 5.

Calloporella vacua, sp. nov.—See page 63.

[1]Proc. U.S. Nat. Mus., 30, 1906, p. 21.

Ceramoporella ohioensis (Nicholson).—Three or four examples of this species were found growing over the zoaria of *Homotrypella* in the Streetsville member. In the Cincinnati basin it is a long-ranging fossil and is therefore of little use for purposes of correlation. See Plate V, Figure 11.

Constellaria cf. *limitaris* (Ulrich).—A small piece of a ramose species of *Constellaria*, measuring one-half inch in length, was found among the collections of the University from Streetsville. It resembles *C. limitaris* of the Ohio Richmond more than any other form, but a definite determination of the species cannot be made until better material is found. The stratigraphic level from which it came cannot be determined. See Plate VI, Figure 6.

Constellaria polystomella, Nicholson.—This species is found in abundance in the *Columnaria* reef at the base of the Meadowvale member. It is an interesting fact that *C. polystomella* as well as *Rhombotrypa quadrata* have not yet been found at a lower horizon than this on the Credit river, although in the Cincinnati basin and on Manitoulin island they are found throughout the Richmond.

Fenestella sp.—One poorly preserved specimen, probably referable to this genus, was found in the *Columnaria* reef in the Meadowvale member.

Eridotrypa cf. *simulatrix*, Ulrich.—A form which is here referred with some doubt to *E. simulatrix* was found in the Erindale and the Streetsville members. The ramose zoaria vary in diameter from two to four millimetres and have low monticules, consisting of average-sized zooecia, scattered evenly over their surfaces, with an average distance of two millimetres between them. The internal characteristics, as shown by tangential and vertical sections, agree fairly well with the type, except that the acanthopores cannot be clearly seen. They are apparently extremely small. According to Shideler, *E. simulatrix* ranges from the Lower Arnheim to the Lower Whitewater in Ohio. See Plate VII, Figure 6.

Hallopora aequalis, sp. nov.—See page 63.

Hallopora maculosa, sp. nov.—See page 64.

Hallopora cf. *onealli* (James).—A small form which occurs in the Erindale member and in the *Columnaria* reef of the Meadowvale member, appears to be closely related to *H. onealli* of the Eden shales of Ohio and the Indian Ladder shales of New York. Satisfactory sections could not be prepared, owing to the poor state of preservation in which the fossils were found, and definite specific determination is therefore impossible. A very similar form has been found in the Humber River section at Toronto. See Plate VII, Figure 3.

Hallopora onealli creditensis, var nov.—See page 64.

Hallopora cf. *rugosa* (Milne-Edwards and Haime).—Two examples of a small, ramose bryozoan were found in the Streetsville member, which possess the prominent, ridged monticules of *Hallopora rugosa* of the McMillan formation of Ohio. As good sections of it could not be prepared, its reference to the above species and even to the genus *Hallopora* is somewhat doubtful. Cumings[2] describes a similar species from the Whitewater member of Indiana, which he also ascribes to *H. rugosa*. See Plate VII, Figure 7.

Hallopora subnodosa, Ulrich.—This species occurs in the *Strophomena varsensis* zone of the Erindale member, in association with *Hallopora onealli*

[2]32nd Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 793, pl. 10, fig. 2; pl. 27, figs. 14, 14a.

creditensis, and in the lower part of the Streetsville member. The character of the surface is like that of the type in being somewhat variable; in some forms it is quite smooth and in others it has low monticules scattered over it. The groups of large-sized tubes, often seen in the type species, are apparently wanting in the Credit River specimens. The peculiar tabulation of the zooecial tubes and mesopores so characteristic of *H. subnodosa* is very clearly seen in vertical sections. *H. subnodosa* ranges from the Lower Arnheim to the Elkhorn in Ohio, and, therefore, is of little use in the determination of the more detailed geological subdivisions.

Heterotrypa definita, sp. nov.—See page 65.

Heterotrypa prolifica, Ulrich.—This species occurs in the bryozoan reef in the *Strophomena varsensis* zone of the Erindale member. It differs from the type species in a few minor details. The acanthopores in the Credit River forms are a little larger than in the type and show a slight variation in size. There is also a greater tendency toward the grouping of mesopores in the type species. In Ohio, according to Shideler, *H. prolifica* ranges from the Lower Arnheim to the Upper Whitewater and, accordingly, is of little use for purposes of exact correlation. See Plate V, Figure 3.

Heterotrypa robusta, sp. nov.—See page 66.

Heterotrypa simplex, sp. nov.—See page 66.

Heterotrypa simplex maculosa, var nov.—See page 67.

Heterotrypa cf. *subfrondosa* (Cumings).—A large frondescent form with indistinct monticules is common in the bryozoan reef in the *Strophomena varsensis* zone of the Erindale member. In general appearance, it is like *H. prolifica*, but differs surficially in being smoother and internally in the possession of more numerous mesopores and a much more distinct variation in size of the acanthopores. It closely resembles *H. subfrondosa* (Cumings), of the Fairmount of the Ohio valley.

Heterotrypa subpulchella parvulipora, var nov.—See page 67.

Homotrypa communis, Bassler.—This species is found in association with *H. streetsvillensis* in the Streetsville member. The two species cannot be distinguished from each other until tangential sections, prepared from each, are examined. The tangential section of *H. communis* reveals the presence of maculae, consisting of secondarily calcified mesopores, which are lacking in *H. streetsvillensis*. Of the two species *H. streetsvillensis* is much more abundant on the Credit river. According to Shideler, *H. communis* is found in the Upper Waynesville and Lower Liberty of Ohio.

Homotrypa creditensis, sp. nov.—See page 68.

Homotrypa cf. *richmondensis*, Bassler.—A fourth species of *Homotrypa* occurs in the *Homotrypa streetsvillensis* zone, but in such a poor state of preservation that the species can not be determined with any degree of satisfaction. The character of the growth can not be ascertained, but the features shown by tangential sections are like those of *H. richmondensis* of the Whitewater of the Ohio valley.

Homotrypa streetsvillensis, sp. nov.—See page 68.

Homotrypella dubia (Cumings and Galloway).—Thin, bifoliate expansions are found in the *Bythopora meeki* zone of the Streetsville member, which can without doubt be referred to this species. This is a rather interesting occurrence, since, heretofore, the species has not been found in rocks higher than the Arnheim in Indiana and Ohio. See Plate VII, Figure 10.

Homotrypella expansa, sp. nov.—See page 69.

Homotrypella hospitalis (Nicholson).—This species is abundant in the Credit River section, being found in all three members of the Richmond formation. It is most abundant in the Meadowvale member. The species may form very regular hemispheric masses as in Plate V, Figure 2, or irregular lobate masses as in Plate V, Figure 1. The smallest specimen measures 16 millimetres in diameter by 12 millimetres in height; the largest specimen is twice this size. In the Ohio valley, *H. hospitalis* occurs in all the members of the Richmond formation.

Homotrypella hospitalis peculiaris, var nov.—See page 69.

Mesotrypa patella (Ulrich).—One good example of this species was found in the Streetsville member. It agrees with the type from the Whitewater of the Ohio valley in all details except one: the maculae, consisting of larger tubes than the average, which are characteristic of *M. patella*, have not been seen in the Credit River example. If the absence of the maculae is found, after an examination of more material, to be a constant feature of the Streetsville form, a new variety would be justified. See Plate V, Figure 9.

Monotrypella curvata, sp.nov.—See page 70.

Monticulipora parasitica multipora, var nov.—See page 71.

Rhinidictya cf. *parallella* (James).—Abundant specimens of a cryptostomatous bryozoan are found in the Erindale member on the Credit river. They are very close in their relationships to *R. parallella* of the Southgate member of the Eden of the Ohio valley, but as no well-preserved specimens were obtained, and as they are characteristic of a much higher zone, it is thought best not to refer them too definitely to James' species.

Rhombotrypa quadrata (Rominger).—This species and *Constellaria polystomella* are abundant in and confined to the *Columnaria* reef in the Meadowvale member. This is an interesting fact, since both species are found in all the members of the Richmond formation, in the Cincinnati basin and on Manitoulin island. See Plate IV, Figure 5; Plate VI, Figure 4.

Stigmatella crenulata, Ulrich and Bassler.—Typical representatives of this species are found in the Erindale formation. The Credit River forms differ from those described by Parks and Dyer from the Humber river at Toronto, which they ascribe to the same species, in that the walls of the former are inflected by the acanthopores, to a greater extent. The Humber River forms are probably forerunners of *S. crenulata*, but should at least be given a new varietal name. In Ohio, according to Shideler, *S. crenulata* is confined to the Waynesville member of the Richmond. See Plate IV, Figure 6; Plate VII, Figure 8.

Stigmatella hybrida, sp. nov.—See page 71.

Stigmatella incrustans, Cumings and Galloway.—Several examples of a bryozoan have been found in the *Homotrypa streetsvillensis* zone of the Streetsville member of the Richmond, which are referred to *S. incrustans* of the Liberty of Indiana. They incrust crinoid columns and brachiopod and pelecypod shells. Many forms of incrusting bryozoans, referred to the genus *Stigmatella*, are very close to one another in their relationships; among this number are: *S. incrustans*, *S. sessilis*, *S. clavis*, and *S. nicklesi*. *S. incrustans* is distinguished by the possession of monticules and by its loose, irregular habit of growth. See Plate VI, Figure 7.

Stigmatella interporosa, Ulrich and Bassler.—A fragment of a ramose bryozoan was found in the Streetsville member which is herein referred to *S. interporosa*. This species, according to Cumings and Galloway resembles *S. catenulata*, being distinguished from that species by the less robust growth and thinner mature region, by the weaker development of chain-like mesopores, and by the greater number of these mesopores. According to Ulrich and Bassler, *S. interporosa* occurs in the Waynesville of the Cincinnati basin.

Stigmatella cf. *lambtonensis*, Parks and Dyer.—Two or three specimens which resemble this species were found in the Erindale member. In the original description of the species, *S. lambtonensis* was distinguished from *S. sessilis*, Cumings and Galloway, by a difference in growth. The latter species is incrusting and forms rather delicate discs, while the former is not incrusting and forms coarser, more irregular zoaria. Internally, the two species are identical. It is possible that future study will show that the two species are identical, or more probable still that *S. lambtonensis* is identical with the variety *Stigmatella sessilis crassa*, of the Credit member of the Dundas formation. See Plate V, Figure 8.

Stigmatella catenulata var. B., Parks and Dyer.—A single example of this variety was found in the quarry at Port Credit, incrusting a joint of the column of *Lichenocrinus* sp. The zoarium of the Credit River form is less robust than that of the type specimen from the Humber member of the Dundas formation, and the development of the chain-like mesopores is not so great. In these features it is more like *S. sessilis crassa* of the Credit member. It agrees, however, with the type of *S. catenulata var. B.* in the neat regular growth about a crinoid column.

There is evidently very little difference between certain species of the genus *Stigmatella* of the Dundas and Richmond formations. When more material is procured and a further intensive study made upon the genus, it may be found that *S. catenulata*, *S. sessilis crassa*, *S. lambtonensis*, *S.* cf. *clavis*, and *S. incrustans* are variants of single species. On the other hand, *S. crenulata*, at least the form found on the Credit river, *S. hybrida*, *S. interporosa*, and *S. personata* seem to be better defined species.

Stigmatella sessilis crassa, var. nov.—See page 72.

Stigmatella personata lobata, var. nov.—See page 72.

Brachiopoda

Catazyga headi, Billings.—This species undoubtedly occurs on the Credit river, but no good examples of full-grown forms have been found during recent investigations. Several typical examples were found by Joseph Townsend and are now in the collections at the University, labelled as coming from Streetsville. Young forms of *Catazyga* were found on Mullet creek in the zone of *Strophomena varsensis*, which in all probability are the young of *C. headi*, and it is probable, also, that Townsend procured his specimens from this zone.

C. headi is represented in the Cincinnati basin by the variety *C. headi schuchertana* (Ulrich), which is with difficulty separated from the type species of Canadian localities. According to Foerste,[1] this variety differs in not possessing the broad but very shallow median depression along the anterior part of the pedicle valve, and also in the greater tendency in the Ohio variety toward a subquadrate outline in the case of the brachial valve, at least posteriorly, owing to the considerable lateral extension of the hinge line. Foerste evidently considers these distinctions of little value, as he says:—

If these features do not prove comparatively constant for the Cincinnatian specimens all attempt to distinguish them under a separate designation may prove of little value.

C. headi schuchertana occurs in the upper part of the middle or Clarkesville division of the Waynesville and at the base of the Blanchester or upper division, according to Foerste. *C. headi* occurs in strata correlated with the Waynesville on Manitoulin and at Meaford; in Quebec, in addition to occurring abundantly in Waynesville strata, it ranges for many feet down into rocks which are correlated with the Maysville.

Hebertella occidentalis, Hall.—This is a very abundant species in the Richmond of the Credit river. It occurs in all three members although perhaps in greatest abundance at the top of the Meadowvale. *H. occidentalis* is the only species of brachiopod usually regarded as typically Richmond to be found in the Dundas formation on the Credit river, a few examples being found in the Credit member at Erindale.

Platystrophia cf. *acutilirata* (Conrad).—One specimen was selected from a trayful of brachiopods labelled "*Platystrophia clarkesvillensis* Streetsville," which resembles *P. acutilirata* more closely. It is more extended along the hinge line than *P. clarkesvillensis*, and has more numerous lateral plications than the latter. The exact horizon from which the specimen came is not known.

Platystrophia clarkesvillensis, Foerste.—This is one of the most abundant species of brachiopods on the Credit river, being found in the Meadowvale, in the Streetsville, and in the upper part of the Erindale members of the Richmond. In Ohio, according to Shideler, it is confined to the Waynesville. Its range is thus considerably higher in the Credit River section than in Ohio.

Rafinesquina alternata, Emmons.—Two forms of *R. alternata* are found on the Credit river. One of these forms is herein referred to the type, while the other is given the new varietal name *R. alternata subcircularis*. *R. alternata* is abundant in the bryozoan reef in the Erindale member and in the rocks immediately overlying the *Columnaria* reef in the Meadowvale member, but has not yet been found in the Streetsville. No evidence of the presence of either of the forms has yet been obtained from the Dundas formation on the Credit river, although *R. alternata* is abundant in this formation on the Humber river

Rafinesquina alternata subcircularis, var. nov.—See page 73.

[1]Bull. Sci. Lab. Denison Univ., 16, 1910, p. 32, *et seq.*

Rafinesquina mucronata torontonensis, Parks and Dyer.—This brachiopod is very abundant in the Humber member on the Credit river, where it occurs in limestone in association with *Zygospira erratica.* It does not differ from the form described by Parks and Dyer from the Humber River section.

Strophomena planumbona erindalensis, var. nov.—See page 74.

Strophomena varsensis, sp. nov.—See page 75.

Trematis millepunctata, Hall.—This species has been found in all formations of the Cincinnatian series in the United States and Canada, from the Eden to the Richmond. A single fragment only was found on the Credit river, in the zone of *Strophomena varsensis* in the Erindale member of the Richmond, but this fragment shows the ornamentation characteristic of the species so clearly that there can be no mistake about its identity.

Zygospira (?) *erratica* (Hall).—This species is found in great abundance in the Humber formation in the quarry at Port Credit, in association with *Rafinesquina mucronata torontonensis*, Parks and Dyer. These two forms are also abundant on the Humber river at Weston and Lambton. *Z. erratica* forms one of the connecting links between the Dundas formation of Toronto and the Lorraine of New York, being common to these two formations but absent from the Cincinnatian rocks of the Ohio valley.

Zygospira modesta, Hall.—This is the most abundant brachiopod on the Credit river, being found in the Dundas formation and in all the members of the Richmond except the Queenston. It is a long-ranging form and, therefore, is of little use for purposes of correlation.

Pelecypoda

Anoptera cf. *miseneri*, Ulrich.—The exterior of a left valve of a pelecypod was found at the foot of the cliff on the Credit river opposite the Streetsville fair grounds. It is either from the upper part of the Erindale or lower part of the Streetsville member, these portions of the two members being exposed at this locality. The outline of the shell and the character of the plications are like *A. miseneri*, but as no interiors have been seen and since the horizon at which the species occurs in the Ohio valley (Elkhorn) is much higher than on the Credit, it is thought best not to refer the shell definitely to this species.

Byssonychia grandis, Ulrich.—This species occurs in the Streetsville member of the Richmond formation. In Ohio, according to Shideler, it occurs at a somewhat higher horizon than it does on the Credit, namely, in the Saluda and Whitewater divisions.

Byssonychia radiata (Hall).—This is not a very common species on the Credit river, but typical specimens do occur at various horizons, namely, in the Humber and Credit members of the Dundas formation and in the Erindale and Streetsville members of the Richmond.

Byssonychia robusta, Miller.—Beautifully preserved examples of *B. robusta*, of the Whitewater and Saluda members of the Richmond of Ohio, are found in the zone of *Ischyrodonta miseneri* in the Streetsville member on the Credit river. *Byssonychia robusta* and *B. richmondensis*, Ulrich, are very similar and occur at the same horizon in the Cincinnati basin. The ribs are coarser in the former species, varying, according to Foerste, from 38 to 41 in number, while in the original description of *B. richmondensis*, Ulrich states that although the ribs are difficult to count, there are not less than 50 of them on each valve. Foerste also states that the valves of *B. robusta* are relatively shorter and broader than those of *B. richmondensis*. It is Foerste's opinion, however, that these two forms are very closely allied if not identical, *B. richmondensis* being a laterally compressed form of *B. robusta*.

Byssonychia cf. *praecursa*, Ulrich.—Pelecypods resembling *B. radiata*, but with the flattening of the anterior side characteristic of *B. praecursa*, are found in the *Strophomena varsensis* zone in the Erindale member of the Richmond and in the Credit member of the Dundas formation on the Credit river. Typical forms are found in the Pulaski shale of New York and in the Maysville of Ohio.

Clidophorus fabula (Hall).—This species is found in the shale overlying the *Columnaria* reef in the Meadowvale member of the Richmond. In Ohio, it ranges from the Eden to the Richmond.

Clidophorus planulatus (Conrad).—This is a common species in the Eden and Maysville of Ohio and the Pulaski shale of New York, but in Canada it extends its range upward into the Richmond. It has been reported from the Waynesville of eastern Ontario and Quebec. On the Credit river, one example was found in the Credit member of the Dundas formation and one in the Erindale member of the Richmond.

Ctenodonta cingulata (Ulrich).—A single well-preserved example of this species was found in the *Strophomena varsensis* zone. *C. cingulata* occurs in the Richmond in Ohio, Kentucky, and on Manitoulin island, but one example from the Dundas formation of the Humber river has been referred to it by Miss H. Stewart.

Ctenodonta filistriata, Ulrich.—Two or three examples of this species were found in the Humber member on the Credit. It is found all through the Dundas formation of Toronto with the exception of the Credit member. In the United States it is found only in the Eden of Kentucky.

Cuneamya scapha brevior, Foerste.—This form occurs abundantly in shale of the Humber member in the quarry at Port Credit. In the State of New York and the Province of Quebec, it is found in the Lower Lorraine shales, and in the vicinity of Toronto it is found both on the Don and on the Humber river.

Cymatonota cf. *lenior*, Foerste.—Fragments of the shells of a species of pelecypod evidently referable to *C. lenior* were found in the Credit member of the Dundas formation. Previously *C. lenior* had been reported by Foerste from rocks in Quebec which he correlates with the Pulaski and by Stewart from the Dundas formation of the Humber river.

Ischyrodonta miseneri, Ulrich.—Well preserved examples of this species were found on the Credit river, in the lower five feet of the Streetsville member, herein called the zone of *I. miseneri*. The Streetsville specimens are a little thinner than the type forms from Indiana, but in all other respects they are very similar. In Indiana and Ohio, according to Shideler, *I. miseneri* is found in the Upper Whitewater.

Ischyrodonta unionoides (Meek).—One beautifully preserved and unmistakable example was found in the Credit member of the Dundas formation. A few doubtful forms from the Humber member of the Dundas at Port Credit have also been referred provisionally to this species. It is found in the Maysville of Ohio and the Pulaski of New York.

Modiolopsis concentrica, Hall and Whitfield.—This is a common species throughout the Cincinnatian series of Ontario, but in Ohio it is found only in the Richmond. On the Credit river it is found in both members of the Dundas formation and in all three members of the fossiliferous Richmond.

Modiolopsis postplicata, Foerste.—A single example of this species was found in the Humber member in the quarry at Port Credit. It has previously been reported from the Pulaski of Quebec, Dundas of the Humber river, and doubtfully from the Waynesville of Quebec.

Modiolopsis versaillensis, Miller.—A single example of this species is among the older collections of Streetsville fossils in the Royal Ontario Museum of Paleontology. The exact stratigraphical horizon from which it came is not known.

Modiolopsis borealis, Foerste.—A single right valve of this species was found in the Credit member on the Credit river, just below Erindale. Foerste reports the same species from the Lorraine, one mile south of the clay cliffs, at the eastern end of Manitoulin island.

Opisthoptera fissicosta, Meek.—The range of this species is higher in the Credit River section than in the Ohio valley. In Ohio it occurs in the Waynesville, but on the Credit it is found in the Streetsville and Meadowvale members of the Richmond. It has not yet been obtained from the Erindale.

Orthodesma cf. *canaliculatum*, Ulrich.—A pelecypod was found in the Streetsville member which in outline, in the character of the concentric striae, and in the prominence of the anterior and posterior muscle scars, is close to *Orthodesma canaliculatum* of the Blanchester division of the Waynesville of Ohio. The peculiar pallial line and radiating striae seen in the type are not present on the Credit River specimens.

Ortonella cf. *hainesi* (Miller).—One specimen of a pelecypod was found in association with *Ischyrodonta miseneri* in the Streetsville member, which greatly resembles the above species in outline and in the character of the concentric plications. The preservation of the specimen, however, is too imperfect to allow any indication of the lunule and escutcheon characteristic of *O. hainesi* to be seen, and hence it can only be placed provisionally under that species.

Pterinea demissa, Conrad.—This species is abundant and evenly distributed throughout all the divisions of the Cincinnatian series of the Credit River section.

Whiteavesia pholadiformis (Hall).—Fragments of the shells of this species showing the characteristic transverse plications are found in all the divisions of the Dundas and Richmond formations of the Credit River section with the exception of the Queenston. No complete specimens, however, were found. *W. pholadiformis* is a characteristic Richmond species in the Ohio valley, but has not been found in the Maysville or Eden of that area. In Ontario, on the other hand, it has been found in all the divisions of the Cincinnatian series with the exception of the Utica.

Whitella cf. *hindi*, Billings.—A few examples of a pelecypod, very similar in form to this species were found in both the Credit and Humber members of the Dundas formation on the Credit river. The type of the species was obtained in the Dundas formation on the Humber river.

Whitella cf. *torontonensis*, Stewart.—One of the specimens of *Whitella* from the Humber member at Port Credit is more quadrate in form than the specimens referred to *W. hindi* and more closely resembles *W. torontonensis*. This latter species was founded on a single specimen, which was thought to have come from the Don River valley.

Gastropoda

Bellerophon cf. *mohri*, Miller.—A single specimen of a gastropod closely related in form to this species was found in the zone of *Ischyrodonta miseneri* in the Streetsville member of the Richmond formation. The character of the mouth, whether widely flaring as in *B. mohri*, or relatively narrow as in *B. subangularis*, Ulrich, can not be determined; but in general proportions and in the smooth character of the surface, the Streetsville specimen more closely resembles the former species. According to Shideler, both of these forms are found in the Saluda and Upper Whitewater in the Ohio valley.[1]

Clathrospira cf. *subconica*, Hall.—Two specimens in the older collections of the Royal Ontario Museum of Paleontology are referred to this species. One was labelled as coming from "Credit river" and the other from "Streetsville".

Cyclonema sp.—A few body whorls of a gastropod showing the characteristic surface markings of the genus *Cyclonema* were found in the *Columnaria* reef of the Meadowvale member of the Richmond on the Credit river.

Cyrtolites ornatus, Conrad.—This species occurs in the strata overlying the *Columnaria* reef of the Meadowvale member of the Richmond.

Liospira helena (Billings).—This species occurs in the *Columnaria* reef on the Meadowvale member on the Credit river. It is an Anticosti species, but has been reported from rocks correlated with the Whitewater on Manitoulin island.

Lophospira bowdeni, Safford.—This is the most abundant gastropod in the Richmond of the Credit river, being found in all three members. It is a long-ranging form and, therefore, is of little use in determining the sequence of the rocks.

Lophospira tropidophora, Meek.—This is another common gastropod in the Richmond of the Credit river. In the Ohio valley, it ranges from the Eden to the Richmond, but in Ontario it is more common in the Richmond formation than in the Dundas.

Oxydiscus sp.—One poorly preserved example of the genus *Oxydiscus* was found among the older collections of Streetsville fossils at the University.

Cephalopoda

Actinoceras crebriseptum (Hall).—A single example of this species was found in the Credit member of the Dundas formation at Erindale. It is a very abundant species in the Humber member of the Dundas formation in the prison quarry at New Toronto; in New York state it occurs in the Pulaski shales.

[1]Foerste has described a new species from a similar horizon on Manitoulin island as *Bellerophon parksi*. It is possible that our specimen belongs to this new species.

Orthoceras lamellosum, Hall.—A single example of this species was found in the Humber member in the quarry at Port Credit. It has been reported by Parks and Fritz from the Humber member of the prison quarry at New Toronto, but it is not so abundant as *Actinoceras crebriseptum* at that locality. *A. crebriseptum* has not yet been found in the quarry at Port Credit, but its presence there is to be expected, since it is so abundant in the prison quarry at New Toronto, which occupies practically the same stratigraphic level. In New York, *O. lamellosum* is found in the Pulaski shales.

Trilobita

Calymene sp.—An indeterminate specimen belonging to this genus was found among the collections at the University, labelled as coming from the Richmond of Streetsville.

Isotelus maximus, Locke.—Fragments of *Isotelus* probably belonging to the above species occur at many horizons in the Dundas formation and in the Erindale member of the Richmond in the Credit River section. It is most abundant in the Credit member of the Dundas where it is found incrusted with the zoaria of *Stigamatella sessilis crassa.* Some of the fragments occurring in this member are very large. On comparing the measurements of some of the largest fragments found with corresponding fragments of the large forms of the Don Valley brick yard, it was found that the specimens from the Credit compared favourably with the largest forms from the Don.

Incertae Sedis

Pasceolus cf. *camdenensis*, Foerste.—The impression of part of the external surface of a specimen of *Pasceolus* was found at the foot of the cliff at Section No. 12, near Streetsville; it came either from the Erindale or Streetsville member of the Richmond, parts of both members being exposed at this locality. The impression of the plates is very distinct and shows that the plates were convex when looked upon from the exterior as in *P. camdenensis*.

DESCRIPTION OF NEW SPECIES

AMPLEXOPORA SOLITARIA, *sp. nov.*

Plate I, Figures 1 and 3; Plate VII, Figure 2

This species is represented by one small fragment of a ramose zoarium from the *Homotrypa streetsvillensis* zone of the Streetsville member. The surface of the specimen is so thickly covered by limestone that its character can scarcely be seen, but it is apparently smooth.

In tangential sections cut from the mature zone, it is seen that the zooecial tubes, which average eight in two millimetres, have extremely thick walls, as much as two-fifths of the diameter of each tube being taken up by the walls. A peculiar feature, however, is that at certain places the walls become thin as if monticules had been cut through. In tangential sections, the dark boundary between the walls of the adjacent tubes is not always seen, but in deeper tangential sections it is clearly marked. Mesopores are numerous and are usually found scattered throughout the zoarium. The arrangement of the acanthopores is much the same as in *Heterotrypa robusta* (see p. 66). They are found between the angles of junction of the zooecial walls, usually inflecting the latter.

One of the most distinctive features of the species is seen in vertical sections. The walls of the zooecia are very thin in the sub-mature region, but assume their great thickness very suddenly as the mature region is reached. The dark boundary line between the walls of the zooecia is very clearly seen in vertical sections. In the mature region, diaphragms cross the tubes at distances, approximately equal to the internal diameter of the latter, but are much less frequent in the immature region.

Although in the opinion of the writer (see p. 66), the division of the trepostomatous bryozoans into the *Amalgamata* and *Integrata*, on the basis of the presence or absence of the dark line bounding adjacent zooecial walls, is an artificial one, still it must be admitted that certain forms show this boundary line more clearly than others and can with convenience be assembled into the family *Amplexoporidae*. *Amplexopora solitaria* is one of these forms and is the only member of the family with acanthopores to be found on the Credit river. It can be distinguished from other species of the genus by the great thickness of the zooecial walls and by the sudden manner in which they thicken on passing from the immature to the mature zone.

Locality.—Credit river, Streetsville.
No. 12147, Royal Ontario Museum of Paleontology.

ATACTOPORELLA DENSA, *sp. nov.*

Plate I, Figures 2 and 4

A single example of a bryozoan, showing the internal characters of the genus *Atactoporella*, was found in the zone of *Bythopora meeki* in the Streetsville member. It is not well preserved, but it differs so decidedly from any previously described member of the genus from the Cincinnatian series that it has been decided to erect a new species for its reception.

The zoarium consists of four superimposed layers, which are rather thick for the genus, each layer varying from two to three millimetres in a vertical direction. It could not be ascertained, on account of the poor preservation of the fossil, whether the surface is monticulose or smooth. It apparently is not an incrusting form.

In characters shown by both tangential and vertical sections, *A. densa* resembles *A. ortoni* (Nicholson), of the Maysville of Ohio. The tubes are small, nine to ten in two millimetres, with the comparatively thick walls lined by average-sized acanthopores. As many as twelve acanthopores have been counted surrounding a single zooecial tube. The mesopores, so far as can be determined, are not as numerous as in *A. ortoni*, and are not filled by secondary deposits as in that species, but are open throughout their length. The mesopores are crossed by numerous diaphragms, while the zooecia have both diaphragms and cystiphragms.

In addition to the differences already enumerated, *A. densa* differs from *A. ortoni* in the manner of growth. The latter species forms exceedingly thin, monticulose crusts, usually attached to the shells of brachiopods. The Streetsville form differs from *A. schucherti*, Ulrich, the only other member of the genus found in the Richmond, in the much smaller size of the acanthopores, in the smaller number of mesopores, and in the manner of growth.

Locality.—Credit river, Streetsville.
No. 12148, Royal Ontario Museum of Paleontology.

