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INTRODUCTORY LETTER

TO THE HONOURABLE JAMES A. MALONEY, Q.C.
Minister of Mines

SIR: The undersigned has the honour to submit the Sixty-ninth Annual Report of the Department of Mines, issued in eight parts as follows:

PART 1

Statistical Review of the Mineral Industry for 1959, by T. J. Kelly.
Provincial Assay Office, 1959, by D. A. Moddle.
Mining Accidents in 1959, by the Staff of the Mines Inspection Branch.
Classes for Prospectors, 1959-60, by M. E. Hurst.

PART 2

Mining Operations in 1959, compiled by the Staff of the Mines Inspection Branch.

PART 3

Geology of the Saganash Lake–Wakusimi River Area, by R. C. McMurchy.

PART 4

Geology of the Bennett-Tanner Area, by W. L. Young.

PART 5

Geology of the Lumby Lake Area, by Ralph S. Woolverton.

PART 6

Geology of the Dyment Area, by J. Satterly.

PART 7

Gunflint Iron Range in the Vicinity of Port Arthur, by W. W. Moorhouse.
Gunflint Iron Formation of the Whitefish Lake Area, by A. M. Goodwin.

PART 8

Nepheline Syenite Deposits of Southern Ontario, by D. F. Hewitt.

Respectfully submitted,
D. P. DOUGLASS
Deputy Minister of Mines

DEPARTMENT OF MINES

Toronto, 1961

ONTARIO

DEPARTMENT OF MINES

HON. JAMES E. MALONEY, *Minister* D. P. DOUGLASS, *Deputy Minister*

Statistical Review of the Mineral Industry for 1959

by T. J. KELLY

Provincial Assay Office, 1959

by D. A. MODDLE

Mining Accidents in 1959

by THE STAFF OF MINES INSPECTION BRANCH

Classes for Prospectors, 1959–60

by M. E. HURST

Volume LXIX, Part 1, 1960

TORONTO
Printed and Published by Frank Fogg, Printer to the Queen's Most Excellent Majesty
1961

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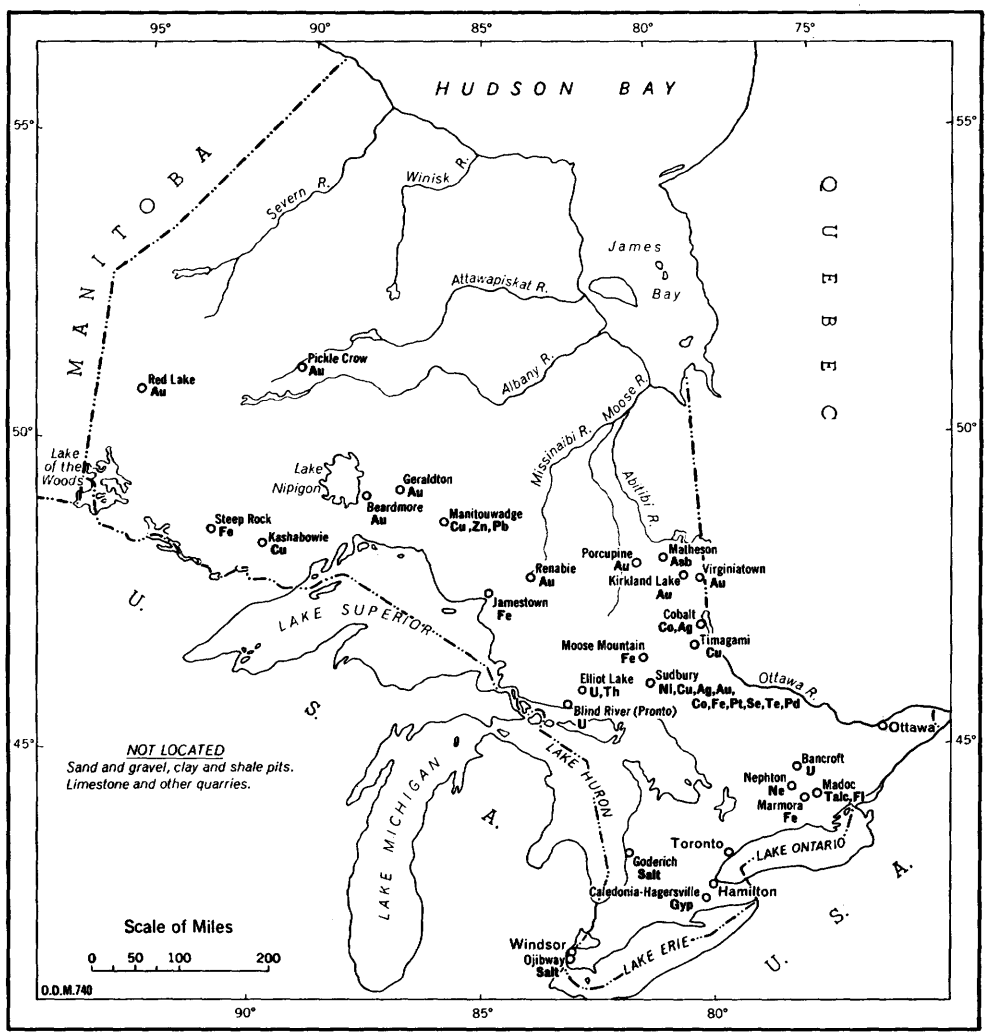
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PRINCIPAL MINING AREAS OF THE PROVINCE OF ONTARIO



KEY TO SYMBOLS

Ag	**— Silver**	**Fl**	**— Fluorspar**	**Pt**	**— Platinum**
Asb	**— Asbestos**	**Gyp**	**— Gypsum**	**Se**	**— Selenium**
Au	**— Gold**	**Ne**	**— Nepheline syenite**	**Te**	**— Tellurium**
Co	**— Cobalt**	**Ni**	**— Nickel**	**Th**	**— Thorium**
Cu	**— Copper**	**Pb**	**— Lead**	**U**	**— Uranium**
Fe	**— Iron**	**Pd**	**— Palladium**	**Zn**	**— Zinc**

Statistical Review of the Mineral Industry for 1959

BY

T. J. Kelly[1]

GENERAL SUMMARY

Mineral Production

The value of mineral production in Ontario in 1959 was greater than the $801,280,000 previous all-time high of 1958. It increased by 22.37 percent to $980,581,000. The value of metallic mineral increased by 28.09 percent to $806,775,000.

Once again the greatest proportion of the production of metallics came from the Sudbury district. This area accounted for 44.75 percent of the total. The value of the area's production increased 108 million dollars over the 1958 value. The Blind River area accounted for 30.53 percent of the metallics production. The contribution of this area has greatly increased the value of the mineral production of the Province. As a result, the relative importance of the Sudbury area has declined. The Rainy River-Kenora (Patricia) area accounted for 5.15 percent of the metallics total, the Porcupine area for 4.56 percent, Thunder Bay for 4.15 percent, Kirkland Lake-Larder Lake for 3.84 percent, Eastern Ontario for 3.69 percent, Algoma for 2.24 percent, and the Cobalt area for 1.09 percent.

The value of non-metallics increased 10.13 percent over the 1958 value; structural materials decreased 1.00 percent, and clay products decreased 2.75 percent.

Metallics made up 82.27 percent of the total value of mineral production, non-metallics 4.51 percent, structural materials 10.96 percent, and clay products 2.26 percent.

During the year the metal mines paid out $89,217,716 in dividends.

The *Emergency Gold Mining Assistance Act* was in force for the whole period, and 22 gold producers received assistance.

---

[1]Statistician, Ontario Department of Mines.

SUMMARY OF MINERAL STATISTICS, 1959

Product	Quantity	Value	Percent Total Canadian Value	Wage-Earners[1]	Wages
METALLIC					
Gold ..... oz.	2,683,449	$ 90,083,383	59.85	10,598	$ 38,314,195
Silver ..... oz.	10,540,856	9,252,763	33.02	563	2,021,424
Copper in matte exported ..... lb.	36,312,312	9,804,324	47.42	18,129	86,609,668
Copper, metal and concentrates ..... lb.	340,232,059	100,742,713			
Nickel, matte, metal and salts ..... lb.	347,929,183	240,053,265	93.40		
Platinum metals ..... oz.	328,091	16,932,178	99.99		
Selenium ..... lb.	101,400	709,800	27.54		
Tellurium ..... lb.	6,900	14,835	52.98		
Pyrrhotite	.....	632,140	18.41		
Cobalt, metal and salts ..... lb.	2,835,684	5,414,246	90.93	(2)	(2)
Iron ore ..... tons	6,018,089	50,830,404	26.38	2,291	11,887,253
Calcium ..... lb.	67,429	76,409	100.00	102	320,280
Magnesium ..... lb.	8,144,940	2,202,392	69.27		
Lead ..... lb.	3,222,447	341,902	0.86	618	2,972,291
Zinc ..... lb.	89,963,215	11,011,498	11.36		
Uranium (U_3O_8) ..... lb.	25,492,171	268,529,993	81.09	9,368	51,688,045
Thorium ..... lb.	47,447	105,676	100.00		
Bismuth ..... lb.	31,457	37,748	6.39	(3)	(3)
Total	.....	806,775,669	58.71	41,669	193,813,156
NON-METALLIC AND FUELS					
Arsenic trioxide ..... lb.	1,578,307	63,786	100.00	(3)	(3)
Mica, amber ..... lb.	35,433	531	1.52	.....	.....
Mica, white ..... lb.	325	428			
Mineral water ..... gals.	3,025	1,936	0.95	.....	.....
Natural gas ..... M cu. ft.	16,839,236	16,335,742	16.45	554	2,152,973
Petroleum ..... bbls.	1,001,580	3,194,000	0.76	107	218,738
Quartz and quartzite ..... tons	1,600,352	1,363,541	39.67	91	289,360
Silica, brick ..... M	[illegible]	[illegible]	[illegible]		

Sulphur[4]			1,041,857	19.52	(5)	(5)
Asbestos	tons	24,350	4,327,628	4.03		
Fluorspar			100,594	5.44		
Gypsum	tons	412,100	1,017,340	12.12	441	1,856,910
Nepheline syenite	tons	228,722	2,930,932	100.00		
Peat moss	tons	10,925	295,390	4.74		
Talc	tons	8,796	125,903	24.58		
Total			44,143,269	4.83	1,642	6,502,865
STRUCTURAL MATERIALS						
Cement	tons	2,386,334	31,731,767	33.35	999	4,463,050
Hydrated lime	tons	125,791	2,409,514	65.74	584	2,305,673
Quicklime	tons	1,004,264	11,597,018			
Sand and gravel	tons	73,981,703	39,695,602	37.93	1,937	6,864,932
Stone	tons	17,288,796	22,053,425	36.18	1,558	5,737,393
Total			107,487,326	38.11	5,078	19,371,048
CLAY PRODUCTS						
Brick, face	M	249,554	14,441,307			
Brick, common	M	21,420	547,260			
Brick, fancy and ornamental	M	291	34,092			
Brick, sewer	M	1,205	48,185			
Tile, drain	M	44,483	2,595,721			
Tile, structural, roofing, and floor			1,138,045			
Sewer pipe, copings, flue-linings, etc.			2,317,028			
Pottery and other products			1,053,257			
Total			22,174,895	52.16	1,938	6,908,420
GRAND TOTAL			980,581,159		50,327	226,595,489

(1)"Wage-Earners" for any mineral industry represents the employees of companies whose chief product is that mineral, or employees of the companies who produce the greater part of the total quantity of that mineral.
(2)Included with Nickel-Copper and Silver.
(3)Included with Silver.
(4)Value of elemental sulphur and sulphur content of sulphuric acid produced from smelter gases.
(5)Included with Nickel-Copper.

COMPARATIVE OUTPUT AND VALUE OF MINERAL PRODUCTION

Product	1955	1956	1957	1958	1959
METALLICS					
Bismuth lb.	.....	6,980	14,214	18,581	31,457
$	.....	10,586	21,372	26,779	37,748
Calcium lb.	.....	394,900	221,225	25,227	67,429
$	1,293,657	515,305	282,378	31,256	76,409
Cerium; rare earths $	988	.....	.....	.....	.....
Cobalt lb.	3,296,270	3,392,543	3,750,596	2,436,064	2,835,684
$	8,510,314	8,781,626	7,541,258	4,866,767	5,414,246
Copper lb.	292,813,108	312,541,701	343,406,269	284,069,476	376,544,371
$	107,215,943	128,552,450	98,488,877	71,267,895	110,547,037
Gold oz.	2,523,040	2,513,912	2,578,206	2,716,514	2,683,449
$	87,223,660	86,489,962	86,621,067	92,192,231	90,083,383
Iron ore tons	4,362,191	5,558,203	4,867,105	3,644,952	6,018,089
$	34,340,897	44,177,246	41,317,629	36,851,421	50,830,404
Lead lb.	3,853,603	3,010,163	1,012,565	2,513,224	3,222,447
$	554,148	466,876	141,354	285,502	341,902
Magnesium lb.	.....	14,639,734	15,184,373	9,087,362	8,144,940
$	3,374,923	4,543,202	4,767,043	2,747,755	2,202,392
Nickel lb.	322,322,355	335,152,371	354,792,843	254,286,784	347,929,183
$	198,489,258	208,099,454	243,518,138	177,168,918	240,053,265
Platinum metals oz	384,746	314,818	416,147	300,458	328,091
$	23,069,365	22,407,090	25,731,333	14,321,443	16,932,178
Pyrrhotite tons	.....	193,737	264,141	279,422	.....
$	.....	759,449	685,335	655,569	632,140
Selenium lb.	94,465	109,156	86,459	90,295	101,400
$	708,488	1,473,606	951,049	677,213	709,800

Silver ..... oz.	6,051,017	6,625,447	6,910,130	9,815,257	10,540,856
$	5,337,163	5,940,586	6,034,598	8,529,142	9,252,763
Tellurium ..... lb.	6,455	6,305	6,915	6,692	6,900
$	11,296	11,034	12,101	11,376	14,835
Thorium ..... lb.	.....	.....	.....	.....	47,447
$	.....	.....	.....	.....	105,676
Uranium (U_3O_8) ..... lb.	.....	906,614	7,970,598	19,970,136	25,492,171
$	487,054	9,361,867	82,940,763	210,149,700	268,529,993
Zinc ..... lb.	3,095,640	2,454,297	22,591,677	92,478,339	89,963,215
$	422,555	364,218	2,731,334	10,061,643	11,011,498
Total Value ..... $	471,039,709	521,954,557	601,785,629	629,844,610	806,775,669
NON-METALLICS					
Arsenic trioxide ..... lb.	1,571,787	1,790,381	3,697,317	2,323,320	1,578,307
$	69,159	77,612	137,112	94,542	63,786
Asbestos ..... tons	24,550	26,748	20,947	21,650	24,350
$	3,317,542	3,929,782	3,529,570	3,849,370	4,327,628
Fluorspar ..... tons	730	270	2,430	1,256	.....
$	29,796	12,521	94,239	57,834	100,594
Gypsum ..... tons	366,416	366,956	379,621	425,733	412,100
$	808,424	840,829	853,199	1,059,590	1,017,340
Mica, amber ..... lb.	41,356	46,527	74,429	17,590	35,433
$	906	635	2,332	736	531
Mica, white ..... lb.	18	8	16,487	6,961	325
$	40	10	3,941	1,370	428
Mineral water ..... gals.	3,573	2,000	2,500	2,433	3,025
$	2,015	1,700	2,012	1,946	1,936

COMPARATIVE OUTPUT AND VALUE OF MINERAL PRODUCTION—*Continued*

Product	1955	1956	1957	1958	1959
NON-METALLICS—*Continued*					
Natural gas ..... M cu. ft.	10,852,857	12,811,618	14,400,913	16,147,986	16,839,236
$	12,263,732	14,220,898	15,985,013	17,760,000	16,335,742
Nepheline syenite ..... tons	146,068	180,006	200,016	201,306	228,722
$	2,099,512	2,574,140	2,754,060	2,613,446	2,930,932
Peat moss ..... tons	4,284	3,267	4,720	6,123	10,925
$	123,862	97,091	220,232	216,055	295,390
Petroleum, crude ..... bbls.	525,509	593,370	623,666	778,341	1,001,580
$	1,715,630	1,958,121	2,160,000	2,623,000	3,194,000
Quartz and quartzite ..... tons	1,421,302	1,571,819	1,591,091	922,599	1,600,352
$	1,032,938	1,413,191	1,428,400	666,275	1,363,541
Silica brick ..... M	3,498	4,243	2,902	1,740	1,123
$	313,256	384,648	291,412	187,061	114,684
Salt ..... tons	998,789	1,347,729	1,538,805	2,126,483	3,036,230
$	5,845,340	7,932,294	9,478,587	10,204,472	13,228,977
Sulphur[1] ..... tons	57,100	53,481	54,264	.....	.....
$	571,000	534,810	542,846	622,619	1,041,857
Talc and soapstone ..... tons	14,591	12,371	11,236	8,725	8,796
$	194,952	167,851	160,015	125,511	125,903
Total Value ..... $	28,388,104	34,146,133	37,642,970	40,083,827	44,143,269
STRUCTURAL MATERIALS					
Portland cement ..... tons	1,341,276	1,450,437	2,211,887	2,400,158	2,386,334
$	19,707,042	21,455,019	33,505,994	35,195,552	31,731,767
Lime, hydrated, and quicklime ..... tons	698,245	673,357	766,143	1,009,916	1,130,055
$	8,420,382	8,258,857	9,416,868	12,644,925	14,006,532

Sand and gravel.....tons	51,488,067	61,436,363	66,129,158	67,469,064	73,981,703
$	29,945,730	34,379,015	36,699,895	40,055,031	39,695,602
Sand-lime brick.....$	512,713	748,533	441,086	.....	.....
Stone.....tons	12,739,139	15,734,664	17,390,438	15,756,560	17,288,796
$	16,307,975	20,820,727	22,195,815	20,670,480	22,053,425
Total Value.....$	74,893,842	85,662,151	102,259,658	108,565,988	107,487,326
CLAY PRODUCTS					
Face brick.....M	225,015	226,241	212,764	254,453	249,554
$	11,944,146	12,396,750	11,761,223	14,608,555	14,441,307
Common brick.....M	12,313	15,132	19,432	17,978	21,420
$	388,852	434,764	474,546	591,662	547,260
Fancy and ornamental brick.....M	1	627	255	450	291
$	81	71,175	29,428	52,820	34,092
Sewer brick.....M	249	815	1,109	1,091	1,205
$	10,861	38,779	44,563	47,923	48,185
Drain tile.....M	43,398	42,761	41,013	49,163	44,483
$	2,384,413	2,441,571	2,407,912	2,909,168	2,595,721
Tile, structural, roof, etc.....$	1,260,415	1,295,145	1,100,457	990,159	1,138,045
Sewer pipe, copings, flue linings, etc.....$	1,827,717	1,383,344	1,680,140	2,624,679	2,317,028
Pottery and other products.....$	379,543	1,111,237	854,682	961,325	1,053,257
Haydite and clay.....$	118,292	571	348	.....	.....
Total Value.....$	18,314,320	19,173,336	18,353,299	22,786,291	22,174,895
GRAND TOTAL.....$	592,635,975	660,936,177	760,041,556	801,280,716	980,581,159

(1)Value of elemental sulphur and sulphur content of sulphuric acid produced from smelter gases.