CALLOPORELLA VACUA, *sp. nov.*

Plate I, Figures 5 and 6

This species occurs in the *Strophomena varsensis* zone of the Erindale formation, on Cooksville creek. The zoarium is discoidal, with a convex upper surface and a concave lower surface, as in *Mesotrypa patella* (Plate V, Figure 9). The lower surface is covered by an epitheca. The discs measure about 15 mm. in diameter and are 2.5 mm. thick at the centre. The character of their surfaces can not be ascertained as the apertures of the tubes are filled with limestone.

The zooecial tubes are of average size and thin-walled, as seem in tangential sections. Mesopores are large, but are less numerous than in other members of the genus, there being usually only three or four in contact with each zooecial tube. This disposition of the mesopores allows adjacent zooecia to touch one another at many points. Acanthopores are absent.

In vertical sections, it is seen that the mesopores and zooecial tubes alternate with one another with considerable regularity. Diaphragms are crowded in the mesopores, but the zooecial tubes have few or no diaphragms. The arrangement of the bases of the alternating zooecia and mesopores is quite regular as in *Peronopora vera*, Ulrich, as described by Parks and Dyer for specimens from the Don River section at Toronto. The bases of the zooecia are small and trapezohedral in shape, while the bases of the mesopores are larger and hexagonal.

C. vacua differs from any other member of the genus in the paucity of the mesopores and in the apparent lack of diaphragms in the zooecial tubes. The latter feature is so marked that the reference of the species to *Calloporella* is doubtful, as the genus is characterized by numerous diaphragms in the zooecial tubes. On the other hand, there is no other described genus to which the form could be more suitably ascribed.

Locality.—Cooksville creek.
No. 12149, Royal Ontario Museum of Paleontology.

HALLOPORA AEQUALIS, *sp. nov.*

Plate I, Figure 7; Plate II, Figures 1 and 2; Plate VII, Figure 15

A species of *Hallopora* which differs from any previously described form is well represented in the Streetsville and Erindale members; it is ramose in growth and rather large, the branches averaging seven millimetres in diameter. The surface is smooth. The zooecial apertures are polygonal, somewhat variable in size, and comparatively small, nine to ten occurring in two millimetres. Mesopores are extremely few.

In tangential sections cut from near the surface, the mesopores ares omewhat more numerous than at the actual surface, there being on the average two or three mesopores for every zooecial tube, but considerable portions of these sections can be found in which mesopores are entirely absent. The mesopores occur at the angles of the walls and are very often found in pairs. In deeper tangential sections, the mesopores are more numerous, showing that they pinch out on approaching the surface. In still deeper tangential sections, the mesopores are very numerous, entirely surrounding the zooecial tubes.

Vertical sections demonstrate beautifully the manner in which the mesopores pinch out on approaching the surface. In deeper parts of the zoarium they are numerous, but outwards they grow smaller and finally disappear altogether before the surface is reached. There is no definite boundary between the mature and submature regions, but one fades gradually into the other.

Hallopora aequalis differs from *Hallopora onealli creditensis,* the only other species on the Credit river for which it might be mistaken, in the manner in which the mesopores pinch out at the surface, resulting in the polygonal shape of the apertures in the former, while in the latter species the zooecial apertures are rounded or oval, with numerous mesopores between them.

H. aequalis resembles *H. onealli communis* (James) in the manner in which the mesopores pinch out at the surface, but differs distinctly in having no maculae, in having smaller tubes, and by the fact that the branches do not appear to form bushy masses by anastomosis as in the case of *H. onealli communis.*

Bassler in his study of the James types of bryozoans makes a few comments on *H. onealli communis,* but does not infer that "maculae or monticules occupied by calices much larger than the average occur in most specimens" as stated by James in the original description of the same species. If it is true that the presence of maculae is not a varietal featurę in *H. onealli communis,* then our species differs from it chiefly in the smaller size of the tubes.

Locality.—Credit river, Streetsville.
No. 12150, Royal Ontario Museum of Paleontology.

HALLOPORA MACULOSA, *sp. nov.*

Plate II, Figures 3 and 4

A single specimen of *Hallopora* was found in the *Stromatocerium* reef in which the arrangement of the mesopores is very peculiar. Instead of being more or less regularly distributed throughout the zoarium, as in all other species of *Hallopora* which have been studied for this paper, the mesopores are confined to maculae in each of which they occur to the number of 15 or 20. In the features shown by the vertical section, *H. maculosa* does not differ from *H. onealli* or the variety of that species so common on the Credit river, *H. onealli creditensis.*

Very little of the specimen was left after the sections were made; in consequence, the general shape of the zoarium cannot be described. Vertical sections, however, show that the specimen had grown over the ramose zoarium of another species of *Hallopora,* indicating a probable encrusting habit. It is hoped that further search will yield other examples of this species, which will serve for further description as to structure and manner of growth.

Locality.—Credit river, Streetsville.
No. 12151, Royal Ontario Museum of Paleontology.

HALLOPORA ONEALLI CREDITENSIS, *var. nov.*

Plate I, Figure 8; Plate V, Figures 6 and 7

A form of *Hallopora* is abundant in the Credit member and at various levels in the Erindale and Streetsville members, which closely resembles *Hallopora onealli sigillarioides* (Nicholson) of the Eden, forming branching stems with an average diameter of 4.5 mm. It also resembles that species closely in internal characters, but is given a new varietal name partly on account of one small internal difference and also because of the much higher horizon at which it is found. No sign of larger tubes has ever been seen in the Credit River variety; a feature which is often present to some extent in *H. onealli sigillarioides.*

The form is very close to *Hallopora onealli danforthensis*, Parks, of the Danforth member of the Dundas formation of the Don River valley. The present form differs only in a somewhat less robust zoarium and in the manner in which the tubes turn out toward the surface, as seen in longitudinal sections; in *H. onealli danforthensis* they turn rather sharply outwards at the boundary between the mature and the immature zones, while in *H. onealli creditensis* they bend very gradually outward, the boundary between the two zones being scarcely distinguishable. It should be stated, however, that certain specimens have been found on the Credit which cannot be distinguished from the Don Valley forms.

Locality.—Credit river, Streetsville.
Nos. 12152, 12153, Royal Ontario Museum of Paleontology.

HETEROTRYPA DEFINITA, *sp. nov.*

Plate II, Figures 5 and 6; Plate VI, Figure 11

The coarse branching zoaria of this well-defined species are found in great numbers in the bryozoan reef in the *Strophomena varsensis* zone of the Erindale member.

The branches are large, commonly reaching 15 mm. in diameter. Maculae, each one made up of about 20 mesopores, are arranged evenly over the surface with an average distance of two millimetres between them.

In tangential sections, *H. definita* resembles *H. simplex maculosa* of the Streetsville member in that the acanthopores are arranged very regularly, one to each angle of junction of the zooecial walls. It differs, however, from that species in the distribution of mesopores. In *H. definita* they are gathered into maculae as well as being distributed evenly throughout the whole zoarium, while in *H. simplex maculosa* they are found only in the maculae. In addition, the groups of mesopores are never surrounded by zooecia of larger than average size in the former as they are in the latter.

The most striking characteristic of this species is observed in the longitudinal sections. At definite periods of the growth of the zooecia the walls become so swollen that a long continuous line of swellings can be followed for considerable distances along the same level through the zoarium, sometimes for the whole length of the section, in one instance, a distance of three millimetres. The diaphragms are comparatively numerous, an average of 10 being found in each tube, but they are entirely wanting in the axial zone. In the same manner as the swellings referred to above, the diaphragms occur at similar levels in the various zooecia, giving the appearance of continuous horizontal lines in vertical section. In some cases the lines of diaphragms coincide with the lines of swellings, and in other cases they alternate with them.

This species has been placed under the genus *Heterotrypa* on account of the numerous diaphragms, thick walls, and general resemblance to undoubted members of that genus from the Credit River section. In one feature, however, it greatly resembles *Stigmatella*, namely, in the possession of the periodic thickenings which is considered by Ulrich and Bassler as one of the characteristics of the latter genus.

The coarse, branching growth, the surface covered with maculae, and the periodic thickening of the walls form a combination of features by which this form is easily distinguished from any other species of *Bryozoa*.

Locality.—Mullet creek, Erindale.
Nos. 12154, 12155, Royal Ontario Museum of Paleontology.

HETEROTRYPA ROBUSTA, *sp. nov.*

Plate II, Figures 7 and 8; Plate VI, Figure 2

In the Streetsville member, several specimens of a coarse, ramose, smooth-surfaced bryozoan were found, in which the zoarium varies from 12 to 15 mm. in diameter.

In tangential sections, the outstanding features of the species are the strong inflection of walls by the acanthopores and the fact that most of these acanthopores are found between the angles of junction of the zooecial walls. They are fairly numerous and of medium size. The zooecial tubes are small, 11 being found in a space of two millimetres. The mesopores are not numerous and are usually distributed evenly throughout the zoarium but are occasionally gathered into maculae.

In some parts of the tangential sections, distinct dark boundaries are seen between the adjacent zooecial walls, while in other parts of the same sections no evidence of a separation is visible, the walls being completely fused. Less diversity is seen in the immature region where the walls are usually separate. The variability in this respect leads to the conclusion that the fusion of the walls is not a specific feature. A similar conclusion was reached with regard to other species. In view of these observations the writer is inclined to question the value of subdividing the trepostomatous bryozoans into *Integrata* and *Amalgamata*.

In longitudinal sections the axial portion is seen to be comparatively small, with a diameter not more than one-half that of the whole zoarium. In this axial part the tubes run upward and outward with very thin and crenulated walls. There are no diaphragms. On reaching the mature zone, the tubes turn abruptly and run directly to the surface of the zoarium at the same time becoming thick-walled. In this zone the walls are even and straight with a slight suggestion of periodic thickening. Diaphragms are present with a distance equalling one tube-diameter between them. Mesopores and acanthopores are seldom seen in longitudinal sections.

Heterotrypa robusta resembles *Heterotrypa microstigma*, Cumings and Galloway, of the Waynesville of Indiana, more than any other species, but the average diameter of the ramose zoarium in the former is greater, and the minute, raised, sub-solid maculae of *H. microstigma* are wanting.

Locality.—Credit river, Streetsville.
Nos. 12156, 12157, 12158, Royal Ontario Museum of Paleontology.

HETEROTRYPA SIMPLEX, *sp. nov.*

Plate III, Figure 1

This species is rather common in the Streetsville member where it forms ramose or sub-ramose, smooth-surfaced zoaria, with an average diameter of 10 mm., as in *H. simplex maculosa* (Plate VII, Figure 10).

In tangential sections, it is seen that the tubes are of a very uniform size and rather small, twelve being found on the average in a distance of two millimetres. Mesopores are entirely absent. Acanthopores are numerous, comparatively small, and the regularity of their distribution is remarkable, one being found at each angle of junction of the zooecial wall. Very rarely is a departure from this occurrence found.

In vertical sections, *Heterotrypa simplex* is almost identical with *H. robusta* (Plate II, Figure 7). The structure is so similar, as thus revealed, that a repetition of the description is unnecessary.

In internal characters, *Heterotrypa simplex* resembles *H. solitaria*, Ulrich, of the Fairmount, but this species is frondescent rather than ramose in its manner of growth. From all other species of *Bryozoa* occurring in the Credit River section, the present species may be distinguished by the very regular arrangement of the acanthopores and the entire absence of mesopores.

Locality.—Credit river, Streetsville.
No. 12159, Royal Ontario Museum of Paleontology.

HETEROTRYPA SIMPLEX MACULOSA, *var. nov.*

Plate III, Figure 2; Plate VII, Figure 9

The above variety differs from *Heterotrypa simplex* only in the occurrence of maculae. These are placed at wide irregular intervals over the surface of the zoarium and are not raised above the general level of the zoarial surface. They are composed of mesopores, five to twenty in number, and in certain places are surrounded by zooecia larger than the average.

In both *Heteroptrypa simplex* and *H. simplex maculosa*, quite definite boundaries between the zooecia are seen in sub-mature regions, but, as in *Heterotrypa robusta*, the walls become fused in the mature regions.

The variety occurs in the Streetsville member, very often in association with *Heterotrypa simplex*.

Locality.—Credit river, Streetsville.
Nos. 12160, 12175, Royal Ontario Museum of Paleontology.

HETEROTRYPA SUBPULCHELLA PARVULIPORA, *var. nov.*

Plate VI, Figure 9

Among the older collections of *Bryozoa* from Streetsville in the Royal Ontario Museum of Paleontology, one specimen was found which closely resembles *Heterotrypa subpulchella* (Nicholson), of the Maysville of Ohio. In form it is a flattened sub-ramose mass, measuring 32 mm. in length, 20 mm. in width, and 13 mm. in height. It probably branched, since the broken bases of branches are still seen. Maculae are scattered over the surface of the zoarium, with an average distance of one millimetre between them. They are scarcely raised above the general surface of the zoarium.

The variety resembles the type in tangential sections, particularly in the character of the maculae, which consist of mesopores to the number of 10 or 15 in each, surrounded by zooecial tubes of distinctly larger than average size. The acanthopores are numerous and vary considerably in size, some of them being abnormally large. They are usually found between the angles of junction of the zooecial walls. The zooecia of the new variety are smaller than in the type of the species, 11 to 12 being found in two millimetres, in the former; while in the latter, no specimens have been recorded in which they are more numerous than nine in two millimetres, and according to Nicholson there are only six to seven tubes in this distance. This is the most outstanding difference between the two forms. Another difference is that in *H. subpulchella parvulipora*, the mesopores are confined to the maculae, while in Nicholson's species they are sometimes found between the maculae.

The two forms are very similar in vertical sections. They possess thin, crenulated walls, with the average number of diaphragms for the genus to which they are referred. Even here, however, there is a difference, *H. subpulchella* having more diaphragms in the axial region than *H. subpulchella parvulipora.*

Locality.—Credit river, Streetsville.
No. 12161, Royal Ontario Museum of Paleontology.

Homotrypa creditensis, *sp. nov.*

Plate III, Figures 3 and 4; Plate VII, Figure 5

This member of the *Homotrypa communis* group of *Bryozoa* occurs in the zone of *Homotrypa streetsvillensis*, in association with the type species of the zone. *H. creditensis* is the only member of the genus in the Credit River section which bears monticules. These are distributed regularly over the surface of the zoarium with an average distance of three millimetres between them. Their character cannot be determined by an examination of the surface, but tangential sections show them to be composed of mesopores, surrounded by zooecial tubes of almost twice the average size.

In tangential sections, the zooecial tubes are seen to be small, twelve occurring in two millimetres. Their walls are thin for the greater part of their course but appear thicker near the surface of the zoarium, as the mesopores in this part are filled with a secondary deposit of calcite. Numerous angular mesopores are scattered throughout the zoarium as well as being grouped into the monticules as mentioned above. Acanthopores are present but are small and unimportant.

In vertical sections, it is seen that cystiphragms only are present in the zooecial tubes. They are restricted to the younger part of the mature region, both zooecia and mesopores being empty near the surface. Closely crowded diaphragms are found in the mesopores.

H. creditensis is closer to *H. nodulosa*, Bassler, than to any other form, these two species being very similar in vertical sections, but differing decidedly in tangential sections, and in growth.

Locality.—Credit river, Streetsville.
No. 12162, Royal Ontario Museum of Paleontology.

Homotrypa streetsvillensis, *sp. nov.*

Plate III, Figures 5 and 6; Plate VI, Figure 5a, b, c; Plate VII, Figure 4

A ramose representative of the *Homotrypa communis* group is found in such numbers in a definite horizon of the Streetsville member that it has been selected as the type fossil of the zone.

In this species the branches vary from five to ten millimetres in diameter, and in some cases reach a length of 50 mm. The surface is smooth without any indication of maculae; the apertures indicate thick-walled zooecia of small but uniform size—twelve in two millimetres.

In tangential sections, the mesopores are few in number and the tubes polygonal in shape, but as the axial region is approached the mesopores become numerous and the tubes become rounded or oval in shape. Acanthopores of medium size are usually found at the angles of junction of the walls. The characters of this species as revealed by vertical sections are very like those of *Homotrypa communis*, diaphragms being absent and the broken type of cystiphragms, so characteristic of that species, being well shown.

The relationships of the present form, as already stated, are with *H. communis*, but a decided difference from that species is indicated by the smaller size of the tubes and by the absence of maculae of any kind. It perhaps resembles *H. austini*, Bassler, still more closely, but differs in having the cystiphragms distributed evenly throughout the peripheral zone, whereas in that species they are confined to the maculae.

Locality.—Credit river, Streetsville.
Nos. 12163, 12164, 12165, Royal Ontario Museum of Paleontology.

HOMOTRYPELLA EXPANSA, *sp. nov.*

Plate V, Figure 11

A specimen was found in the Streetsville collection of *Bryozoa* in the Royal Ontario Museum of Paleontology, which in its internal characters resembles *Homotrypella hospitalis* (Nicholson), very closely. The growth, however, is vastly different from the typical growth of the latter species, the zoarium being a broad, undulating expansion, 90 mm. in diameter, with an average thickness of three millimetres instead of a sub-hemispheric, sub-conical, or irregular compact mass. In places the expansion consists of a single layer, in other places of two or more successive layers. Over the surface are evenly distributed low but distinct monticules, which consist of tubes somewhat larger than average in size.

The presence of monticules and the peculiar form suggest that the species might be referred to the genus *Monticulipora*, but it has been retained in the genus *Homotrypella* on account of its very close similarity, internally, to *H. hospitalis*, and because the walls are clear and definite in structure. Bassler states that one of the best features for the determination of the genus *Monticulipora* is the hazy, indefinite character of the walls.

Locality.—Credit river, Streetsville.
No. 254, Royal Ontario Museum of Paleontology.

HOMOTRYPELLA HOSPITALIS PECULIARIS, *var. nov.*

Plate IV, Figure 1

MONTICULIPORA (Prasopora) SELWYNII, *var.* HOSPITALIS, *Nicholson.* Genus Monticulipora, 1881, p. 209, fig. 45.
PRASOPORA HOSPITALIS, *Cumings.* 32nd Rep. Dept. Geol. Nat. Res. Indiana, 1908, p. 871, pl. 23, figs. 1, 1b; pl. 31, fig. 6.
HOMOTRYPELLA HOSPITALIS, *Bassler.* Bull, U.S. Nat. Mus., 77, 1911, p. 174 (gen. ref.).

The original description of *Homotrypella hospitalis* appears below:—

M. selwynii var. *hospitalis* is invariably an attached form, all the numerous examples which I have seen being fixed to the exteriors of the shells of brachiopods. In form they are hemispheric, rarely nearly globular, and their general size is from six to ten lines (about 12 to 20 mm.) in diameter and from three to four to seven or eight lines (6 to 16 mm.) in height.

Tangential sections show a close correspondence in general structure with the type form of *M. selwynii* from the Trenton Limestone. The corallum (zoarium) is composed of large and small corallites (zooecia) the former being oval or circular in shape and varying from 1/50 to 1/70 of an inch in diameter (four to six in two millimetres), each showing an excentrically perforated tabula (diaphragm). The small corallites (mesopores) are numerous, sub-angular and wedged in between all the larger tubes occasionally being aggregated into star-shaped groups or maculae.

Besides the normal two kinds of corallites, a considerable number of thick-walled, hollow spines (acanthopores) may be observed which I have not detected as present in the examples from the Trenton Limestone.

Vertical sections show the same marked difference in the tabulation of the large and small corallites as has been previously noticed in the type form with some differences. The large tubes are always doubly tabulate, one set of tabulae forming a series of large lenticular vesicles (cysts) while the remaining tabulae are horizontal and remote. The small corallites are furnished with numerous complete horizontal tabulae.

Cumings (*op. cit.*) states that:—

In form *H. hospitalis* is fairly typical, although rather more inclined to form irregular masses than its Trenton relatives which are usually very regularly hemispherical or sub-conical in form.

H. hospitalis is abundant in all the subdivisions of the Richmond formation on the Credit river, with the exception of the Queenston. At times it forms very regular, hemispheric or sub-conical zoaria, while at other times the zoaria are very irregular in shape (Plate V, Figures 1 and 2). In addition, a few specimens have been ascribed to a new variety.

H. hospitalis peculiaris differs from the type in one feature only, namely, in the possession of numerous minute acanthopores, which are situated along the zooecial walls between the large acanthopores characteristic of the type. These small acanthopores are much more pronounced near the surface of the zoarium, where as many as six have been counted between two large acanthopores. Deeper in the zoarium they may disappear altogether. They are apparently of the nature of true acanthopores since hollow centres have been seen in many instances.

Locality.—Credit river, Streetsville.
No. 12166, Royal Ontario Museum of Paleontology.

MONOTRYPELLA CURVATA, *sp. nov.*

Plate IV, Figures 3 and 4; Plate VI, Figure 3

This species is represented by a single specimen, which was found among the Townsend collection of Streetsville fossils in the Royal Ontario Museum of Paleontology. The exact stratigraphic level from which it came is not known, but it was probably from the *Columnaria* reef of the Meadowvale member, since a fragment of *Columnaria calicina*, a species very common in the reef, was found adhering to the zoarium. In form it is an irregular, sub-ramose mass, 35 mm. in length and 25 mm. in diameter, with a smooth surface.

Tangential sections show the zooecia to be of large size, six occurring in two millimetres. A few small tubes are scattered among the larger ones which are probably not of the nature of mesopores as no evidence of the presence of two types of tube is seen in vertical sections. The zooecial walls are comparatively thick near the surface, but are much thinner in sub-mature regions. The line of demarcation between adjacent tubes is very distinct and there is a total absence of acanthopores.

In vertical sections, numerous well-defined diaphragms are seen crossing the tubes. They are in most cases considerably curved and approach the funnel-shaped diaphragms of *Amplexopora robusta*, Ulrich. These curved diaphragms appear in tangential sections as complete rings, within the walls of the zooecia.

M. curvata differs from other members of the genus in the curved diaphragms and the large size of the tubes. It resembles *Amplexopora robusta* in some features but differs in the absence of groups of larger tubes and in the absence of acanthopores.

Locality.—Credit river, Streetsville.
No. 12167, Royal Ontario Museum of Paleontology.

Monticulipora parasitica multipora, *var. nov.*

Plate IV, Figure 2; Plate VI, Figure 8

Monticulipora parasitica, *Ulrich.* Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 238, pl. 10, figs. 3, 3a.
Monticulipora parasitica, *J. F. James.* Ibid., 18, 1895, p. 81.
Monticulipora parasitica, *Cumings.* 32nd Rep. Dept. Geol. Nat. Res. Indiana, 1908, p. 862, pl. 21, figs. 2, 2b; pl. 31, fig. 2.

The original description of *Monticulipora parasitica*, somewhat abbreviated, is as follows:—

The zoarium is usually attached to *Streptelasma* (*corniculum*). Regularly arranged in decussating series and at distances apart of about .1 inch, the surface presents small conical monticules, the summits of which usually appear to be solid, as they are occupied by minute cells; while on their slopes they carry the apertures of cells slightly larger than the average. The largest of these have a diameter of 1/85 of an inch (about seven to two millimetres). The spaces between the monticules are flat and are occupied by the polygonal and moderately thin-walled ordinary cells varying from 1/110 to 1/100 of an inch (eight to nine in two millimetres). Interstitial cells (mesopores) are developed only in the monticules, the summits of which are usually occupied by their apertures.

Tangential sections show the tubes to be polygonal. Their angles of junction are usually thickened and the small space thus formed incloses almost invariably a minute lucid spot. They represent in all probability very small spiniform tubuli (acanthopores). Between the groups of slightly larger cells a few thick-walled minute tubes (mesopores) may generally be observed.

Longitudinal sections show that all the matured tubes have one or both sides lined by a series of cystoid diaphragms while the space between the double series and opposite wall is crossed by straight diaphragms, which are placed at distances apart of about one-third of a tube-diameter. (Diaphragms only are found in the mesopores.)

Cumings (*op. cit.*) makes the following remarks concerning a form which he finds at the base of the Liberty at Weisburg, Indiana, and which he refers to *Monticulipora parasitica*:—

The specimen figured by me may not belong to this species as it has well developed mesopores. Its habit and superficial appearance are, however, the same as those of Ulrich's species. In its internal characters it is more like *M. cincinnatiensis*, James.

Two specimens were obtained from the Streetsville member which appear to belong to *Monticulipora parasitica* except for the fact that they possess numerous mesopores. In this respect they agree with the form described and figured by Cumings from the Liberty of Indiana, as belonging to this species. The apparent identity of our specimens with those of Cumings and the constant departure from the type of the species, as indicated by the presence of mesopores, seems to justify the creation of a new variety. The new variety resembles *M. cincinnatiensis*, as stated by Cumings, but it differs in having acanthopores and in the lower type of monticule.

Locality.—Credit river, Streetsville.
Nos. 12168, 12169, Royal Ontario Museum of Paleontology.

Stigmatella hybrida, *sp. nov.*

Plate IV, Figures 7 and 8; Plate VII, Figure 1

A bryozoan, which differs from any previously described species, was found in the *Strophomena varsensis* zone of the Streetsville member at Cooksville creek. The zoarium consists of a large, more or less cone-shaped mass, measuring 40-45 mm. in diameter, with a smooth surface, there being no evidence of either maculae or monticules.

In tangential sections, the typical appearance of *S. crenulata*, Ulrich and Bassler, is presented. Zooecial tubes are of medium size. The acanthopores, which are numerous, are found between the junction angles of the walls of the zooecia and strongly inflect the walls. The mesopores are gathered into maculae.

The features of the species as shown by vertical sections, differ decidedly from those of *S. crenulata*, and suggest *S. catenulata*, Cumings and Galloway. The zooecial walls are not crenulated as in the former species but are straight as in the latter. There is also a marked development of chain-like mesopores as in *S. catenulata*.

S. hybrida is one of the best-defined species of the genus *Stigmatella*. It differs quite strongly in growth and in the combination of characters as seen in sections from any other form in the Cincinnatian series.

Locality.—Cooksville creek.
No. 12170, Royal Ontario Museum of Paleontology.

Stigmatella personata lobata, *var. nov.*

Plate VI, Figure 1

Stigmatella personata, *Ulrich and Bassler*. Smiths, Misc. Coll., Quart., 47, 1904, p. 36, pl. 12, figs. 1-3.
Stigmatella personata, *Cumings*. 32nd Rep. Dept. Geol. Nat. Res. Indiana, 1908, p. 884, pl. 24, figs. 3, 3d.
Stigmatella *cf.* personata, *Parks and Dyer*. Dept. Mines Ontario, Vol. 30, pt. 7, 1921, p. 16, pl. 3, fig. 61; pl. 4, figs. 6, 7.

The original description of *Stigmatella personata* is as follows:—

This is one of the non-mesopored species of the genus and forms smooth, branching zoaria very much like *S. crenulata* and *S. spinosa*. From the former it is distinguished by having fewer acanthopores and in lacking the crenulation of the walls in the immature region. From *S. spinosa* it is separated by its larger zooecia, seven to eight being found in two millimetres, while 10 are required in that species to cover an equal distance. The acanthopores in *S. personata* also afford a difference, being but seldom more numerous than the junction angles which they usually occupy. In *S. spinosa* it will be remembered they are so abundant that they almost completely surround the zooecium.

A new variety of this species was found among the older collection of fossils at the University. The exact horizon at which it occurs is not known.

S. personata lobata differs from the type species in the manner of growth and in the character of the surface; it forms an irregular, lobate mass 30 mm. in diameter, with the surface covered by low but conspicuous monticules composed of tubes which are slightly greater in size than the average. The specimens from the Humber river, ascribed by Parks and Dyer (*op. cit.*) to *S. personata*, are more branching in form than the Credit River variety, but resemble it in the possession of low monticules.

Locality.—Credit river, Streetsville.
No. 12171, Royal Ontario Museum of Paleontology.

Stigmatella sessilis crassa, *var. nov.*

Plate VI, Figure 10

Stigmatella sessilis, *Cumings and Galloway*. 37th Ann. Rep. Dept. Geol. Nat. Res. Indiana, 1913, p. 87, pl. 19, fig. 3; pl. 20, figs. 2-2b.
Stigmatella sessilis, *Parks and Dyer*. Dept. Mines Ontario, vol. 30, pt. 7, 1921, p. 15 (gen. ref.).

Cumings and Galloway (*op. cit.*) describe the species *Stigmatella sessilis* in the following terms:—

Zoarium discoidal about 15 mm. in diameter and three millimetres thick in the centre, growing parasitically upon foreign objects. There is no basal epitheca.

The zooecia as shown by tangential sections, are polygonal, their apertures oval or circular, 10 zooecia in two millimetres. Surrounding the aperture is a ring of very light coloured schlerenchyma, which is in turn surrounded by a very thin dark ring. The median line is usually light in colour, but is absent in some places, in which case the two dark rings constitute the median line. Mesopores are practically absent. Acanthopores are numerous, 10 in 10 zooecia, quite constant in size about 2/3 the size of number 1, that is 1/30 mm. in diameter. The lumen is clear.

The zooecia at first are crossed by thin diaphragms, their own diameter or less apart. In this region there is also a considerable number of chain-like mesopores. In the remaining portion of the zooecia the diaphragms are twice their diameter apart. At several successive levels, four in the type specimen, the acanthopores and walls show the characters of maturity, at these levels there is one diaphragm, occasionally two in each tube, at the same height in adjacent zooecia. That these levels represent successive stages of maturity is proven by the specimen, for the growth is interrupted completely in one part of the zoarium at these four levels. This characteristic of rejuvenation and overgrowth is not confined to the genus *Stigmatella*. It is a common feature of a good many species of *Trepostomata* and we consider it as an inadequate basis upon which to found a genus. We consider *Stigmatella* as a valid genus; but we rely chiefly upon the thin walls, small acanthopores, few diaphragms and the presence of mesopores for its recognition.

The variety *Stigmatella sessilis crassa* is abundant in the Credit member. It is very similar to *S. sessilis* in internal characters, but differs decidedly in manner of growth. The variety forms coarse irregular zoaria, tightly adhering to the fragments of other fossils, chiefly the trilobite *Isotelus*. In some parts, the zoarium is as thin as two millimetres, but in other parts it is very coarse, approaching 20 mm. in thickness.

Locality.—Credit river, Erindale.
No. 12172, Royal Ontario Museum of Paleontology.

Rafinesquina alternata subcircularis, *var. nov.*

Plate VII, Figure 14

In examining the various specimens of *Rafinesquina alternata* from the Credit River localities, it was found that they can be separated into two groups. The members of one group resemble the type and are retained under it. The members of the other group differ decidedly from the first and it was decided to give them a new varietal name.