TOTAL MINERAL PRODUCTION

Year	Metallics	Non-Metallics	Structural Materials	Clay Products	Total
To Dec. 31, 1954..	$6,437,467,523	$496,664,980	$ 800,775,853	$259,352,975	$ 7,994,261,331
1955.....	471,039,709	28,388,104	74,893,842	18,314,320	592,635,975
1956.....	521,954,557	34,146,133	85,662,151	19,173,336	660,936,177
1957.....	601,785,629	37,642,970	102,259,658	18,353,299	760,041,556
1958.....	629,844,610	40,083,827	108,565,988	22,786,291	801,280,716
1959.....	806,775,669	44,143,269	107,487,326	22,174,895	980,581,159
To Dec. 31, 1959..	$9,468,867,697	$681,069,283	$1,279,644,818	$360,155,116	$11,789,736,914

Metal Production

During the recorded history of the mining industry in Ontario, metals have accounted for 80.31 percent of the accumulated mineral production value.

METAL PRODUCTION TO DECEMBER 31, 1959

Metal or Product	To December 31, 1958	1959	To December 31, 1959
Barium	$ 9,266	.....	$ 9,266
Bismuth	322,350	37,748	360,098
Calcium	11,201,062	76,409	11,277,471
Cerium, rare earths	988	.....	988
Chromite	55,090	.....	55,090
Cobalt	82,999,494	5,414,246	88,413,740
Copper	1,432,655,079	110,547,037	1,543,202,116
Gold	2,692,459,546	90,083,383	2,782,542,929
Iron ore	312,780,680	50,830,404	363,611,084
Lead	7,178,651	341,902	7,520,553
Magnesium	35,775,172	2,202,392	37,977,564
Molybdenum	224,110	.....	224,110
Nickel	2,918,891,207	240,053,265	3,158,944,472
Pig iron, from domestic ore	98,257,508	.....	98,257,508
Platinum metals	400,778,132	16,932,178	417,710,310
Pyrrhotite	2,100,353	632,140	2,732,493
Selenium	8,815,094	709,800	9,524,894
Silver	338,626,602	9,252,763	347,879,365
Tellurium	317,981	14,835	332,816
Thorium	.....	105,676	105,676
Tungsten	808,338	.....	808,338
Uranium (U_3O_8)	302,939,384	268,529,993	571,469,377
Zinc, in ore and concentrates	14,895,941	11,011,498	25,907,439
Total	$8,662,092,028	$806,775,669	$9,468,867,697

Dividends

During 1959, dividends were paid by 20 gold mining companies, 2 nickel-copper mining companies, 1 silver-cobalt mining company, and 3 uranium mining companies. The cumulative total of dividends paid by the silver-cobalt mining companies includes those paid by investment or holding companies. This practice was discontinued about 1940, but it is not possible to separate the amounts included before that date.

DIVIDENDS PAID BY METAL-MINING COMPANIES TO DECEMBER 31, 1959

Industry	To end of 1958	1959	To end of 1959
Gold	$ 687,005,978	$22,706,416	$ 709,712,394
Nickel-copper	1,024,615,440	48,267,656	1,072,883,096
Silver-cobalt	106,776,425	406,350	107,182,775
Uranium	1,893,000	17,837,294	19,730,294
Total	$1,820,290,843	$89,217,716	$1,909,508,559

Metal Prices and Exchange

METAL PRICES AND EXCHANGE, 1958 AND 1959

Month	Average Exchange Rate, U.S. Dollar in Canadian Dollars	Pound Sterling in Canadian Dollars	Silver, Cents per Ounce		Copper, Cents per Pounds, New York Export, U.S. Funds	Gold in Canadian Dollars per Fine Ounce
			New York Market, U.S. Funds	Montreal, Canadian Funds		
1958						
January	0.9847	2.7707	89.449	88.53	21.253	34.464
February	0.9810	2.7629	88.625	87.35	20.079	34.334
March	0.9773	2.7519	88.625	86.95	20.738	34.205
April	0.9706	2.7345	88.625	86.97	21.631	33.973
May	0.9669	2.7228	88.625	86.05	21.944	33.844
June	0.9618	2.7044	88.625	85.63	23.670	33.664
July	0.9600	2.6923	88.625	85.35	24.397	33.600
August	0.9646	2.7065	88.625	85.79	25.179	33.761
September	0.9768	2.7388	88.673	86.91	25.489	34.185
October	0.9707	2.7254	89.966	87.55	28.573	33.976
November	0.9683	2.7171	90.125	87.63	29.476	33.895
December	0.9646	2.7050	89.935	87.03	27.041	33.737
Average (12 months)[1]	0.9706	2.7275	89.043	86.81	24.122	33.970
1959						
January	0.9669	2.7140	90.206	87.33	27.927	33.840
February	0.9749	2.7392	90.444	88.65	28.726	34.121
March	0.9698	2.7278	91.351	88.85	30.271	33.933
April	0.9635	2.7140	91.375	88.38	29.397	33.726
May	0.9629	2.7103	91.375	88.38	28.814	33.700
June	0.9588	2.6971	91.375	87.97	28.108	33.557
July	0.9574	2.6921	91.375	87.73	26.732	33.508
August	0.9544	2.6818	91.399	87.57	28.270	33.408
September	0.9516	2.6682	91.399	87.41	28.015	33.306
October	0.9477	2.6597	91.375	86.90	29.150	33.167
November	0.9503	2.6635	91.375	87.06	30.481	33.259
December	0.9512	2.6621	91.375	87.18	30.801	33.287
Average (12 months)[1]	0.9590	2.6939	91.202	87.78	28.891	33.568

[1] Computed from daily quotations.

Development

Operating mines, and those preparing for production, reported 9,800 feet of shaft-sinking, 172,300 feet of crosscutting, 425,350 feet of drifting, and 110,729 feet of raising.

Prospecting

There were 2,051 more claims recorded in 1959 than in 1950. The Larder Lake mining division recorded the largest number, immediately followed by the Sudbury, Port Arthur, Patricia, Red Lake, and Porcupine mining divisions. The amount reported as spent on prospecting and exploration in the province by Ontario companies was about $3,000,000. Also reported was about 2,750,000 feet of diamond-drilling.

MINING CLAIMS RECORDED IN THE ONTARIO MINING DIVISIONS

Mining Division	1953	1954	1955	1956	1957	1958	1959
Eastern Ontario	2,582	6,218	4,802	4,111	2,003	987	993
Fort Frances	729	725	2,063	1,103	433	801	422
Kenora	621	2,400	4,504	2,731	1,247	1,090	1,146
Kowkash[1]	.....	.....	.....	.....	3,549	896	1,368
Larder Lake	618	1,139	1,091	2,112	1,630	2,276	3,540
Montreal River	738	631	799	2,556	1,458	1,462	1,579
Parry Sound	1,359	564	384	423	291	39	182
Patricia	704	862	955	3,150	3,074	2,002	2,628
Porcupine	285	813	1,793	1,536	2,456	1,451	2,247
Port Arthur	2,586	21,055	14,552	8,532	4,351	4,027	3,479
Red Lake	1,127	1,299	1,875	2,657	1,078	2,657	2,554
Sault Ste. Marie	6,504	5,397	12,273	5,313	2,842	1,385	1,112
Sudbury	10,128	7,895	9,984	8,768	4,959	3,063	3,481
Timiskaming	1,038	1,178	2,292	5,005	1,576	1,844	1,300
Total	29,019	50,176	57,367	47,997	30,947	23,980	26,031

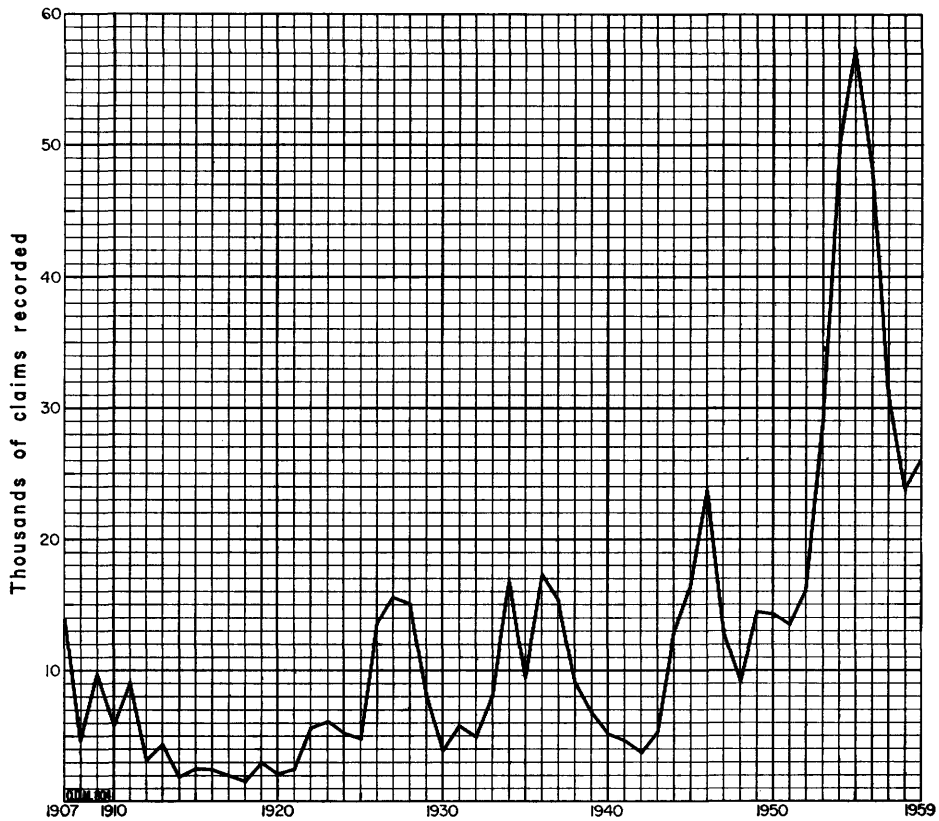
[1]Handled by the office of the Patricia Mining Division since April 1, 1956.

MINING CLAIMS CANCELLED IN THE ONTARIO MINING DIVISIONS

Mining Division	1953	1954	1955	1956	1957	1958	1959
Eastern Ontario	482	1,610	3,179	5,075	4,974	3,270	1,701
Fort Frances	588	662	665	1,651	1,177	833	630
Kenora	1,754	1,003	812	3,249	3,595	2,433	1,697
Kowkash[1]	.....	.....	.....	.....	3,288	1,526	1,228
Larder Lake	1,619	1,395	2,238	1,450	2,004	2,201	1,604
Montreal River	944	945	795	792	2,196	1,911	1,858
Parry Sound	87	870	570	528	468	640	122
Patricia	1,434	130	929	1,198	1,064	1,725	1,273
Porcupine	748	968	757	958	2,440	2,147	1,803
Port Arthur	3,634	3,869	13,905	12,355	8,362	5,791	4,265
Red Lake	855	1,254	1,890	1,570	1,569	1,345	1,843
Sault Ste. Marie	468	1,921	6,216	9,436	9,362	4,570	2,203
Sudbury	4,108	5,498	8,656	6,326	9,821	8,160	4,036
Timiskaming	1,457	1,652	966	1,352	4,012	2,996	2,132
Total	18,178	21,777	41,578	45,940	54,332	39,548	26,395

[1]Handled by the office of the Patricia Mining Division since April 1, 1956.

MINING CLAIMS RECORDED, 1907–1959



MINERS' LICENCES AND MINING CLAIMS, 1959

Mining Division	Miners' Licences		Mining Claims	
	Issued	Renewed	Recorded	Cancelled
Eastern Ontario	.....	.....	993	1,701
Fort Frances	34	85	422	630
Kenora	61	115	1,146	1,697
Kowkash[1]	.....	.....	1,368	1,228
Larder Lake	162	223	3,540	1,604
Montreal River	69	98	1,579	1,858
Parry Sound	.....	.....	182	122
Patricia	171	122	2,628	1,273
Porcupine	268	224	2,247	1,803
Port Arthur	372	510	3,479	4,265
Red Lake	80	146	2,554	1,843
Sault Ste. Marie	102	200	1,112	2,203
Sudbury	274	414	3,481	4,036
Timiskaming	127	175	1,300	2,132
At Toronto	601	1,939	.....	.....
Total	2,321	4,251	26,031	26,395

[1]Handled by the office of the Patricia Mining Division since April 1, 1956.

METALLIC MINERALS

Gold

GOLD PRODUCTION, 1959

Areas and Mines	Rated Daily Mill Capacity	Daily Operating Average	Ore Milled	Bullion Recovered				Total Value of Bullion
				Gold Content		Silver Content		
				Quantity	Value	Quantity	Value	
	tons	tons	tons	ounces	Canadian $	ounces	Canadian $	Canadian $
PORCUPINE								
Aunor	725	728	265,558	86,183	$ 2,893,163	6,348	$ 5,572	$ 2,898,735
Broulan Reef	700	484	113,750	31,218	1,047,988	2,601	2,283	1,050,271
Coniaurum	500	378	120,345	27,595	926,364	5,245	4,604	930,968
Delnite	520	501	182,746	43,933	1,474,830	3,228	2,834	1,477,664
Dome	1,975	1,980	712,900	173,851	5,836,178	36,027	31,625	5,867,803
Hallnor	400	325	118,601	46,043	1,545,664	2,991	2,625	1,548,289
Hollinger	3,900	3,620	980,887	260,145	8,733,068	43,226	37,944	8,771,012
Hugh-Pam	milled at Broulan Reef		62,871	10,752	360,945	.....	.....	360,945
McIntyre	2,400	2,276	773,980	228,373	7,666,482	37,364	32,798	7,699,280
Pamour	1,750	1,746	637,403	61,574	2,067,039	8,411	7,383	2,074,422
Paymaster	750	570	207,831	43,493	1,460,060	9,119	8,005	1,468,065
Preston East Dome	800	612	223,460	57,878	1,942,964	7,027	6,168	1,949,132
Ross	360	348	121,217	18,654	626,215	51,360	45,084	671,299
Total	14,780	13,568	4,521,549	1,089,692	$36,580,960	212,947	$186,925	$36,767,885
KIRKLAND LAKE								
Kirkland Minerals	400	191	69,624	30,594	1,027,041	2,515	$ 2,209	$ 1,029,250
Lake Shore	1,200	961	180,577	66,265	2,224,516	23,426	20,563	2,245,079
Macassa	500	433	158,130	69,668	2,338,755	10,702	9,394	2,348,149
Sylvanite	600	401	146,401	39,306	1,319,502	8,257	7,248	1,326,750
Teck-Hughes	650	504	184,170	25,149	844,252	3,291	2,889	847,141
Upper Canada	550	550	200,773	52,264	1,754,502	29,663	26,038	1,780,540
Wright-Hargreaves	milled at Lake Shore		170,220	69,001	2,316,364	17,232	15,126	2,331,490
Total	3,900	3,040	1,109,895	352,247	$11,824,932	95,086	$ 83,467	$11,908,399
LARDER LAKE								
Kerr-Addison	4,000	4,555	1,662,534	567,304	19,044,395	31,864	27,970	19,072,365

SUDBURY								
Renabie	550	537	195,898	36,350	1,220,269	10,579	9,286	1,229,555
KENORA DISTRICT (PATRICIA PORTION)								
Campbell Red Lake	700	703	256,721	162,273	5,447,505	9,540	8,374	5,455,879
Cochenour Willans	200	230	84,004	67,614	2,269,802	2,372	2,082	2,271,884
Madsen Red Lake	800	827	301,999	118,796	3,987,982	20,401	17,908	4,005,890
McKenzie Red Lake	230	217	79,133	17,572	589,892	4,927	4,325	594,217
New Dickenson	470	470	171,227	85,851	2,882,018	8,126	7,133	2,889,151
Pickle Crow	400	307	112,045	32,432	1,088,742	4,319	3,791	1,092,533
Total	2,800	2,754	1,005,129	484,538	$16,265,941	49,685	$ 43,613	$16,309,554
THUNDER BAY								
Leitch	120	101	36,862	36,422	$ 1,222,687	1,547	$ 1,358	$ 1,224,045
MacLeod-Cockshutt	1,900	1,899	693,322	66,616	2,236,299	6,383	5,603	2,241,902
Total	2,020	2,000	730,184	103,038	3,458,986	7,930	6,961	3,465,947
SUNDRIES								
Clean-up of abandoned operations	.....	.....	.....	343	11,515	23	20	11,535
TOTAL FOR GOLD MINES, 1959	28,050	26,454	9,225,189	2,663,512	$88,406,998	408,114	$358,242	$88,765,240
Nickel-copper refining	.....	.....	.....	42,509	$ 1,427,027	.....	.....	.....
Base metal mines	.....	.....	.....	7,428	249,358	.....	.....	.....
Total Gold Production, 1959	.....	.....	.....	2,683,449	$90,083,383	.....	.....	.....
GOLD PRODUCTION, 1958								
Porcupine	.....	.....	4,620,286	1,138,190	$38,635,747	231,289	$198,832	$38,834,579
Kirkland Lake	.....	.....	1,161,995	362,167	12,284,192	100,652	86,881	12,371,073
Larder Lake	.....	.....	1,661,980	542,269	18,394,923	35,407	30,590	18,425,513
Sudbury	.....	.....	177,475	27,858	945,600	8,427	7,281	952,881
Kenora Patricia Portion	.....	.....	989,344	482,394	16,374,837	57,363	49,504	16,424,341
Thunder Bay	.....	.....	699,599	106,856	3,627,541	9,052	7,812	3,635,353
Sundries	.....	.....	.....	460	15,631	59	51	15,682
Total for Gold Mines, 1958	.....	.....	9,310,679	2,660,194	$90,278,471	442,249	$380,951	$90,659,422
Nickel-copper refining	.....	.....	.....	47,367	$ 1,609,530	.....	.....	.....
Base metal mines	.....	.....	.....	8,953	304,230	.....	.....	.....
Total Gold Production, 1958	.....	.....	.....	2,716,514	$92,192,231	.....	.....	.....

In 1959 the 30 gold mines, the nickel-copper mines of the Sudbury district, and the base-metal mines, produced gold valued at $90,083,383. The gold mines produced 2,633,512 ounces of gold valued at $88,406,998, and 408,114 ounces of silver valued at $358,242, for a total production value of $88,765,240; they milled 9,225,189 tons of ore with an over-all grade of $9.62 per ton. The gold mines receive $35 (United States funds) per ounce from the Royal Canadian Mint; therefore, the actual amount received fluctuates with the rate of exchange.

The gold mines paid $6,161,203 to 1,138 salaried personnel, and $38,314,195 to 10,598 wage earners. They paid out $4,303,800 for fuel and electricity, and $15,352,295 for process supplies.

DIVIDENDS AND BONUSES PAID BY GOLD-MINING COMPANIES, BY AREAS

Year	Porcupine	Kirkland Lake, Larder Lake, and Sudbury	Northwestern Ontario	Total
1912–54	$309,884,444	$267,557,852	$47,712,221	$625,154,517
1955	6,146,058	6,194,728	2,948,348	15,289,134
1956	6,082,909	5,672,498	3,487,141	15,242,548
1957	8,177,576	5,255,623	3,011,421	16,444,620
1958	6,828,268	4,963,127	3,083,764	14,875,159
1959	14,313,084	5,052,304	3,341,028	22,706,416
Total	$351,432,339	$294,696,132	$63,583,923	$709,712,394

Nickel-Copper and Platinum Metals

Nickel and copper production was greatly increased over 1958, but because that year's production represented only nine months' operation for a large part of the industry, a reasonable comparison cannot be made of these two years. The year's production is close to that of 1957, although copper is up in quantity and value to an all-time high and nickel is down slightly in quantity and value.

The output of copper from the mines of the Manitouwadge and Timagami areas decreased 12 percent in quantity from 1958, but increased 3 percent in value. These mines produced 62,000,000 pounds valued at $18,400,000.

The nickel-copper industry of Sudbury milled 15,895,691 tons of ore and produced 314,330,000 pounds of copper worth $92,125,000 and 347,750,000 pounds of nickel worth $239,919,000. There was about 178,000 pounds of nickel produced outside this area and its value was $133,000. Also produced in the Sudbury area was the entire amount of Ontario's platinum metals, selenium and telurium, and 80 percent of its cobalt. A complete list of production of metals for the area is given in the table on page 16. The value of precious metals recovered in the refining process was $19,574,000. The nickel-copper industry of Sudbury used fuel and electricity worth $22,485,478 and process supplies worth $27,828,927.

Operations at the Mines

International Nickel Company of Canada Limited operated the Creighton, Frood-Stobie, Garson, Levack, and Murray mines throughout the year. Development work continued at the Crean Hill mine and development work was begun in October at the Victor mine. The smelters at Copper Cliff and Coniston, the iron-ore recovery plant at Copper Cliff, the copper refinery at Copper Cliff, and the nickel refinery at Port Colborne, operated throughout the year.

Falconbridge Nickel Mines Limited operated the Falconbridge, East, McKim, Hardy, Fecunis Lake, and Longvack mines, and the smelter at Falconbridge, throughout the year. The Onaping mine was brought into production during the year, and a small amount of development work was done at the Boundary mine.

Geco Mines Limited and Willroy Mines Limited operated mine and mill in the Manitouwadge area throughout the year. Temagami Mining Company Limited operated its mine in the Timagami area throughout the year, and its mill from April 1.

NICKEL-COPPER MINING AND SMELTING

	1955	1956	1957	1958	1959
	tons	tons	tons	tons	tons
Ore treated	14,260,466	15,798,970	16,474,142	11,735,895	16,554,454
Copper in blister produced in Ontario	133,218	141,304	155,987	125,895	170,116
Nickel produced in Ontario	108,319	108,613	117,992	71,422	110,282
Matte exported	87,262	95,675	99,817	93,748	107,131
Nickel content of matte exported	52,842	58,391	60,364	55,899	63,682
Copper content of matte exported	13,198	14,966	15,900	16,185	18,156

PRECIOUS METALS RECOVERED

	1955	1956	1957	1958	1959
Platinum metals:					
Platinum ..... ounces	170,494	151,357	199,565	146,092	150,378
Palladium, rhodium, ruthenium, and iridium ..... ounces	214,252	163,461	216,582	154,366	177,713
Total ..... ounces	384,746	314,818	416,147	300,458	329,081
Value	$23,069,365	$22,407,090	$25,731,333	$14,321,443	$16,932,178
Gold ..... ounces	46,133	44,129	43,391	47,367	42,509
Silver ..... ounces	1,480,728	1,391,545	1,576,138	1,217,510	1,384,223

STATISTICAL SYNOPSIS OF THE NICKEL-COPPER INDUSTRY IN ONTARIO

Year	Number of Producing Companies	Dividends Paid	Number of Plants in Ontario	Salaried Employees		Wage-Earners		Selling Value of Products	
				Number	Salaries	Number	Wages	Kind	Value
1955	4	$60,733,931	17 mines[1]	943	$ 5,563,139	9,434	$40,211,200	Nickel in matte	$ 63,410,359
			3 smelters	1,044	5,495,197	5,964	23,939,492	Metallic nickel	119,372,607
			2 refineries	330	1,733,318	2,464	9,680,993	Nickel oxide and salts	15,440,154
								Copper in matte	8,974,691
								Converter copper	96,842,950
								Gold	1,592,511
								Silver	1,305,706
								Platinum metals	23,069,365
								Selenium and tellurium	719,784
								Cobalt	5,279,524
								Sulphur	571,000
Total		$60,733,931		2,317	$12,791,654	17,862	$73,831,685		$336,578,651
1956	4	$61,131,568	18 mines[1]	955	$ 6,093,001	9,901	$44,079,494	Nickel in matte	$ 71,345,815
			3 smelters	1,066	5,954,658	6,063	26,081,794	Metallic nickel	122,161,530
			2 refineries	336	1,895,705	2,684	11,132,512	Nickel oxide and salts	14,021,419
								Copper in matte	11,539,238
								Converter copper	114,508,139
								Gold	1,520,245
								Silver	1,247,938
								Platinum metals	22,407,090
								Selenium and tellurium	1,484,640
								Cobalt	5,519,843
								Pyrrhotite	759,449
								Sulphur	534,810
Total		$61,131,568		2,357	$13,943,264	18,648	$81,293,800		$367,050,156
1957	4	$65,206,713	20 mines[1]	1,047	$ 7,069,063	10,338	$49,003,038	Nickel in matte	$ 79,601,346
			4 smelters	1,145	6,962,569	6,494	29,542,695	Metallic nickel	143,163,737
			2 refineries	363	2,132,908	2,682	11,836,568	Nickel oxide and salts	20,221,978
								Copper in matte	8,427,008
								Converter copper	83,741,114
								Gold	1,455,768
								Silver	1,376,188

								Selenium and tellurium...	963,150
								Cobalt	4,889,505
								Pyrrhotite	685,335
								Sulphur	542,846
Total		$65,206,713		2,555	$16,164,540	19,514	$90,382,301		$370,799,308
								Nickel in matte	$ 76,338,284
								Metallic nickel	90,601,931
								Nickel oxide and salts	10,108,807
								Copper in matte	7,526,058
1958[2]	3	$42,425,991	16 mines[1]	1,003	$ 6,940,510	9,334	$35,348,771	Converter copper	45,890,976
			4 smelters	1,105	7,607,745	6,153	21,096,430	Gold	1,609,530
			2 refineries	347	2,243,207	2,303	7,542,760	Silver	1,056,920
								Platinum metals	14,321,443
								Selenium and tellurium...	688,589
								Cobalt	3,359,984
								Pyrrhotite	655,569
								Sulphur	622,619
Total		$42,425,991		2,455	$16,791,462	17,790	$63,987,961		$252,780,710
								Nickel in matte	$ 85,970,920
								Metallic nickel	138,036,499
								Nickel oxide and salts	15,912,284
								Copper in matte	9,804,234
								Converter copper	82,322,026
1959	3	$ 48,267,656	16 mines[1]	975	7,146,760	9,220	45,601,540	Gold	1,427,027
			4 smelters	1,108	7,112,238	6,308	29,320,254	Silver	1,215,071
			2 refineries	374	2,476,620	2,538	11,219,286	Platinum metals	16,932,178
								Selenium and tellurium...	724,635
								Cobalt	4,451,593
								Pyrrhotite	632,140
								Sulphur	1,041,857
Total		$48,267,656		2,457	$16,735,618	18,066	$86,141,080		$358,470,464

[1]The figures for "mines" includes the following that were active but non-producing:
1955—Crean Hill (International Nickel, and Boundary and Onaping (Falconbridge).
1956—Crean Hill (International Nickel), Boundary and Onaping (Falconbridge), and Jonsmith Mines Limited.
1957—Crean Hill (International Nickel), Boundary and Onaping (Falconbridge), Coppercorp, Jonsmith, and Temiskaming Inspiration.
1958—Crean Hill (International Nickel), Boundary and Onaping (Falconbridge).
1959—Crean Hill, Victor (International Nickel), Boundary (Falconbridge).
[2]Only 9 month's operation by International Nickel Company of Canada Limited.

Silver-Cobalt

In 1959 the mines of the Cobalt and Gowganda areas shipped 5,776 tons of ore and concentrates to the refineries of Deloro Smelting and Refining Company Limited and Noranda Mines Limited, and 100 tons of concentrates to refineries in the United States. From this total of 5,876 tons, 6,657,162 ounces of silver were recovered. The nickel-copper mines produced 1,384,223 ounces, the base metal mines 2,091,357 ounces, and the gold mines 408,114 ounces, making up the province's total of 10,540,856 ounces.

The Deloro refinery reported the recovery of 554,531 pounds of cobalt, in the form of metal and salts, from the ores of the Cobalt and Gowganda areas. The nickel-copper mines recovered 2,281,153 pounds, a total of 2,835,684 pounds for the province. Its value was $5,414,246.

The Cobalt-Gowganda mines and the Deloro smelter employed 137 salaried personnel and paid them $642,848; 563 wage-earners were paid $2,021,424. The mines and smelter used fuel and electricity worth $440,800 and process supplies worth $865,974.

Agnico Mines Limited operated the Agaunico, Christopher, and O'Brien mines, and the Foster mill, throughout the year. Mining was done intermittently at the Foster mine.

Langis Silver and Cobalt Mining Company Limited operated its mine and mill in Casey township throughout the year.

Mining and milling were carried out at the Capitol and Castle properties of Castle-Trethewey Mines Limited throughout the year. Property and assets were purchased by McIntyre Porcupine Mines in December.

Silver-Miller Mines Limited carried on mining operations in Coleman township throughout the year; milling was done only between January 1 and February 7.

Siscoe Metals of Ontario Limited operated mine and mill in Haultain and Nicol townships throughout the year.

SILVER PRODUCTION

Source		1955	1956	1957	1958	1959
Sales of bullion by the reduction companies, smelters, and mines.	ounces	4,066,453	4,721,556	4,316,480	6,043,502	6,657,162
	$	3,585,798	4,234,291	3,771,309	5,257,847	5,843,657
Contained in silver-cobalt concentrates exported from Canada.						
Estimated as recovered from concentrates treated in other provinces.						
In crude gold bullion.	ounces	407,559	408,997	425,875	442,249	408,114
	$	360,762	364,776	368,451	380,951	358,242
Recovery for nickel-copper refineries.	ounces	1,480,728	1,391,545	1,575,138	1,217,510	1,384,223
	$	1,305,706	1,247,938	1,376,188	1,056,920	1,215,071
In copper-gold-silver ores.	ounces	12,025	12,215	17,056	.....	.....
	$	10,604	10,955	14,968	.....	.....
In silver-lead-zinc-copper ores.	ounces	84,252	92,134	575,581	.....	.....
	$	74,293	82,626	503,682	.....	.....
Base metal mines.	ounces	.....	.....	.....	2,111,996	2,091,357
	$	.....	.....	.....	1,833,424	1,835,793
Total Production	ounces	6,051,017	6,626,447	6,910,130	9,815,257	10,540,856
Total Value	$	5,337,163	5,940,586	6,034,598	8,529,142	9,252,763

SHIPMENTS FROM SILVER MINES, SMELTERS, AND REFINERIES

Year		Bismuth	Copper	Lead	Nickel	Cobalt	Arsenic	Silver	Total
1904–54	tons	113	1,149	373	7,283	19,404	81,539	oz. 461,426,000	.....
	$	251,791	380,497	33,718	2,261,258	39,781,301	6,721,500	280,095,510	329,525,575
1955	tons	.....	.....	.....	152	607	786	oz. 4,067,000	.....
	$	.....	.....	.....	266,128	3,230,790	69,159	3,585,798	7,151,875
1956	tons	3	265	12	305	629	895	oz. 4,722,000	.....
	$	10,586	219,100	2,991	570,690	3,261,783	77,612	4,234,291	8,377,053
1957	tons	7	228	27	218	669	1,848	oz. 4,316,000	.....
	$	21,372	131,927	5,589	531,077	2,647,917	137,112	3,771,309	7,246,303
1958	tons	9	113	34	79	379	1,162	oz. 6,043,000	.....
	$	26,779	57,340	4,661	119,896	1,506,783	94,542	5,257,847	7,067,848
1959	tons	16	92	63	89	277	789	oz. 6,657,000	.....
	$	37,748	46,913	8,559	133,562	962,653	63,786	5,843,657	7,096,878
Total	tons	148	1,847	509	8,126	21,965	87,019	oz. 487,231,000	.....
	$	348,276	835,777	55,518	3,882,611	51,391,227	7,163,711	302,788,412	366,465,532

Iron Ore, Pig Iron, and Steel

In 1959 a little over 6,000,000 tons of iron ore, sinter, and pelletized ore, with a value of $50,800,000 were shipped from Ontario mines. This was a large increase over the 1958 production; 65 percent greater in quantity, and 39 percent in value. About 84 percent of the production was shipped to steel plants in the United States, which follows the pattern of previous years.

Algoma Ore Properties Limited operated their Helen, Victoria, and Sir James mines, and their concentrators in the Michipicoten area, throughout the year.

Canadian Charleson Limited carried on concentration from hematite-bearing gravel, from May 1 to November 1, in the Atikokan area.

Lowphos Ore operated its mine and concentrator near Sudbury from the beginning of April to the end of the year.

Marmoraton Mining Company Limited operated mine and concentrator for the year, except for a period of interruption by strike action between July 15 and November 14.

Steep Rock Iron Mines Limited operated its mines in the Atikokan area throughout the year, and its concentrators from May 11 to October 31.

Caland Ore Company Limited continued the development of its Atikokan property.

The iron-mining industry paid $3,171,762 to 474 salaried personnel, and $11,887,253 to 2,291 wage-earning employees. Fuel and electricity used cost $3,968,000, and process supplies cost $3,544,744.