R. alternata subcircularis is a long form, the length being equal to or slightly greater than the width. The greatest width is not along the hinge line but slightly in front if it, giving a more circular outline to the shell than exists in any previously described form of the species. The shell is very flat; the alternation of the striae is very clearly shown and the median stria is always most prominent.

R. alternata subcircularis resembles *R. alternata fracta* (Meek), more than any other form, but it is more circular in outline and without the parallel sides so characteristic of the latter variety.

The average width of the specimens is 23 mm. and the height 22 mm. The smallest specimen measures nine millimetres in length, by the same in width, while the largest is 28 mm. long and 32 mm. wide. It is most abundant in the *Strophomena varsensis* zone in the Erindale member but also occurs in the rocks immediately above the *Columnaria* reef in the Meadowvale member.

Locality.—Credit river, Streetsville.
No. 12173, Royal Ontario Museum of Paleontology.

STROPHOMENA PLANUMBONA ERINDALENSIS, *var. nov.*

Plate VII, Figures 11, 12, and 16

LEPTAENA PLANUMBONA, *Hall.* Pal. New York, 1, 1847, p. 112, pl. 31, fig. 4.
STROPHOMENA PLANUMBONA, *Emmons.* Amer. Geol., 1, pt. 2, 1885, p. 198, pl. 11, fig. 2; p. 186, figs. 54-56.
STROPHOMENA PLANUMBONA, *Foerste.* Bull. Sci. Lab. Denison Univ., 17, 1914, p. 26, pl. 2, figs. 4a, 4b.

The original description of *Strophomena planumbona* follows:—

Shell resupinate, robust, length and breadth as nine to eleven; cardinal line straight, suddenly deflected at the extremities, equal to or greater than the width of the shell; sides a little contracted just below the cardinal extremities, leaving slightly salient angles; ventral (dorsal) valve flat or slightly depressed near the beak, elevated and very convex in the middle, somewhat abruptly and concentrically deflected towards the margin; dorsal (ventral) valve flat on the disc, slightly elevated towards the beak and deflected to correspond to the other valve; surface marked by radiating striae, every third, fourth or fifth of which is alternated by a stronger one; entire surface (in perfect specimen) marked by fine concentric elevated lines and a few imbricating lines of growth.

Foerste (*op. cit.*) referring to the same species, makes the following remarks as to the proportions of the shell and the number of striae:—

In the specimen represented by Fig. 4a the length is 20 mm.; the width, 25 mm.; and the convexity about six millimetres. In the specimen represented by Fig. 4b the convexity equals seven millimetres and in the most gerontic specimens it may attain even 11 mm. Surface striae fine and thread-like, about 13 in a width of five millimetres, occasionally as few as 11, rarely as many as 20.

Numerous examples of a variety of this species occur in the zone of *Strophomena varsensis* in the Erindale member on Mullet creek. They differ from the type of the species in the more evenly-rounded antero-posterior outline, and in the finer striation. The dorsal valve of the variety from the Credit river is more rounded in the portion anterior to the beak and is not so incurved along the anterior margin, while the convexity of the valve is less than in·the type. The radiating striae are much finer in *S. planumbona erindalensis:* they average 30 in five millimetres at the anterior margin, but certain specimens were found in which the number reaches 35 in an equal distance. The striae may be sub-equal or there may be an alternation of coarse and fine ones. On some valves, it has been observed that three or four fine striae may group themselves between two coarse ones. By the aid of a good lens extremely fine concentric lines can be seen to cross the radiating striae.

The average width of the Credit River variety is 18 mm. and the length 12.3 mm. The smallest specimen measures 12 mm. in width by nine millimetres in length. The type specimen (a dorsal valve) is 28 mm. wide and 17 mm. long, with a convexity of 2.5 mm.

Examples of the above form were sent to Dr. Foerste whose opinion was that they should be given a new varietal name, based on the flatter form and finer striation. He also said that in many of the forms from the Credit river which were already in his possession, the callosity bordering the margin of the pedicle valves, a small distance back of their anterior and lateral edges, was rather narrower than in typical *S. planumbona.* No valves showing good interiors are contained in our collections.

According to Foerste, the forms most closely resembling *S. planumbona erindalensis* are found in the Waynesville division of the Richmond in Ohio and Indiana.

Locality.—Mullet creek, Erindale.
No. 12174, Royal Museum of Paleontology.

STROPHOMENA VARSENSIS, *sp. nov.*

Plate VII, Figure 13

STROPHOMENA VARSENSIS, *Foerste*, MSS.

In the lowermost 20 feet of the Erindale formation, a brachiopod which resembles *Strophomena sulcata*, De Verneuil, is so abundant that it is taken as the type species of the zone.

S. varsensis resembles *S. sulcata* in being a moderately convex, rather short shell with a well-defined mesial sulcus in the anterior of the ventral valve and a corresponding elevation in the anterior of the dorsal valve. The Credit River species differs from *S. sulcata* in its smaller size and coarser radiating plications. The former averages 14 mm. in width and nine millimetres in length, with a convexity of two millimetres, but many specimens are not over 11 mm. in width by seven millimetres in length. The fold and sulcus are scarcely perceptible in these smaller forms, which may represent the immature stages in the life history of the species. The type specimen, somewhat larger than the average, is 16 mm. in width by nine millimetres in length. The radiating plications appear to be much coarser than those of *S. sulcata*, since in addition to being actually coarser, they are on a considerably smaller shell. They average nine in five millimetres at a distance of five millimetres from the beak, and eight in five millimetres at the anterior margin. The increase in their number is accomplished by fission.

S. varsensis approaches *S. sinuata*, James, in the coarseness of the plications, but the latter species is even larger than *S. sulcata*, while our species is smaller than that form.

Foerste in a letter to the writer makes the following remarks in reference to *S. varsensis*:—

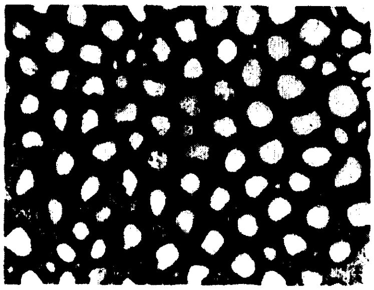
> Many of your specimens contain also a coarse ribbed form of *Strophomena* belonging to the *Strophomena sulcata* group. The nearest approach to this form in Ohio occurs in the base of the Blanchester division of the Waynesville member of the Richmond formation, where it is associated with *Catazyga headi* just as in the case also with your Credit River specimens. It so happens, however, that I studied forms of this kind from the Waynesville of the Richmond area east of Ottawa, in Canada, where I called it *Strophomena varsensis*, in the unpublished manuscript on the fossils of that area. Your specimens resemble the Ottawa Basin specimens more closely than the Ohio and Indiana representatives in having slightly wider radiating plications.

Locality.—Mullet creek, Erindale.
No. 12174, Royal Ontario Museum of Paleontology.

PLATE I

Unless otherwise stated, figures are magnified thirty diameters.

Plate I



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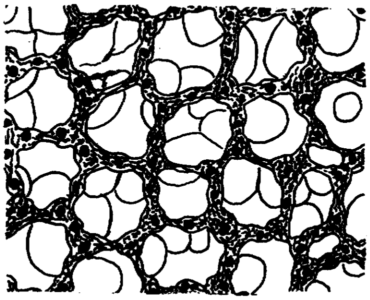

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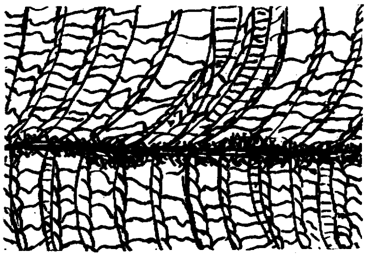

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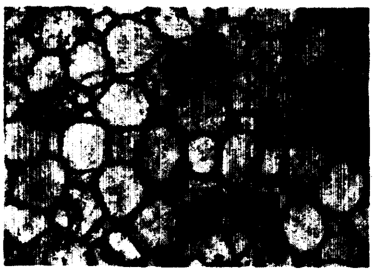

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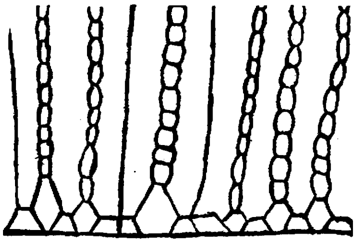

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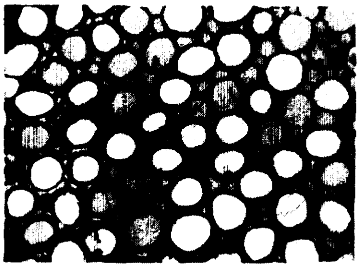

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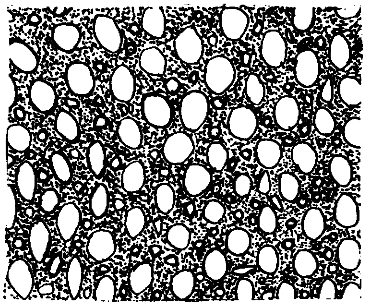

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PLATE II

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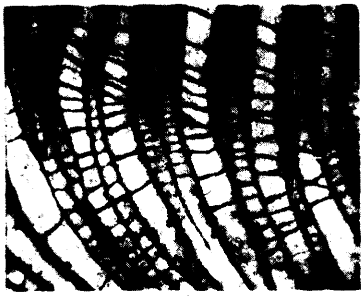
Plate II



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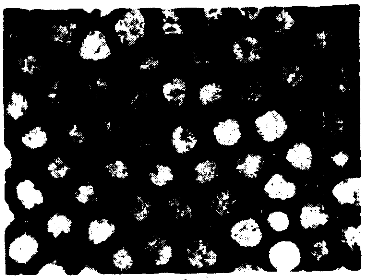

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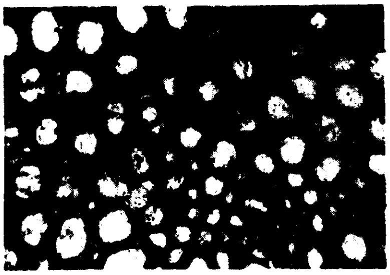

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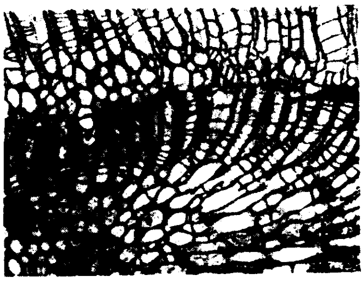

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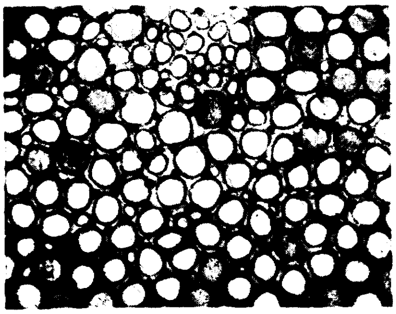

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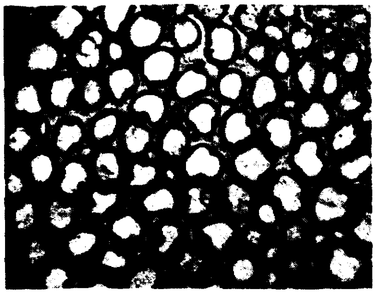

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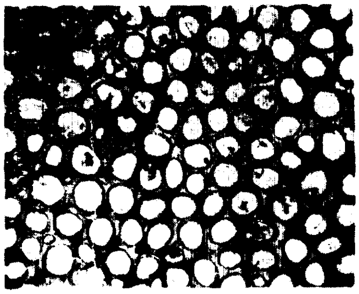
Plate III

All figures are magnified thirty diameters.

Plate III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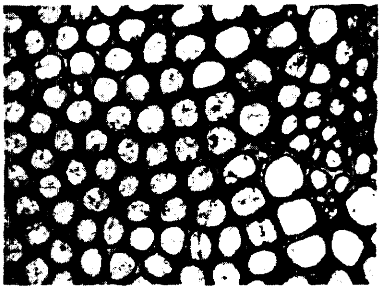
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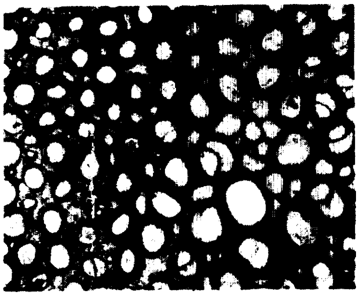
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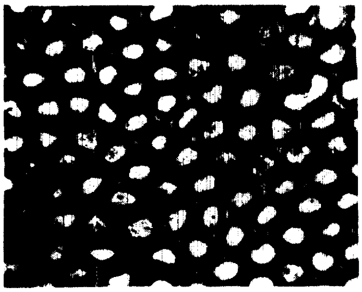
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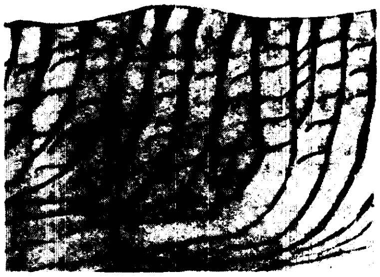
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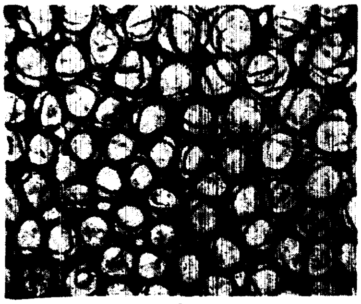
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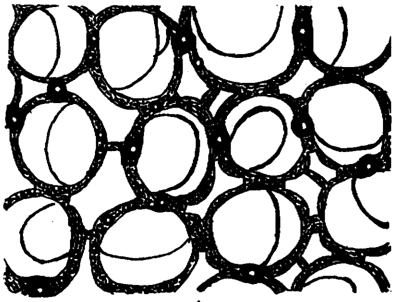
Plate IV

All figures are × 30 except Fig. 1, which is × 60.

Plate IV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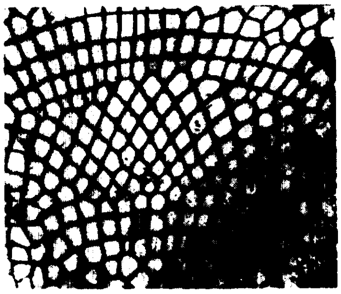
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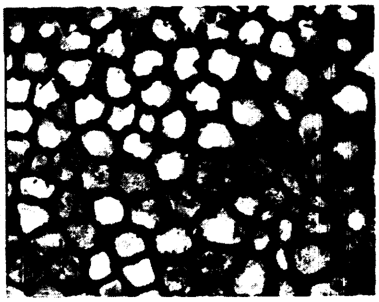
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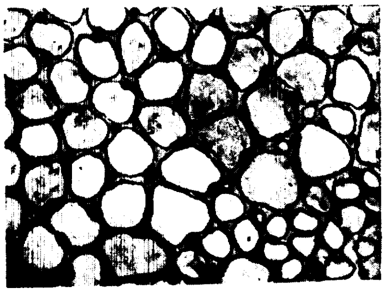
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PLATE V

All figures are natural size.

Plate V

Plate VI

All figures are natural size.

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Plate VI

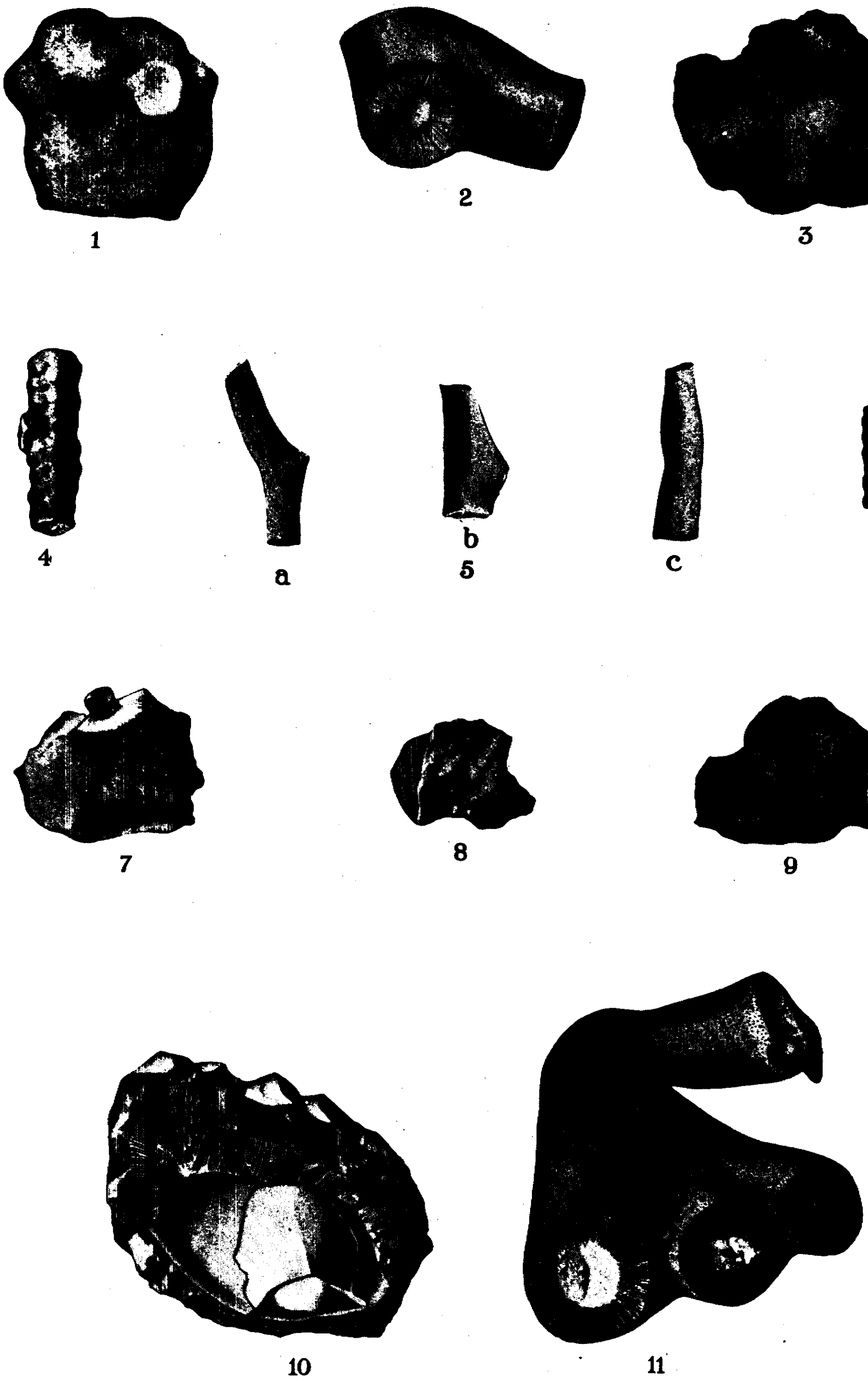

PLATE VII

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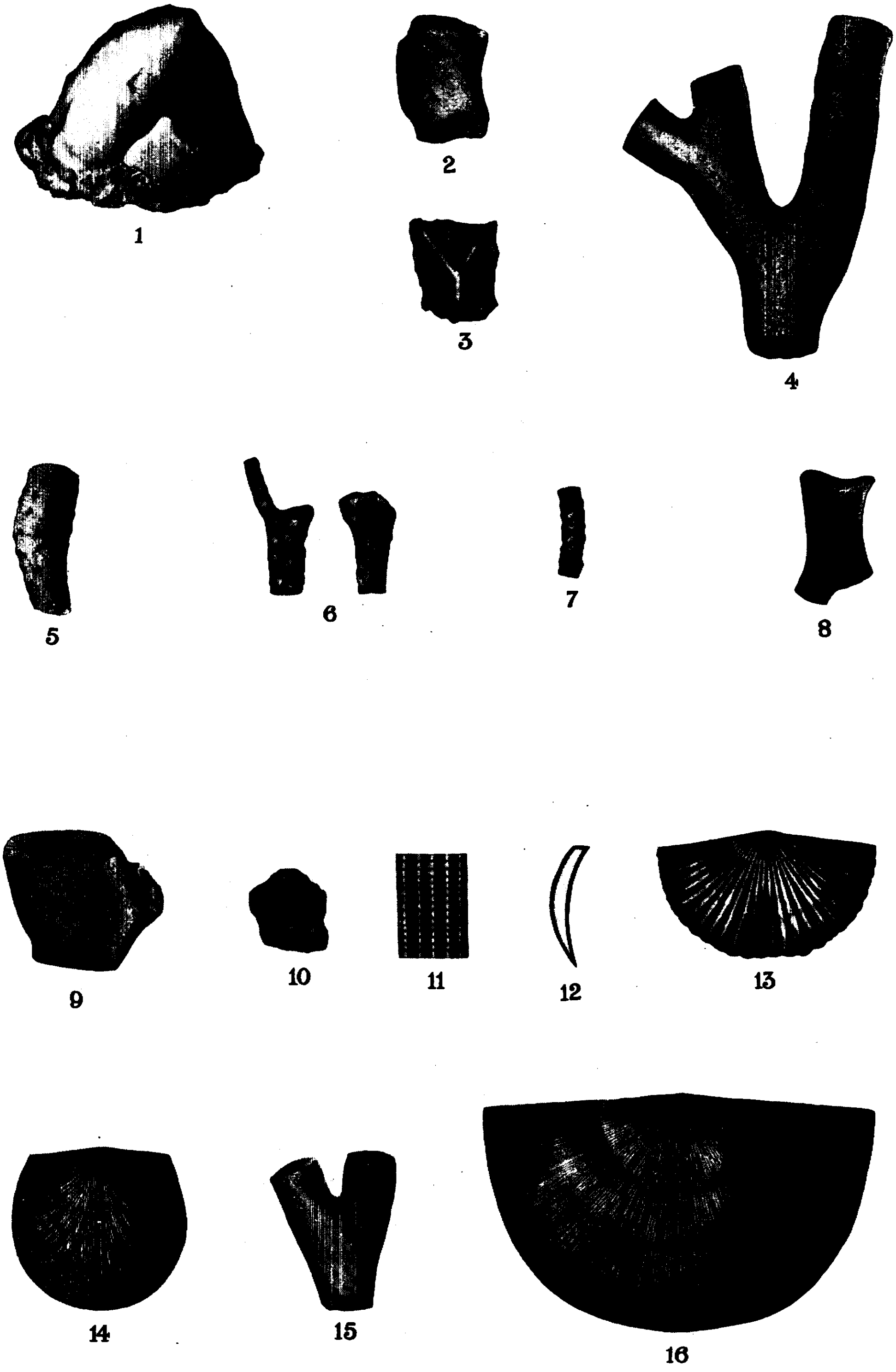
Plate VII



Part VI.—Stratigraphy

A.—STRATIGRAPHY AND CORRELATION OF THE DUNDAS FORMATION

By

W. A. Parks

Historical and Introductory

In southern Ontario, the Trenton limestone is overlain with apparent conformity by strata of great thickness consisting chiefly of shale, but showing also thin layers of limestone and of sandstone, the latter with both calcareous and argillaceous cement. Throughout the whole mass no distinct evidence of disconformity has been found, nor have sharply defined stratigraphic or petrographic distinctions been observed. This statement is not intended to mean that the strata cannot be divided petrographically, but that such divisions as may be established fade more or less imperceptibly into one another.

From the bottom of the series, the Collingwood and Utica formations characterized by the presence of black bituminous shales may be separated with some facility. The upper limit of the Utica, however, cannot be determined by the character of the rock, as the black shales pass imperceptibly into the overlying grey shales. Fossil evidence must be used to establish the separation: this is commonly placed at the level where the trilobite *Triarthrus* disappears. This level lies about four feet above Georgian bay in the excellent section on Workman's brook near Meaford, Ont. It is not to be observed in the vicinity of Toronto.

The uppermost beds of the series may be separated, somewhat more clearly, as the red, almost unfossiliferous shales of the Queenston formation, which, nevertheless, appear to be conformable with the underlying grey shale and to fade imperceptibly into it. This contact may be observed on Workman's brook and in the vicinity of Streetsville, Ont.

The subdivision of the mass of grey shales, limestones, and sandstones lying between the Utica and the Queenston formations is a problem of some difficulty, the solution of which depends chiefly on the evidence afforded by the fossil content.

These grey shales and associated rocks have a thickness of about 450 feet on Workman's brook, but in the region immediately north of Lake Ontario the total thickness is not less than 577 feet and probably is considerably more, as the bottom cannot be observed.

In the early days of geological investigation, strata more or less comparable with those under review were assigned by James Hall to the *Hudson River group* which included all the strata of the State of New York between the Utica shale and "a quartzose conglomerate in the eastern part of the state, and a grey sandstone in the western".[1] The term *Pulaski shales* was early given to a series of shales exposed at Pulaski, N.Y., but in 1842 Emmons proposed

[1]Nat. Hist., N.Y., Pt. IV, Geology, 1843, p. 30.

the name *Lorrain shales* to replace *Pulaski*, on the ground that the Pulaski shales were only a part of the sequence which was more fully exposed at Lorrain, N.Y.[1] As far back as 1839, Vanuxem recognized two divisions in the shales, the lower of which he named *Frankfort slate* and the upper *Pulaski shale*. Above these he placed the *Sandstones of Salmon river*, evidently the conglomerates and sandstones of Hall. Conrad in 1839 used the expression *Salmon River sandstones and shales* for the whole series. In the more comprehensive sense the two terms *Hudson River* and *Lorraine* survived, the latter word having acquired a final "e" in the interval. Clarke and Schuchert, in 1898, use *Lorraine;* but Merrill in 1901 uses *Hudson River* to include both the Utica and Lorraine beds.

In 1901, Ruedemann proved that the original Hudson River beds were of very mixed character including strata now ascribed to older series. Since this time the term has gradually disappeared from the literature.[2]

The State of New York, however, had no monopoly in the early study of the strata of Upper Ordovician age. Rocks of this age form a great sequence in the middle west, particularly in Ohio, Illinois, Indiana, and Kentucky. In the Proceedings of the Philadelphia Academy of Sciences for August, 1865, Meek proposed the name *Cincinnati group* for the upper group of Lower Silurian (Ordovician) rocks in this region on the grounds that the term *Hudson River* was a misnomer because the so-called Hudson River rocks do not reach the Hudson and the strata attributed to this group in eastern New York are of different age from those in the western part of that state. This view was endorsed by Worthen for the State of Illinois.[3] Newberry likewise approved this nomenclature for Ohio but with some differences. He states that rocks of the Hudson River group *do* reach the Hudson and considers that the name cannot be dropped on that account; but, as the more or less equivalent rocks of Ohio constitute a homogeneous group containing the representatives of the Trenton, Utica, and Hudson River of New York, he proposed to use *Cincinnati group* as a comprehensive name for the western strata, leaving *Hudson* as a *time* term.[4] This very wide use of the term *Cincinnatian* was gradually discontinued as knowledge of subdivision advanced. Orton had early used the word *Eden* for the western representatives of the New York Utica; strata comparable with the Lorraine were recognized; and above these, a series of fossiliferous strata was found, unrepresented in the State of New York and occupying the position of the overlying sandstones and conglomerates of that state—the Shawangunk grit, Oneida conglomerate, Salmon River sandstone, Oswego sandstones. This important formation was named *Richmond*.

Under the influence of the New York nomenclature, Nickles, in 1906, published a classification of the Ohio rocks, including in the Cincinnati group only the three upper formations—Richmond, Lorraine, and Utica.[5] The confusion and difficulty of using the New York *formational* names was so great, however, that Foerste advocated a return to the use of Orton's original name *Eden* for the western strata correlated with the Utica.[6] He also proposed the name *Maysville*, from Maysville, Kentucky, for the strata correlated with the Lorraine. Nickles endorsed this view in Bulletin 5 of the Kentucky Geological Survey, published in 1905.

[1]Nat. Hist., N.Y., Pt. IV, Geology, 1842, p. 119.
[2]New York State Mus., Bull. 82, Vol. 8, 1901.
[3]Geol. Surv. Ill., Vol. 1, 1866, p. 136.
[4]Geol. Surv. Ohio, Vol. I, 1873, p. 116.
[5]Cin. Soc. Nat. Hist., Vol. XX, 1906, p. 64.
[6]Science, New Series, Vol. XXII, August, 1905, p. 150.

Cumings gives a full account of the growth of the nomenclature of the Upper Ordovician in the west.[1] Three of the later classifications of the Cincinnati group as given in Cumings' table are reproduced below:—

CLASSIFICATION OF THE CINCINNATI GROUP

Nickles and Foerste, 1905		Ulrich, 1906 (Bassler)		Cumings, 1907	
Richmond	Saluda Whitewater Liberty Waynesville	Richmond	Saluda Whitewater Liberty Waynesville Arnheim	Richmond	Elkhorn Whitewater Saluda Liberty Waynesville Arnheim
Maysville	Arnheim Mt. Auburn Corryville Bellevue Fairmount Mt. Hope	Covington	McMillan Fairview McMicken Southgate Economy Fulton	Maysville or Lorraine	Upper Middle Lower
Eden	Upper Middle Lower			Eden or Utica	McMicken Southgate Economy

In 1911, Ulrich removed the Richmond from the Cincinnatian and proposed the following classification of the western rocks and their correlation with those of New York:—

ULRICH'S CLASSIFICATION OF 1911[2]

General Time Scale			North Central New York	Cincinnati Dome
Juniata			Queenston	
Cincinnatian	Maysville	McMillan Fairview	Oswego Pulaski	McMillan Fairview
	Eden	Frankfort Utica	Frankfort Utica	Frankfort Gratz-Fulton

It will be observed that the main divisions of the *time* scale are founded on the western *rock* or *strata* names, and the minor divisions are selected from both areas; also, that no western *formational* names are used for the actual strata in New York, nor are New York names similarly used in the western area, with the exception of *Frankfort*. The removal of the Richmond from the Cincinnatian became necessary in view of Ulrich's contention that the whole Ordovician system terminated with the Juniata sandstone of Central Pensylvania, a formation which he correlates with the Queenston shale. At a later date he drew the boundary of the Silurian still lower—at the base of these shales.[3] We are not at present concerned with this discussion, but it is interesting to note that Ulrich, in his emended classification, removes the term *Frankfort* from his list of western formations.

[1]Geol. and Nat. Res., Indiana, 32nd Rep., 1907, pp. 607-687.

[2]Bull. Geol. Soc. Am., Vol. XXII, No. 3, 1911, p. 608.

[3]The question of the Ordovician-Silurian boundary is fully discussed by Ulrich in Compte-Rendu du Congrès Géologique International, XIIe Session, 1913, pp. 593-669.

The above brief account of the development of the terminology of the Upper Ordovician rocks of America indicates at least four rather important facts:—

1. The tendency to restrict formational names to the localities and rocks for which they were first coined.

2. The selection of certain terms as time divisions, these terms being founded on the most appropriate formational names irrespective of locality.

3. The entire disuse of the term *Hudson River* either as a time or as a formational name.

4. The adoption of *Cincinnatian* as a time term but with a much restricted range.

Returning to the State of New York we find the effect of these developments in the classification of the strata of that state as below:—

HARTNAGEL'S CLASSIFICATION OF THE UPPER ORDOVICIAN OF NEW YORK, 1912[1]

Western	Central	East Central	Eastern
No strata below the Oswego sandstone are exposed. Following Ulrich this is regarded as Silurian.	Cincinnatian Pulaski shale Frankfort shale Utica shale	Cincinnatian . . . . Frankfort shale Utica shale	Cincinnatian . . . . Indian Ladder . . . .

It is worthy of note that the Ordovician-Silurian boundary is drawn between the Pulaski shales and the Oswego sandstone, that the Queenston red shale is considered as Silurian, and that the term *Lorraine* does not appear in the table.

In the Geology of Canada, 1863, Logan referred all the strata between the Trenton limestone and the Queenston red shale to the "Hudson River group", the red shale was regarded as Medina, and the contact between the "Lower Silurian" and "Middle Silurian" was considered to lie at its base. The Hudson River group was divided into Hudson River or Lorraine shales and Utica shales.

The next contribution to our knowledge of the grey shale series of Ontario was afforded by Dr. H. M. Ami in his report on the fossils collected by Dr. Robert Bell on Manitoulin island. Ami recognized the presence of Richmond fossils—unknown in the State of New York. His statement as below is very significant:—

> The sedimentation of that area (Manitoulin island) is not only quite distinct from that of the Niagara and Toronto districts of the Ontario basin, but bears strong resemblance to the succession known and recorded in Indiana, Ohio, and Kentucky to the south, as well as that of the Island of Anticosti, in the valley of the St. Lawrence east. Especially is this resemblance a striking one as regards the calcareous sediments of the Richmond formation, whose presence in the Grand Manitoulin island had not been hitherto detected.[2]

Following Ami's discovery, it gradually became known that the grey shales and limestones of Ontario—the Hudson River formation—consisted of two fairly distinct divisions, an upper "Richmond" and a lower "Lorraine."

[1]New York State Museum, Handbook No. 19, 1912. Dr. John M. Clarke has kindly informed me that this classification is officially in use at the present date.

[2]Geol. Surv. Can., Annual Report, Vol. XV, 1906, p. 323A.

This terminology was used in the literature of the Twelfth International Geological Congress, by Foerste for Manitoulin island and by Parks for the section on the Credit river.[1]

Since 1913, two very important contributions to the subject have been made by Foerste.[2] In Memoir 84 of the Geological Survey of Canada, to which frequent reference will be made in later pages, he reviews the physical and faunal evidence afforded by the Upper Ordovician strata as exposed at various points in the provinces of Ontario and Quebec.

Foerste's general conclusions as to stratigraphy are interesting and at variance with the established nomenclature in the State of New York (page 92). He avoids the use of the word "Cincinnatian" as a time term; resurrects "*Lorraine*" and "*Salmon River*"; and correlates the Queenston shale with the Whitewater and Saluda divisions of the western Richmond.

Foerste's classification of the New York strata, a very significant paragraph which I have italicized, and his classification of the Canadian strata are reproduced below.

FOERSTE'S CLASSIFICATION OF THE UPPER ORDOVICIAN OF THE STATE OF NEW YORK

Lorraine	Salmon River sandstone Pulaski shales and sandstones Lower Lorraine shales, unnamed (near Eden of Cincinnatian)
Unnamed group	Frankfort Utica

In western New York, the Queenston red shales intervene between the Medina and the Lorraine; at various localities in Ontario and Quebec, the lower or Waynesville division of the Richmond intervenes between the Queenston and the Lorraine; and the Salmon River sandstone is absent, so that in Canada the succession becomes:—

FOERSTE'S CLASSIFICATION OF THE CANADIAN STRATA

Medina	
Queenston........................	Whitewater and Saluda divisions of the Richmond
Waynesville division of Richmond	
Lorraine........................	Pulaski. Unnamed division (near Eden of Cincinnatian)
Utica shale of New York	
Collingwood	
Trenton	

The above italicized paragraph is of vital importance as it emphasizes the great difference in the succession of strata in Ontario as compared with that of New York or of Ohio. In view of this difference, we are in no position to accept or reject the views of nomenclature on the part of either New York or Ohio geologists. In the first place, the use of the time term *Cincinnatian* in the sense of Upper Ordovician requires that we shall definitely settle the Ordovician-Silurian boundary. Do the observed facts in Ontario throw any

[1]XIIth Int. Geol. Cong., Guide Book No. 5, 1913.

[2]Notes on the Lorraine Faunas of New York and the Province of Quebec, Bull. Sci. Lab., Denison University, Vol. XVII, 1914, pp. 247-340.

Geol. Surv. Canada, Memoir 84, 1916.

light on this question? The section on the Credit river shows no evidence of a break between the so-called Lorraine and the so-called Richmond (Waynesville of Foerste). On the other hand, the upper surface of the Queenston shale as exposed along the Niagara escarpment and in the gorge of the Niagara river shows far greater evidence of a disconformity with the basal Cataract sandstone. It is not the immediate purpose of this review to discuss this question, and much as I hesitate to differ from Dr. Ulrich, I am forced to include the so-called Richmond of the Credit river and the Queenston shale in the Upper Ordovician or Cincinnatian.

In the second place, it is impossible to arrive at any proper conclusion as to the classification of the series of grey shales, until we discard the practice of trying to use formational names given to strata so far away as eastern New York or Ohio. Foerste realized this necessity in his studies on Manitoulin island where he was forced to introduce three formational names, Kakawong, Wekwemikongsing, and Sheguiandah, for strata which he regarded as belonging, respectively, to Richmond, Maysville, and Eden time. The same necessity arises in the study of the series of grey shales exposed near Toronto, on the Credit river, and along Workman's brook at Meaford.

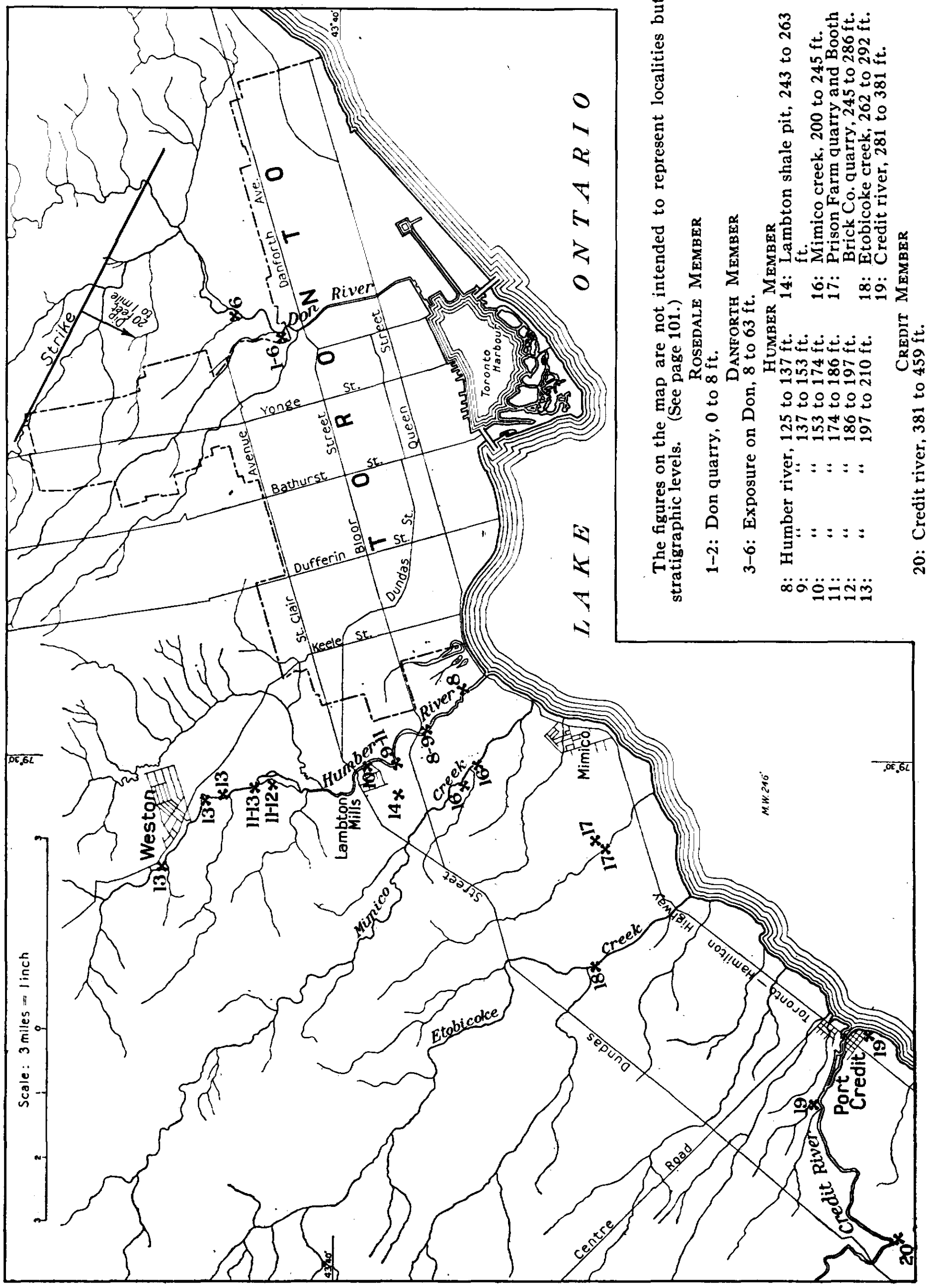
The strata between the Utica and the red Queenston shales are being made the subject of a series of studies in the University of Toronto. Extensive collections have been made from all accessible levels on the Don and Humber rivers at Toronto, on the Mimico, Etobicoke, and Credit rivers west of the city, and throughout the splendid section at Workman's brook. Dr. W. S. Dyer has written a critical analysis of the Credit River section which is included in this series as Part V and Part VI B. On the upper stretches of the river, he recognizes strata of undoubted Richmond affinities; near the mouth he ascribes the strata to a lower series, the same as that exposed at Toronto. Miss M. Fritz is engaged on a detailed description of the section on Workman's brook. Enough has been done in all these localities to establish the two main divisions, to prove the lack of disconformity between them, and to furnish reasonable grounds for their subdivision.

The present series of studies has presented in the five previous parts figures and descriptions of all the fossils known to occur in the lower division near Toronto and also of those which are new to science from the upper division on the Credit river. A comparison of the faunas with those of other regions shows that the upper division may be correlated with the Richmond of the middle west, but that the lower division, while referable in time to the Lorraine or Maysville, cannot stratigraphically be assigned to either. It is proposed to call this division the *Dundas formation*, and to divide it into four members in descending order as follows: *Credit*, *Humber*, *Danforth*, *Rosedale.*

General and Petrographic

The region about Toronto is so heavily covered with drift that exposures are separated by unfortunately long intervals. On the Rouge river, 15 miles east of the city, are shales containing *Triarthrus*, which must therefore be ascribed to the Utica. These shales, however, are not particularly black or bituminous and probably lie near the summit of the Utica. No exposures occur between the Rouge and Don rivers, the latter of which has cut a deep valley through the drift in the eastern part of the city. In this valley, a large quarry has been opened, the bottom of which is 218 feet above sea level, or 28 feet below the level of Lake Ontario. In this quarry 63 feet of strata are exposed and somewhat higher layers can be seen a quarter to half a mile farther up the valley. Across the city of Toronto there is an unexposed interval of about five miles to the valley of the Humber river. Here an excellent section is exposed, revealing in all about 147 feet from the level of the lake to the highest strata at Weston. Owing to the dip, however, the actual thickness of the strata is probably not more than 85 feet.

West of the Humber river, at the Lambton shale pit, 20 feet are exposed in beds of greater elevation stratigraphically than any exposed along the river.



The figures on the map are not intended to represent localities but stratigraphic levels. (See page 101.)

ROSEDALE MEMBER

1–2: Don quarry, 0 to 8 ft.

DANFORTH MEMBER

3–6: Exposure on Don, 8 to 63 ft.

HUMBER MEMBER

8: Humber river, 125 to 137 ft.
9: " " 137 to 153 ft.
10: " " 153 to 174 ft.
11: " " 174 to 186 ft.
12: " " 186 to 197 ft.
13: " " 197 to 210 ft.
14: Lambton shale pit, 243 to 263 ft.
16: Mimico creek, 200 to 245 ft.
17: Prison Farm quarry and Booth Brick Co. quarry, 245 to 286 ft.
18: Etobicoke creek, 262 to 292 ft.
19: Credit river, 281 to 381 ft.

CREDIT MEMBER

20: Credit river, 381 to 459 ft.

Map of Vicinity of Toronto, showing outcrops of Dundas formation.

Still farther west, in the quarries at New Toronto, and in cuts on Mimico and Etobicoke creeks, exposures of 20 to 30 feet may be seen. Finally, on the lower stretch of the Credit river, Dr. W. S. Dyer measured a thickness of 176 feet for the Dundas formation.

The dip of the strata is almost impossible to determine by direct observation, as characteristic continuous layers which may be measured at three points reasonably separated do not occur. A number of more or less unsatisfactory observations indicate a dip in a general southwesterly direction of from 17 to 23 feet to the mile. Dr. Dyer obtained a dip of 20 feet in his observations on the Richmond strata of the Credit river and Colonel Harkness has arrived at the same conclusion in plotting the contour of the Trenton limestone from well records. Taking the strike as N. 65° W. and the dip as 20 feet to the mile S. 25° W., as determined by Dr. Dyer, the more important exposures indicate stratigraphic levels above the bottom of the Don quarry as follows:—

	Stratigraphic elevation
	feet
Don Valley quarry	0 to 63
Don Valley above quarry	60 " 67
Unexposed interval	67 " 125
Humber river	125 " 210
Lambton shale pit	243 " 263
Mimico creek	200 " 245 (?)
Etobicoke creek	262 " 292
Prison Farm quarry	245 " 263
Booth Brick Co. quarry	258 " 286
Credit river	281 " 457

Throughout the Dundas formation, the prevailing rock is a greyish blue shale, weathering lighter. Much variation in texture and composition is shown—from a dense bluish, highly argillaceous shale to a yellowish, silty, sometimes distinctly arenaceous type. On the whole, the latter variety increases towards the top of the formation. Analyses of two typical examples of the denser shales gave the following results:—

ANALYSES OF TYPICAL SHALE

	Two feet above bottom of Don quarry	Booth Brick Company's quarry
	per cent.	per cent.
Silica	55.3	57.5
Alumina and ferric oxide	23.0	27.0
Calcium oxide (lime)	6.4	2.54
Magnesia	trace	trace
Loss on ignition (water and carbonic acid)	8.5	7.15
CALCULATED:		
Carbonic acid	5.03	1.99
Water	3.47	5.16

The mineralogical composition of shale is very difficult to determine from a partial analysis, or even from a complete analysis. In both the above cases, the amount of water is insufficient to account for the high percentage of alumina, assuming the water to be present as a component of kaolin. If *all* the water is calculated as kaolin, there would be present of that mineral in the two cases, 24.1 per cent. and 36.8 per cent., respectively. The alumina in both cases is far in excess of the amount required for the above percentages of kaolin. It is probable that the excess of alumina occurs in the form of muscovite or in the form of finely-divided feldspar.

Microscopic examination shows that even in these denser shales there is a small quantity of exceedingly fine, angular quartz grains. This material increases in amount in the more silty types together with visible flakes of white mica.

Throughout the shales occur the so-called hard layers which are always of limited extent both vertically and horizontally. With rare exceptions they do not exceed a foot in thickness, and the average is much less. The horizontal extent is likewise very limited, the bed-like structures being better described as lenses. In the Don quarry, for instance, no layer has been observed to extend over the whole area of the excavation.

These hard layers are of two kinds: limestones crowded with fossils, and hard, grey to yellowish stones made up of extremely fine, angular quartz grains, argillaceous matter, and a considerable amount of finely crystalline calcite. Fossils are rare in this type of stone which, for convenience, will be referred to as sandstone.

Throughout the shales, limestones, and sandstones, there is always more or less of the tiny angular quartz grains which are at a minimum in the shales and limestones, increase in amount in the more silty shales, and reach a maximum in the sandstones.

Analyses of typical examples of the hard layers gave the following results:—

ANALYSES OF HARD LAYERS

	Thin sandstone lens, Humber river at Lambton	Typical limestone, Prison Farm quarry	Yellowish sandstone, Humbervale quarry	Argillaceous sandstone, Humber river at Bloor street
	per cent.	per cent.	per cent.	per cent.
Silica	50.5	34.7	63.6	61.3
Alumina and ferric oxide	14.5	9.0	15.0	18.5
Lime	16.3	30.3	7.28	4.8
Magnesia	trace	trace	trace	trace
Loss on ignition	14.25	24.7	9.25	7.8
CALCULATED:				
Carbonic acid	12.8	23.8	5.72	3.78
Water	1.45	0.9	3.53	4.02

It will be seen that the three sandstones consist of variable amounts of free silica, carbonate of lime, and argillaceous matter. The latter component is probably a mixture of kaolin and muscovite as in the case of the shales. In each instance the amount of water, calculated to kaolin, is insufficient to account for all the alumina present.

The limestone is very impure containing only about 56 per cent. carbonate of lime. The balance, as in the case of the sandstones, is made up of free silica, kaolin, and probably muscovite.

While the mineralogical composition of these rocks, as deduced from the analysis, cannot have the merit of accuracy; taken together with the microscopic examination, it indicates that all the hard layers consist of mixtures, in varying amount, of kaolinite or an allied hydrated silicate, carbonate of lime, quartz, and an uncertain aluminum alkali silicate, possibly muscovite, possibly decomposed feldspar or other silicate. I would emphasize the very impure character of the limestone, the universal presence of more or less of the very small angular quartz fragments, and the absence of any coarse clastic material, not only in these examples, but throughout the whole formation.

Well preserved calcareous fossils, with the exception of bryozoans, crinoid columns, and an occasional cephalopod, are found only in the limestone layers. The most abundant calcareous shells, those of brachiopods and pelecypods, are not found in the shales, although the impressions of such shells in shale constitute the chief fossils of the formation. It is apparent that the removal of these shells by solution has provided a large amount of carbonate of lime and has occasioned a considerable lessening of the original thickness of the beds.

The best impressions are found in the dense, plastic, bluish shale. They decrease in number and deteriorate in the state of preservation as the shale becomes more and more silty. In the very silty types such impressions as may be found are so poor as to be very difficult of identification. The thicker sandstone layers frequently have a limestone base which is full of fossils while the sandstones rarely contain any organic remains.

In many places in the shale, particularly in the somewhat sandy types, are elongated, branch-like, hard structures, usually convex below and flat above. They are often as large as a man's arm and frequently attain a greater size. When cut across, the lamination is seen to be horizontal in accord with that of the enclosing shale, not corresponding with the convex under side. Other less branch-like but otherwise similar structures are found, sometimes presenting vertical edges of several inches abutting against the enclosing shale.

Microscopic examination and analysis of these hard bodies reveal a composition and structure identical with that of the lens-like sandstone layers and of the more extensive beds of the same stone. It seems reasonable to infer that they are due to the same set of causes.

One is impressed in examining a section of our rocks with the remarkable lack of continuity of the hard layers. In places they appear to the eye as distinct beds but of very limited extent; in other places they are visibly mere lenses; and in extreme cases they take the form of the ramose structures already referred to. It is not uncommon for these hard lenses to make up 10 per cent. of the face of a cut, and in some cases even more. The limited extent and the frequent occurrence of these layers or lenses seem to require some other explanation than mere differences in the conditions of sedimentation.

The considerable geographical extent of the formation, the prevalence of shale, the universal presence of tiny angular quartz grains, the absence of coarse clastics, and the abundance of life seem to indicate deposition in water of moderate depth of fine clastic material brought in suspension. Many ripple marks on the sandstone layers indicate that the water was not very deep, and, on the other hand, the numerous crinoids and the free-moving cephalopods and trilobites attest at least a moderate depth.

Under the above conditions, it is easy to imagine a degree of variation in the character of the clastics and also in the rate of deposition of organic remains. It is very difficult, however, to account for the very abrupt and at the same time excessively local changes that would be necessary to account for the present disposition of the hard layers on the basis of original differences of sedimentation.

The following explanation of the origin of the hard layers is suggested as a possibility; it is not advanced with any feeling of conviction, but merely as offering a better explanation than mere sedimentation.

First, with regard to the sandstone layers and lenses and the ramose hard structures already referred to: All these structures consist of the usual clastics in varying amount cemented by fine crystalline secondary calcite. In the smaller lenses, fossils are practically absent; in the larger layers, they are sparingly present. It is suggested that the position of these hard layers was more or less predetermined by the presence of greater amounts of sandy matter in the original sediments, that the first result of solution was to remove, for the most part, such shells as may have been included, and that the subsequent hardening was due to the later infiltration and deposition of carbonate of lime.

It is possible to explain the limestone lenses with their many fossils as the result of wave action having aggregated into isolated spots the shells which were accumulating on the floor of the sea. Another explanation, however, is possible, although it may be regarded as fanciful.

While the amount of life in the sea undoubtedly fluctuated, it could not have fluctuated in the excessively local manner which the present disposition of the limestone lenses would seem to indicate. One cannot imagine that at the same time, in the same sea, at intervals of only a few feet or yards, that the character of the clastics or the amount of shelly matter could vary so abruptly. It may be postulated, however, that there was a much greater similarity of deposition than the present conditions indicate, that sand, mud, and shells were more or less uniformly deposited. The limestone lenses can then be explained as those parts of the general complex into which lime salts were introduced before the solution of the entombed shells.

The prevalence of impressions in the denser shales indicate the entombment of vast numbers of organisms which subsequently have been dissolved with the production of much carbonate of lime. Even in the silts, occasional impressions are found, but these are so badly preserved as to suggest that many more may have been present originally.

That the limestone lenses are merely favourable parts of a general complex of shells and clastics preserved by the infiltration of secondary carbonate of lime is suggested by observations elsewhere, of which one or two examples will suffice. In the Cretaceous shales of Alberta, in places practically devoid of fossils, there occur large sub-spherical concretions rich in carbonate of lime and showing traces of the original stratification as well as a faint concentric structure. These concretions are literally full of fossils. On the South Saskatchewan such concretions in barren shales are crowded with *Pteria nebrascensis*. At Vanguard in Saskatchewan, quarries in barren shale are worked for brickmaking; the operators throw aside numerous large concretions filled with *Inoceramus*, *Scaphites*, and other forms. It is difficult to imagine any other explanation for these fossil-filled concretions except that they are due to the preservation of portions of the equally fossil-filled shale.

Fauna, Subdivision, and Correlation

The Dundas formation is essentially a unit stratigraphically, and, as already stated, it is defined neither above nor below by any sign of disconformity with the adjacent strata. The lowest rocks are blue shales with few hard bands (Rosedale); the strata above these are chiefly shale, seldom arenaceous, and with hard layers which are chiefly limestone (Danforth). These two members are seen in the Don valley only. The third member is the most extensive; it consists of shale, decidedly more silty on the whole and with more of the sandstone layers as well as limestone (Humber). This member is seen in all the exposures on the Humber river, in the quarries and creeks to the west, and on the lower reaches of the Credit river. The uppermost part of the formation is decidedly silty, less fossilferous, and with hard layers of limestone only (Credit).

SUBDIVISION AND CORRELATION OF THE DUNDAS FORMATION

General Time Scale		Formation	Member	Thickness
Cincinnatian	Richmond	Richmond		
Cincinnatian	Maysville-Lorraine	Dundas	Credit Humber Danforth Rosedale	50 feet 282+ " 57+ " 10+ "
Cincinnatian	Utica	Utica		

In all, about 187 species and some varieties of fossils have been recorded from the Dundas formation. Arranged in zoological groups in order of their relative importance, the total fauna is indicated below:—

FAUNA OF THE DUNDAS FORMATION

	Species
Pelecypoda	63
Vermes	37
Bryozoa	30
Brachiopoda	16
Gastropoda	12
Graptolitoidea	7
Fucoids, markings, etc.	6
Cephalopoda	6
Crinoidea	4
Trilobita	3
Stromatoporoidea	1
Conularida	1
Asterozoa	1
Total fauna	187

For purposes of correlation, the whole of the above 187 species cannot be employed, certain forms being rare and doubtful. The *Ctenodonta*, for instance, are mere impressions in shale, the identification of which must be regarded as provisional. Other species, like *Orthoceras mohri*, *Actinoceras clouei*, and *Liospira helena* are rare and are referred to with some hesitation.

Many species of the above list are common with the Pulaski or Lorraine of New York, while, on the other hand, many are common with the Maysville of Ohio. There is a considerable admixture of forms occurring elsewhere in the Richmond and a few which are typically Trenton or Eden. The following table shows the distribution elsewhere of the species identified from the Dundas. It is necessarily somewhat inexact and is founded on the assumption that all our species are accurately determined and that the range elsewhere of the species is accurately known. It is evident that some latitude must be allowed in interpreting the table, but it will serve, nevertheless, to give a general idea of the distribution of the Dundas fauna as a whole:—

DISTRIBUTION OF THE DUNDAS FAUNA
(Annelids and conodonts omitted)

	Species
Only in the Pulaski or Lorraine of New York	10
Only in the Maysville of the Ohio basin	25
In both Richmond and Maysville, but not in New York	7
Only in the Richmond of Ohio basin	18
In both Lorraine or Pulaski and in the western basin	24
Only in the Eden	6
Only in eastern Canada as determined by Foerste	10
New species or varieties	29
Long range forms, Trenton, Silurian, etc.	13
Total	142

In view of this table, it is impossible to correlate the Dundas formation directly with either the eastern or the western representative of Maysville-Lorraine time. The early appearance of typical Richmond forms is significant as well as the occurrence of the new fauna described by Foerste from eastern Canada.

The following table contains nearly all the known fossils of the Dundas formation, except the annelids and conodonts, and indicates all the horizons from which they have been collected. Actual occurrences are indicated by "X", and questionable occurrences by "?". The figures at the heads of columns indicate stratigraphic elevations and, consequently, also the position in the various members, as follows:—

1—Lower two feet, Don quarry 2—2 to 8 feet, Don quarry	ROSEDALE MEMBER
3—8 to 12 feet, Don quarry 4—12 to 19 feet, Don quarry 5—24 to 31 feet, Don quarry 6—45 to 63 feet, Don quarry	DANFORTH MEMBER
7—Unknown levels, Don quarry	
8—125 to 137 feet, Humber river 9—137 to 153 feet, Humber river 10—153 to 174 feet, Humber river 11—174 to 186 feet, Humber river 12—186 to 197 feet, Humber river 13—197 to 210 feet, Humber river 14—243 to 263 feet, Lambton shale pit 15—Unknown levels, Humber river 16—200 to 245 feet, Mimico creek 17—245 to 286 feet, New Toronto quarries 18—262 to 292 feet, to Etobicoke creek 19—281 to 407 feet, Credit river	HUMBER MEMBER
20—407 to 457 feet, Credit river	CREDIT MEMBER

21—Recorded as occurring in the Lorraine or Pulaski.
22—Recorded as occurring in the Maysville.
23—Recorded as occurring in the Richmond.
24—Notes on occurrences elsewhere, formations or localities.