PIG IRON, STEEL, AND FERRO-ALLOY PRODUCERS, 1959

Company	Location	Products
Algoma Steel Corporation Ltd.	Sault Ste. Marie	Pig iron, steel
Atlas Steels Ltd.	Welland	Steel
Burlington Steel Co. Ltd.	Hamilton	Steel
Canada Electric Castings Ltd.	Orillia	Steel
Canadian Carborundum Co. Ltd.	Niagara Falls	Ferro-silicon
Canadian Furnace Co. Ltd.	Port Colborne	Pig iron
Dominion Foundries and Steel Ltd.	Hamilton	Pig iron, steel
Electro Metallurgical Company (division of Union Carbide Canada Ltd.)	Welland	Ferro-alloys
Exolon Co. Ltd.	Thorold	Ferro-silicon
Fahralloy Canada Ltd.	Orillia	Steel
Ford Motor Co. of Canada Ltd.	Windsor	Steel
The Indiana Steel Products Co. of Canada Ltd.	Kitchener	Steel
Lionite Abrasives Ltd.	Niagara Falls	Ferro-silicon
Neelon Steel Ltd.	Lebel	Steel
Norton Co.	Chippawa	Ferro-silicon
Steel Co. of Canada Ltd.	Hamilton	Pig iron, steel
Welland Electric Steel Foundry Ltd.	Welland	Steel
William Kennedy and Sons Ltd.	Owen Sound	Steel

IRON AND STEEL STATISTICS[1]

Year	Domestic Ore Smelted[2]	Foreign Ore Smelted[2]	Limestone for Flux (Pig-Iron)	Pig Iron Produced	Steel Made
	tons	tons	tons	tons	tons
1955	779,000	3,824,000	849,000	2,813,000	3,717,000
1956	2,084,000	3,631,000	896,000	3,102,000	4,267,000
1957	2,350,000	3,450,000	866,000	3,196,000	4,015,000
1958	2,023,000	2,733,000	584,000	2,667,000	3,504,000
1959	3,613,976	2,712,811	641,985	3,572,140	4,905,424

[1]Figures supplied by the Dominion Bureau of Statistics.
[2]In the production of pig iron.

IRON BLAST FURNACES IN OPERATION, 1959

Company	Stacks Operating Dec. 31	Furnaces		Location
		Number of Stacks	Annual Capacity	
			tons	
Algoma Steel Corporation Ltd.	3	5	1,484,000	Sault Ste. Marie
Canadian Furnace Company Ltd.	1	1	190,000	Port Colborne
Dominion Foundries and Steel Ltd.	2	2	640,000	Hamilton
Steel Company of Canada Ltd.	4	4	1,450,000	Hamilton

Lead and Zinc

Geco Mines Limited and Willroy Mines Limited operated mines and mills in the Manitouwadge area for the full year. Lead production increased 28 percent in quantity and 19 percent in value over 1958. Zinc production decreased 3 percent in quantity from 1958, but increased in value 9 percent over 1958. About 125,800 pounds of lead were recovered in the refining of silver-cobalt ores.

The base-metal mines employed 162 salaried personnel and paid them $842,732, and 618 wage-earners and paid them $2,972,291. Fuel and electricity used cost $429,087 and process supplies cost $1,412,358.

Calcium and Magnesium

Dominion Magnesium Limited operated throughout the year in Renfrew county. Calcium production was up from the low figure in 1958, being 167 percent greater in quantity and 144 percent in value. Magnesium production was down 11 percent in quantity and 24 percent in value from 1958. The industry used fuel and electricity worth $201,940 and process supplies worth $455,385.

Bismuth

This metal is recovered in the refining of ores from the silver-cobalt mines. The 1959 production was 70 percent greater in quantity and 41 percent greater in value than that of 1958.

Thorium

The new Elliot Lake thorium-recovery plant of Rio Tinto Dow Limited produced the first thorium concentrate from Ontario mineral sources in 1959. It is extracted from the waste of uranium recovery. An increase in production is planned. Thorium is important in the production of magnesium alloys and, in the field of nuclear energy, is of potential use as a fuel for breeder reactors.

Uranium

Production for 1959 increased 28 percent in quantity, and 28 percent in value, over 1958.

In the Algoma district, Algom Uranium Mines Limited operated the Nordic and Quirke mines and mills throughout the year. Can-Met Explorations Limited, Consolidated Denison Mines Limited, Milliken Lake Uranium Mines Limited, Pronto Uranium Mines Limited, Stanleigh Uranium Mining Corporation Limited, and Stanrock Uranium Mines Limited, operated mines and mills throughout the year. Northspan Uranium Mines Limited operated their Lacnor and Panel mines and mills throughout the year and the Spanish American mine from January 1 to 31, and the Spanish American mill from January 1 to February 4.

In the Haliburton-Hastings area, Bicroft Uranium Mines Limited, Canadian Dyno Mines Limited, and Faraday Uranium Mines Limited operated mines and mills throughout the year. Greyhawk Uranium Mines Limited operated only from January 1 to March 31, shipping ore to Faraday Uranium Mines Limited for milling, and on April 8, 1959 went into voluntary bankruptcy.

The industry paid $10,412,377 to 1,850 salaried employees and $51,688,045 to 9,368 wage-earning employees, and consumed fuel and electricity worth $6,181,359 and process supplies worth $49,093,593.

NON-METALLIC MINERALS

Asbestos

Canadian Johns-Manville Company was the only producer in Ontario. They carried on operations throughout the year at their Munro mine in Munro township Production increased 12 percent in quantity and value over 1958.

Fluorspar

Huntingdon Fluorspar Mines Limited was the only producer in Ontario. Mining operations were carried out for a total of 176 days, and milling operations for a total of 118 days, at the Kilpatrick mine in Huntingdon township. Production value was 74 percent greater than that of 1958.

Gypsum

Canadian Gypsum Company Limited, and Gypsum Lime and Alabastine Limited operated in Haldimand County throughout the year. Production decreased 3 percent in quantity and 4 percent in value from the 1958 production.

Nepheline Syenite

American Nepheline Limited, and International Minerals and Chemical Corporation (Canada) Limited operated their mines and mills in Peterborough County throughout the year. Production increased 9 percent in quantity and 12 percent in value over the 1958 production.

Peat Moss

There was only one operator. Atkins and Durbrow (Erie) Limited gathered material from April 1 to November 30, and operated their processing plant throughout the year. Their location is in Welland County. Production was up 78 percent in quantity and 37 percent in value from 1958.

Talc

Canada Talc Industries Limited carried on operations at mine and mill in Huntingdon township throughout the year. The year's production was only slightly increased from the 1958 figure.

General Statistics, Non-Metallic Minerals

The operators in the above six non-metallic mineral industries paid $649,506 to 116 salaried employees and $1,856,910 to 441 wage-earning employees. They used fuel and electricity worth $520,300 and process supplies worth $311,360.

Arsenic

In 1959, Deloro Smelting and Refining Company Limited shipped 1,578,307 pounds of arsenic trioxide valued at $63,786, recovered in the refining of silver-cobalt concentrates.

Mica

In 1959, 35,433 pounds of amber mica valued at $531, and 325 pounds of muscovite valued at $428, were produced in Ontario.

Mineral Waters

One operator, Breuvages Excel, Ltée., in Russell county near Ottawa, processed 3,025 gallons valued at $1,936.

Natural Gas and Petroleum

The Ontario Fuel Board's report for 1959 gives complete information concerning operations in this industry. About 16,800,000 M cubic feet of gas came from the province's wells in 1959. About 67,000,000 M cubic feet were imported, making a total of distributed gas of about 84,000,000 M cubic feet.

Petroleum production increased 28 percent in quantity and 22 percent in value over the 1958 production.

Quartz, Quartzite, and Silica Brick

In 1959 the International Nickel Company of Canada Limited, and Falconbridge Nickel Mines Limited, produced from their own quarries and pits about 1,400,000 tons of material for use as flux in smelter operations.

Electro Metallurgical Company, a division of Union Carbide Canada Limited, operated their quarry in Killarney township from May 18 to November 18 and their mill from June 1 to November 13.

Canadian Silica Corporation Limited operated their plant at Whitby throughout the year, their quarry on Manitoulin Island from June 15 to September 10, and their mill on Manitoulin Island from June 30 to August 31.

The greater amount of the production of these two operators was used in the manufacture of ferro-silicon.

Algoma Steel Corporation Limited milled 1,268 tons of quartzite to produce 1,123,000 silica bricks, to be used for furnace linings in their own plants.

The industry paid $76,657 to 12 salaried employees and $289,360 to 91 wage-earning employees. Fuel and electricity used cost $59,000 and process supplies cost $97,600.

Salt

Production of salt was 43 percent greater in quantity and 30 percent greater in value, than it was in 1958. Brunner Mond Canada Limited, Canadian Brine Limited, The Canadian Rock Salt Company Limited, and The Canadian Salt Company Limited, operated throughout the year in Essex county. Dow Chemical of Canada operated throughout the year at Sarnia, and Sifto Salt Limited operated wells at Goderich and Sarnia, throughout the year, and began production from their rock salt mine at Goderich on October 1. The Canadian Rock Salt Company Limited operation in Essex county is also a mining operation.

The industry paid $493,401 to 199 salaried employees and $1,984,884 to 449 wage-earning employees. Fuel and electricity used cost $726,100 and process supplies cost $1,004,000.

Sulphur

The value of sulphur produced in 1959 was $1,041,857. Some elemental sulphur is produced in Ontario, but the greater part of the production reported represents the value of the sulphur content of sulphuric acid and liquid sulphur dioxide manufactured from smelter gases.

STRUCTURAL MATERIALS

Construction Contracts

The value of construction contracts awarded in Canada in 1959 as published in *MacLean Building Guide* was $3,219,073,300 as compared with $3,593,702,200 in 1958. The value of Ontario contracts was $1,262,306,000, which was 39.21 percent of the total for Canada.

VALUE OF CONSTRUCTION CONTRACTS

Classification	1955	1956	1957	1958	1959
Residential...	$ 575,556,900	$ 578,170,100	$ 457,476,500	$ 675,763,300	$ 504,842,600
Business.....	305,515,200	351,401,600	330,616,800	429,419,600	418,894,500
Industrial....	144,341,800	213,497,400	199,995,600	84,507,000	95,534,400
Engineering..	274,873,800	284,752,200	324,331,400	299,903,600	243,034,500
Total.....	$1,300,287,700	$1,427,821,300	$1,312,420,300	$1,489,593,500	$1,262,306,000

Cement

Canada Cement Company Limited operated quarries and plants at Point Anne and Woodstock throughout the year. They operated their quarry at Port Colborne from June 5 to November 27 and their plant from May 11 to November 20.

Lake Ontario Portland Cement Company Limited operated at Picton, the St. Lawrence Cement Company operated at Clarkson, and the St. Mary's Cement Company Limited operated at St. Mary's, throughout the year.

Production was down 0.57 per cent in quantity and 10 percent in value from 1958 production. The industry paid $1,209,238 to 183 salaried employees and $4,463,050 to 999 wage-earning employees. Fuel and electricity costs totalled $6,469,457, and process supplies cost $1,495,842.

Lime

Production of quicklime increased 13 percent in value, and that of hydrated lime increased 3 percent in value over the production of 1958. There were 11 producers with 15 plants, with 54 kilns in use. They paid $249,336 to 58 salaried employees and $2,305,673 to 584 wage-earning employees. Fuel and electricity used cost $3,587,680 and process supplies cost $299,571.

The following operated throughout the year:

Bonnechere Lime Limited, Grattan Township, Renfrew county.
Brunner Mond, Canada, Limited, Amherstburg.
Carleton Lime Products Company, Carleton Place.
Canadian Gypsum Company Limited, Guelph.
Chemical Lime Limited, Beachville.
Cobo Minerals Limited, Coboconk.
Cyanamid of Canada Limited, Ingersoll.
Cyanamid of Canada Limited, Niagara Falls.
Dominion Magnesium Limited, Haley.
Gypsum Lime and Alabastine Limited, Beachville.
Gypsum Lime and Alabastine Limited, Hespeler.
Gypsum Lime and Alabastine Limited, Milton.
Rockwood Lime Company Limited, Rockwood.

Canada and Dominion Sugar operated for 102 days at Chatham, and 86 days at Wallaceburg.

LIME, 1959

Industrial Consumption	Quicklime		Hydrated Lime	
	Quantity	Value	Quantity	Value
	tons		tons	
Building trades, finishing, and masonry	24,832	$ 397,331	104,169	$2,095,516
Agriculture	111	1,290	1,019	12,648
Industry:				
Smelters	6,018	76,717	3,485	45,245
Iron and steel	150,104	1,723,630	2,202	27,656
Gold-milling	15,041	178,644	127	1,603
Uranium milling	275,079	3,369,002	.....	.....
Pulp and paper	19,507	222,286	1,244	17,065
Glass	16,972	224,876	.....	.....
Sugar	12,137	84,319	.....	.....
Tanneries	801	9,460	3,111	39,067
Fertilizers and insecticides	65	1,035	879	20,866
Chemicals	446,867	4,886,172	423	9,330
Other consumers	36,730	422,256	9,132	140,518
Total	1,004,264	$11,597,018	125,791	$2,409,514

Sand and Gravel

Production was up 9 percent in quantity over 1958 but the value of the production decreased 1 percent. There were 356 reporting pit operators and 12 dredge operators. The industry employed 295 salaried personnel and paid them $1,398,925, and 1,937 wage-earning employees and paid them $6,864,932. Fuel and electricity used cost $2,654,498 and process supplies cost $546,925.

OUTPUT OF SAND AND GRAVEL

Source	1955	1956	1957	1958	1959
Private pit operators ... tons	28,048,958	29,583,879	32,134,104	31,853,372	34,559,281
$	19,062,578	19,595,413	21,100,962	23,514,262	24,520,143
Dredged from the Great Lakes and rivers ... tons	1,305,454	1,570,836	1,862,920	1,263,381	1,306,943
$	1,369,151	1,649,841	1,742,507	1,421,628	1,616,294
Ontario Department of Highways ... tons	12,380,750	18,250,000	19,537,000	21,077,081	24,776,179
$	4,993,500	7,610,000	7,808,000	8,460,000	7,226,546
Counties and townships ... tons	8,254,633	10,309,882	10,455,849	11,816,303	11,919,781
$	4,127,317	5,154,941	5,227,925	5,908,152	5,959,891
Railway ballast ... tons	1,498,272	1,721,766	2,139,285	1,458,927	1,419,519
$	393,184	368,820	820,501	750,989	372,728
Total ... tons	51,488,067	61,436,363	66,129,158	67,469,064	73,981,703
$	29,945,730	34,379,015	36,699,895	40,055,031	39,695,602

Stone

Production increased 9 percent in quantity and 7 percent in value over the 1958 amounts. There were 86 reporting operators drawing from about 98 quarries. The industry paid $1,141,637 to 252 salaried employees, and $5,737,393 to 1,558 wage-earning employees. Fuel and electricity used cost $1,812,493 and process supplies cost $2,706,030.

There were 2,950,000 tons of limestone quarried for the manufacture of cement and 1,800,000 tons for the manufacture of lime. These amounts are not included in the year's statistics as stone production because this would duplicate their final value as reported under cement and lime.

OUTPUT OF STONE

Variety	1955	1956	1957	1958	1959
Limestone.....tons	12,233,730	15,207,534	16,592,404	15,144,361	16,322,071
$	14,765,784	18,941,565	19,748,013	18,542,922	19,363,443
Marble.....tons	33,699	34,178	40,328	33,989	51,440
$	258,813	267,486	298,496	301,135	327,644
Trap and granite.....tons	444,140	445,072	719,026	550,362	882,236
$	1,013,510	1,132,614	1,605,542	1,265,996	1,811,344
Sandstone.....tons	27,570	47,880	38,680	27,848	33,049
$	269,868	479,062	543,764	560,427	550,994
Total.....tons	12,739,139	15,734,664	17,390,438	15,756,560	17,288,796
$	16,307,975	20,820,727	22,195,815	20,670,480	22,053,425

Clay Products

The value of clay products in Ontario in 1959 decreased 2.75 percent from the 1958 value. There were 54 reporting operators with 59 plants. The industry employed 196 salaried personnel and paid them $1,110,134, and 1,938 wage-earners and paid them $6,908,420. Fuel and electricity cost $3,695,363 and process supplies cost $494,438.

CLAY PRODUCTS MARKETED, 1959

Kind	Quantity	Value
Brick:		
Soft-mud process {face.....M	7,344	$ 478,945
Soft-mud process {common.....M	195	8,050
Stiff-mud (wire-cut) process {face.....M	194,125	10,804,268
Stiff-mud (wire-cut) process {common.....M	18,277	458,826
Dry-press {face.....M	48,084	3,158,094
Dry-press {common.....M	2,796	68,205
Fancy or ornamental brick (including special shapes, embossed and enamelled brick).....M	291	34,092
Sewer.....M	1,205	48,185
Paving brick.....M	152	12,179
Tile:		
Structural (hollow blocks, including fireproofing and load-bearing tile).....tons	54,504	1,053,970
Floor tile (quarries).....sq. ft.	186,118	84,075
Drain.....M	44,483	2,595,721
Sewer pipe.....feet	3,427,347	1,412,181
Pottery from domestic clay.....	.....	518,122
Flue linings.....feet	1,173,846	904,847
Other products.....	.....	535,135
Total.....		$22,174,895

Provincial Assay Office, 1959

BY

D. A. MODDLE[1]

GENERAL

As an aid to the development of the mineral resources of Ontario, the Government established a Provincial Assay Office in Belleville in 1898. This was for the purpose of assaying the various ores found in the Province, and to assist the prospector in the development of claims. The laboratory was later moved to Toronto and is now established in the East Block of the Parliament Buildings.

Changes are required continually to cope with the varying needs of the industry and to provide new and improved techniques. Present facilities provide for: chemical, spectrographic, radiometric, and x-ray fluorescence and x-ray diffraction analysis; fire assaying; and mineralogical and petrological work.