FOSSILS OF THE DUNDAS FORMATION

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Actinoceras crebriseptum		X		X				X	X	X	X	X		X	X	X	X	X		X	X			
Actinoceras *cf.* clouei												X												Newfoundland
Arthropora shafferi							X															X		
Arthraria biclavata									X		X											X		
Archinacella pulaskiensis	X	X		X			X	X	X		X	X	X			X					X			
Aspidopora *cf.* areolata											X	X		X										Fulton
Atactopora maculata							X															X		
Byssonychia alveolata											X	X	?	?	X							X		
Byssonychia praecursa							X	X	X		X	X	X		X						X	X		
Byssonychia radiata	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Byssonychia vera		X	X	X	X	X	X	?	?		X				X									Eden
Byssonychia vera plana		X	X	X	X	X	X	?	?	X	X	X	?		X									
Bythopora arctipora	X	X		X		X	X	X	X	X	X	X	X	X		X	X	X						Eden, etc.
Bythopora *cf.* delicatula												?	?										X	
Bythopora gracilis													?									X		
Buthotrephis gracilis							X									X								Silurian
Calymene meeki		X	X	X		X	X			X	X	X	X			X	X					X	X	
Chiloporella flabellata							X															X		
Clidophorus *cf.* faberi										X	X	X	X										X	
Clidophorus fabula		X	X						X	X	X	X	X	X				X				X	X	Eden
Clidophorus obliquus									X	X	X	X	X					X						
Clidophorus planulatus	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X		X	X	X	X	Eden
Clidophorus praevolutus		X					X			X		X	X			X	X	X						Eden, Chambly
Clathrospira subconica											?	?												Trenton
Climacograptus putillus						X															X	X	X	
Climacograptus *cf.* typicalis						X																		Trenton-Eden
Colpomya faba													?											Trenton
Colpomya faba pusilla	X	X	X	X	X	X	X		X	X	X	X	X		X	X					X			Chambly
Conularia formosa							X															X	X	
Cornulites sterlingensis		X		X						X	X	X	X				X				X			
Cryptolithus tessellatus							X														X	X		Trenton
Ctenodonta cingulata										X	X	X											X	
Ctenodonta filistriata						?		X	X	X	X	X	X				X	X	X					Eden
Ctenodonta *cf.* albertini												X	?										X	
Ctenodonta myalta		X						X	X	X	X	X	X				?							
Cyclonema bilix													X										X	
Cyclonema *sp.*							X																	
Cyrtolites ornatus		X		X		X	X	X	X		X	X				X					X	X	X	
Cuneamya neglecta		?					X					X	?										X	

FOSSILS OF THE DUNDAS FORMATION—*Continued*

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Cuneamya scapha										X		X	X	X									X	
Cuneamya scapha brevior	X	X				X	X	X			X	X	X	X		X		X	X					R. des Hurons
Cymatonota lenior											X	X	X		X		X	X		X				R. des Hurons
Cymatonota parallella											X	X	X	X	X						X	X		
Cymatonota pholadis							X				?	?	?					?			X	X		
Cymatonota recta		X	X	X	X	X	X				?					?	?					X		
Dalmanella rugostriata	X	X		X																				
Dekayella ulrichi							X																	Eden
Dendrograptus sp.				X																				
Dermatostroma scabrum															X							X	X	
Dendrocrinus dyeri															X									Trenton
Diplograptus vespertinus								X																Trenton
Endoceras proteiforme		X	X	X		X			X		X	X		X							X	X	X	
Glossograptus *sp.*				X																				
Glyptocrinus decadactylus		X	X	X		X	X	X								?	X					X		
Hallopora communis							X															X		
Hallopora dalei subalta				X		X	X																	
Hallopora onealli						?			X	X	X	X	X	X			X	X			X	X		
Hallopora onealli creditensis																				X				
Hallopora onealli danforthensis				X	X	X	X																	
Heterocrinus juvenis		X			X	X	X	X													X			
Hormotoma gracilis							?														X	X		Trenton, Eden
Inocaulis yorkensis							X																	
Iocrinus subcrassus torontonensis							X	X							?									
Ischyrodonta elongata									?		?	?			?		?						X	
Ischyrodonta unionoides							X				X	X			X		X		?	X	X	X		
Isotelus maximus	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Trenton, etc.
Leptaena rhomboidalis (L. moniquensis)						X								X										Wide range
Leptotrypa expansa														X										
Licrophycus flabellum									X		X											X		
Lichenocrinus sp.	X					X		X			X	X		X		X								
Lingula *cf.* progne							X		X		X	X						X						Trenton, etc.
Lingula rectilateralis						X	X				X										X			Utica
Lingula westonensis													X											
Liospira helena											X	X				X		X						Cape Smyth
Lophospira beatrice						X			X					X	X									R. des Hurons
Lophospira beatrice parva							X							X			X							
Lophospira tropidophora						?					X	X										X	X	Eden
Lyrodesma cincinnatiense		X					X								X							X		

FOSSILS OF THE DUNDAS FORMATION—*Continued*

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Lyrodesma poststriatum		X	X	X		X	X		X	X	X	X	X		X	X		X			X	X		
L. poststriatum elongatum			X	X			X			X	X	X												
Mastigograptus gracillimus	X																					X		
Mesotrypa distincta															X		X							
Modiodesma modiolare	X	X	X	X	X	X	X	X	X	X	X	X	X			X		X			X	X		
Modiolodon *cf.* poststriatus						X									X									Vars
Modiolodon subovalis							X								X								X	
Modiolopsis borealis																			X					
Modiolopsis concentrica		X	X	X		X	X	X	X	X	X	X			X	X	X		X	X	?		X	
Modiolopsis ovata																	X				X			
Modiolopsis postplicata											X	X			X				X					R. des Hurons
Modiolopsis striata												X												
Modiolopsis valida																	?						X	
Orthoceras duseri				X							X				X								X	
Orthoceras lamellosum											X	X					X		X		X			
Orthoceras mohri															?								X	
Orthodesma approximatum							X	?	?		X	X			X									Chambly
Orthodesma nasutum							X				X	X		X	X						X			Trenton
Orthodesma *cf.* parvum								?			X	X	X	X				?				X		
Orthodesma subangulatum											X	X			X			?					X	
Orthodesma *cf.* rectum															X								X	
Palaeophycus virgatus											X		X										X	
Paleschara beani		X				X	X							X		X							X	
Peronopora vera							X						X									X		
Pholidops cincinnatiensis		X	X	X		X			X	X	X	X	X	X	X		X					X		
Plectambonites rugosus				X			X															X		
Plectambonites sericeus	?	?	X	X	X	X	X						X											Trenton
Prasopora donensis	X	X				X																		
Promopalaeaster solitarius							?								X									
Psiloconcha inornata											X	X	X	X		?						X		Quebec
Psiloconcha sinuata		?					X					X	X	X								X		
P. sinuata borealis		X					X	X	X	X	X	X	X	X	X	X		X						R. des Hurons
Psiloconcha subovalis						?	X			X			?	X								X		
Psiloconcha subrecta										?	X	X	X	X		?							X	
Pterinea cincinnatiensis								X		X	X		X	X								X		
Pterinea demissa		X									X	X	X	X	X	X	X		X	X	X	X	X	
Rafinesquina alternata						X			X		X	X	X								X	X	X	
R. mucronata torontonensis								X		X	X	X	X	X		X	X		X					
Rusophycus *sp*															X			X						

FOSSILS OF THE DUNDAS FORMATION—*Continued*

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Rhytimya colemani				X		?				X														
Rhytimya compressa		X																?				X		
Rhytimya granulosa		X									X					X		?						Ottawa
Rhytimya oehana		X	X				X									X		X				X		Chambly
Schizocrania filosa						X	X						X			X	X				X	X	X	Trenton, etc.
Sinuites cancellatus										X				X							X	X	X	
Spatiopora maculosa							?															X		
Spatiopora varians														X										
Stigmatella catenulata (b)								X						X					X					
Stigmatella catenulata (a)														X										
Stigmatella catenulata diversa										X		X	X											
Stigmatella clavis						?		?			X	X										X		
Stigmatella crenulata										X	X	X		X									X	
Stigmatella intermedia																X								
Stigmatella lambtonensis														X										
Stigmatella *cf.* personata									X	X	X	X		X	X								X	
Stigmatella sessilis crassa																				X				
Stigmatella vulgaris				X			X																	
Trichophycus venosum									X		X		X									X		
Trochonema umbillicatum		X	X	X		X				X	X													Trenton, etc.
Trematis millepunctata							X															X	X	
Trematis ottawaensis											X													Trenton
cf. Trematis fragilis						X																		Trenton
Whiteavesia pholadiformis								X	X	X	X	X	X	X	X	X	X		X	X	X		X	Quebec
Whitella acutiumbonis	X	X				?																		
Whitella goniumbonata	X	X				?												?						R. des Hurons
Whitella hindi															X				?	?				
Whitella impressata	X	X		X		?																		
Whitella lata	X	X																						
Whitella parksi	X	X																						
Whitella radiata	X	X					X																	
Whitella torontonensis															X				?					
Zygospira cincinnatiensis				X	X	X	X		X		X			X			X				X	X		
Zygospira erratica				X	X	?	X	X	X		X	X	X	X	X	X	X		X		X			
Zygospira modesta		X		X	X	X	X	X	X	X	X	X	X	X			X			X	X	X	X	Utica

The above table and the analysis of the fauna given on page 101 indicate that we have an assemblage of forms that would be regarded as "mixed" by either the New York or Ohio standard. Both the stratigraphic position and the fauna indicate Maysville-Lorraine time, but it is evident that formationally the Dundas is a unit deserving a local name. The fauna is, to some extent, general throughout the formation, but certain species are restricted to narrower zones and others differ greatly in their relative development at different horizons in the formation. The subdivision into members or faunal zones has already been indicated: these members are briefly considered below. Full faunal lists are not given as these may be deduced from the list of occurrences as indicated in the table.

Rosedale Member

Whitella zone

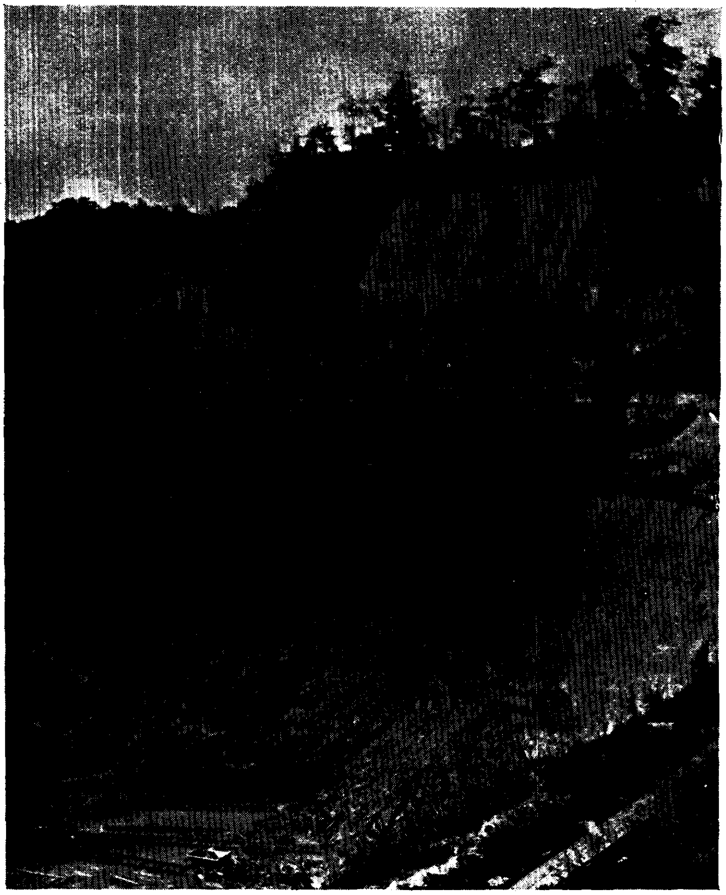
Of this member only the upper ten feet is exposed in the bottom of the Don quarry. The thickness is quite conjectural but it is probably considerable, as no exposure is known between the Don quarry and the Rouge river, 15 miles to the east. The rock is typical blue shale with a minimum of hard bands.

The most striking positive features are the presence of great numbers of different species of *Whitella* and the occurrence of *Mastigograptus gracillimus*. Negatively, the member is defined from that above by the practical absence of *Plectambonites sericeus*, *Hallopora dalei subalta*, and *Hallopora onealli danforthensis*, the three most typical fossils of the Davenport member. The commonest and most characteristic fossils are as follows:—

	Recorded elsewhere
Cuneamya scapha brevior	Quebec
Colpomya faba pusilla	Pulaski, Quebec
Clidophorus planulatus	Wide range
Archinacella pulaskiensis	Pulaski
Actinoceras crebriseptum	Pulaski
Modiodesma modiolare	Pulaski, Maysville (?)
Isotelus maximus	Wide range
Mastigograptus gracillimus	Economy
Bythopora arctipora	Eden
Byssonychia radiata	Wide range
Dalmanella rugostriata	New species
Whitella goniumbonata	Quebec
Whitella acutiumbonis	New species
Whitella lata	New species
Whitella parksi	New species
Whitella impressata	New species
Whitella radiata	New species
Prasopora donensis	New species

The eastern character of this member is clear, and it has decided affinities with the Pulaski of New York. While *Mastigograptus gracillimus* is a western type, it is represented in the Utica of New York by *M. tenuiramosus*, from which it can scarcely be differentiated.

While some of the species of *Whitella* are confined to this horizon, others occur sparingly in the overlying Danforth member; the large forms *W. hindi* and *W. torontonensis* are not found here. The genus *Whitella* seems to have been distributed widely in Black River and Trenton time but is rare in the Pulaski, Lorraine, or Maysville. In the west, however, it recurs in some abundance in the Richmond. It is very significant, also, that Foerste found a strong *Whitella* fauna with some identical species in the Province of Quebec, more particularly on the Rivière des Hurons. There, however, the association is with species that occur at much higher levels at Toronto. It would appear that the Toronto basin contained survivors of the earlier Whitellas which did not gain access to either the New York or Ohio basins; and that they developed here and migrated eastward to Quebec and westward to Ohio, appearing in those localities in Richmond time



Glacial and interglacial beds overlying shales of the Dundas formation in the Don Valley brick yards, Toronto.

Danforth Member

Plectambonites sericeus zone

Fifty-three feet of strata above the Rosedale member in the Don quarry and a few feet of still higher beds on the Don river above the quarry are the only exposures of this member in the vicinity of Toronto.

The rock of the member is chiefly blue shale, seldom silty or sandy, with numerous thin, hard layers of limestone but with few layers or lenses of the sandstone type.

While certain of the fossils are more numerous at fixed levels, we have not been able to establish any constant difference whereby the member can be subdivided; it seems to be a single and fairly uniform faunal zone.

The index fossils of the member, sharply differentiating it from the Rosedale below and the Humber above, are *Plectambonites sericeus*, which occurs in enormous numbers, *Hallopora dalei subalta*, and *Hallopora onealli danforthensis*.

The following list contains the more characteristc species of the Danforth member. Long-range species and those common with the Humber member are omitted.

	Recorded elsewhere
Prasopora donensis	Rosedale
Stigmatella vulgaris	New species
Arthropora shafferi	Bellevue, Corryville
Atactopora maculata	Fairmount
Chiloporella flabellata	Corryville
Hallopora dalei subalta	New variety
Hallopora onealli danforthensis	New variety
Leptaena rhomboidalis *cf.* invenusta[1]	
Plectambonites sericeus	Wide range
Plectambonites rugosus	Economy, Southgate
Trematis millepunctata	Maysville, Richmond
Whitella impressata	Rosedale
Cymatonota pholadis	Pulaski, Maysville
Rhytimya colemani	Rosedale
Glossograptus sp.	
Dendrograptus sp.	
Inocaulis yorkensis	New species
Climacograptus putillus	Wide range
Climacograptus *cf.* typicalis	Wide range
Cryptolithus tessellatus	Pulaski, Maysville
Dalmanella rugostriata	Rosedale
Conularia formosa	Maysville, Richmond

Some species of the above list are survivals from the Rosedale; the others are essentially western, *i.e.*, the *unique* species of the Danforth suggest a correlation with the lower part of the Maysville and with the Eden of the Ohio basin. On the other hand, the long-range species, and those common with the Humber member (not included in the list) are either Pulaski in their affinities or known to occur in both the New York and the Ohio basins. It would appear, therefore, that the Danforth represents the incursion of western species into a sea containing essentially a Pulaski fauna, or better, the coming into this region of a sea in which Pulaski and Maysville types had already become mixed.

Humber Member

The Humber member has an observed thickness of 256 feet, but the total is probably considerably greater as the contact with the Danforth member is hidden under the thick mantle of drift which covers the site of the City of Toronto. Almost continuous exposures are presented by the banks of the Humber river from Lake Ontario to Weston, a distance of about six miles. Immediately west of the river, near the crossing of the Dundas road, is the excavation known as the old Lambton shale pit which exposes the highest strata in the immediate vicinity of Toronto (243 to 262 feet above bottom of Don quarry; 361 to 380 feet above sea level). Farther west, exposures are to be seen in the valleys of Mimico and Etobicoke creeks and at various pits from which shale is quarried for brick-making. The most westerly exposures occur on the lake shore near the mouth of the Credit river, at a large quarry which is sunk to a depth of 12 feet below lake level, and at a few points on the lower stretch of the river.

[1]This form is ascribed by Foerste to *Leptaena moniquensis* in a publication which appeared just as this was going to press. See Mem. No. 138, Geol. Surv. Can., 1924.

The rock throughout shows a preponderance of bluish shale which, however, varies in the amount of fine sandy matter and passes into considerable bands of greenish-yellow color which might be described as argillaceous silt. The silty material increases in amount with the higher levels of the member and, throughout, it is far more abundant than in the Danforth or Rosedale members. Consequent on the presence of more fine sandy matter in the sediments, there is a greater number of hard sandstone bands. The peculiar, tortuous, calcareo-arenaceous structures already referred to are much more common than in the lower members; they occur generally in the more silty types of shale and are probably to be regarded as portions of the shale hardened by the infiltration of carbonate of lime. Throughout the member, highly fossiliferous limestone bands are common; these are somewhat more continuous than the sandstone lenses, but none were found sufficiently extended to serve as the basis of measurement for strike and dip.

No table can be constructed to show the actual succession of strata through the Humber member. The various elements are too local in their horizontal extent to make this possible. Cases are known, within the area of a single quarry, in which the workings have to be abandoned on one side on account of a preponderance of hard layers while another side presents a face of almost continuous shale. The strata along the Humber have been carefully levelled instrumentally, and the figures corrected for dip. The following table will give a fair idea of the general succession, but, as shown in the case of overlaps, the strata of a given level may vary greatly in different places.

STRATA OF THE HUMBER MEMBER AS EXPOSED ON THE HUMBER RIVER

	Thickness	Stratigraphic elevation above bottom of Don quarry
Exposure at Weston, west side of river:	feet	feet
Yellow silty shale, no hard layers, few fossils	10	220–210
Bluish shale, many fossils	2	210–208
Sandy shale, few fossils	3	208–205
Shale with hard layers, *Plectambonites sericeus*	3	205–202
Limestone layer with *P. sericeus*	0.2	202–201.8
Dark blue shale, many fossils	1	201.8–200.8
Yellow fissile shale, no fossils	1.8	200.8–199
Thin limestone and thick sandstone, *P. sericeus*	1	199–198
Greenish silty shales, no fossils	1	198–197
Shale with thick hard layers	2	197–195
Yellowish silty shale	5	195–190
Exposure at Weston, east side (lower):		
Hard bluish shale with bands of limestone	5	190–185
Shales with limestones along river bed	3	185–182
Shales with sandy and limey layers, *Actinoceras*, *Byssonychia*, *etc.*	3	182–179
Shale without fossils	2	179–177
Hard shale, few fossils; thick limestone, shale with fossils below	5	177–172
Exposure at Humbervale quarry:		
Bluish grey shales with hard layers and silty bands	15	201–186
Hard sandy layer with limestone full of fossils at bottom	2	186–184
Shale with thin hard layers of sandstone and limestone	6	184–178
Exposure at Humbervale mill-race:		
Bluish grey shales with few hard bands	7	196–189
Hard sandstone layer in two or three beds	3	189–186
Shale with hard sandy and limy layers	10	186–176
Exposure at railway bridges (lower part):		
Heavy layer, possibly same as in mill-race and quarry. Actual level of surface here, mill-race, quarry, respectively, 316.1, 339.5, 342.86	1.5	183–181.5
Grey shales, silty in places, hard bands	17	181.5–164.5
Persistent hard layer of limestone to water level	0.5	164.5–164

Exposure on west side of river below Lambton bridge:		
Shale with numerous hard layers	3	178–175
Limestone layer	1	175–174
Shale with hard layers	2	174–172
Greenish silty shale without fossils	3	172–169
Bluish shale with many fossils	3	169–166
Unexposed interval, elsewhere shales with hard bands	8	166–158
Layer with numerous *Rafinesquina mucronata*	0.5	158–157.5
Shale and limestone layers to water	1.5	157.5–156
Exposure on west side of river near old mill:		
Shale with thick hard sandy layers,	7	182–175
Heavy limestone layer with *Zygospira erratica*	1	175–174
Shale with thin hard layers sparingly fossiliferous	27	174–147
Limestone with many brachiopods	1	147–146
Shale with thin hard bands, gastropod zone at middle	5	146–141
Exposure on east side at Bloor street and below:		
Thick argillaceous sandstone with *Rafinesquina alternata*	2	153–151
Shale with thin hard layers of both kinds, few fossils	14	151–137
Sandy layer with *Diplograptus vespertinus*	0.5	137–136.5
Shale with thin hard layers	6.5	136.5–130
Sandy layer with *Diplograptus vespertinus*	0.5	130–129.5
Shale with fossils	1.5	129.5–128
Thin layer crowded with crinoid columnals	......	....
Shale with thin hard bands	3	128–125
Level of Lake Ontario, 246 feet above sea	......	125

The strata in the Lambton shale pit lie at a higher level both actually and stratigraphically than any of the outcrops on the Humber river. The actual elevation is from 361 to 380 feet above sea level. According to the strike and dip which we have established as approximately correct, this corresponds to an elevation stratigraphically above the bottom of the Don quarry of from 243 to 262 feet, leaving an unrecorded interval between the bottom of the shale pit and the highest strata at Weston of 23 feet.

The rock in this exposure is the usual alternation of shale with various hard bands. The upper three feet is greatly weathered and is rusty in appearance; there is a pronounced hard layer of 10 inches in thickness at the top. Beneath this are 11 feet of shale with some hard bands followed downwards by a thick limestone layer of characteristic rusty appearance. At the bottom occur four or five feet of shale with a few hard bands.

The layer of rusty limestone referred to above is unusually continuous showing all around the quarry. It was thought that some information as to the dip might be obtained from this layer; in consequence, it was carefully levelled as well as the floor of the quarry which seems to be a stratigraphic level. The results follow:—

LEVELS IN LAMBTON SHALE PIT

	Top of limestone layer, feet above sea level	Floor of quarry, feet above sea level
East side of pit	365.8	......
Northeast side of pit	365.35	360.67
North side	367.40	360.83
North, 25° west side	365.80	361.02
Northwest side	368.0	361.22

These figures can be of local significance only; they indicate an irregular surface with a general southerly dip. The lowest level on the northeast side is directly at variance with the accepted dip to the southwest.

The chief exposures on Mimico creek are at the crossing of Queen street and at a point about a half mile above. Twenty feet are exposed at the bridge, chiefly shale. The section above shows in descending order: soft, fissile, greenish, silty shale without fossils, 15 feet; shale with many hard bands and numerous fossils, 10 feet. The soft fissile shales without fossils overlying the blue fossiliferous shale suggest the section at Weston. If these two exposures are correlated, the dip is somewhat less than 20 feet to the mile.

The chief exposures on the Etobicoke are at and above the bridge on the road between concessions II and III of the township of Etobicoke. A section of about 30 feet is exposed. The lower 18 feet are chiefly shale and the upper 12 feet, shale with more numerous thin, hard bands of both kinds. Much of the shale is silty and fossils are few. The limestone bands are full of the broken shells of brachiopods, but fairly complete shells of *Actinoceras* are found.

Two quarries are now being worked near New Toronto: Prison Farm quarry and the quarry of the Booth Brick Company. The actual elevations of the sections are respectively 298.52 to 320.56 feet and 308.64 to 334.86 feet above sea level. Stratigraphically, the former represents a section from 245 to 267 feet above the bottom of the Don quarry. The rock in both quarries is a somewhat sandy shale with few fossils and many hard bands of both kinds.

The limestones are richly fossiliferous with great numbers of *Actinoceras crebriseptum*, *Modiolopsis ovata*, *M. concentrica*, and *Whiteavesia pholadiformis* mingled with numerous fragments of *Isotelus maximus*.

The most westerly exposures of the Humber member are on the Credit river near its mouth. The following section was measured by Dr. Dyer:—

HUMBER MEMBER ON CREDIT RIVER

	Thickness	Stratigraphic level
	feet	feet
Brownisn shales, nodular, no fossils	74	381-307
Shales with limestone bands, ripple marked	26	307-281

Faunally, the Humber member is distinguished from the underlying Danforth member in three ways: the total disappearance of some species, the occurrence of new species, and the difference in relative development of others.

The more typical fossils of the Humber member, omitting those of long range and those common with the Danforth, are listed below:—

TYPICAL FOSSILS OF THE HUMBER MEMBER

	RECORDED ELSEWHERE
Arthraria biclavata	Maysville
Byssonychia alveolata	Corryville
Clidophorus *cf.* faberi	Richmond
Clidophorus obliquus	New species
Ctenodonta *cf.* cingulata	Richmond
Cymatonota lenior	Quebec
Cymatonota parallella	Pulaski, Maysville
Dermatostroma scabrum	Maysville, Richmond
Diplograptus foliaceus vespertinus	Manitoulin island
Leptotrypa expansa	New species
Licrophycus flabellum	Corryville
Lingula westonensis	New species
Liospira helena	Richmond
Mesotrypa distincta	New species
Modiolopsis postplicata	Quebec
Modiolopsis ovata	Pulaski
Modiolopsis striata	New species
Modiolopsis *cf.* valida	Richmond
Orthoceras lamellosum	Pulaski
Orthodesma subangulatum	Whitewater
Palaeophycus virgatus	Waynesville
Psiloconcha inornata	Bellevue, Quebec
Psiloconcha subrecta	Waynesville
Pterinea cincinnatiensis	Fairmount
Rafinesquina mucronata torontonensis	New variety
Sinuites cancellatus	Wide range
Spatiopora varians	New species
Aspidopora *cf.* areolata	Fulton
Stigmatella catenulata	Arnheim
Stigmatella personata	Waynesville
Stigmatella crenulata	Waynesville
Stigmatella intermedia	New species
Trichophycus venosum	Fairmount
Trematis ottawaensis	Trenton
Whiteavesia pholadiformis	Waynesville, Pulaski, Quebec
Whitella hindi	Local
Whitella torontonensis	New species

Certain species common to the Humber and Danforth members show a distinct difference in relative development in the two members. The chief of these are as follows:—

SPECIES MORE NUMEROUS IN THE HUMBER THAN IN THE DANFORTH

Clidophorus fabula	Eden-Richmond
Clidophorus praevolutus	Quebec
Ctenodonta *cf.* albertini	Waynesville
Ctenodonta filistriata	Eden
Ctenodonta myalta	New species
Hallopora onealli	Indian Ladder-Eden
Ischyrodonta unionoides	Pulaski, Bellevue
Psiloconcha sinuata borealis	Quebec
Rafinesquina alternata	Long range
Stigmatella clavis	Maysville
Zygospira erratica	Pulaski
Modiolopsis concentrica	Waynesville

SPECIES LESS NUMEROUS IN THE HUMBER THAN IN THE DANFORTH

Colpomys faba pusilla	Chambly
Modiodesma modiolare	Pulaski, Maysville
Trochonema umbillicatum	Trenton, etc.
Cymatonota pholadis	Pulaski, Maysville

The most obvious differences are the failure in the Humber member of the three most characteristic fossils of the Danforth, *Plectambonites sericeus*, *Hallopora dalei subalta*, and *H. onealli danforthensis* (*Plectambonites sericeus* recurs in the highest strata at Weston), the occurrence of *Rafinesquina mucronata torontonensis*, and the much greater development of *Zygospira erratica* in the limestones and of *Psiloconcha sinuata borealis* in the shales.

The Humber fauna is more extensive than the Danforth and contains more species listed as Richmond from the western basin, but a direct correlation with either the Maysville or the Pulaski does not seem to be justified.

While it seems impossible to draw sharp lines of division within the Humber member, it is, nevertheless, not difficult to separate the strata into ill-defined faunal zones characterized by the occurrence of certain species or by the relatively great development of others.

The full fauna at all levels may be ascertained from the extended table already given; it is not proposed to repeat the list but to indicate below the characteristic features of the different zones which we have been able to recognize.

1. *Zone of Diplograptus foliaceus vespertinus, 12 feet, stratigraphic level 125 to 137 feet.*—This zone is characterized by the presence of the above graptolite and by the first appearance of *Rafinesquina mucronata torontonensis*. It contains an unusual number of crinoid columnals, but most of the common fossils of the Humber member are not found. The only pelecypod at all abundant is *Clidophorus planulatus*.

2. *Zone of Rafinesquina alternata, 14 feet, stratigraphic elevation 137 to 151 feet.*—While the type fossil of the zone is by no means confined here, we have found it far more abundantly than at any other level. The graptolite of zone No. 1 fails, but the rest of the fauna is similar. Thin layers with gastropods occur and *Hallopora onealli* is common for the first time.

3. *Zone of Psiloconcha sinuata borealis, 47 feet, stratigraphic level 151 to 198 feet.*—The type fossil is not confined to the zone, but it is wonderfully abundant wherever the shales contain any organic remains. Most of the Humber species occur in this zone.

4. *Zone of recurrence of Plectambonites sericeus, 7 feet, stratigraphic level 198 to 205 feet.*—This zone is marked only by the sudden and unexpected occurrence in large numbers of *Plectambonites sericeus* which, however, shows evidences of varietal differences from the Danforth type.

5. *Stigmatella zone, 19 feet, stratigraphic level 243 to 262 feet.*—In this zone occurs a greater variety of bryozoans than elsewhere: here only, were found *Stigmatella lambtonensis*, *Leptotrypa expansa*, and *Spatiopora varians*. The other species of *Stigmatella* are represented here by a greater profusion of specimens. *Modiodesma modiolare, Modiolopsis concentrica,* as well as most of the rarer pelecypods, are absent. *Byssonychia* is common, however, and *Psiloconcha sinuata borealis* is present.

This zone is seen in the Lambton shale pit. According to the accepted dip and strike of the formation, the same zone should appear in the Prison Farm quarry: this is not the case, however, probably due to some unexplained fluctuation of the strata or to a slight error in the angle of dip.

6. *Zone of Modiolopsis ovata, 41 feet, stratigraphic level 245 to 286 feet.*—In this zone the shales contain few fossils and the total fauna is not abundant. The limestone layers, however, are crowded with *Modiolopsis ovata* and a variety or perhaps a distinct species to be ascribed to *Modiolopsis valida.* With these are associated numerous *Byssonychia, Modiolopsis concentrica, Whiteavesia pholadiformis*, and *Actinoceras crebriseptum.* Fully as abundant are the remains of the trilobite *Isotelus maximus* but in a fragmentary condition only.

The zone is typically exposed in the two quarries at New Toronto. The exposure on Etobicoke creek is included in this zone on account of the barren nature of the shales and the presence of numerous *Actinoceras, Whiteavesia, Isotelus*, and *Modiolopsis concentrica* in the limestones. *Modiolopsis ovata,* however, has not been identified with certainty from the Etobicoke.

7. *Zone of Rafinesquina mucronata torontonensis, 26 feet, stratigraphic level 281 to 307 feet.*—This zone is not sharply defined from the preceding: the figures given above show an overlap. Fossils are rare, only 17 species having been determined. The most characteristic faunal feature is the occurrence of immense numbers of *Rafinesquina mucronata torontonensis* in thin layers. It will be remembered, however, that this species occurs throughout the Humber member. *Zygospira erratica* is also common. The zone is exposed in the quarry at the mouth of the Credit river.

8. *Barren zone, 100 feet, stratigraphic level 307 to 407 feet.*—Practically no fossils are found in this zone as exposed on the Credit river. A further account is given by Dr. Dyer on page 119.

Credit Member
407 to 457 feet

This member is more fully described by Dr. Dyer on pages 120 to 129. For the present it will suffice to state that the fauna is distinctly of the Dundas rather than of the Richmond type, but that it is much impoverished. Common surviving types are *Actinoceras crebriseptum*, *Byssonychia radiata*, *Cymatonota lenior*, *Whiteavesia pholadiformis*, *Isotelus maximus*, *Zygospira modesta*, and *Modiolopsis concentrica*. The typical fossils are the two new bryozoans described by Dr. Dyer as *Stigmatella sessilis crassa* and *Hallopora onealli creditensis*.

The stratigraphic position of this member suggests a correlation with the Salmon River sandstone. The fauna, also, while by no means identical, does not make the correlation impossible.

B.—STRATIGRAPHY AND CORRELATION OF THE CREDIT RIVER SECTION

By

W. S. Dyer

Introduction

The strata exposed on the Credit river between Lake Ontario and Meadowvale, as pointed out in Part V of this series, belong in ascending order to the Humber and Credit members of the Dundas formation; the Erindale, Streetsville, and Meadowvale members of the Richmond formation; and the Queenston, a red shaly member of the Richmond, probably representing an estuarine phase of the latter formation.

With the exception of the overlying Queenston shales, the rocks consist of grey to blue or brown fissile shales with interstratified beds of harder rock which vary in composition from pure crystalline limestone to impure calcareous sandstone or arenaceous shales. The rocks indicate deposition in comparatively shallow water as attested by the ripple marks which are frequently seen, as well as by the discontinuity of the limestone and other hard layers.

The rocks of the Dundas formation, as exposed on the Credit, are very similar to those of the same formation as exposed in the Humber valley to the east and form a direct upward extension of these rocks. They are largely of shale, there being on the average one foot of hard rock to six feet of shale. The Dundas formation on the whole is much less fossiliferous than the Richmond, as many feet of shale are entirely devoid of fossils, which, nevertheless, are found in abundance in the limestone at two rather distinct horizons.

The Richmond formation rests conformably on the Dundas formation without any apparent change in the lithological character of the rocks; the faunal break, however, is distinct. The Erindale member of the Richmond is very similar lithologically to the Dundas formation, but the Streetsville member differs considerably in that it contains more limestone. The lower part of the Meadowvale is also limy, but the upper part of this member consists largely of shale.

In both formations on the Credit, very few of the fossils are found in the shale, although they nearly always occur in profusion in the limestone layers. With regard at least to the lower or Dundas formation, this paucity of fossils in the shale is rather surprising, as the similar shales on the Don and Humber rivers at Toronto are usually very rich in fossils.

The continuity of the section on the Credit river is interrupted very little. The chief unexposed interval is of 50 feet and occurs in the unfossiliferous zone of the Humber member. At this horizon, near the Mississauga golf links, the river drops very little and there are no rock outcrops.

The following table indicates the detailed subdivision of the rocks of the Credit river, together with an approximate correlation with those of the Ohio valley.

STRATIGRAPHY AND CORRELATION OF THE CREDIT RIVER ROCKS

Credit River				Ohio	
Formation	Member	Zone	Thickness	Foerste	Shideler
Richmond	Queenston		feet ??	Whitewater—Saluda	Upper Whitewater
Richmond	Meadowvale	Upper Meadow-vale *Columnaria* reef	30	Whitewater—Saluda	Saluda
Richmond	Streetsville	*Bythopora meeki* *Stromatocerium* reef *Homotrypa streetsvillensis* *Ischyrodonta miseneri*	20	Liberty	Lower Whitewater Liberty
Richmond	Erindale	Upper Erindale *Strophomena varsensis*	65	Waynesville	Waynesville
Dundas	Credit	*Stigmatella sessilis crassa*	50	Maysville	Maysville
Dundas	Humber	Unfossiliferous	100	Maysville	Maysville
Dundas	Humber	Fossiliferous	26	Maysville	Maysville

Attitude of the Strata.—It has been known for years that the Paleozoic rocks of Ontario dip in a general southwesterly direction, and various estimates have been made as to the angle of dip. Very recently, Colonel Harkness, Commissioner of Gas, Ontario, has gathered together much information with regard to this matter, based chiefly on records of well-boring, and has made a contour map of the top of the Trenton limestone in Ontario. According to this map, the dip in the vicinity of Streetsville was determined to be about 20 feet to the mile and in a direction a few degrees west of south.

There are two beds in the Richmond which can be recognized at localities some distance apart, both by their lithological character and by their fossils. One of these beds is the bryozoan reef of the Erindale member, which has been recognized on Mullet creek and on Cooksville creek, just north of stop No. 35, Toronto Suburban Railway, three and a quarter miles northeast of Mullet creek. Another bed is the limestone layer, eight feet above the reef, recognized not only by the numerous specimens of *Strophomena planumbona erindalensis* and *Strophomena varsensis* contained in it, but also by the fact that it is the uppermost layer of limestone in the *Strophomena varsensis* zone. This stratum was seen at Mullet creek and five feet above the water level at the outcrop on the west side of the river, northeast of the home of William Crozier (Section No. 10).

By means of the wye level, the exact elevations of these two beds above sea-level at the localities mentioned were obtained. From these observations the dip was determined to be in a direction S. 26° W., at the rate of 20 feet per mile. Estimates based on other distinctive beds, which could be followed down the river, such as the *Columnaria* reef in the Meadowvale member and the heavy bed of limestone in the *Homotrypa streetsvillensis* zone of the Streetsville member, bore out the accuracy of these figures. Once the dip was determined with satisfaction, the stratigraphic intervals between all the exposures on the river could be calculated, as well as the intervals between them and the exposures to the east and west.

Explanation of Composite Section.—A composite section, making use of these figures will be found on the folded page. All figures referring to level in this section and throughout the article are not elevations above the sea, but denote the position of the horizon under discussion in the above composite section, the base of which is the bottom of the quarry at the mouth of the Credit river (this horizon being taken as 234 feet above sea-level).

Dundas Formation

Humber Member

The lower 26 feet (234 to 260) as exposed in the quarry at the mouth of the Credit river at Port Credit, and for some distance above, consist of rocks which are more calcareous than usual and contain very large numbers of *Rafinesquina mucronata torontonensis*, described by Parks and Dyer from the Dundas formation of the Humber river, and *Zygospira erratica* (Hall) from the New York Pulaski.

The following fossils were found at this horizon:—

Stigmatella catenulata var. B, *Parks* and *Dyer*.
Rafinesquina mucronata torontonensis, *Parks* and *Dyer*.
Byssonychia radiata (*Hall*).
Ctenodonta filistriata, *Ulrich*.
Cuneamya scapha brevior, *Foerste*.
Ischyrodonta *cf.* unionoides (*Meek*).
Modiolopsis postplicata, *Foerste*.
Modiolopsis concentrica, *Hall* and *Whitfield*.
Pterinea demissa (*Conrad*).
Whiteavesia pholadiformis (*Hall*).
Whitella *cf.* hindi (*Billings*).
Whitella *cf.* torontonensis, *Stewart*.
Orthoceras lamellosum, *Hall*.
Isotelus maximus, *Locke*.
Glyptocrinus *sp*.
Lichenocrinus *sp*.

This fauna is very similar to that of the Humber River section to the east. Compared with the faunas of the Ohio Valley formations, it shows a mixture of typical Waynesville and Maysville types but with a much stronger leaning toward the Maysville. In view of the relative paucity of species, it seems impossible to correlate the strata with any of the divisions of the Maysville recognized in Ohio. It is to be noted also that six out of the fifteen definite species listed are unrecorded from the Ohio valley or from New York.

For a distance of 100 feet above the top of the fossiliferous zone of the Humber member, shales greatly predominate, and up to the present no fossils have been found. At some localities the shales look inviting to the collector, being of a rubbly or nodular character, and it was only after much searching that the writer gave up hope of finding fossils.

Credit Member

From the 360- to the 370-foot levels, the limy layers appear again, and several species of fossils are found, the most striking occurrence being that of *Isotelus* cf. *maximus* in large and numerous fragments, each fragment encrusted with the bryozoan *Stigmatella sessilis crassa.*

The following species occur:—

Hallopora onealli creditensis, *var. nov.*
Stigmatella sessilis crassa, *var. nov.*
Zygospira modesta, *Hall.*
Byssonychia radiata (*Hall*).
Clidophorus planulatus (*Conrad*).
Cymatonota *cf.* lenior, *Foerste.*
Ischyrodonta unionoides (*Meek*).
Modiolopsis borealis, *Foerste.*
Modiolopsis concentrica, *Hall* and *Whitfield.*
Pterinea demissa (*Conrad*).
Whiteavesia pholadiformis (*Hall*).
Whitella *cf.* hindi (*Billings*).
Whitella *sp.*
Actinoceras crebriseptum (*Hall*).
Crinoid columns.
Isotelus *cf.* maximus, *Locke.*

This fauna is very different from that of the upper part of the Humber member as seen at the exposures at the mouth of the Credit with its profusion of *Zygospira erratica* and *Rafinesquina mucronata torontonensis.*

Most of the species from the Credit member, however, are represented on the Humber river: they indicate almost equally strong affinities with the Maysville of Ohio and the Pulaski of New York, with a sprinkling of local Dundas forms. Many of the species found in the Credit member are also found in the Salmon River sandstone, and it is probable that these two subdivisions are correlatable.

From the 370- to the 380-foot levels, a small number of species is found, including *Stigmatella sessilis crassa*, *Hebertella occidentalis*, and *Zygospira modesta.* The fauna alone does not give much clue as to where these ten feet of rock should be placed, but they are included in the Credit member for reasons appearing below.

Dundas-Richmond Contact

It has been found that between the 380- and the 410-foot levels, the shales are devoid of life, but from the 410 foot level upward, the rocks again become calcareous and yield a rather large assemblage of fossils which are beyond doubt of Richmond age. This 30-foot band of barren shale forms the boundary between the Dundas and the Richmond. The contact cannot be sharply drawn, but the faunal break is distinct, comparatively few species being common to the uppermost zone of the Dundas and the lowermost zone of the Richmond.

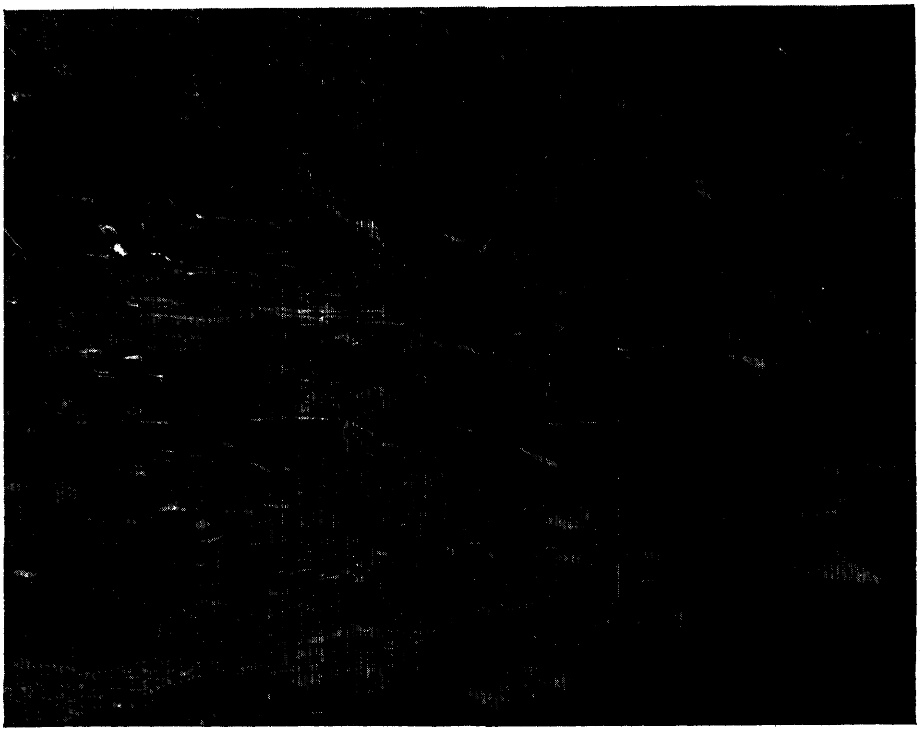
In eastern Ontario and Quebec, Foerste describes a somewhat different set of conditions. In that area the Richmond sea entered the Maysville sea very slowly, its fauna replacing the older fauna, species by species; consequently for many feet above and below the boundary the fauna is not definite, typical Richmond species such as *Catazyga headi* being found low in undoubted Maysville strata, while many Maysville species such as *Cymatonota lenior*, *Clidophorus planulatus*, and *Cuneamya scapha brevior*, range high up into the Richmond.

Richmond Formation

Erindale Member

The first fossiliferous rocks, after the barren zone marking the boundary of the Dundas and the Richmond is passed through, are also shales of the same character as the shales of the Dundas formation, but containing *Strophomena varsensis* and numerous examples of *Hebertella occidentalis*.

Zone of Strophomena varsensis.—The shales referred to above mark the base of the *Strophomena varsensis* zone, which forms the lower part of the Erindale member. Above, calcareous bands become more common and *Strophomena varsensis* much more abundant, and at the 420-foot level a bryozoan reef occurs. This reef is one of the most characteristic beds in the whole Credit River section.



An exposure of Erindale shale and sandstone on the Credit river near Streetsville.

It consists of compact crystalline limestone, varying in thickness from four to 18 inches. In places it forms a single massive stratum, while at other places, usually where it is thickest, it is separated into two or three strata by thin layers of shale. It is full of *Heterotrypa definita*, a species of *Bryozoa* herein described as new. This species is easily recognized in the field by its robust branching zoaria and by the fact that the surfaces are covered with well-marked maculae. It is almost confined to the reef, only a few specimens having been found at any other level. *Heterotrypa prolifica*, Ulrich, and *Stigmatella hybrida*, another new species, are confined to the reef but are much less abundant than *Heterotrypa definita*. Eight feet above the reef, at the 428-foot level, the stratum of limestone which marks the top of the zone of *Strophomena varsensis* makes its appearance. This layer is filled with *Strophomena planumbona erindalensis. Strophomena varsensis* is also common, as well as young forms of *Catazyga headi.*

In addition to the fossils already mentioned, the following species occur rather abundantly in the limestone of the zone. *Hallopora onealli creditensis, Hebertella occidentalis, Rafinesquina alternata,* and *Rafinesquina alternata subcircularis.*

There seems to be very little doubt that the rocks of the above zone represent a time equivalent to the Waynesville of the Cincinnati basin. Foerste first found *Strophomena varsensis* in the Cincinnatian area east of Ottawa and has recorded it in an unpublished manuscript on the fossils of that area. He states that the nearest approach to this species can be seen in the Blanchester division of the Waynesville of Ohio. The variety *Strophomena planumbona erindalensis* differs only slightly from the type form of the species from the Waynesville of Ohio, and *Catazyga headi* of the Erindale member is also represented in that state by the variety *Catazyga headi schuchertana.*

Upper Erindale.—Above the zone of *Strophomena varsensis,* the rocks greatly resemble those of the lower members of the Dundas formation as seen at Toronto. Limestone layers are few and far between, and the fossils are less abundant than in the lower part and are of less determinative value.

The fauna is made up of long-ranging forms, such as *Whiteavesia pholadiformis, Pterinea demissa, Byssonychia radiata,* and *Modiolopsis concentrica,* mingled with a few other species which are characteristic of the Richmond as a whole, but which are of very little use in more detailed correlation, such as *Homotrypella hospitalis, Hebertella occidentalis,* and *Rafinesquina alternata subcircularis.* Only two species typical of the Waynesville are present, *Stigmatella crenulata* and *Platystrophia clarkesvillensis,* and of these the former is represented on the Humber by a form which was described as *S. crenulata* by Parks and Dyer but which more correctly should be known as a variety of *S. crenulata. Platystrophia clarkesvillensis* on the Credit river ranges up into the Meadowvale member.

Correlation.—While the relationships of the Erindale are with the Waynesville of Ohio and Indiana, nevertheless great differences are noticed. Many of the most characteristic Cincinnati forms have not been found on the Credit, such as *Dalmanella meeki,* which gave the original name "*Dalmanella meeki zone*" to the Waynesville, *Hebertella insculpta, Protarea vetusta, Streptelasma divaricans, Rhynchotrema dentata,* and *Batostoma prosseri.* In addition, five new species of *Bryozoa* and one new species of *Brachiopoda* are found on the Credit, and one brachiopod shows varietal differences from a related Ohio form.

Streetsville Member

Zone of Ischyrodonta miseneri.—The lower beds of the Streetsville member (from the 475- to the 480-foot levels) consist of argillaceous limestone, varying from six to 18 inches in thickness, separated by narrower bands of shale, and characterized by the occurrence of *Ischyrodonta miseneri* and *Byssonychia robusta.* The following fossils also occur: *Hebertella occidentalis, Platystrophia clarkesvillensis, Byssonychia grandis, Ortonella* cf. *hainesi, Opisthoptera fissicosta,* and *Bellerophon* cf. *mohri.*

Zone of Homotrypa streetsvillensis.—From the 480- to the 489-foot level, the rocks are still calcareous; and at the 483-foot level, there is a massive bed of limestone, 18 inches to two feet in thickness, which can be followed for some distance down the river and which was of use in the determination of the dip of the strata. *Homotrypa streetsvillensis* is very abundant, and the lower three feet are practically composed of its ramose zoaria. *Homotrypa creditensis*, *Homotrypa communis*, and *Homotrypa* cf. *richmondensis* also occur but are much less abundant. Numerous specimens of *Stigmatella incrustans* were found incrusting the shells of brachiopods and pelecypods and also the zoaria of other *Bryozoa*. Other species are: *Heterotrypa simplex*, *Heterotrypa robusta*, *Stigmatella interporosa*, *Amplexopora solitaria*, *Monticulipora parasitica multipora*, *Mesotrypa patella*, *Hallopora aequalis*, *Hebertella occidentalis*, *Platystrophia clarkesvillensis*, and *Zygospira modesta*.

Stromatocerium Reef.—From the 489-foot level to the 492-foot level, *Stromatocerium huronense* is sufficiently abundant to form a reef. Many specimens measuring one foot in diameter are found. The corals *Columnaria alveolata*, *Columnaria calicina*, and *Tetradium approximatum*, and the bryozoans *Heterotrypa simplex*, *Hallopora maculosa*, and *Homotrypella hospitalis peculiaris*, are also present.

Zone of Bythopora meeki.—Above the *Stromatocerium* reef and continuing to the top of the member, the rocks consist of thin bands of limestone, weathering to a buff colour, alternating with shale and arenaceous shale, the latter showing good ripple marks. Numerous specimens of *Bythopora meeki*, *Heterotrypa simplex*, *Heterotrypa simplex maculosa*, and *Hallopora onealli creditensis*, and occasional specimens of *Atactoporella densa*, *Homotrypella dubia*, *Homotrypella hospitalis*, *Hebertella occidentalis*, *Batostoma* cf. *varians*, and *Byssonychia grandis* are found.

Correlation.—The Streetsville member is the best-defined subdivision on the Credit, 23 out of its total of 40 species being confined to it. The problem of correlating it with any of the subdivisions of the typical section in Ohio has, however, presented some difficulties, as the fauna of the Streetsville includes elements of several of the Ohio subdivisions. Before proceeding further, however, in the faunal discussion, it should be explained that Shideler differs from the majority of the workers on the Richmond in that he divides the Upper Liberty of other authors into two parts by the *Gyroceras baeri* bed, calling the upper part Lower Whitewater, and the lower part Upper Liberty. The Whitewater of other authors thus becomes the Upper Whitewater of Shideler. On the basis of Shideler's tables, we find that three Streetsville species are Upper Whitewater forms: *Ortonella* cf. *hainesi*, *Bellerophon* cf. *mohri*, and *Homotrypa* cf. *richmondensis*, while a fourth, *Homotrypa streetsvillensis*, a new species exceedingly abundant in this formation, is very like *Homotrypa austini*, an Upper Whitewater form. According to Shideler, four of these species listed from the Streetsville range in Ohio from the Upper down into the Lower Whitewater: *Ischyrodonta miseneri*, *Byssonychia grandis*, *Byssonychia robusta*, while a fourth, *Monticulipora parasitica multipora*, a new variety from the Streetsville, is probably identical with the form listed as *Monticulipora parasitica* from the same horizon in Indiana. One species, *Eridotrypa* cf. *simulatrix*, ranges in Ohio from the Lower Arnheim to the Lower Whitewater, and another species *Stigmatella incrustans*, which is comparatively abundant in the *Homotrypa streetsvillensis* zone, is confined to the Liberty in Indiana. Again, according to Shideler, three Streetsville species range from lower horizons up into the Lower Liberty: *Opisthoptera fissicosta*, *Homotrypa communis*, and *Batostoma* cf. *varians*. Three species are characteristic of lower horizons than the Liberty: these are *Homotrypella dubia* and *Stigmatella interporosa*, both of the Lower Arnheim, and *Platystrophia clarkesvillensis*, of the Blanchester division of the Waynesville. The latter species, however, ranges up into the Meadowvale on the Credit. The remaining species are either new or long-ranging.

It will be seen from the above analysis of the fauna that the closest relationships are with the Liberty as defined by the majority of authors or with the Liberty and Lower Whitewater of Shideler.

Although the relationships of the Streetsville are as stated above; nevertheless, the member differs greatly from the Liberty of Ohio. The predominant fossils of the former are *Bryozoa*, and of the latter *Brachiopoda*. Many of the characteristic fossils of the Liberty are entirely absent from the whole Credit River section, such as *Dinorthis subquadrata*, *Plectambonites sericeus*, *Rhynchotrema capax*, *Strophomena planumbona*, and *Amplexopora granulosa*. In addition, the Streetsville member has yielded eight new species and three new varieties which are almost entirely confined to it.

In connection with the fauna of the Streetsville, it must be stated that Dr. E. O. Ulrich, in a letter to the writer, records the occurrence of *Modiolopsis valida* associated with *Opisthoptera alternata* and *Modiolopsis concentrica*. No examples of *Modiolopsis valida* were found at this horizon, but Dr. Ulrich identifies the species from the Prison Farm quarry in strata which are ascribed to the Humber member of the Dundas formation.

Meadowvale Member

Columnaria Reef.—The Meadowvale member begins with the conspicuous *Columnaria* reef, in which *Columnaria alveolata*, *Tetradium approximatum*, and *Stromatocerium huronense* are very abundant. *Columnaria calicina* is also present but is not so abundant as the foregoing species. *Tetradium approximatum* assumes at times very large proportions, one specimen being found with a diameter of 18 inches. In addition to the above coelenterates, the two bryozoans, *Rhombotrypa quadrata* and *Constellaria polystomella*, are very abundant. It is strange that these two species, which in other areas are found in nearly all of the divisions of the Richmond, should be found only at this horizon on the Credit. The following fossils, also, are found in the *Columnaria* reef: *Hallopora* cf. *onealli*, *Homotrypella hospitalis*, *Hebertella occidentalis*, *Platystrophia clarkesvillensis*, *Zygospira modesta*, *Byssonychia* sp., *Opisthoptera fissicosta*, *Lophospira bowdeni*, *Lophospira tropidophora*, *Cyclonema* sp., and an indeterminable species resembling *Fenestella*. Foerste lists from this horizon *Calapoecia cribriformis* and small specimens of *Streptelasma rusticum*. The reef varies in thickness from 18 inches to five feet and consists chiefly of limestone, but thin bands of shale are also present, and in many cases the corals lie embedded in shales.

Upper Meadowvale.—From the reef to the top of the section, the rocks are chiefly shale with a few beds of limestone and arenaceous limestone and shale. The fossils occurring in these upper layers are: *Hebertella occidentalis*, *Platystrophia* cf. *clarkesvillensis*, *Rafinesquina alternata*, *Rafinesquina alternata subcircularis*, *Zygospira modesta*, *Homotrypella hospitalis*, *Clidophorus fabulus*, *Byssonychia* sp., *Modiolopsis concentrica*, *Opisthoptera* cf. *fissicosta*, *Pterinea demissa*, and *Whiteavesia pholadiformis*.

There is only one horizon above the *Columnaria* reef worthy of special mention and that is at the 525-foot level at the very top of the section. Here there are a few beds of limestone in which *Hebertella occidentalis* is exceedingly abundant. *Platystrophia clarkesvillensis*, indeterminable species of *Modiolopsis* and *Byssonychia*, and casts of *Bryozoa* are also found.

Correlation.—There is nothing very diagnostic about the fauna occurring in the Meadowvale, but what there is points to a relationship with the Saluda or Whitewater. The *Columnaria* reef is an important paleontological horizon since it marks the disappearance of the greater part of the Streetsville fauna. Foerste says that *Columnaria alveolata*, which is so abundant in the *Columnaria* reef, is most abundant at the base of the Saluda in Ohio. *Columnaria calicina*, which is more abundant in the reef than at any other horizon, is most abundant in the Saluda, although it occurs in most of the Richmond members in other areas. The Meadowvale member resembles the lower part of the Whitewater section on Manitoulin island from the Gore Bay reef to the Mudge Bay reef, but the upper part of the Whitewater of Manitoulin, with its ostracod fauna and characteristic Whitewater species, is missing.

Comparison of the Credit River Section with the Manitoulin Section

In comparing the Credit River section with the Manitoulin Island section, many differences will be noticed. In the first place, the upper part of the Whitewater of Manitoulin with its typical ostracod fauna is entirely missing from the Credit river. In the second place, on Manitoulin, the Gore Bay coral reef and the Mudge Bay *Stromatocerium* reef above are separated by practically unfossiliferous strata, the whole being included in the Whitewater. On the Credit, the *Stromatocerium* reef is below and is separated from the coral reef by four feet of limestone and shale containing a bryozoan fauna which is distinctly lower than Whitewater in aspect. The *Stromatocerium* reef itself contains species of bryozoans which are characteristic of the Liberty or even lower horizons. The *Stromatocerium* reef on the Credit is, therefore, distinctly lower than Whitewater; in this report it is included in a member which is correlated with the Liberty. In the above discussion, the terms Whitewater and Liberty are based on Foerste's classification of the Richmond formation.

Many fossils which are abundant in the rocks below the Gore Bay reef on Manitoulin island are entirely missing from the Credit River section, such as *Hebertella insculpta*, *Protarea papillata*, *Plectambonites sericeus*, *Rhynchotrema perlamellosa*, *Rhynchotrema capax*, *Strophomena nutans*, *Crania scabiosa*, and *Strophomena neglecta*.

Apart from the bryozoans, which have not been studied on Manitoulin, the fauna of that island is richer than the fauna of the Credit river. A careful investigation of the *Bryozoa* of Manitoulin should yield a correspondingly large number of species.

It would appear from a study of Foerste's report on the Manitoulin section that no rocks equivalent to the Streetsville or Liberty members were laid down on that island. No mention is made of a more calcareous part and the occurrence of numerous bryozoans which are the outstanding features of the Streetsville. The zone of *Strophomena sulcata* and *S. planumbona* runs practically as far up as the Gore Bay reef leaving very little room for another member; while on the Credit, the highest occurrence of any of the strophomenoids is 65 feet below the *Columnaria* reef marking the base of the Meadowvale. It appears, however, that no study of the Ontario Richmond localities can be satisfactory without a study of the *Bryozoa*.

Comparison of Eastern Canadian Sections with the Section on the Credit River

The differences between the Richmond of the island of Anticosti and of the Credit river are very marked. Very few Anticosti species occur on the Credit river with the exception of certain very wide-spread corals, such as *Columnaria alveolata*, *Calapoecia cribriformis*, and *Streptelasma rusticum*. Another great difference is the almost total absence of trepostomatous bryozoans in Anticosti.[1]

Farther west we find that the sections at Nicolet river and adjoining localities in western Quebec and eastern Ontario resemble somewhat more strongly the Credit River section, but even here the differences are still marked. In the first place, the coral reef is missing from the former sections, and one passes directly upward from strata equivalent to the Waynesville into the red Queenston shales. In the second place, the Anticosti brachiopods, *Strophomena hecuba*, *Strophomena fluctuosa*, and *Rhynchotrema perlamellosa*, which are so abundant in western Quebec, are missing from the Credit river. Foerste does describe a stratigraphic interval in the Nicolet River section which more or less corresponds with the *Strophomena varsensis* zone of the Credit. This interval consists of the rocks from 76 feet to 156 feet below the base of the Queenston. In the upper part of the interval, *Strophomena sulcata* (or *S. varsensis*) is common, and in the lower 100 feet *Strophomena planumbona* is common. Associated with the latter species at various levels are *Catazyga headi*, *Heterotrypa prolifica*, and *Hallopora subnodosa*, which also are associated with it on the Credit. A study of the *Bryozoa* from the upper levels of these eastern regions may bring to light a fauna corresponding to that of the Streetsville member.

Detailed Description of Sections on the Credit River with Complete Faunal Lists

Port Credit, which is at the mouth of the Credit river and near which the lowest exposure on the river is situated, is reached directly by the cars of the Toronto and York radial railway; it is not more than a forty minutes' journey west of the city limits. The exposure which is about a mile west of the terminus of the radial must be reached on foot. It is here that the rocks of the Humber member are seen.