ROUTINE ASSAY WORK, 1959

Determinations	For Coupons	For Cash	For the Department	Accounts Outstanding	Total
Aluminium	2	25	.....	2	29
Antimony	1	.....	1	.....	2
Arsenic	1	.....	.....	.....	1
Barium	1	1	.....	.....	2
Beryllium	9	2	1	7	19
Bismuth	3	.....	.....	.....	3
Calcium	2	22	9	2	35
Chromium	5	1	1	.....	7
Cobalt	41	2	25	.....	68
Copper	276	53	44	13	386
Germanium	1	.....	.....	.....	1
Gold[1]	1,206	260	64	76	1,606
Iron	116	21	19	4	160
Lead	22	4	10	2	38
Lithium	3	1	3	.....	7
Magnesium	.....	19	10	2	31
Manganese	18	3	1	1	23
Molybdenum	33	.....	3	4	40
Nickel	96	17	41	8	162
Palladium[2]	13	1	.....	1	15
Platinum[2]	35	17	.....	4	56
Potassium	.....	.....	1	1	2
Phosphorus	20	1	5	.....	26
Silicon	15	15	8	2	40
Silver[1]	306	64	19	50	439
Sodium	.....	.....	8	1	9
Strontium	1	.....	.....	.....	1
Sulphur	18	1	4	.....	23
Tin	3	.....	2	.....	5
Titanium	27	1	5	.....	33
Tungsten	1	2	.....	.....	3
Uranium	7	4	.....	.....	11
Vanadium	2	.....	.....	1	3
Zinc	51	15	29	7	102
Others	8	29	21	4	62
Total	2,343	581	334	192	3,450

[1]Fire assays.
[2]Fire assays—spectrographic determinations.

[1]Provincial Assayer, Ontario Department Mines.

The staff consists of the Provincial Assayer, one spectrographer, one x-ray spectrographer, one chemist, one mineralogist, one assayer, and laboratory assistants with specialized training and experience.

Free assays are made according to the coupon system as provided by the Mining Act of Ontario, R.S.O. 1950, Chapter 236, Section 67, as amended. Work may also be done for a fee as outlined by a schedule of charges. Identifications of minerals and rocks not requiring analysis and tests for radioactivity are made free of charge.

The Provincial Assayer, D. A. Moddle, gives the following report of activities for the calendar year of 1959.

SUMMARY OF REGULAR WORK

	Calendar Years	
	1958	1959
Regular Assays	3,365	3,450
Qualitative Spectrographic Analyses:		
Samples for 29 elements	674	500
Miscellaneous determinations	400	215
Radioactivity determinations	247	80
Examination, identification and evaluation of mineral and rock samples	690	405
Detailed studies of mineral and rock samples	101	73
Complete analysis (silicate rocks)	25	17
Complete analysis (carbonate rocks)	.....	120

FEES RECEIVED

Calendar Year	Cash	Coupons
1958	$4,080.05	4,264
1959	$2,600.00	3,715

SUMMARY OF SPECIAL WORK

Service was rendered to the highgrading squad of the Ontario Provincial Police. Various analyses were carried out, and one court appearance was made.

Standard checks were run periodically on sodium fluoride pellets used in uranium analysis. The work was done for the manufacturer of the pellets.

Assistance was given in connection with a project designed to establish the fundamental composition of certain radioactive minerals. Quantitative analysis was made of rare-element constituents.

Mining companies took greater advantage of the facilities for complex mineralogical and petrological investigations. More rock sections and ore sections were prepared in the laboratory, and the practice of including photomicrographs with reports whenever possible was initiated. A number of interesting minerals and associations were encountered; the following are worthy of mention: jarosite; non-metamict pyrochlore; pollucite; altaite; violarite in pyrrhotite; pigeonite; and brochantite.

As usual, much of the special work was done in connection with projects of the Geological Branch. The following are in this category.

One hundred and fourteen complete analyses of limestone and dolomites were made in connection with the investigation of the limestone industry in Ontario.

A program was planned to study specific gravity in the classification of basic volcanic rocks and the use of silica contained in these rocks. Procedures were worked out, and were tried on six samples.

Analyses for lithium, rubidium, and cesium, were made on ninety-four samples from the vicinity of Georgia Lake. The purpose was to find a locus of concentration of lithium and related elements.

Complete analyses were run on picked specimens of spodumene to study the sequence of alteration.

Rocks from certain alkali complexes were investigated. For two localities, accessory minerals were identified and described. For five localities, carbonate rocks were described and major constituents determined from representative samples. Specimens of selected calcite were analyzed for minor constituents.

Laboratory work was required in connection with the geological investigation of clay deposits. Mechanical soil analysis, in accordance with A.S.T.M. standard method D 422, was made of sixty-eight clays. Heavy-mineral separations and microscope slides were made from fractions of fourteen selected samples. Determinations of the percentage of nineteen minor elements were made on the same set of specimens.

Mining Accidents in 1959

By the Staff of the Mines Inspection Branch

STATISTICAL REVIEW

Introduction

During 1959, at the mines, metallurgical works, quarries, clay, shale, sand, and gravel pits, and contract diamond-drilling regulated by *The Mining Act* of Ontario, there were 4,169 accidents reported to the Ontario Department of Mines up to January 20, 1960: 47 fatalities and 4,122 non-fatal accidents.

The report shows a fatality rate of 0.39 per million man-hours, the same as for the preceding year and 0.10 less than the average for the last 25 years. There were 34 non-fatal accidents per million man-hours, the same as for 1958 but an increase of 3 from the average for the last 25 years.

The total employment figures show an increase of 2.3 percent from 58,124 in 1958 to 59,474 in 1959.

CLASSIFICATION OF OPERATIONS

Classification	Men Employed
Group 1. Underground at mines[1]	24,465
Group 2. On surface at mines	14,395
Group 3. Metallurgical works	13,715
Group 4. Quarries	2,232
Group 5. Clay, shale, sand, and gravel pits	3,990
Group 6. Contract diamond-drilling	677
Group 7. Operations in the mining industry for which employment figures are not available	.....
Total	59,474

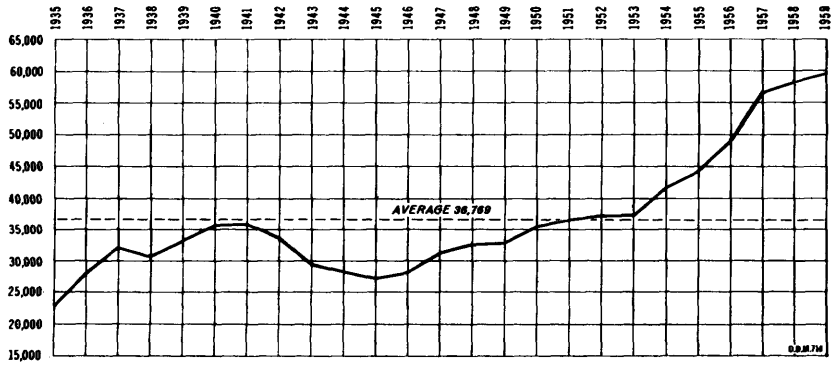
[1]Open-pit mining operations such as at the Frood-Stobie, American Nepheline, Marmoraton Mining Co., and Steep Rock mines (as distinct from rock quarries) are included in Group 1.

EMPLOYMENT UNDERGROUND AND ON SURFACE AT MINES
(GROUPS 1 AND 2)

Year	Underground (Group 1)		Surface (Group 2)		Total
	Number	Percent	Number	Percent	
1949	13,968	64	7,918	36	21,886
1950	14,591	64	8,372	36	22,963
1951	15,000	63	8,626	37	23,626
1952	15,201	65	8,283	35	23,484
1953	14,415	63	8,401	37	22,816
1954	16,246	65	8,910	35	25,156
1955	16,114	62	9,907	38	26,021
1956	17,636	61	11,418	39	29,054
1957	20,733	59	14,676	41	35,409
1958	22,063	58	15,937	42	38,000
1959	24,465	63	14,395	37	38,860
Average	17,312	62	10,622	38	27,934

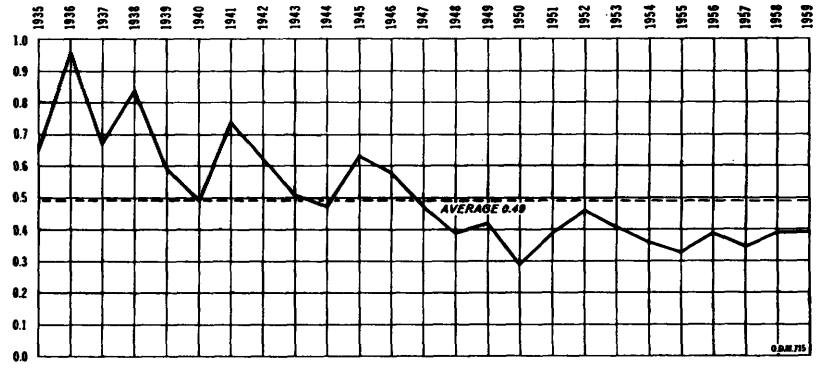
Employment and Accident Statistics (Group 1-6) Shown Graphically

1–EMPLOYMENT



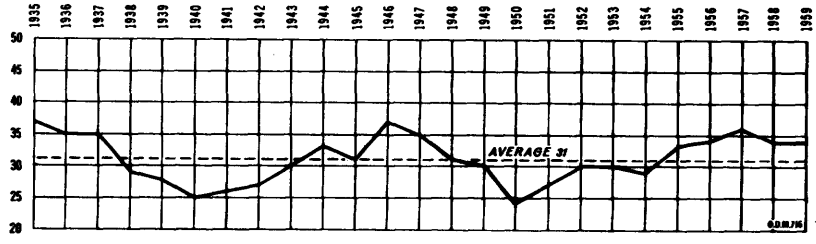
Total number of persons employed in mining operations.

2–FATAL ACCIDENTS



Number of fatalities per million man-hours in mining operations.

3–NON-FATAL ACCIDENTS



Number of non-fatalities per million man-hours in mining operations.

Summary of Employment and Fatal and Non-Fatal Accidents

The following table is a summary of the number employed, and the number injured per million man-hours at mining operations in the past 25 years.

EMPLOYMENT AND ACCIDENTS TO EMPLOYEES AT MINES
(GROUPS 1–6)

Year	Number Employed	Persons Injured			Number of Million Man-Hours			Rate per Million Man-Hours	
		Fatally	Non-Fatally	Total	Producing Operations	Non-Producing Operations	Total	Fatally	Non-Fatally
1935....	22,972	36	2,048	2,084	51.466	3.667	55.133	0.65	37
1936....	28,272	65	2,359	2,424	61.740	6.113	67.853	0.96	35
1937....	32,158	52	2,721	2,773	69.451	7.728	77.179	0.67	35
1938....	30,855	62	2,147	2,209	70.642	3.410	74.052	0.84	29
1939....	33,341	47	2,246	2,293	77.866	2.153	80.019	0.59	28
1940....	35,575	42	2,128	2,170	84.329	1.051	85.380	0.49	25
1941....	35,935	64	2,240	2,304	84.761	1.483	86.244	0.74	26
1942....	33,767	50	2,167	2,217	80.006	1.034	81.040	0.62	27
1943....	29,477	36	2,101	2,137	69.799	0.946	70.745	0.51	30
1944....	28,476	32	2,238	2,270	67.277	1.066	68.343	0.47	33
1945....	27,052	41	2,026	2,067	61.534	3.391	64.925	0.63	31
1946....	28,149	39	2,483	2,522	61.099	6.458	67.557	0.58	37
1947....	31,101	35	2,608	2,643	71.916	2.726	74.642	0.47	35
1948....	32,707	31	2,429	2,460	75.770	2.726	78.496	0.39	31
1949....	32,913	33	2,341	2,374	78.206	0.785	78.991	0.42	30
1950....	35,554	25	2,070	2,095	84.175	1.154	85.329	0.29	24
1951....	36,729	34	2,387	2,421	86.827	1.322	88.149	0.39	27
1952....	37,261	41	2,697	2,738	88.222	1.205	89.427	0.46	30
1953....	37,401	37	2,654	2,691	88.274	1.488	89.762	0.41	30
1954....	41,784	33	2,668	2,701	88.450	2.282	90.732	0.36	29
1955....	44,366	32	3,202	3,234	91.903	4.118	96.021	0.33	33
1956....	49,035	41	3,555	3,596	98.834	6.610	105.444	0.39	34
1957....	56,758	42	4,254	4,296	113.405	6.210	119.615	0.35	36
1958....	58,124	44	3,861	3,905	111.575	0.881	112.456	0.39	34
1959....	59,474	47	4,122	4,169	118.832	1.479	120.311	0.39	34
Total	919,236	1,041	65,752	66,793	2,036.359	71.486	2,107.845	.....	.....
Average	36,769	42	2,630	2,672	81.454	2.859	84.313	0.49	31

Fatal Accidents

FATALITY RATE PER MILLION MAN-HOURS (GROUPS 1–6), 1959

Distribution	Group	Million Man-Hours	Number Killed	Rate per Million Man-Hours
Mines, underground	1	47.321	38	0.80
Mines, surface	2	29.422	2	0.07
Metallurgical works	3	26.961	3	0.11
Quarries	4	5.023	1	0.20
Clay, shale, sand, and gravel pits	5	9.970	2	0.20
Contract diamond-drilling	6	1.614	1	0.62
Total		120.311	47	0.39

A COMPARISON OF FATAL ACCIDENTS AND FATALITIES (GROUPS 1–6)

Distribution	Group	1955		1956		1957		1958		1959	
		Accidents	Killed	Accidents	Killed	Accidents	Killed	Accidents	Killed	Accidents	Killed
Mines, underground	1	22	22	21	23	26	27	35	37	35	38
Mines, surface	2	2	2	3	3	5	5	4	4	2	2
Metallurgical works	3	2	2	2	3	2	6	1	1	3	3
Quarries	4	2	2	3	3	2	2	2	2	1	1
Clay, shale, sand, and gravel pits	5	1	1	3	3	2	2	0	0	2	2
Contract diamond-drilling	6	1	3	5	6	0	0	0	0	1	1
Total		30	32	37	41	37	42	42	44	44	47

FATALITIES ACCORDING TO INDUSTRIES (GROUPS 1–6)

	1955	1956	1957	1958	1959
Asbestos mines	0	0	1	0	0
Copper, nickel, and zinc mines	6	10	8	7	6
Gold mines	12	9	12	7	14
Iron mines	3	1	2	1	0
Nepheline mines	0	0	0	0	0
Salt mines	0	0	1	0	1
Silver-cobalt mines	2	0	0	0	1
Uranium mines	4	6	8	26	18
Metallurgical works	2	3	6	1	3
Quarries	2	3	2	2	1
Clay, shale, sand, and gravel pits	1	3	2	0	2
Contract diamond-drilling	0	6	0	0	1
Total	32	41	42	44	47

FATALITIES AT MINES (GROUPS 1–6)

UNDERGROUND (GROUP 1)

Cause	Class of Accident	1955	1956	1957	1958	1959	
		percent	percent	percent	percent	number	percent
Fall of ground	A	18	40	48	54	14	37
Explosives	B	0	4	4	5	1	3
Run of ore, rock, etc.	C	9	4	19	0	5	13
Shaft accidents	D	41	22	11	17	3	8
Fall down stope, raise, etc.	E	18	22	0	8	3	8
Haulage	F	9	4	7	8	4	10
Rock burst	G	0	0	0	3	2	5
Unclassified	H	5	4	11	5	6	16
Total		100	100	100	100	38	100

ON SURFACE (GROUPS 2–6)

Cause	Class of Accident	1955	1956	1957	1958	1959	
		percent	percent	percent	percent	number	percent
Falling objects	A	10	11	7	0	0	0
Explosives	B	10	6	0	0	0	0
Run of materials	C	0	0	13	0	0	0
Machinery	D	10	11	27	29	0	0
Fall of persons	E	0	11	7	14	2	22
Transportation and haulage	F	40	44	0	14	5	56
Chemicals and burns	G	10	11	33	0	1	11
Unclassified	H	20	6	13	43	1	11
Total		100	100	100	100	9	100

FATALITIES BY MONTHS (GROUPS 1–6), 1959

	Accidents	Men Killed
January	2	3
February	2	2
March	5	5
April	4	4
May	3	4
June	4	5
July	4	4
August	2	2
September	5	5
October	4	4
November	6	6
December	3	3
Total	44	47

Non-Fatal Accidents

Mines (Groups 1 and 2)

There were 76.743 million man-hours at mines in Ontario in 1959. During the year there were 3,127 injuries, giving a non-fatal accident rate of 41 per million man-hours.

NON-FATAL ACCIDENTS AT MINES, 1959

Cause	Underground (Group 1)	On Surface (Group 2)	Total
Fall of person	344	82	426
Strain while lifting	207	48	255
Fall of rock or ore, drilling, scaling, etc.	253	2	255
Strain while moving	157	47	204
Drilling machine	190	1	191
Fall of loose rock or ore	168	0	168
Falling object	124	23	147
Handling material other than rock or ore	99	46	145
Running into or striking object	101	30	131
Flying object, drilling, sledging, etc.	97	19	116
Roll of broken rock or ore	114	1	115
Handling or tramming mine cars	103	3	106
Hand tool	70	28	98
Mechanical transportation	78	12	90
Tugger hoist, scraper, etc.	87	0	87
Crushed between two objects	70	15	85
Rock or ore at chute	84	1	85
Handling rock or ore	83	0	83
Nail or splinter	62	9	71
Machinery, general	11	57	68
Burns	21	28	49
Mechanical loader	40	0	40
Cage, skip, or bucket in shaft	30	0	30
Explosives	25	0	25
Fall down winze, shaft, or stope	22	1	23
Rockburst	9	0	9
Dermatitis	6	0	6
Electricity	3	3	6
Noxious gas	2	2	4
Unclassified	4	5	9
Total	2,664	463	3,127

Metallurgical Works (Group 3)

There were 26.961 million man-hours at metallurgical works in Ontario in 1959. During the year there were 504 injuries, giving a non-fatal accident rate of 19 per million man-hours.

NON-FATAL ACCIDENTS AT METALLURGICAL WORKS, 1959

Cause		Cause	
Strain while lifting or moving	98	Flying object, sledging, etc.	21
Fall of person	55	Burns	19
Running into or striking object	41	Dermatitis, chemical burns, etc.	19
Burned by slag or metal	41	Machinery	10
Falling object	38	Transportation	10
Loading, unloading, or handling cars	35	Noxious gas	7
Handling material	28	Nail or splinter	3
Hand tool	26	Unclassified	3
Crushed between two objects	26		
Hoisting equipment, hooks, slings, blocks	24	Total	504

Quarries (Group 4)

There were 5.023 million man-hours at quarries in Ontario in 1959. During the year there were 161 injuries, giving a non-fatal accident rate of 32 per million man-hours.

NON-FATAL ACCIDENTS AT QUARRIES, 1959

Cause		Cause	
Strain while lifting or moving	31	Burns	6
Fall of person	25	Crushed between two objects	5
Machinery	15	Running into or striking object	3
Flying object, sledging, etc.	13	Fall of material from face	2
Falling object	11	Dermatitis	1
Drilling machine	11	Electrical	1
Fall of material during handling	9	Unclassified	2
Hand tool	9		
Transportation	9	Total	161
Handling material	8		

Clay, Shale, Sand, and Gravel Pits (Group 5)

There were 9.970 million man-hours at clay, shale, sand, and gravel pits in Ontario in 1959. During the year there were 182 injuries, giving a non-fatal accident rate of 18 per million man-hours.

NON-FATAL ACCIDENTS AT CLAY, SHALE, SAND, AND GRAVEL PITS, 1959

Cause		Cause	
Fall of person	32	Hand tool	8
Transportation	29	Fall of material during handling	3
Strain while lifting or moving	27	Fall of material from bank	3
Machinery	20	Flying object	3
Running into or striking object	15	Handling material	2
Crushed between two objects	15	Nail or splinter	2
Falling object	12		
Burns	11	Total	182

Contract Diamond-Drilling (Group 6)

There were 1.614 million man-hours in contract diamond-drilling in Ontario in 1959. During the year there were 148 injuries, giving a non-fatal accident rate of 92 per million man-hours

NON-FATAL ACCIDENTS IN DIAMOND-DRILLING, 1959

Cause		Cause	
Handling drill rods	39	Burns	8
Strain while lifting or moving	21	Machinery	3
Fall of person	18	Handling material	3
Falling object	12	Caught in moving parts	2
Transportation	11	Running into or striking object	2
Wire, nail, or splinter	9	Flying object, sledging, etc.	2
Hand tool	9		
Crushed between two objects	9	Total	148

Infection (Groups 1–6)

Infection followed in 92 cases out of a total of 4,122 accidents in 1959.

ACCIDENTS FOLLOWED BY INFECTION, 1959

Location	Group	Number of Accidents	Accidents Followed by Infection	Percentage Infection
Mines underground	1	2,664	48	1.8
Mines, surface	2	463	8	1.7
Metallurgical works	3	504	11	2.2
Quarries	4	161	5	3.1
Clay, shale, sand, and gravel pits	5	182	5	2.7
Contract diamond-drilling	6	148	15	10.1
Total		4,122	92	2.2

Electrical Accidents (Groups 1–6)

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	Total
Fatal	0	1	1	1	1	0	0	0	0	0	4
Non-fatal	2	8	2	9	5	3	8	7	4	8	56
Total	2	9	3	10	6	3	8	7	4	8	60

Explosives

CAUSES OF ACCIDENTS FROM EXPLOSIVES, 1959

Cause	Number of Accidents	Persons Injured		
		Non-Fatally	Fatally	Total
Explosion while loading hole	1	1	.....	1
Delayed too long at scene of blast	1	1	.....	1
Detonation due to run or handling of muck	1	1	.....	1
Returned too soon to scene of blast	2	2	.....	2
Did not take sufficient cover	4	3	.....	3
Injury due to blast concussion	3	3	.....	3
Improper guarding of blast	2	3	.....	3
Drilled into missed hole	8	11	1	12
Total	22	25	1	26

Classes for Prospectors, 1959–60

BY

M. E. Hurst[1]

GENERAL

The Ontario Department of Mines has, for many years, sponsored a short course of instruction for prospectors, which is given during the winter months at various centres across the province. Since 1936, and until his retirement in 1959, W. D. Harding organized and conducted most of the classes. No classes were held in the fall of 1959, but instruction was resumed early in 1960 with classes being given in Cochrane and Toronto by R. M. Ginn, resident geologist at Timmins, and in Port Arthur by E. G. Pye, resident geologist at Port Arthur. Particulars about these classes are given below.

Cochrane

It was at the written request of C. J. Kennedy, representing the Cochrane Board of Trade, that the Cochrane classes were held. The assistance of Mr. Kennedy and C. A. Stanbury is gratefully acknowledged. The facilities provided by the Ontario Department of Lands and Forests were well suited to the purpose. The classes were held January 4–8, and the instruction was given by R. M. Ginn, resident geologist at Timmins.

The classes were conducted for one hour each afternoon, and 2½–3 hours every evening. At the afternoon sessions the following topics were discussed: map reading, bush equipment, prospecting and staking procedures, and the general geology of Ontario. Four motion-picture films were shown to illustrate the constitution of the earth, the nature of several types of ore deposits, staking procedures, and mining methods.

During the more fully attended evening classes, the following subjects were considered: mineralogy, petrography, structural geology, and geophysical and geochemical prospecting. Rock and mineral samples were distributed. The film which had been shown during the afternoon was repeated after each evening period of instruction for the benefit of those unable to attend the daytime classes.

Port Arthur

Classes were conducted at Port Arthur for six days by E. G. Pye, resident geologist at Port Arthur. The instruction was given in the Public Library both afternoons and evenings, February 15–19, and in the afternoon of February 20. A total of 89 persons registered for the course.

Most of the instruction at these classes was given by E. G. Pye. In addition, J. C. Smith, mining recorder for the Port Arthur Mining Division, led a discussion of staking regulations in the province; T. Christianson, mining claims inspector, gave a talk on "The Use of the Gold Pan"; and E. H. Brinley, geologist in charge of exploration for Anaconda Company (Canada) Limited, Port Arthur office, spoke on the subject of "sampling."

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[1]Provincial Geologist, Ontario Department of Mines.

CLASSES FOR PROSPECTORS, 1959–60

Centre	Classroom	Dates	Total Registration	Average Attendance	Number with Prospecting or Mining Experience	Number who have Attended a Previous Class
Cochrane	Ontario Department of Lands and Forests Warehouse	Jan. 4–Jan. 8	43	39	13	4
Port Arthur	Public Library	Feb. 15–Feb. 20	89	82	33	33
Toronto	Mining Building, University of Toronto	Feb. 29–Mar. 4	89	83	33	22

Toronto

The Toronto classes were held in the Mining Building, University of Toronto, during the week preceding the annual convention of the Prospectors and Developers Association. Some of those attending the classes were in Toronto to attend this convention. As the lecture room was available during only one evening, most of the instruction was given at the afternoon sessions.

The relatively small registration at the classes is believed to reflect the slight decrease in prospecting activity during the past year. During five afternoon classes, S. A. Ferguson spoke on geophysical prospecting, P. F. Karrow considered Pleistocene geology and map reading, and R. M. Ginn gave instruction on mineralogy, petrography, structural geology, geochemical prospecting, and the services of the Ontario Department of Mines. One motion-picture film was shown during the afternoon sessions. Rock and mineral samples were distributed.

F. W. Matthews and D. S. Andrews conducted the evening class, discussing staking procedures and assessment work. Two motion-picture films were shown.

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ONTARIO

DEPARTMENT OF MINES

HON. JAMES A. MALONEY, *Minister* D. P. DOUGLASS, *Deputy Minister*

M. E. HURST, *Director of Geological Branch*

Mining Operations in 1959

Compiled by the Staff of The Mines Inspection Branch

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Mining Operations in 1959

Compiled by the Staff
of
The Mines Inspection Branch

Only those mines or mining properties that have reported actual mining or development operations for the year 1959 are included in this report.

ASBESTOS

Canadian Johns-Manville Company Limited

Canadian Johns-Manville Company Limited was incorporated in September 1918. It is a wholly owned subsidiary of Johns-Manville Corporation. The authorized capitalization is 25,000 shares of $100 par value. The officers and directors were: A. R. Fisher, chairman; C. B. Burnett, president; L. M. Adamson, Roger Hackney, N. W. Hendry, J. A. O'Brien, F. A. H. Gallop, R. S. Gardner, K. W. Huffine, K. V. Lindell, C. F. Rassweiler, A. G. Sinclair and J. P. Syme, vice-presidents and directors; H. M. Ball, secretary; J. M. Shacklford, treasurer. The head office is at 310 Victoria Avenue, Westmount, Que. The mine address is Matheson.

The company's holdings in Ontario include the properties known as the Munro mine in Munro township, and the Barton Creek mine in Beatty township, Porcupine area, District of Cochrane. No work was done at the Barton Creek mine in 1959.

Mining and milling at the Munro mine continued throughout 1959. Open-pit operations ceased in January, subsequent mill feed came from underground mining and from the open-pit stockpile.

SHAFTS, MUNRO MINE

Shaft	Claim No.	Inclination	Number of Compartments	Sinking in 1959	Depth below Surface
				feet	feet
No. 1 main	Veterans lot P.1152	Vertical	4	.....	882
No. 1 service	L.4510	Vertical	3	.....	629
No. 3 (below 637-foot level)	L.16365	Vertical	2	94	731

Sinking of No. 3 internal shaft, collared on the 637-foot level, was continuing at the end of the year and was 94 feet below the collar at that time.

Development during 1959 consisted of 4,551 feet of drifting and 2,053 feet of crosscutting. The total-development footages to December 31, 1959, were as follows: overburden stripped, 1,837,436 tons; drifting, 21,429 feet; crosscutting, 13,373 feet; raising, 4,329 feet. Diamond-drilling in 1959 consisted of 105 holes from underground, totalling 14,257 feet.

ASBESTOS—Continued

New construction included a concrete-block enclosure for the mine ore-bin.

The following new equipment was installed: a hoist at No. 3 shaft (Canadian Ingersoll-Rand, 45 by 30, class SEI, with 100-hp. motor); Simplex gyratory screen (Hall Machinery of Canada, 4 by 10); a crusher (Hazemag, Munster, Germany); two tailings conveyors with drives (Stephens-Adamson); various 2-, 4-, and 6-inch-diameter natural gas distribution lines on surface.

Of the ore milled, 10,464 tons were mined from the open pit in January, 176,099 tons were mined underground, and 218,397 tons were removed from the open-pit stockpile. The mill treated 394,850 tons, operating at an average daily rate of 1,734 tons.

The average number of employees was 255: 79 underground, and 176 on surface. R. D. Baker was mine manager.

COPPER

International Molybdenum Mines Limited

International Ranwick Limited was incorporated in October 1949. In 1959 the company name was changed to International Molybdenum Mines Limited. The authorized capitalization is 5,000,000 shares of $1 par value, of which 3,753,520 shares have been issued. The officers and directors were: V. N. Harbinson, president; J. D. Bateman, vice-president; V. D. Harbinson, secretary-treasurer; M. E. Cork, R. R. Ranson, and Bruce Hardy, directors. The head office address is 80 Richmond Street West, Toronto. The mine address is Matachewan.

The company operated, until July 1959 under lease, the New Ryan Lake mine of Min-Ore Mines Limited, in Powell township, Matachewan area, District of Timiskaming. The property consists of 10 claims, totalling 513 acres.

There is a vertical, two-compartment shaft, 459 feet deep, on claim M.R. 12548, with four levels, on which considerable development work has been done.

The following table shows the development work done until July 1959, and the totals at the end of the year.

Level	Drifts		Crosscuts		Raises	
	1959	Total	1959	Total	1959	Total
	feet	feet	feet	feet	feet	feet
92-foot	.....	1,364	.....	195	.....	403
192-foot	.....	2,029	.....	579	.....	662
317-foot	50	1,481	.....	904	.....	836
442-foot	117	1,576	.....	602	.....	1,390

Some 15 diamond-drill holes, totalling 5,000 feet, were drilled from underground.

A test mill was set up to provide facilities for conducting experimental work on the ore.

The average number of employees was 5: 2 underground, 3 on surface. Walter Galloway was manager.

COPPER—Continued

Mindecon Limited

Mindecon Limited was incorporated as a private company in July 1955 to investigate for native copper on mining claims held under option by M. J. Boylen Prospector Account (1959). The authorized capitalization is 2,000 preferred shares of $10 par value and 20,000 common shares of $1 par value; 5,503 common shares had been issued to December 31, 1959. The officers and directors were: M. J. Boylen, president; R. J. Isaacs, vice-president; G. L. Moore, secretary-treasurer; C. B. Branningan, assistant secretary; and William Taylor, assistant treasurer. The head office address is Suite 908, 330 Bay Street, Toronto.

The property consists of 12 claims on the north shore at the western end of Michipicoten Island, in the Sault Ste. Marie Mining Division, and held under option from W. L. Lahay and P. M. Leary. The property was formerly operated by Quebec and Lake Superior Mining Association. A shaft on claim No. 42747 was dewatered by Mindecon, and between June and September 400 feet of drifting was done on the 190-foot level. The shaft opening was bulkheaded after cessation of work.

The work was directed by W. B. Anderson, field engineer, and 6 men were employed during the period of operation.

North Coldstream Mines Limited

Coldstream Copper Mines Limited was incorporated in November 1951 with an authorized capitalization of 3,000,000 shares of $1 par value. The number of shares was increased in April 1955 to 6,000,000, in April 1957 to 7,000,000, and in November 1957 to 8,000,000. In August 1959, the name was changed to North Coldstream Mines Limited on a one for four share basis; the authorized capitalization is 5,000,000 shares of no par value, of which 3,738,596 shares had been issued to December 31, 1959. The officers and directors were: W. S. Row, president; R. V. Porritt, vice-president; R. D. Stewart, secretary-treasurer; B. C. Bone, assistant secretary-treasurer; H. L. Roscoe, N. C. Urquhart, K. A. Davis, E. T. Donaldson and L. J. Moreaux, directors. The head office is at 44 King Street West, Toronto. The mine address is Kashabowie.

The property, comprising 71 claims, includes the old Tip Top mine. It is located about 90 miles west of Fort William in the area east of Moss township and south of Ames township, District of Thunder Bay, and is 8½ miles by road south of Kashabowie station on the Canadian National railway.

Mining operations were resumed on May 15, 1959, and were proceeding at the end of the year. The company is preparing to resume milling operations early in 1960.

SHAFTS, NORTH COLDSTREAM MINE

Shaft	Claim No.	Inclination	Number of Compartments	Sinking in 1959	Total Depth from Surface
				feet	feet
No. 1 shaft[1]	K.65	80°	2	.....	200
No. 2 shaft[1]	K.65	Vertical	1	.....	50
No. 3 shaft[1]	K.65	Vertical	1	.....	20
No. 4 shaft	K.65	Vertical	3	604	1,542

[1] Sunk by former operators; not in use. Considerable lateral work was done from No. 1 shaft by former operators.

COPPER—Continued

No. 4 shaft was deepened a further 604 feet to a depth of 1,542 feet below surface; the 950-, 1,100-, 1,250-, and 1,400-foot levels were established.

A total of 30 feet of drifting and 636 feet of raising was completed. The total-development footages to December 31, 1959, were as follows: drifting and crosscutting, 11,086 feet; raising, 4,543 feet. Some 23 diamond-drill holes, totalling 4,471 feet, were drilled from underground.

New construction included 25 dwellings built in the townsite. A 30-ton platform-scale was installed at the mine.

The average number of employees was 34: 6 underground, and 28 on surface. L. R. Redford was manager.

Temagami Mining Company Limited

Temagami Mining Company Limited was incorporated in August 1954. It is an amalgamation of Temagami Mining Company and Derosier Nickel and Copper Mines. The authorized capitalization is 5,000,000 shares of $1 par value, of which 2,990,267 shares have been issued. The officers and directors were: N. B. Keevil, president and managing-director; C. G. MacIntosh, vice-president; J. L. C. Jenner, secretary; D. S. Brown, treasurer; R. A. Cranston, assistant secretary; and W. A. Robinson, director. The head office is at 11 Adelaide Street West, Toronto. The mine address is Timagami.

The company's holdings consist of 261 acres in Phyllis, Briggs, Joan, Yates, and Scholes townships, Timagami area, District of Nipissing.

The vertical, four-compartment, No. 1 shaft, located in Phyllis township on mining lease No. 11446, is 880 feet deep with levels at 400, 525, and 825 feet. There was no shaft-sinking in 1959.

Mining operations continued throughout 1959. The mill commenced treatment of ore on April 1 and continued to December 20.

UNDERGROUND DEVELOPMENT, TEMAGAMI MINE

Level	Drifts		Crosscuts		Raises	
	1959	Total	1959	Total	1959	Total
	feet	feet	feet	feet	feet	feet
400-foot	.....	3,646	.....	750	.....	1,090
525-foot	.....	4,270	437	5,202	213	434
825-foot	3,367	4,215	254	254	617	617

Diamond-drilling consisted of 16 holes from surface, totalling 3,719 feet, and 127 holes from underground, totalling 24,060 feet.

Construction work completed during the year included a 40- by 60-foot steel and asbestos-sided concentrator building; a 16- by 70-foot steel and concrete-block crusher building; a 16- by 16-foot wood-frame tailings-filter building; a 230-foot conveyor and gallery; and a 16- by 16-foot ventilation-raise building.

The following new equipment was installed: a primary crusher, a secondary crusher, a ball mill, a classifier, 17 flotation cells (Denver Equipment), a thickener tank, 3 disc filters, and other miscellaneous mill equipment.