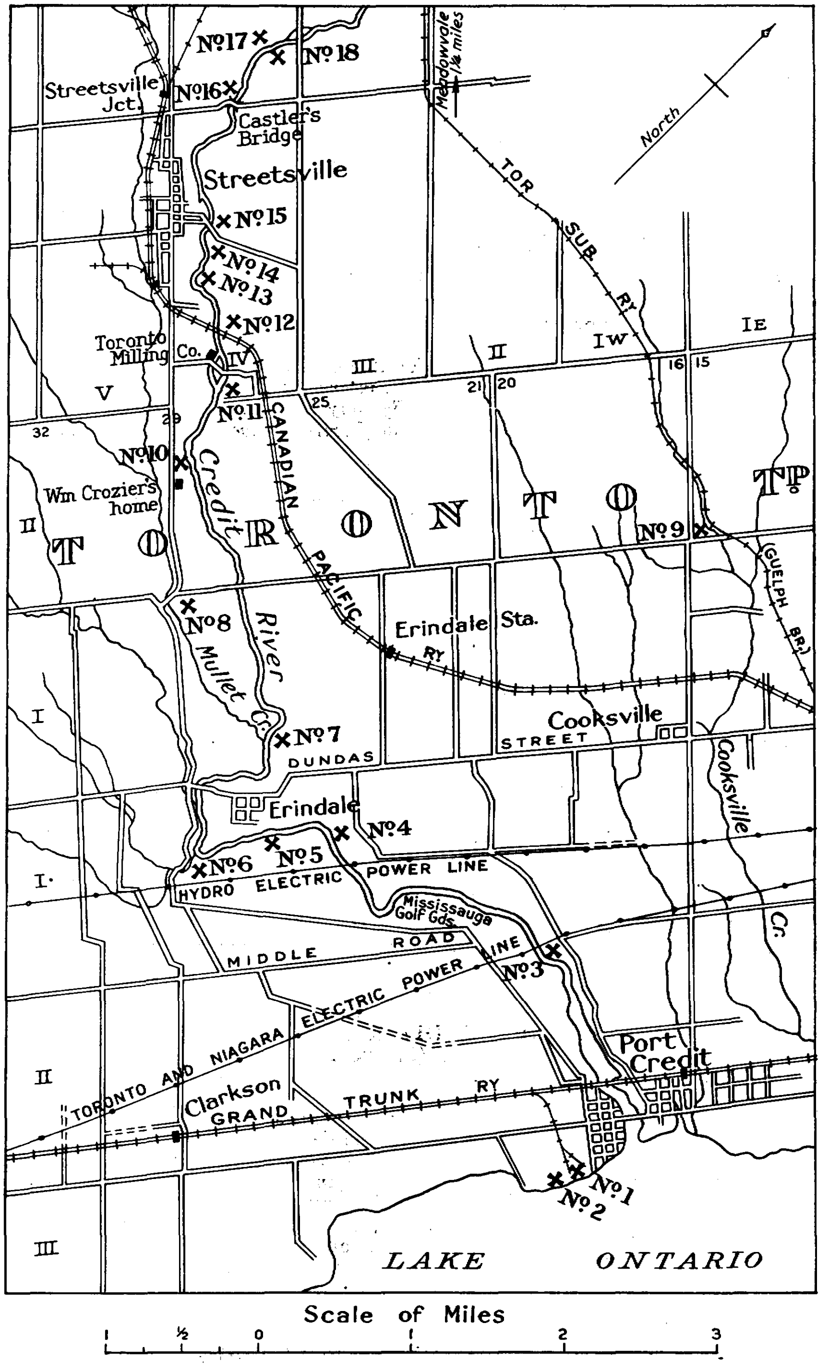
The village of Streetsville, about six miles up the river from Port Credit, is reached directly by the Canadian Pacific railway. Section No. 14, where the Streetsville member of the Richmond and its included bryozoan fauna can best be seen, is directly opposite the middle of the village. The *Stromatocerium* reef and the *Columnaria* reef can also be seen here, but the latter is better exposed immediately above Castler's bridge, a little more than a mile farther up the river.

The outcrops of the *Strophomena varsensis* zone at the base of the Erindale member of the Richmond with its bryozoan reef are not so accessible. This zone can best be studied at Section No. 8 on Mullet creek which flows into the Credit river one mile northwest of Erindale, the latter village being about two miles south of the station of the same name on the Canadian Pacific railway.

A detailed account of the various sections exposed on the Credit river with complete faunal lists follows.

The base of the whole series, at the bottom of the quarry near the mouth of the river, is 234 feet above sea-level; the figures given with each section, indicate the position in a vertical column above this datum level, not the actual elevation above sea-level.

[1]Schuchert and Twenhofel, Bull. Geol. Soc. Amer., Vol. 21, No. 4, p. 700.



Sketch map of the lower Credit river, showing location of outcrops described in detail in the text.

SECTION No. 1.—QUARRY AT PORT CREDIT (234 TO 251)

HUMBER MEMBER:	THICKNESS feet
In descending order:—	
(3) Grey to blue, fissile shales with limestone bands near the top. Sandy layers in places. In the limestone bands the following fossils occur: *Zygospira erratica* (abundant), *Zygospira modesta*, *Rafinesquina mucronata torontonensis* (abundant), *Byssonychia radiata*, *Modiolopsis concentrica*, *Whiteavesia pholadiformis*, *Ctenodonta filistriata*, *Whitella* cf. *torontonensis*, *Whitella* cf. *hindi*, *Modiolopsis posplicata*, *Pterinea demissa*, *Lophospira* sp., *Glyptocrinus* sp., *Isotelus* sp.	5
(2) Grey, unfossiliferous, fissile shale with a few bands of impure argillaceous sandstone and one band of limestone with *Byssonychia radiata*, *Modiolopsis* sp., *Isotelus* (fragments), *Zygospira modesta*	4
(1) Grey, unfossiliferous shale with a few bands of hard, argillaceous sandstone, extending to the bottom of the quarry which is 12 feet below the level of Lake Ontario. In one band of limestone six feet above the bottom of the quarry, the following fossils were found: *Zygospira erratica* (abundant), *Rafinesquina mucronata torontonensis* (abundant), *Zygospira modesta*, *Ischyrodonta* cf. *unionoides*, *Byssonychia* cf. *radiata*, *Modiolopsis* sp., *Pterinea demissa*, *Whiteavesia pholadiformis*, *Orthoceras lamellosum*	8

The bottom of Section No. 1 is at the same level as the top of the section, exposing the highest strata of the Dundas formation east of the Credit river, namely, the Prison quarry at New Toronto. The Humber member as seen in the quarry at Port Credit is, therefore, the immediate upward extension of the Humber member as seen in sections east of the river.

SECTION No. 2.—LAKE SHORE 100 YARDS SOUTH OF SECTION No. 1 (246 TO 256)

HUMBER MEMBER:	THICKNESS feet
In descending order:—	
(2) Brownish to black shale, badly weathered at the top, fresh at the bottom, containing abundant specimens of *Cuneamya scapha brevior*; also: *Stigmatella catenulata* (*var. B.*), *Glyptocrinus* (columnals), *Lichenocrinus* (columnals), *Rafinesquina mucronata torontonensis*, *Byssonychia* sp.	4
(1) Limestone with very numerous specimens of *Zygospira erratica* and *Rafinesquina mucronata torontonensis*. The level of Lake Ontario is taken as 246 feet above sea-level	6

SECTION No. 3.—EAST SIDE OF CREDIT RIVER, ONE MILE NORTH OF PORT CREDIT (247 TO 275)

HUMBER MEMBER:	THICKNESS feet
Grey fissile shale with bands of argillaceous sandstone varying from one-half to three inches in thickness, unfossiliferous for the most part, but 13 feet above the water level, a limestone band contains the following fossils: *Zygospira erratica* (abundant), *Rafinesquina mucronata torontonensis* (abundant), *Zygospira modesta*, *Byssonychia* sp., *Pterinea demissa*, *Orthoceras* sp., *Isotelus* (fragments). The fossiliferous band represents an upward extension of the fossiliferous zone of the Humber member, while the upper 15 feet is part of the unfossiliferous zone of the Humber member.	28

SECTION No. 4.—EAST SIDE OF RIVER, TWO MILES NORTH OF SECTION No. 3 (315 TO 335)

HUMBER MEMBER:	THICKNESS feet
Grey, fissile shales with bands of argillaceous sandstone, but no limestones and no fossils. The rocks of this section all belong to the upper unfossiliferous part of the Humber member	20

SECTION No. 5.—SOUTH SIDE OF RIVER, ONE-HALF MILE DOWNSTREAM FROM SECTION No. 6 (335 TO 395 ?)

HUMBER MEMBER:	THICKNESS feet
Almost entirely shale, brown to black in colour, with a few bands of argillaceous sandstone. The shale is rubbly and looks inviting to the collector, but nothing but an indeterminable species of *Byssonychia* was found. Sixty feet above the water-level, there are some limestone beds, containing *Hebertella occidentalis*, which judging by the dip of the strata probably correspond to the rocks in Section No. 7 (Credit member), which also contain *Hebertella occidentalis*..........................	60 ?

SECTION No. 6.—ON A SMALL CREEK EMPTYING INTO THE RIVER FROM THE SOUTHWEST, ONE-HALF MILE SOUTH OF ERINDALE (360 TO 400)

CREDIT MEMBER:	THICKNESS feet
In descending order:—	
(2) Shale and argillaceous sandstone with no limestone and no fossils.	30
(1) Shale and argillaceous sandstone as above, but with a few lens-like layers of limestone containing numerous fossils. One of these beds, eight feet above water-level, is remarkable for the abundance of large fragments of *Isotelus* cf. *maximus* contained in it and for the abundance of *Stigmatella sessilis crassa* usually covering the fragments of the foregoing trilobite. This upper bed also contains: *Hallopora onealli creditensis*, *Zygospira modesta*, *Byssonychia* cf. *praecursa*, *Pterinea demissa*, *Whiteavesia pholadiformis*, *Whitella* cf. *hindi*, *Modiolopsis borealis*, *Cymatonata* cf. *lenior*, *Ischyrodonta unionoides*, *Modiolopsis* sp., *Byssonychia radiata*, *Actinoceras crebriseptum*, crinoid columns. Another bed three feet above the water-level yielded: *Zygospira modesta*, *Clidophorus*, *planulatus*, *Modiolopsis concentrica*, *Byssonychia* sp., *Isotelus* cf. *maximus*, *Stigmatella sessilis crassa*...	10

SECTION No. 7.—EAST SIDE OF RIVER OPPOSITE MOUTH OF MULLET CREEK (370 TO 390)

CREDIT MEMBER:	THICKNESS feet
Brownish to black shale with bands of argillaceous sandstone with fucoids and ripple marks. At a height of four feet above the water-level, a four-inch band of limestone contains: *Zygospira modesta*, *Byssonychia radiata*, *Modiolopsis* sp., and fragments of *Isotelus*. Six feet above the water level, another band of limestone contains a few specimens of *Hebertella occidentalis*, one small specimen of *Stigmatella sessilis crassa*, and numerous fragments of *Isotelus*. The upper unfossiliferous shales belong to the barren zone marking the boundary between the Dundas and the Richmond formations. The lower part, with fossils, is a continuation of the lower fossiliferous zone of the Credit member, as seen in Section No. 6..	20

SECTION No. 8.—MULLET CREEK (410 TO 450?)

UPPER ERINDALE:	THICKNESS feet
In descending order:—	
(6) Grey to brown and black fissile shale with bands of argillaceous sandstone, unfossiliferous...	20?
ZONE OF STROPHOMENA VARSENSIS:	
(5) Crystalline limestone, characterized by the abundance of *Strophomena planumbona erindalensis* and *Strophomena varsensis*. The elevation of the under side of this layer obtained by wye level is 401.19 feet above sea-level. *Heterotrypa* cf. *subfrondosa*, *Heterotrypa definita*, *Catazyga headi*, *Hebertella occidentalis*, *Rafinesquina alternata*, *Zygospira modesta*, *Byssonychia* sp., *Isotelus* sp., *Conularia* sp. also occur..................	½

(4) Shale with a few thin layers of limestone containing fragments of *Isotelus* sp. 8½

(3) The bryozoan reef, in places a single massive bed of limestone, at other places separated into two or three beds by thin layers of shale. It varies in thickness from six inches to 18 inches and is characterized by the abundance of *Heterotrypa definita.* Examples of *Rafinesquina alternata* are numerous and the following species also occur: *Rafinesquina alternata subcircularis, Catazyga headi, Hebertella occidentalis, Hallopora subnodosa, Hallopora* cf. *onealli, Byssonychia* sp., *Modiolopsis* sp. By wye level the under side of this reef, where it first outcrops east of the bridge over the creek, was found to be 392.77 feet above sea level. 1½

(2) Shale with thin layers of limestone and argillaceous sandstone. The limestone yielded: *Hallopora subnodosa, Rhinidictya* cf. *parallella, Hallopora onealli creditensis, Strophomena planumbona erindalensis* (abundant), *Strophomena varsensis, Rafinesquina alternata, Rafinesquina alternata subcircularis, Hebertella occidentalis, Zygospira modesta, Ctenodonta cingulata, Modiolopsis concentrica, Byssonychia* sp., *Isotelus* sp. 4½

(1) Grey fissile to brown and black, rubbly shale with: *Rafinesquina alternata, Hebertella occidentalis, Strophomena varsensis, Byssonychia radiata, Byssonychia* cf. *praecursa, Whiteavesia pholadiformis, Pterinea demissa, Lophospira tropidophora, Lophospira bowdeni, Clathrospira* cf. *subconica, Isotelus* cf. *maximus*. 4

The rocks below and above the road bridge, one mile west of the mouth of the creek, belong to Horizon No. 6 (Upper Erindale). The bryozoan reef (Horizon No. 3) is seen about 100 yards east of the bridge.

SECTION No. 9.—COOKSVILLE CREEK (394 TO 447)

THICKNESS feet

A full account of this section will not be given here, with the exception of a few features which have a bearing on the Credit River section proper. The *Strophomena varsensis* zone is well exposed and the bryozoan reef is seen approximately in the middle of the zone, just as it is in Mullet creek. By wye level, the elevation above sea-level of the under side of the reef in this section is 459.95 feet. In Cooksville creek as well as in Mullet creek, the zone is characterized by the abundance of *Heterotrypa definita. Stigmatella hybrida,* a new species, was also found. *Calloporella vacua,* another new species, was found about 10 feet below the reef. 53

SECTION No. 10.—WEST SIDE OF RIVER, NORTH OF HOME OF WILLIAM CROZIER (424 TO 447)

ERINDALE MEMBER: THICKNESS feet

In descending order:—

(3) The upper zone consists of shale with numerous layers of argillaceous sandstone varying in width from one inch to one foot. Limestone layers are rare, but two or three one-half inch slabs which evidently came from this horizon were found on the side of the cliff. They contain: *Homotrypella hospitalis, Hallopora onealli creditensis, Hallopora* cf. *onealli, Whiteavesia pholadiformis, Byssonychia* cf. *radiata*. 18

(2) The lower zone (*Strophomena varsensis* zone) consists of limestone with very abundant examples of *Strophomena varsensis*; also: *Strophomena planumbona erindalensis, Rafinesquina alternata subcircularis, Trematis millepunctata, Heterotrypa definita, Hallopora onealli creditensis, Rafinesquina alternata.* The under side of this band was determined by wye level to be 409.41 feet above sea-level. 1

(1) The lower four feet, extending to water-level, consists of fissile, grey shale, with no fossils. By wye level, the creek bed at this locality was determined to be 405.27 feet above sea-level. 4

SECTION No. 11.—EAST SIDE OF RIVER, 200 YARDS SOUTH OF BRIDGE OPPOSITE THE PROPERTY OF THE TORONTO MILLING COMPANY (436 TO 450)

UPPER ERINDALE MEMBER:	THICKNESS feet
Massive beds of hard, calcareous and arenaceous shale, separated by soft, fissile, clay shale. Three feet above the water-level there is a bed of argillaceous sandstone, showing contorted pillow structure with contemporaneous erosion of underlying beds. The following fossils were found in a limy layer about seven feet above the water-level: *Homotrypella hospitalis, Stigmatella crenulata, Zygospira modesta, Rafinesquina alternata Modiolopsis concentrica, Pterinea demissa, Byssonychia* sp., *Isotelus* sp.	14

SECTION No. 12.—WEST SIDE OF RIVER NORTH OF CANADIAN PACIFIC RAILWAY BRIDGE (460 TO 483)

STREETSVILLE MEMBER:	THICKNESS feet
In descending order:—	
(4) Alternating limestone and shale belonging to the zone of *Homotrypa streetsvillensis*. See Section No. 13 below. The bottom of the projecting, massive bed of limestone (485) was determined by hand level to be 23½ feet above the water-level.	8
UPPER ERINDALE MEMBER:	
(3) Grey, fissile shale, marking the top of the Erindale member. One bed of argillaceous sandstone contains: *Rafinesquina alternata, Stigmatella crenulata, Clidophorus planulatus, Pterinea demissa, Atactopora sp., Lophospira* sp., *Byssonychia* sp.	5
(2) Grey, fissile shale with one thin layer of limestone and a few inches of brownish-coloured shale, containing: *Hebertella occidentalis, Rafinesquina alternata, Platystrophia clarkesvillensis, Zygospira modesta, Hallopora aequalis, Hallopora* cf. *onealli, Hallopora onealli, H. creditensis, Stigmatella* cf. *lambtonensis, Byssonychia* sp., *Isotelus* sp.	5
(1) Grey, fissile shale with a few thin layers of limestone extending to water-level. The surfaces of these limestone layers are covered by the zoaria of the cryptostomatous bryozoan *Rhinidictya parallella*. Three feet above the water-level, there is a layer of argillaceous sandstone showing contorted pillow structure with contemporaneous erosion of the underlying shale.	5

In the talus at the bottom of this cliff the following species were found: *Byssonychia radiata, Rafinesquina alternata subcircularis, Platystrophia clarkesvillensis, Hebertella occidentalis, Anoptera* cf. *miseneri, Pasceolus* cf. *camdenensis*.

SECTION No. 13.—EAST SIDE OF RIVER, 600 YARDS NORTH OF SECTION No. 12 (475 TO 492)

STREETSVILLE MEMBER

STROMATOCERIUM REEF:	THICKNESS feet
In descending order:—	
(6) Clay with *Stromatocerium huronense* large and abundant, *Tetradium approximatum, Columnaria alveolata, Heterotrypa simplex*, and *Homotrypella hospitalis*	5½
(5) Thin limestone bands alternating with shale containing: *Columnaria alveolata, Stromatocerium huronense, Heterotrypa simplex, Hallopora maculosa*, and *Homotrypella hospitalis peculiaris*	¾
ZONE OF HOMOTRYPA STREETSVILLENSIS:	
(4) Thin limestone bands, alternating with shale. A few examples of *Homotrypa streetsvillensis* are found and hence the interval is provisionally included in the zone of *H. streetsvillensis*. The fauna includes: *Hebertella occidentalis, Byssonychia* sp., *Homotrypella hospitalis, Stigmatella interporosa, Monticulipora parasitica multipora, Homotrypella hospitalis peculiaris, Hallopora onealli creditensis, Platystrophia clarkesvillensis, Byssonychia* cf. *grandis, Byssonychia radiata, Lophospira* sp., *Heterotrypa simplex maculosa*	3

THICKNESS feet

(3) Massive crystalline limestone which projects beyond the face of the cliff and forms a persistent horizon-marker. Numerous examples of *Homotrypa streetsvillensis* are found.............................. 1½

(2) Alternating limestone and shale, characterized by exceedingly numerous examples of *Homotrypa streetsvillensis*. The large fauna is composed of *Homotrypa streetsvillensis, Byssonychia radiata, Hebertella occidentalis, Zygospira modesta, Modiolopsis* sp., *Stigmatella incrustans, Platystrophia clarkesvillensis, Heterotrypa* cf. *robusta, Orthodesma* cf. *canaliculatum, Byssonychia robusta, Opisthoptera fissicosta, Homotrypa communis, Homotrypa* cf. *richmondensis, Hallopora subnodosa, Heterotrypa* cf. *rugosa*.. 4½

ZONE OF ISCHYRODONTA MISENERI:

(1) Massive limestone beds which become argillaceous toward the bottom, crowded with well-preserved specimens of *Ischyrodonta miseneri, Byssonychia robusta,* and *Opisthoptera fissicosta.* Other species occurring in the interval are: *Platystrophia clarkesvillensis, Hebertella occidentalis* (abundant), *Modiolopsis concentrica, Byssonychia grandis, Pterinea demissa, Bellerophon* cf. *mohri, Ortonella* cf. *hainesi, Orthodesma* cf. *canaliculatum, Lophospira bowdeni.* This horizon extends to water-level........ 2

In examining the rocks of this last interval, thin sections were accidentally cut of numerous small round objects, measuring about one-quarter of a millimetre in diameter, with hollow centres and with radiating structures in their walls. They were at first thought to be organic in origin, but the opinion of Dr. Ulrich, to whom they were referred, is that they are oolites.

SECTION No. 14.—EAST SIDE OF RIVER, SOUTH OF BRIDGE OPPOSITE FLOUR MILL, OPPOSITE MIDDLE OF STREETSVILLE VILLAGE (480 TO 493½)

MEADOWVALE MEMBER

COLUMNARIA REEF: THICKNESS feet

(6) Limestone with *Columnaria alveolata, Columnaria calicina, Tetradium approximatum, Stromatocerium huronense, Hebertella occidentalis, Platystrophia clarkesvillensis,* etc.................................... 2

STREETSVILLE MEMBER

ZONE OF BYTHOPORA MEEKI:

(5) Alternating layers of shale and thin limestone. The weathered limestone contains numerous examples of *Bythopora meeki*. The following fossils also occur: *Columnaria alveolata, Stromatocerium huronense, Hebertella occidentalis, Platystrophia clarkesvillensis, Atactoporella densa, Homotrypella dubia, Homotrypella hospitalis, Heterotrypa simplex, Heterotrypa simplex maculosa, Hallopora onealli creditensis, Batostoma* cf. *varians, Byssonychia grandis*.. 2

STROMATOCERIUM REEF:

(4) Clay with *Stromatocerium huronense* large and abundant, also *Columnaria alveolata, Columnaria calicina,* and *Tetradium approximatum*. 3

ZONE OF HOMOTRYPA STREETSVILLENSIS:

(3) Thin alternating bands of shale and limestone. The fauna consists of the following species: *Columnaria alveolata, Hebertella occidentalis, Platystrophia clarkesvillensis, Zygospira modesta, Ceramoporella ohioensis, Homotrypella hospitalis, Homotrypa streetsvillensis, Monticulipora parasitica multipora, Mesotrypa patella, Heterotrypa robusta, Hallopora onealli creditensis, Hallopora aequalis, Stigmatella incrustans, Byssonychia* sp., *Lophospira bowdeni*.. 3½

(2) Projecting, massive limestone layer with: *Homotrypa streetsvillensis, Homotrypa creditensis, Amplexopora solitaria, Orthoceras* sp., *Lophospira bowdeni, Lophospira tropidophora*....................... 1½

(1) Alternating beds of shale and limestone extending to water-level. The limestone is literally one mass of the zoaria of *Homotrypa streetsvillensis*. The following fossils also occur: *Hebertella occidentalis, Platystrophia clarkesvillensis, Heterotrypa* cf. *rugosa, Eridotrypa* cf. *simulatrix, Stigmatella incrustans, Byssonychia robusta*.................... 3½

SECTION No. 15.—EAST SIDE OF RIVER, NORTH OF BRIDGE IN SECTION No. 14 (480 TO 504)

MEADOWVALE MEMBER:	THICKNESS feet
(4) Hard, compact shale alternating with impure, argillaceous limestone and soft clay shale. The following fossils were found: *Hebertella occidentalis*, *Rafinesquina alternata*, *Rafinesquina alternata subcircularis*, *Zygospira modesta*, *Byssonychia* sp.	6
(3) The *Columnaria* reef with: *Stromatocerium huronense*, *Columnaria alveolata*, *Columnaria calicina*, *Tetradium approximatum*, *Hebertella occidentalis*, *Platystrophia* sp.	2
STREETSVILLE MEMBER:	
(2) Interbedded shale and limestone with: *Hebertella occidentalis*, *Platystrophia clarkesvillensis*, *Columnaria alveolata*	2½
(1) Talus-covered interval extending to water level	13½

Horizon No. 2 is regarded as the upper part of the *Bythopora meeki* zone and is included in the Streetsville member, since the *Columnaria* reef which is an easily recognized horizon is made the base of the Meadowvale member.

SECTION No. 16.—WEST SIDE OF RIVER, 100 YARDS NORTH OF CASTLER'S BRIDGE (495 TO 505)

MEADOWVALE MEMBER:	THICKNESS feet
(2) The *Columnaria* reef made up of the coralla of *Columnaria alveolata*, *Columnaria calicina*, *Tetradium approximatum*, and *Stromatocerium huronense*. The two bryozoans, *Rhombotrypa quadrata* and *Constellaria polystomella*, are very numerous. The following fossils also occur: *Hebertella occidentalis*, *Platystrophia clarkesvillensis*, *Rafinesquina alternata*, *Zygospira modesta*, *Hallopora* cf. *onealli*, *Homotrypella hospitalis*, *Fenestella* sp., *Opisthoptera fissicosta*, *Byssonychia* sp., *Cyclonema* sp., *Liospira* cf. *helena*	6½
STREETSVILLE MEMBER:	
(1) Alternating beds of shale and limestone. The shale is ripple-marked, some cross ripples being noticed. Fucoids are numerous, and *Columnaria alveolata* is found	2½

Horizon No. 1 is herein included in the *Bythopora meeki* zone. Near the northern end of the section the *Columnaria* reef becomes much thinner. At this end, also, a bed of limestone occurs about three feet above the water-level, (500) which yields numerous examples of the gastropods, *Lophospira bowdeni* and *Lophospira tropidophora*. *Platystrophia clarkesvillensis*, *Homotrypella hospitalis*, *Hebertella occidentalis*, and *Byssonychia* sp. also occur.

SECTION No. 17.—WEST SIDE OF RIVER, ONE MILE NORTH OF CASTLER'S BRIDGE (495 TO 505)

MEADOWVALE MEMBER:	THICKNESS feet
(3) Alternating beds of limestone, clay shale, and argillaceous sandstone. The following fossils are found: *Columnaria alveolata*, *Hebertella occidentalis*, *Platystrophia* cf. *clarkesvillensis*, *Zygospira modesta*, *Rafinesquina alternata*, *Rafinesquina alternata subcircularis*, *Byssonychia* sp., *Clidophorus fabula*, *Modiolopsis concentrica*, *Opisthoptera fissicosta*, *Pterinea demissa*, *Whiteavesia pholadiformis*, *Cyrtolites ornatus*, crinoid columns	7
(2) The *Columnaria* reef with: *Columnaria alveolata*, *Columnaria calicina*, *Tetradium approximatum*, and *Stromatocerium huronense*	2
STREETSVILLE MEMBER:	
(1) Alternating beds of soft shale and arenaceous shale, extending to water-level. The arenaceous shale shows beautiful cross ripple marking. *Columnaria alveolata* occurs	1

SECTION No. 18.—EAST SIDE OF RIVER, NORTH OF THE DAVIS FARM (495 TO 530)

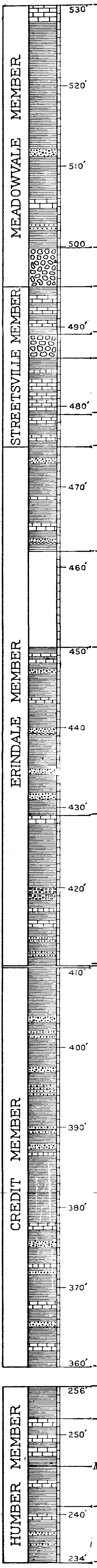
This is the most northerly outcrop at which the grey rocks of the marine Richmond can be seen with the exception of a small outcrop of the *Columnaria* reef 200 yards farther to the east on the same side of the river. The contact with the Queenston red shales is not exposed, and it is probable, also, that the uppermost part of the grey beds is covered by drift. In weathered limestone beds in the upper two feet of this section, *Hebertella occidentalis* is very abundant, and the following fossils are also found: *Homotrypella hospitalis*, *Byssonychia* sp., *Modiolopsis* sp., and casts of ramose bryozoans.

INDEX, PART VII

COMPOSITE SECTION OF THE ROCKS ON THE CREDIT RIVER

(The figures indicate altitudes above sea-level)

RICHMOND FORMATION



MEADOWVALE MEMBER

UPPER MEADOWVALE.—Hebertella occidentalis, Platystrophia clarkesvillensis, Homotrypella hospitalis, Byssonychia *sp.*, Modiolopsis *sp.*

Columnaria alveolata, Hebertella occidentalis, Platystrophia *cf.* clarkesvillensis, Rafinesquina alternata, Rafinesquina alternata subcircularis, Zygospira modesta, Byssonychia *sp.*, Clidophorus fabula, Modiolopsis concentrica, Opisthoptera fissicosta, Pterinea demissa, Whiteavesia pholadiformis, Cyrtolites ornatus, crinoid columns.

COLUMNARIA REEF.—Calapoecia cribriformis, Columnaria alveolata, Columnaria calicina, Stromatocerium huronense, Tetradium approximatum, Constellaria polystomella, Homotrypella hospitalis, Rhombotrypa quadrata, Hebertella occidentalis, Liospira *cf.* helena, etc.

STREETSVILLE MEMBER

ZONE OF BYTHOPORA MEEKI.—Columnaria alveolata, Stromotocerium huronense, Batostoma *cf.* varians, Bythopora meeki, Hallopora onealli creditensis, Homotrypella dubia, Homotrypella hospitalis, Heterotrypa simplex, Heterotrypa simplex maculosa, Hebertella occidentalis, Platystrophia clarkesvillensis, Byssonychia grandis.

STROMATOCERIUM REEF.—Columnaria alveolata, Stromatocerium huronense, Tetradium approximatum, Heterotrypa simplex, Homotrypella hospitalis, Hallopora maculosa, Homotrypella hospitalis peculiaris.

ZONE OF HOMOTRYPA STREETSVILLENSIS.—Hebertella occidentalis, Platystrophia clarkesvillensis, Zygospira modesta, Hallopora onealli creditensis, Hallopora aequalis, Hallopora subnodosa, Heterotrypa robusta, Heterotrypa simplex maculosa, Homotrypa communis, Homotrypa streetsvillensis, Homotrypella hospitalis, Mesotrypa patella, Monticulipora parasitica multipora, Stigmatella incrustans, Stigmatella interporosa, Byssonychia *cf.* grandis, Byssonychia robusta, Opisthoptera fissicosta, Lophospira bowdeni, etc.

ZONE OF ISCHYRODONTA MISENERI.—Hebertella occidentalis, Byssonychia grandis, Byssonychia robusta, Ischyrodonta miseneri, Modiolopsis concentrica, Opisthoptera fissicosta, Ortonella *cf.* hainesi, Bellerophon *cf.* mohri, Lophospira bowdeni, Pterinea demissa, etc.

ERINDALE MEMBER

UPPER ERINDALE.— Rafinesquina alternata, Atactopora *sp.*, Rhinidictya parallella, Stigmatella crenulata, Byssonychia *sp.*, Clidophorus planulatus, Pterinea demissa, Hallopora aequalis, Hallopora onealli creditensis.

Talus-covered interval.

Rafinesquina alternata, Zygospira modesta, Hallopora onealli, Hallopora onealli creditensis, Homotrypella hospitalis, Stigmatella crenulata, Byssonchia radiata, Modiolopsis concentrica, Pterinea demissa, Whiteavesia pholadiformis, Isotelus *sp.*

ZONE OF STROPHOMENA VARSENSIS.—Catazyga headi, Hebertella occidentalis, Rafinesquina alternata, Rafinesquina alternata subcircularis, Strophomena varsensis, Strophomena planumbona erindalensis, Zygospira modesta, Trematis millepunctata, Calloporella vacua, Hallopora onealli creditensis, Hallopora subnodosa, Heterotrypa definita, Heterotrypa prolifica, Heterotrypa *cf.* subfrondosa, Rhinidictya parallella, Stigmatella hybrida, Byssonychia radiata, Byssonychia *cf.* praecursa, Ctenodonta cingulata, Pterinea demissa, Whiteavesia pholadiformis, Clathrospira *cf.* subconica, Lophospira tropidophora, Lophospira bowdeni, Isotelus *cf.* maximus.