A total of 29,102 tons of ore was hoisted, and 28,763 tons were milled. During the period of operation the daily average milled was 104 tons.

The average number of employees was 110: 45 underground and 65 on surface. W. P. Houston was mine manager.

COPPER-LEAD-ZINC

Geco Mines Limited

Ceco Mines Limited was incorporated in October 1953, with an authorized capitalization of 3,000,000 shares of $1 par value; all shares have been issued. The officers and directors were: N. C. Urquhart, president; J. A. H. Paterson, vice-president and general manager; P. D. P. Hamilton, vice-president; William Harrison, secretary-treasurer; D. A. Foster, assistant secretary-treasurer; R. T. Birks, J. R. Bradfield, R. M. P. Hamilton. J. O. Perrin, R. V. Porritt, and W. S. Row, directors. The head office is at 44 King Street West, Toronto. The mine address is Manitouwadge.

The company holds 57 claims in the Manitouwadge Lake area, District of Thunder Bay, eight additional claims having been acquired for tailings disposal purposes in 1959.

SHAFTS, GECO MINE

Shaft	Claim No.	Inclination	Number of Compartments	Sinking in 1959	Total Depth from Surface
				feet	feet
No. 1	T.B.46849	Vertical	5	.....	1,476
No. 2, below 50-foot level, or No. 1 west adit	T.B.46849	Vertical	3	.....	505
No. 3, below 1,050-foot level	T.B.46849	Vertical	3	1,515	2,565

No. 3 internal shaft hoist was installed on the 1,050-foot level, and the shaft was sunk 1,515 feet to a total depth of 2,565 feet below surface. The following new levels were also established during the year: 13A, 1450, 15A, 1650, 17A, 1850, 19A, 2050, 21A, 2250, 2450, and 2560.

The following development work was done during the year: drifting and crosscutting, 23,383 feet; raising, 6,545 feet. The total-development footages to December 31, 1959, were as follows: drifting and crosscutting, 74,472 feet; raising, 21,123 feet. Diamond-drilling consisted of 12 holes from surface, totalling 7,873 feet, and 321 holes from underground totalling 63,692 feet.

The following new plant equipment was installed: three 19-inch fans (J3TH, Woods Manufacturing); two fans (No. 140 Silavent, Sheldon Engineering); one 48-inch fan (J2WF, Woods Manufacturing); one Alimak raising platform (Atlas Copco); one 20-ton overhead crane (Richards-Wilcox); one Ross feeder (Dorr-Oliver-Long); one 60- by 48-inch jaw-crusher (Canadian Allis-Chalmers); one 42-inch belt conveyor (Mine Equipment); one 42-inch belt (Gutta Percha); three vibrating feeders (42- by 84-in., Jeffrey Manufacturing); one bag filter (No. 40, Bracco Manufacturing); and three oil-fired furnaces (Sheldon Engineering).

A total of 1,293,444 tons of ore was hoisted; 1,290,279 tons were milled at an average daily rate of 3,535 tons.

COPPER-LEAD-ZINC—Continued

The following is taken from the mine manager's report for the year ending December 31, 1959:

Production

ORE		
Milled	dry tons	1,290,279
Calculated grade:		
Copper	percent	2.10
Zinc	percent	2.38
Silver	ounces per ton	1.30
Gold	ounces per ton	trace
COPPER		
Concentrate produced	dry tons	23,050
Grade:		
Copper	percent	27.84
Silver	ounces per ton	14.65
Gold	ounces per ton	0.06
ZINC		
Concentrate produced	dry tons	42,178
Grade:		
Zinc	percent	54.73
REVENUE METAL IN ABOVE CONCENTRATES		
Copper	pounds	51,805,109
Zinc	pounds	46,164,948
Silver	ounces	1,363,525
Gold	ounces	5,706

The copper concentrate was shipped to the Noranda smelter, and the zinc concentrate was shipped to a smelter in the United States. A total of 4,317 tons of zinc concentrate containing 4,756,717 pounds of zinc was stockpiled.

Milling

The mill operated 93.70 percent of the total possible time during the year and averaged 3,535 tons per day as compared to 3,524 tons per day in 1958.

Although no important metallurgical problems developed, research, aimed at improvement, was conducted throughout the year.

Operation of an auxiliary re-treatment circuit for zinc concentrate resulted in reduction of the smelter penalty for copper and in a substantial improvement in recovery.

Mechanical components of the plant operated satisfactorily.

Metal recoveries for the year averaged:

	Percent
Copper	95.68
Silver	81.11
Zinc	75.02

Mining

In exploration development, the main program was directed towards the opening of the C ore-zone east of No. 1 shaft. In this area a total drift advance of about 4,000 feet was completed on all six levels.

The A ore-zone provided 90.4 percent of the year's mill feed. About 9.3 percent was from B zone, and 0.3 percent from development. Pillar extraction accounted for 53 percent of the mill feed; primary stopes and stope preparation accounted for 36 percent and 10 percent respectively. The original open-stope mining method is still in effect throughout the mine.

The major effort in stope preparation was directed towards completion of this work in the first block of stopes in the B zone. By the end of the year the bulk of this work was in hand.

The No. 2 underground crusher station, designed to handle ore from the first block of stopes in the B zone, was completed ahead of schedule in September and placed in operation.

Major improvements to the mine ventilation system were made during the second half of the year. These installations, including a heated fresh-air-intake plant and an exhaust system of increased capacity, were in use by the middle of December. The ventilation system for that portion of the mine west of No. 1 shaft is therefore complete.

The mine has developed extensive use of rockbolts and, where necessary, reinforced concrete for ground support. During the year over 19,000 rock bolts were installed, and 500 yards of concrete were placed for all purposes.

Very few additions to underground equipment were required during the year. However, a mechanical raise machine was purchased and has proven successful in increasing driving speed and in reducing costs.

COPPER-LEAD-ZINC—Continued

Ore Reserves

Further information obtained in the C zone during the year substantially improved both grade and tonnage. Detailed re-examination and stope preparation in the B ore-zone reduced tonnage in reserves without alteration of copper grade. The deepest horizon to which reserves were calculated was 25 feet below the 1,450-foot level. Results were as follows:

	Ore	Copper	Zinc	Silver
	tons	percent	percent	ounces
A Orebody	3,016,300	1.94	1.93	1.00
B Orebody	7,098,400	1.57	4.51	1.79
C Orebody	5,927,800	2.38	5.33	3.28
Total and Averages for 1959	16,042,500	1.94	4.33	2.21
Total and Averages for 1958	16,011,200	1.79	3.71	1.84

Grades and tonnages quoted include an allowance for dilution of 10 percent.
In the evaluation of ore reserves, the following prices (Canadian funds) for metals were used:

Copper	per pound	$ 0.30
Zinc	per pound	0.11
Silver	per ounce	0.90
Gold	per ounce	35.00

General

The average number of men employed was 532: 209 underground, and 323 on urface. J. A. Graham was mine manager.

Willroy Mines Limited

Willroy Mines Limited was incorporated in January 1954 with an authorized capitalization of 4,000,000 shares of $1 par value of which 3,944,105 shares have been issued. The officers and directors were: H. W. Knight, president; R. T. Birks, vice-president; B. E. Martin, secretary-treasurer; R. M. P. Hamilton, P. D. P. Hamilton, G. W. Gooderham, J. C. Perry, and N. B. Keevil, directors. The head office is at 25 Adelaide Street West, Toronto. The mine address is Manitouwadge.

The company holds 30 claims in Gemmell and Mapledoram townships, Manitouwadge Lake area, District of Thunder Bay, in the Port Arthur Mining Division, adjoining the west boundary of the Geco property.

Operations continued throughout 1959.

SHAFTS, WILLROY MINE

	Claim No.	Inclination	Number of Compartments	Sinking in 1959	Total Depth from Surface
				feet	feet
No. 1	T.B.46933	Vertical	4	372	1,562
No. 2	T.B.46938	Vertical	4	.....	530

No. 1 shaft was sunk 372 feet to a total depth of 1,562 feet below surface. New levels established were the sixth, seventh, eighth, and ninth, at 973, 1,127, 1,281, and 1,435 feet, respectively, below the shaft collar.

The following development work was done during the year: drifting, 6,245 feet; crosscutting, 4,027 feet; and raising, 7,909 feet. The total-development footages to December 31, 1959 were as follows: drifting, 15,454 feet; crosscutting, 8,592 feet; raising, 9,750 feet. All development was between the first and eighth levels. Diamond-drilling consisted of 10 holes from surface totalling 3,274 feet, and 656 holes from underground totalling 37,228 feet.

COPPER-LEAD-ZINC—Continued

New construction included: a 32- by 40-foot Atkison steel-clad warehouse and dryhouse; a 15- by 47-foot concrete-block steel-sharpening and bit shop; and a 20- by 50-foot asbestos-sided mill-reagent shed attached to the mill building.

The following new plant equipment was installed: one air compressor (Canadian Ingersoll-Rand, 18 by 10¼ by 10, XVHO, serial 9508) in main hoistroom; one dust collector (Dracco, 1MB-72) in crusher building; one ball mill (Allis-Chalmers, 6 by 4 ft.); three air-cooled transformers (Canadian General Electric, 1,500 kva.) in substation; one standard locomotive (Mancha) underground; batteries and rectifier underground; and four flotation cells (Denver No. 24 Sub. A) in the mill building.

A total of 370,091 tons of ore was hoisted; 371,186 tons were milled at an average daily rate of 1,017 tons.

The average number of employees was 213: 86 underground and 127 on surface. R. S. Haflidson was manager.

FLUORSPAR

Huntingdon Fluorspar Mines Limited

Huntingdon Fluorspar Mines Limited was incorporated in June 1953, with an authorized capitalization of 40,000 preferred shares of $10 par value and 500,000 common shares of no par value. The number of shares issued at December 31, 1959, was as follows: preferred, 750; common, 100,003. The officers and directors were: W. J. Symon, president and manager; Mrs. Alein Symon, vice-president and secretary-treasurer; Mrs. Jane Parker, director. The head office and mine office are at Madoc.

The company holds a lease on the east half of lot 9, concession XIV, Huntingdon township, Hastings county. The mine is known as the Detomac.

Mining operations were carried on from January 1 to March 28, and from June 1 to August 28, 1959.

SHAFTS, DETOMAC MINE

Shaft	Location	Inclination	Number of Compartments	Sinking in 1959	Depth Below Surface
				feet	feet
No. 1	E.½, lot 9, con. XIV, Huntingdon tp., Hastings co.	Vertical	2	.....	80
No. 2 (No. 1 escape)		Vertical	1	.....	80
No. 3 (No. 2 escape)		Vertical	2	.....	130
No. 1 winze (below 80-foot level)		Vertical	1	30	110

No. 1 winze, collared on the 80-foot level, was sunk 30 feet; a level was established 110 feet below surface.

Development work for the year consisted of 210 feet of drifting on the 110-foot level. The total-development footages were as follows: 570 feet of drifting on the 80-foot level; 210 feet of drifting on the 110-foot level; and 350 feet of drifting on the 130-foot level.

A total of 2,673 tons of ore was hoisted, of which 696 tons were discarded; 1,977 tons were treated, the mill averaging 17 tons daily during the period of operation.

The average number of employees was 13: 6 underground, and 7 on surface. Percy Keller was superintendent.

GOLD

Abino Gold Mines Limited

Abino Gold Mines Limited was incorporated in September 1939 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 2,117,019 shares had been issued to October 1, 1959. The officers and directors were: Viola R. MacMillan, president; G. A. MacMillan, vice-president; J. Geddes, secretary-treasurer; W. F. Stafford and Albert Kay, directors. The head office is at 25 Adelaide Street West, Toronto. The mine address is Cochenour.

The company's holdings consist of 19 claims on the mutual corners of Balmer, Bateman, Dome, and McDonough townships, District of Kenora (Patricia portion). The property is about three miles north of the Cochenour Willans mine. An all-weather road, two miles long and connecting the property with the Cochenour-McMarmac road, had been completed and an 11,000-foot powerline has been constructed. By the end of the year the concrete collar had been poured, and the shaft had been sunk 50 feet. Diamond-drilling consisted of 8 holes from surface, totalling 5,000 feet.

New construction included the following: a 108- by 28-foot building combining the hoist-house, dryhouse, and machine shop; a 48- by 24-foot building combining an office, a warehouse, and a residence; a headframe (Hill-Clarke-Francis, 65 feet high with 5- by 5½-foot compartments); a 100-ton, 12- by 12-foot, waste bin; a 12- by 16-foot boiler house; a 24- by 30-foot carpentry shop; a 12- by 16-foot cold warehouse; a 16- by 24-foot cookery; a 16- by 20-foot bunkhouse; a powder house; a fuse house; a cap house; and a pump house.

The following new equipment was installed: a hoist (Canadian Ingersoll-Rand, 48 by 36) with motor (Canadian General Electric, 150-hp.); a compressor (Atlas Copco, AR5) with motor (Westinghouse, 200-hp., synchronous); three transformers (200-kva., 60 cycle); a boiler (Napanee, 35-hp.); two water pumps (Westinghouse, 15-hp., and 3-hp.).

C. J. Kuryliw, consulting geologist, was mine supervisor. The work in 1959 was completed under contract.

Aunor Gold Mines Limited

Aunor Gold Mines Limited was incorporated in May 1939 with an authorized capitalization of 2,000,000 shares of $1 par value, all of which have been issued. The officers and directors were: J. R. Bradfield, president; W. S. Row, vice-president; C. H. Windeler, secretary; R. G. Rudolf, treasurer; J. Y. Murdock, N. C. Urquhart, and K. C. Gray, directors. The head office address is Bank of Nova Scotia Building, 44 King Street West, Toronto. The mine address is Box 2001, Timmins.

The company owns nine claims and holds a 99-year lease on two others, in Deloro township, Porcupine area, District of Cochrane.

Mining and milling continued throughout 1959.

SHAFTS, AUNOR MINE

	Claim No.	Inclination	Number of Compartments	Depth Below Collar
				feet
No. 1	H.S.850	Vertical	3	3,082
No. 2 (service winze between 2,125- and 2,900-foot levels)	T.R.S.828	62°	2	902

GOLD—Continued

Development in 1959 consisted of the following: drifting, 2,007 feet; crosscutting, 6 feet; raising, 37 feet. Total-development footages to December 31, 1959, were as follows: drifting, 72,242 feet; crosscutting, 15,593 feet; raising, 32,780 feet. Diamond-drilling in 1959 consisted of 316 holes from underground totalling 22,681 feet.

New equipment installed included a flotation machine and motor, a rectifier, a mucking machine (Eimco), and two slushers (class FF, 211).

The following is taken from the mine manager's report for the year ending December 31, 1959:

Production

Mining was carried on between the 1,375- and 2,900-foot levels. The amount of ore mined below the 2,125-foot level has been gradually increased and has now reached 60 percent of the mine total.

Ore mined during the year amounted to 266,550 tons, some 29,000 tons more than in 1958. The average grade was 0.34 ounces gold per ton as compared with 0.36 in 1958.

Development

Development work between the 2,125- and 2,900-foot levels consisted of drifting, raising, and diamond-drilling designed to further explore the ore-zone and to prepare it for mining.

Sampling of the 3,500-foot level drift and of diamond-drill intersections has indicated an ore shoot 850 feet in length and averaging 0.30 ounces gold per ton over a width of 17.5 feet. Little or no information is available concerning its vertical extent or its relationship to the main ore-zone. More exploration is required before its importance can be evaluated.

Ore Reserves

At the end of the year the proven ore reserves were 1,090,000 tons averaging 0.36 ounces gold per ton.

Some 265,558 tons of ore were milled; about 380,000 tons of new ore was proved, 88 percent of which was in the block between the 2,125- and the 2,900-foot levels.

Mill

	1959	1958	To Date
Milled.....tons	265,558	236,106	3,489,721
Milled per calendar day.....tons	727.6	646.9	478.8
Average gold content per ton.....ounces	0.342	0.362	0.358
Average tailings loss per ton.....ounces	0.017	0.015	0.010
Total recovery.....percent	94.94	95.84	97.07
Total production gold.....ounces	86,183	81,870	1,214,329
Value of total production	$2,898,334	$2,785,203	$43,633,592
Recovery per ton	$10.91	$11.80	$12.50

The daily tonnage treated was increased 80 tons over that of 1958 and there was a very small increase in tailings loss.

Plant

Alterations to the refinery portion of the mill were completed during the year.

General

The average number of employees was 411: 292 underground, and 119 on surface. R. E. Findlay was manager.

Broulan Reef Mines Limited

Broulan Reef Mines Limited was incorporated in June 1951 with an authorized capitalization of 6,000,000 shares of $1 par value, of which 5,961,142 shares have been issued. The officers and directors were: B. W. Lang, president; W. F. James and F. G. Lawson, vice-presidents; W. H. Maedel, secretary-treasurer; J. B. Streit, F. H. Snyder, and N. M. Davis, directors. The head office is at 80 Richmond Street West, Toronto. The mine address is Pamour.

GOLD—Continued

The company owns the Broulan Reef mine and the old Bonetal and Bonwhit mines, in Whitney, Murphy, and Tisdale townships, Porcupine area, District of Cochrane. It also operates, in the same group, the property of Hugh-Pam Porcupine Mines Limited further reported (p. 28). No work has been done for a number of years in the Broulan, Bonetal, or Banner sections of the property.

Work in the Reef section and the Hugh-Pam property continued throughout 1959. All operations were conducted through the Reef No. 1 shaft, on the northeast quarter of the south half of lot 10, concession V, Whitney township (claim P-13091). The vertical, three-compartment shaft is 2,556 feet deep.