The Bryozoan reef at 420′.

DUNDAS FORMATION

(Formerly ascribed to the Lorraine.)

CREDIT MEMBER

Hebertella occidentalis, Zygospira modesta, Stigmatella sessilis crassa, Isotelus *sp.*

Hallopora onealli creditensis, Stigmatella sessilis crassa, Zygospira modesta, Byssonychia radiata, Clidophorus planulatus, Cymatonota *cf.* lenior, Ischyrodonta unionoides, Modiolopsis concentrica, Modiolopsis borealis, Pterinea demissa, Whiteavesia pholadiformis, Whitella *cf.* hindi, Actinoceras crebriseptum, Isotelus maximus.

From 256′ to 360′, unfossiliferous zone of HUMBER MEMBER.

HUMBER MEMBER

Stigmatella catenulata var. b., Rafinesquina mucronata torontonensis, Byssonychia *sp.*, Cuneamya scapha brevior, Glyptocrinus *sp.*, Lichoncrinus *sp.*

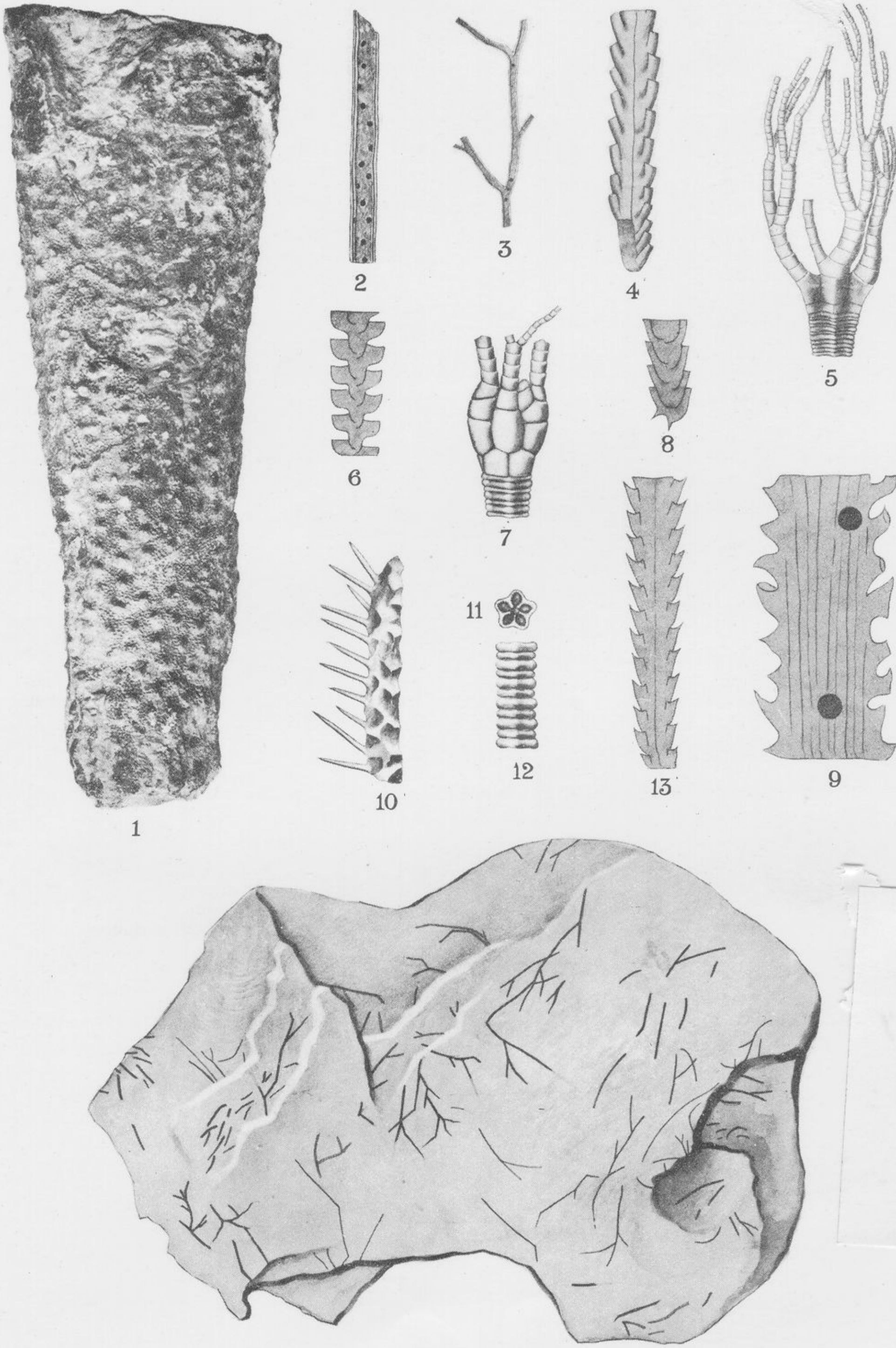
Rafinesquina mucronata torontonensis, Zygospira erratica, Zygospira modesta, Byssonychia radiata, Modiolopsis concentrica, Ctenodonta filistriata, Modiolopsis postplicata, Pterinea demissa, Whiteavesia pholodiformis, Whitella *cf.* torontonensis, Whitella *cf.* hindi, Lophospira *sp.*, Glyptocrinus *sp.*, Isotelus *sp.*

Mean Elevation, Lake Ontario, 246 feet.

Zygospira modesta, Byssonychia radiata, Modiolopsis *sp.*, Isotelus *sp.*

Rafinesquina mucronata torontonensis, Zygospira erratica, Zygospira modesta, Ischyrodonta *cf.* unionoides, Byssonychia *cf.* radiata, Modiolopsis *sp.*, Pterinea demissa, Whiteavesia pholodiformis, Orthoceras lamellosum.

Plate I



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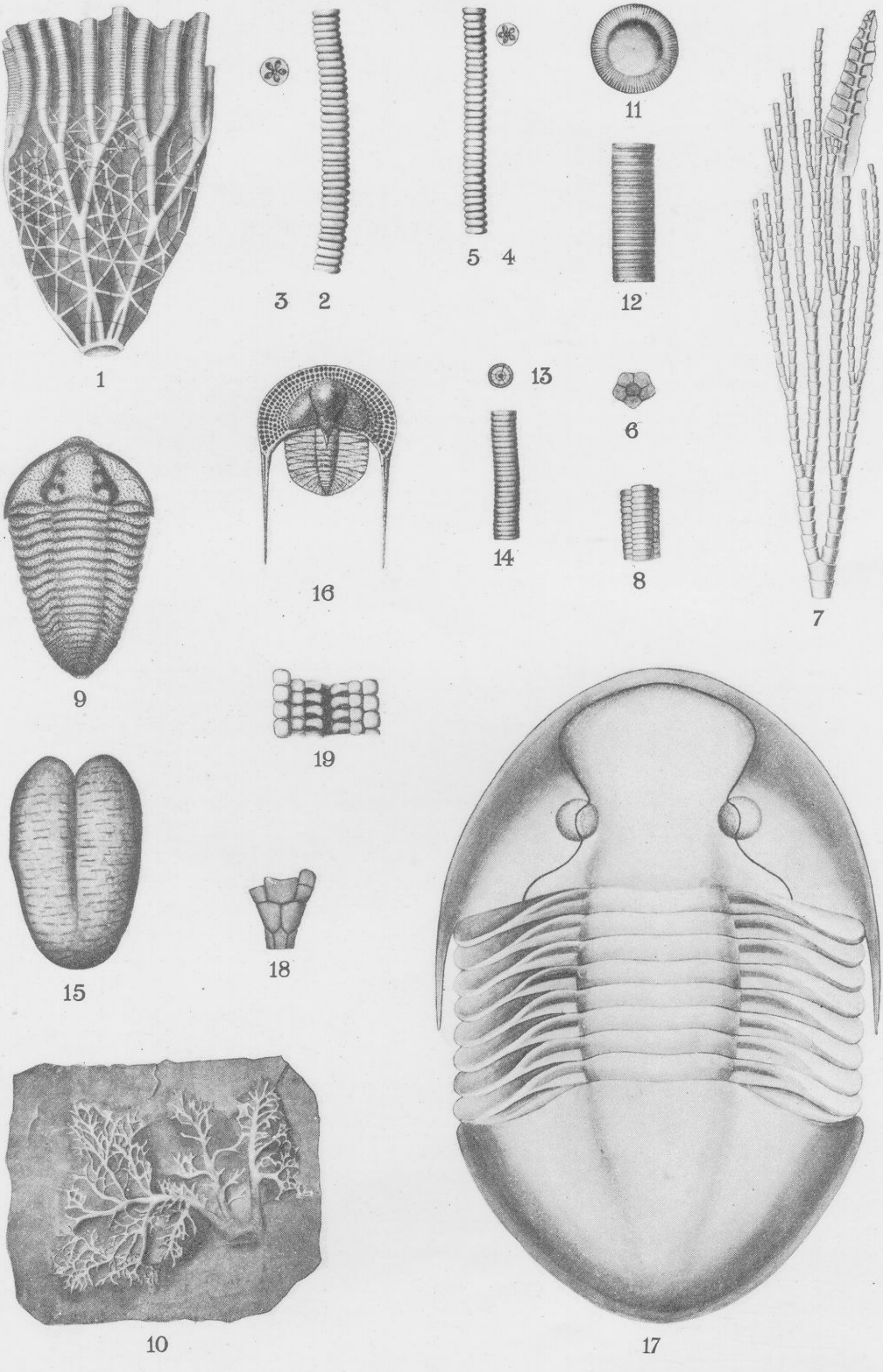

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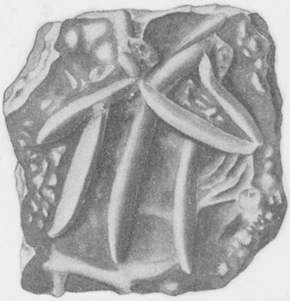

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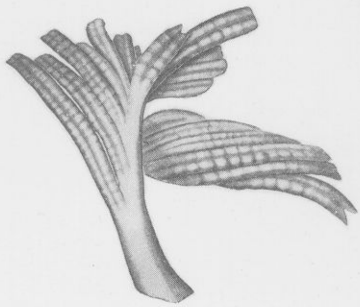

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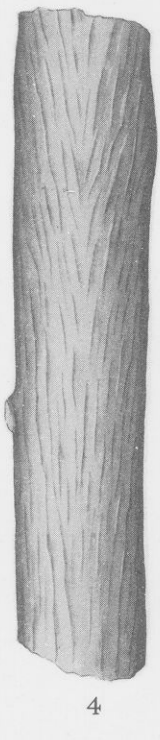

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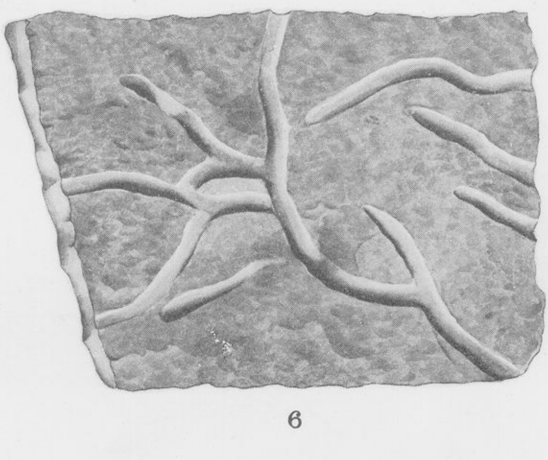

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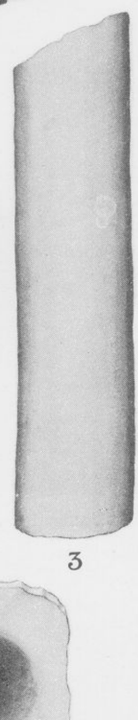

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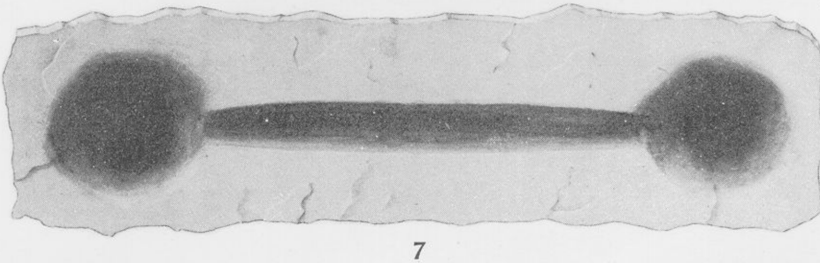

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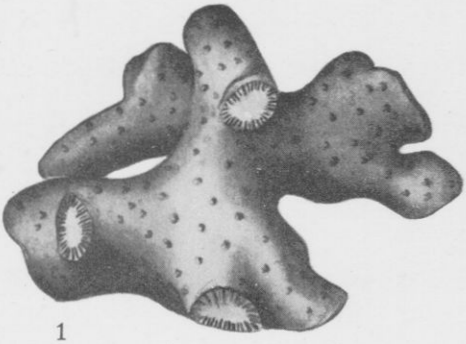

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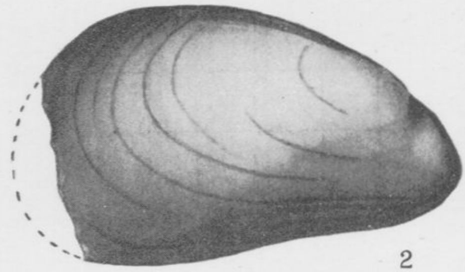

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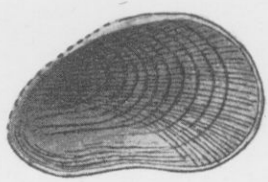

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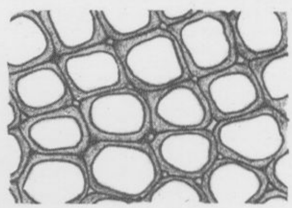

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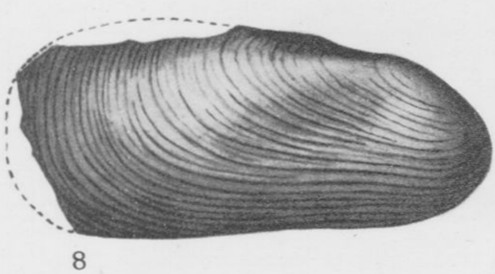

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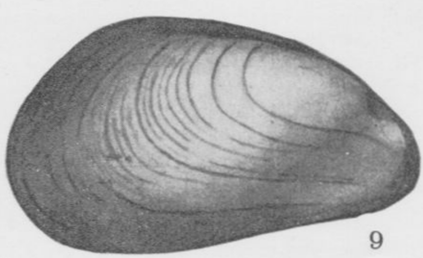

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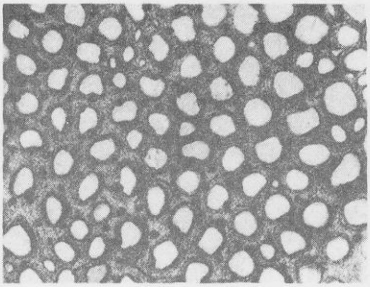

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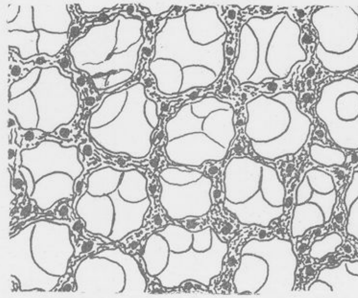

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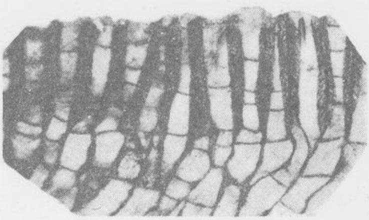

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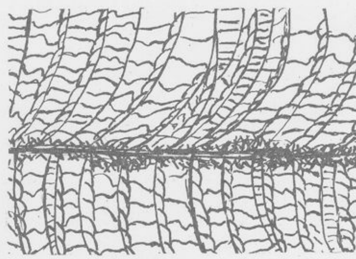

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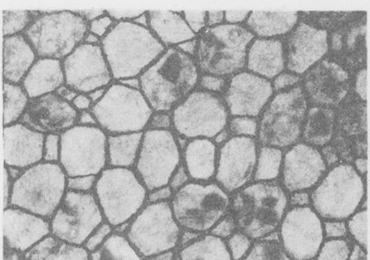

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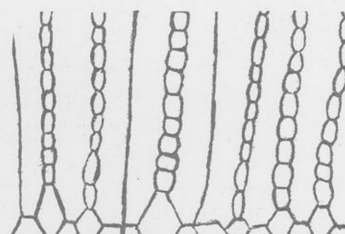

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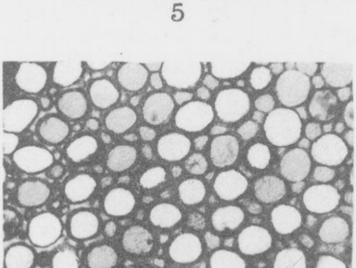

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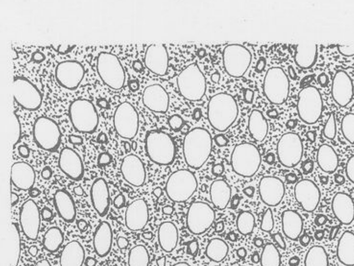

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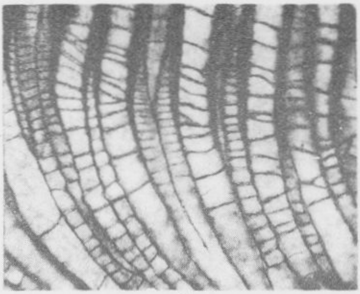

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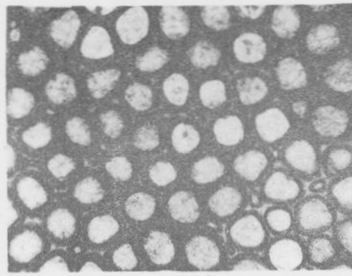

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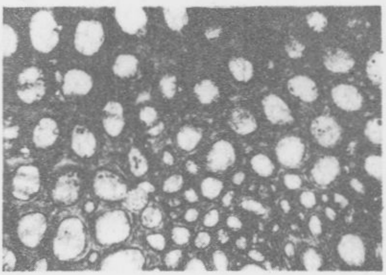

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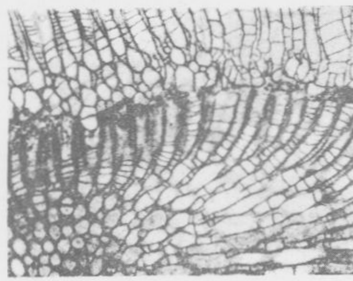

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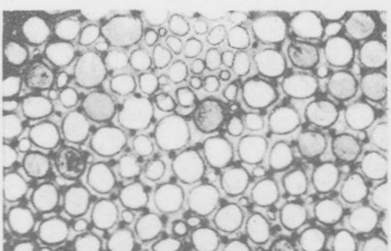

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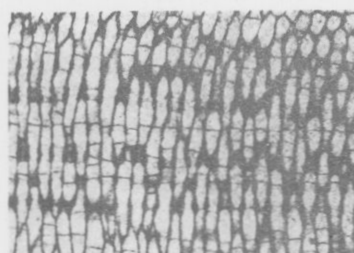

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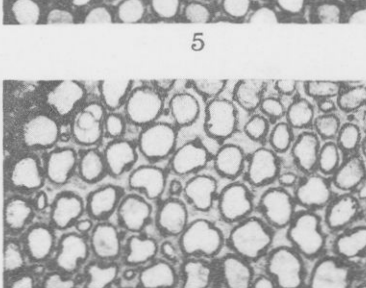

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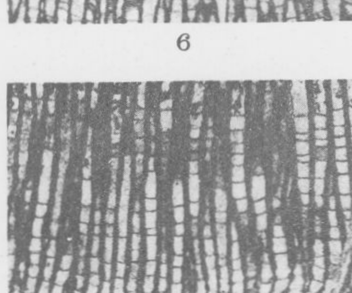

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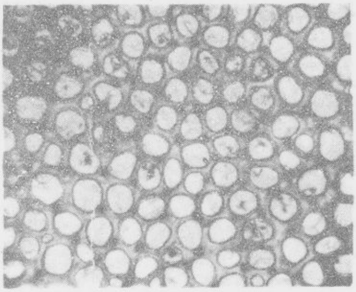

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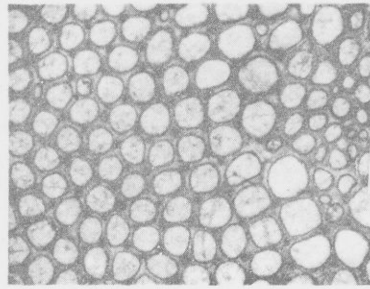

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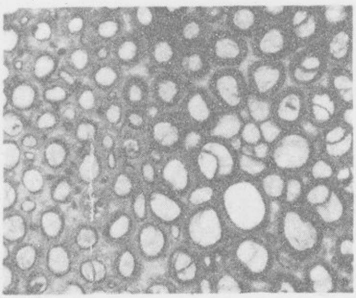

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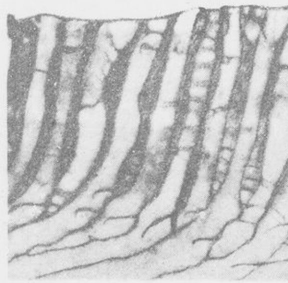

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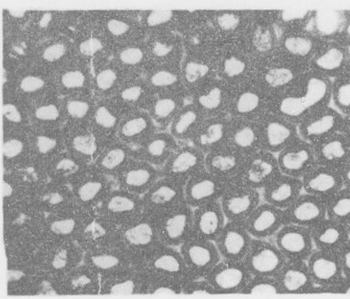

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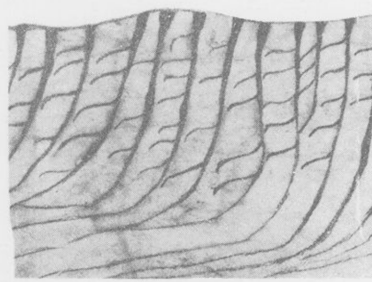

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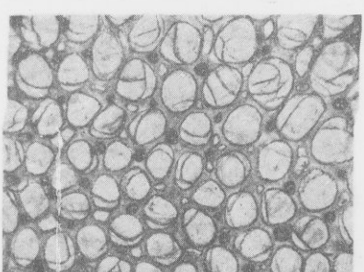

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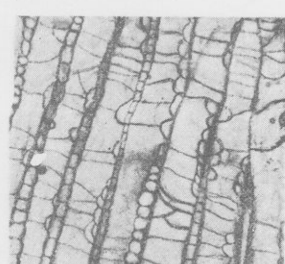

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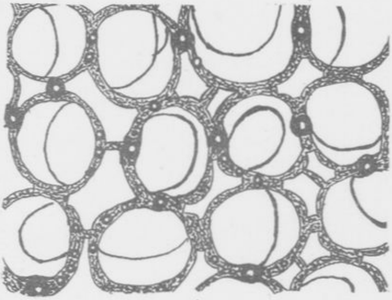
Plate IV



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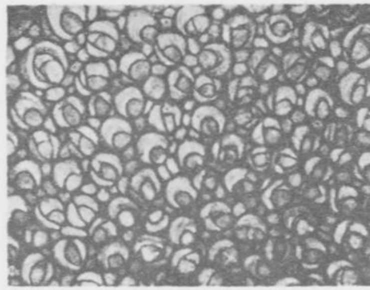

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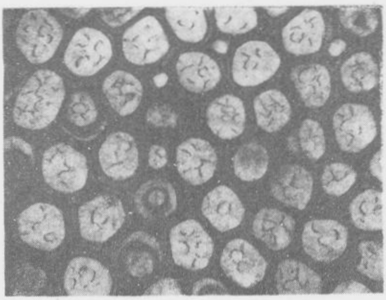

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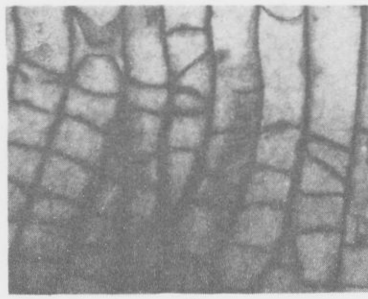

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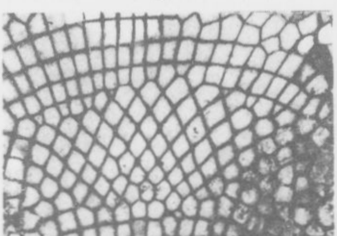

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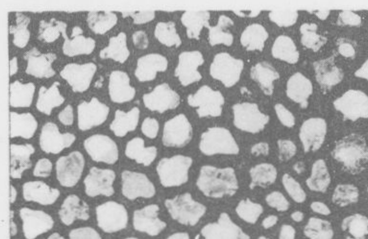

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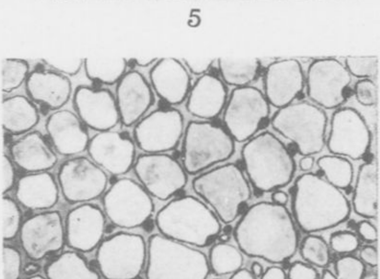

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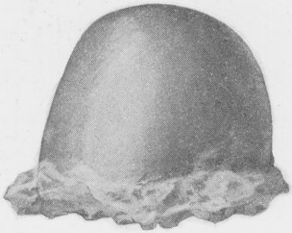

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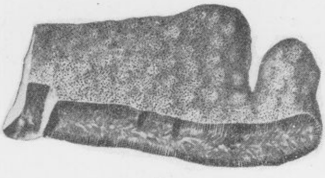

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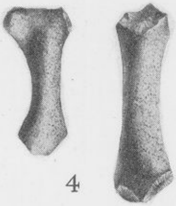

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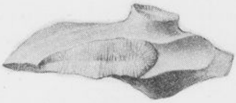

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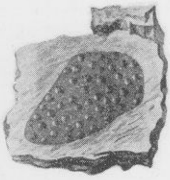

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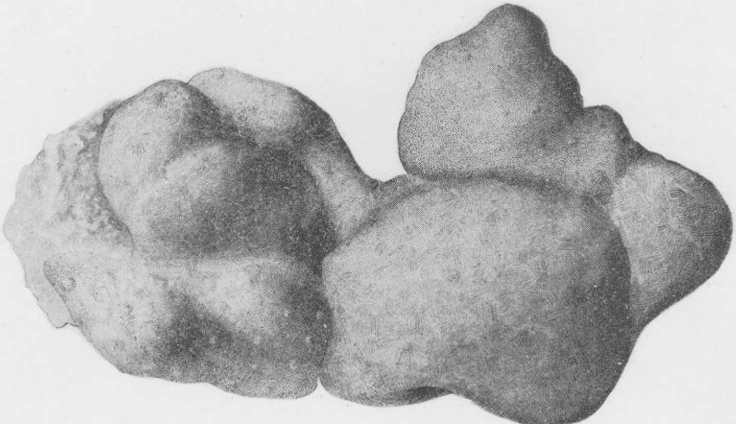

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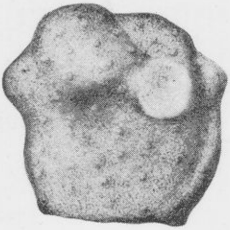
Plate VI



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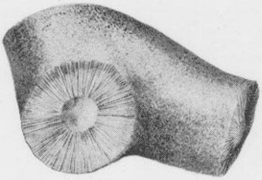

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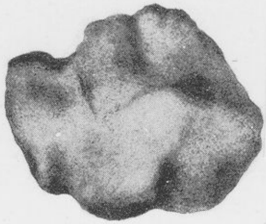

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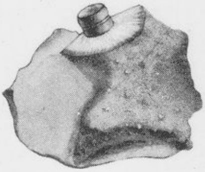

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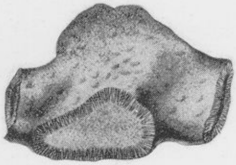

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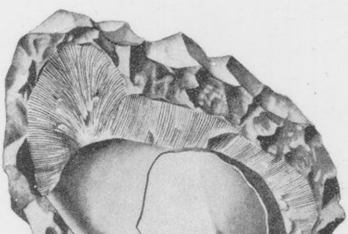

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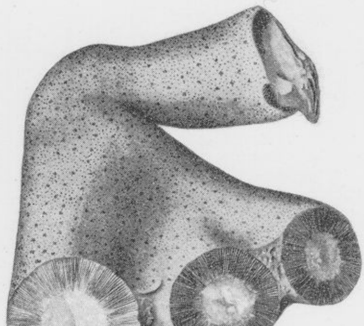

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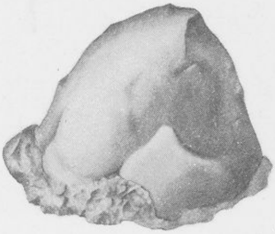

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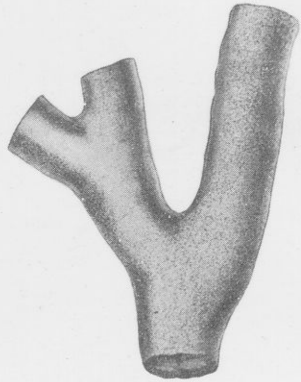

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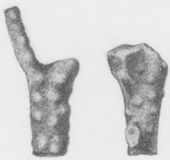

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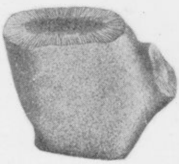

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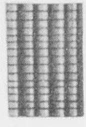

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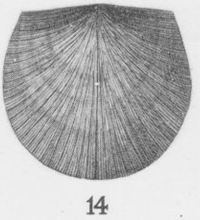

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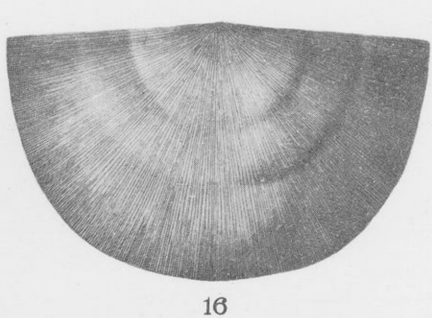

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