Development in 1959 consisted of: drifting, 3,469 feet; crosscutting, 1,026 feet; and raising, 1,104 feet. Total-development footages at the end of the year were as follows: drifting, 32,809 feet; crosscutting, 11,051 feet; raising, 12,971 feet. Diamond-drilling during the year consisted of 140 holes from underground totalling 23,738 feet.

The following is taken from the mine manager's report for the year ending December 31, 1959:

Production and Treatment

During the year 113,750 tons of ore were mined and milled, and produced 31,218.443 ounces of gold valued at $1,047,830.96 and 2,600.90 ounces of silver valued at $2,277.00 It is estimated that $92,354.56 will be received in addition under the terms of the *Emergency Gold Mining Assistance Act*. Average recovery was 0.274 ounces of gold or $9.23 per ton milled.

Ore Reserves

Proven ore reserves are calculated to be 143,000 tons, having an average uncut grade of 0.40 ounces of gold per ton, or grade cut to one ounce of 0.21 ounces per ton.

Milling for Reef and Hugh-Pam Porcupine Mines

During the year the mill treated a daily average of 467 tons of ore, for a total of 176,620 tons from which were recovered 41,970.088 ounces of gold and 2,600.90 ounces of silver. Recovery averaged 97.9 percent.

General

Some 18,284 tons of waste rock were broken and hoisted from exploration and development work.

Operating costs amounted to $8.36 per ton, including head office administration and general expenses, for the 113,750 tons mined and milled during the year from Broulan Reef mine.

The average number of employees was 179: 101 underground and 78 on surface. These figures include the employees at the Hugh-Pam Porcupine mine. R. F. Dewar was mine manager.

Campbell Red Lake Mines Limited

Campbell Red Lake Mines Limited was incorporated in August 1944 with an authorized capitalization of 4,000,000 shares of $1 par value, of which 3,999,500 shares have been issued. The company is controlled by Dome Mines Limited. The officers and directors were: C. W. Michel, chairman; J. B. Redpath, president; C. C. Calvin, vice-president and secretary; E. J. Andrecheck, treasurer; W. F. James and J. K. McCausland, directors. The head office is at 50 King Street West, Toronto. The mine address is Balmertown.

The company owns 27 claims, about 1,175 acres, in Balmer township, Red Lake area, District of Kenora (Patricia portion).

The vertical, four-compartment No. 1 shaft, located in claim K.R.L. 20071, was sunk 620 feet to a depth of 2,860 feet below the collar. New levels established were the 16th, 17th, 18th and 19th at 2,350, 2,500, 2,650, and 2,800 feet respectively, below the collar.

GOLD—Continued

Development in 1959 was as follows: drifting, 12,484 feet; crosscutting, 562 feet; raising, 2,764 feet. Total-development footages to the end of the year were as follows: drifting, 97,255 feet; crosscutting, 19,482 feet; raising, 26,525 feet, most of which was between the 1st and 14th levels. Diamond-drilling in 1959 included 3 holes from surface totalling 2,117 feet, and 223 holes from underground totalling 42,062 feet.

New equipment installed was a boiler (Volcano Manufacturing, 125-hp.) as a replacement.

The following is taken from the general manager's report for the year ending December 31, 1959:

During the year 314,976 tons of material were hoisted, of which 256,721 tons were ore and 58,255 tons were waste.

The 256,721 tons of ore milled yielded bullion containing 162,276 ounces of gold, the average yield being 0.6321 ounces or 12.64 pennyweights per ton. The average price received on all gold production was $33.69 per ounce.

The following statement gives particulars of revenue and expenditure for the year under review:

OPERATING STATEMENT
(For the year ended December 31, 1959)

REVENUE		
Bullion		$5,466,814
EXPENDITURE		
Development (including expenditure for shaft sinking: $178,658)	$823,707	
Mining	665,392	
Reduction	576,657	
Refining and marketing	34,948	
General and administrative	246,669	
Taxes other than income	17,702	
		$2,365,075
PROFIT		
Before depreciation, amortization of deferred development and preproduction expenditures, provision for tax under the Mining Tax Act, outside exploration expenses, interest earned, etc., and provision for income taxes		$3,101,739

Mining

Broken ore, totalling 231,100 tons, remains in the stopes, a decrease of 23,600 tons from the previous year.

In all, 207,272 tons of a grade of 14.40 dwt. were drawn from the stopes and sent to the mill.

All stoping operations were above the 9th level, or 1,300-foot horizon, with the exception of minor stoping on the lower levels which will form part of the ventilation system.

Development

Development showed no new ore-zones. However, some of the main zones were extended in length and dip, and diamond-drilling indicated short parallel veins in some areas. At the end of the year the exploratory drive to the west on the 14th level had reached the Craibbe-Fletcher boundary.

Ore Production

The mine produced 256,721 tons of ore during the year which averaged 13.59 dwt. The stopes produced 207,272 tons averaging 14.40 dwt. and development work produced 49,449 tons averaging 10.19 dwt.

Ore Reserves

The ore reserves are estimated at 1,096,600 tons, an increase of 17,500 tons over last year. The ore reserves include 231,000 tons of broken ore.

GOLD—Continued

A summary of the distribution of ore in place, broken ore, and total ore mined to the end of 1959, is as follows:

SUMMARY OF ORE RESERVES AND EXTRACTION, BY LEVELS

Level	Ore in Place	Average Grade	Broken Ore	Ore Extracted from Stopes to End of 1959
	tons	dwt.	tons	tons
Surface to 1st	22,700	11.20	1,100	214,531
1st to 2nd	20,400	11.91	11,700	257,381
2nd to 3rd	33,000	10.68	2,100	247,177
3rd to 4th	41,500	9.55	19,000	313,161
4th to 5th	89,300	9.68	26,500	219,845
5th to 6th	113,900	14.07	52,300	163,966
6th to 7th	126,500	12.38	32,600	180,044
7th to 8th	76,500	13.22	29,200	99,843
8th to 9th	21,200	14.17	55,300	51,212
9th to 10th	62,500	12.90	.....	.....
10th to 11th	51,500	12.53	.....	.....
11th to 12th	34,000	14.06	600	1,361
12th to 13th	69,800	14.65	300	1,098
13th to 14th	102,700	16.91	400	840
Total	865,500	13.17	231,100	1,750,459

Mill

The following are the results of milling operations:

Treated	tons	256,721
Average treated	tons per day	703
Average grade of ore treated	pennyweights per ton	13.59
Recovery	pennyweights per ton	12.64
Recovery per ton	percent	93.00

Costs

The expenditure on mining was $665,392 or $2.59 per ton milled.

The expenditure on development (excluding shaft sinking) was $645,049 or $2.51 per ton milled.

Operating costs (excluding shaft sinking) were $8.52 per ton milled.

General

Recovery at the mill showed a slight improvement for the year. Development costs remained high due to an exploratory program planned to investigate, by lateral work at depth, certain parts of the property well-removed from known ore-zones. This program will continue and may well be intensified during the coming year.

The average number of employees was 252: 122 underground, and 130 on surface. Joseph Chisholm was general manager.

Cochenour Willans Gold Mines Limited

Cochenour Willans Cold Mines Limited was incorporated in April 1936 with an authorized capitalization of 3,000,000 shares of $1 par value, of which 2,969,655 shares have been issued. The officers and directors were: E. C. Cochenour, president; W. M. Cochenour, vice-president; F. J. Mills, secretary-treasurer; C. V. Maltby, assistant secretary; M. C. Mosher and R. M. Elliot, directors. The head office is at 150 Eglinton Avenue East, Toronto 12. The mine address is Cochenour.

The property consists of 49 claims in Dome township, Red Lake area, District of Kenora (Patricia portion).

GOLD—Continued

SHAFTS, COCHENOUR WILLANS MINE

	Claim No.	Inclination	Number of Compartments	Depth Below Surface
				feet
No. 1	K.R.L.322	Vertical	3	2,246
No. 2	K.R.L.462	Vertical	3	446

Development work in 1959 consisted of the following: drifting, 4,892 feet; crosscutting, 5,311 feet; raising, 4,626 feet. Development footages to December 31, 1959, were as follows: drifting, 74,008 feet; crosscutting, 53,894 feet; raising, 44,333 feet. Diamond-drilling in 1959 consisted of 535 holes from underground totalling 79,987 feet.

New construction included a 50- by 24-foot addition to the mine office, and a new cap and fuse house.

New equipment installed during the year was as follows: 1 compressor (Canadian Ingersoll-Rand, 29 by 18 by 14½); 1 seven-car Coeur D'Alene train unloader (Wabi Iron Works); 6 stopers (Canadian Ingersoll-Rand, J38); and a thickener (Dorr-Oliver-Long, 14 by 10 feet).

The following is taken from the manager's report for the year ending December 31, 1959:

Summary

In the year under review, an all-time company record was established with the production of 67,668.97 ounces of gold.

A highlight was the success achieved in better extraction in the milling of the ore. In the last half of the year the average of total recovery rose to 96.05 percent.

A new ore-making horizon was discovered, within the favourable west zone and making its appearance at depth. Ore-development results to date on the 1,300- and 1,425-foot levels indicate a slight improvement when compared with the levels above these.

Exploratory holes put down to the 1,550-foot-level horizon have located good ore and indicate that the ore continues downwards.

Production

During the year 134,026 tons of rock were hoisted, of which 84,004 tons were ore and 50,022 tons were waste. Mining produced 74,467 tons of the ore milled; the balance, 9,537 tons, came from development.

The 84,004 tons of ore milled yielded a recovery of 67,668.973 ounces of gold and 2,372.220 ounces of silver. The total value of this bullion was $2,280,900.85. The average recovery per ton milled was $27.15.

The average price received for gold during the year was $33.68. This price was $0.25 per fine ounce less than in 1958, being second only to the 1957 record that was the lowest price in twenty years.

Analysis of Operating Costs

With the completion of the shaft-sinking and passes to serve the first two new levels at the 1,300- and 1,425-foot horizons in 1958, the program of underground development and exploration was greatly accelerated during the past year. Total development-footage advance, excluding deferred development, rose to 14,558 feet in the year compared with 9,143 feet in 1958, an increase of more than 50 percent.

Consequently the over-all operating cost increased by $0.68 per ton of ore milled, and $0.955 per ounce of gold produced.

Compared with 1958 figures, the mining cost showed a decrease of $0.239 per ton milled, and the cost for development and exploration underground rose by $0.895 per ton milled.

The milling cost increased by $0.158 per ton milled. This increase was caused by the successful changes made in milling circuit and the regrinding of mill tailings in order to obtain a greater recovery.

GOLD—Continued

General expense, in the cost-per-ton-milled figure, increased by $0.05 over 1958. This cost would have shown a decrease, but for the following reasons:

1) The change in the income tax act, announced by Ottawa, made provision to allow full write-off of past service liability in respect to employees' pension fund. It was decided to write off the past service liability fixed at $34,278 in the years 1959 and 1960. Half of this amount, $17,139, was therefore paid into the fund and charged to expense.

2) A cash donation of $12,000 was made to the Margaret Cochenour Memorial Hospital to assist it to acquire the hospital property.

Head office expense was reduced in the amount of $0.039 per ton milled.

By selling the gold on the open market during the entire year of 1959, bullion marketing charges were reduced. This cost showed a decrease of $0.057 per ton compared with 1958 figures.

Details of the operating costs for 1959 are set out in the following tables, and include data for 1957 and 1958 for purposes of comparison.

COSTS: TOTAL, AND PER TON MILLED

Distribution	Total 1959	Per Ton Milled		
		1959	1958	1957
Development and exploration	$ 349,276.70	$ 4,158	$ 3.263	$ 4.180
Stope preparation	67,769.93	0.807	0.895	0.696
Mining	501,232.06	5.967	6.206	5.876
Milling	251,174.53	2.990	2.832	2.688
General mine expense	202,483.08	2.410	2.360	2.288
Head office expense	28,987.62	0.345	0.384	0.296
Marketing charges	14,829.56	0.177	0.234	0.235
Total Operating Costs	$1,415,753.48	$16.854	$16.174	$16.259
Tons Ore Milled		84,004	77,804	75,550

COSTS: TOTAL, AND PER OUNCE PRODUCED

Distribution	Total 1959	Per Ounce Produced		
		1959	1958	1957
Development and exploration	$ 349,276.70	$ 5.162	$ 4.030	$5.208
Stope preparation	67,769.93	1.002	1.105	0.867
Mining	501,232.06	7.407	7.665	7.322
Milling	251,174.53	3.720	3.497	3.349
General mine expense	202,483.08	2.992	2.915	2.851
Head office expense	28,987.62	0.428	0.474	0.368
Marketing charges	14,829.56	0.219	0.289	0.293
Total Operating Costs	$1,415,753.48	$20.930	$19.975	$20.258
Ounces of Gold Produced		67,669	63,001	60,636

Because the cost per ounce of gold produced was lower than the amount required to qualify for such payments under the Act, no benefits were received from the *Emergency Gold Mining Assistance Act.*

Mining

The mill was supplied by the mining of 73 stopes that produced 74,467 tons averaging 0.846 ounces of gold per ton, and 53 development places that produced 9,537 tons averaging 0.905 ounces of gold per ton; the total was 84,004 tons averaging 0.853 ounces per ton.

An effective broken-ore reserve could not be built up owing to the low average tonnage produced by the stopes and to the highly selective mining techniques applied in the successful upgrading of the ore mined. In order to maintain millfeed, a constant supply of broken ore was derived from the buffer of broken ore within the passes and from developed ore-blocks that were set aside and made available for immediate stoping.

GOLD—Continued

Milling and Metallurgy

Some details of the mill operations are shown in the following table. An increase during this year in the percentage of extraction will be noted, and comments on this are made below.

	1959	1958	1957	1956
Milled.....tons	84,004	77,804	75,550	70,520
Operating time of total time.....percent	99.02	99.16	99.42	99.57
Average milled daily.....tons	230.1	213.2	207.0	192.7
Average gold assay of heads.....ounces	0.8534	0.8726	0.8577	0.7008
Average gold assay of tails:				
Flotation tails.....ounces	0.0226	0.0388	0.0349	0.0316
Calcine tails.....ounces	0.0253	0.0241	0.0202	0.0194
Recovery.....percent	94.39	92.79	93.58	92.72

Test work, conducted at the property and verified at Ottawa, and referred to in the report last year, indicated the definite possibility of increased extraction from the flotation tails by grinding and cyanidation of the coarse fraction. Subsequently, additional equipment was installed and placed in operation on June 8, 1959. This included a wet cyclone, the purpose of which was to separate the coarse from the fine material in the flotation tails. The coarse material containing recoverable gold was reground and cyanided, and the fine product was discharged as tailings.

The unit used for regrinding was the original 6- by 8-foot Allis-Chalmers ball mill in conjunction with a 6-inch cyclone for classification. A Type A Dorr thickener was placed in operation to thicken the calcine pulp from the roaster prior to grinding and to wash out the sulphated solution; this reduced the consumption of lime and cyanide.

Regrinding and cyanidation of the coarse portion of the flotation tails and calcine produced beneficial results, in that the recovery was increased as predicated in the test work. The total value of mill tailing was lowered 47.5 percent when the new process was instituted.

In 1959, the average percentage of total recovery from January 1 to June 7 dropped to 92.16 percent from an average of 92.79 percent in 1958. However, from June 8 to December 31, 1959, the average recovery rose to 96.05 percent.

The average recovery for the whole year of 1959 was 94.39 percent. Calculated increase in recovery, as a result of the regrinding of tailings, from June 7 to the end of the year was estimated to be 1,334.9 ounces of gold valued at $45,365. The cost of the additional process during the same period was $13,272.63; therefore, an estimated savings of some $32,000 was effected.

Outside Exploration

THE WILMAR DRIVE

Progress during 1959 was 1,964 feet. The 4,250-foot Wilmar Drive, an 8- by 9-foot crosscut, is expected to be completed in mid-1960. Geological mapping of this crosscut will keep pace with the advance. On completion of the drive, it is planned that a program of diamond-drilling will be undertaken to explore what is believed to be a large and favourable structural area within Keewatin rocks. The pattern of diamond-drill holes will be guided by the general geology of the area and by the information gained from crosscut mapping. Geological surface mapping done during the summer of 1959, was successful in outlining some structural situations considered favourable.

THE CONSOLIDATED MARCUS

Progress on the drive toward the Marcus boundary amounted to an advance of 450 feet. Work on this drive was curtailed in favour of rushing the Wilmar Drive to completion in order to release it for diamond-drilling; on completion of the Wilmar Drive, the highly successful "continuous trainloader" will be available to the Marcus drive, about mid-1960. It is planned to have about 2,500 feet of the Marcus drive done in 1960, and although the drive will still be in Cochenour ground by the end of 1960, it will be approaching the boundary.

TROUT BAY GROUP

Limited prospecting was continued in the Trout Bay nickel-copper area. The important claims have been patented, and it is proposed to bring other adjoining claims to patent. The property will be held.

General

The average number of employees was 175: 85 underground, and 90 on surface. J. E. J. Fahlgren was manager.

GOLD—Continued

Coniaurum Mines Limited

Coniaurum Mines Limited was incorporated in July 1929 with an authorized capitalization of 3,000,000 shares of no par value, of which 2,766,743 shares have been issued. The officers and directors were: H. S. McGowan, president; A. G. Fulton, vice-president; D. D. Anderson, secretary; J. T. McWhirter, treasurer; Thayer Lindsley, T. H. Rea, W. S. Morlock, and G. T. N. Woodrooffe, directors. The head office is at 25 King Street West, Toronto. The mine address is Schumacher.

The main property consists of 22 claims, adjoining the McIntyre Porcupine mine, in Tisdale township, Porcupine area, District of Cochrane. It includes the former Goldale, Newray, Armstrong-Booth, and Strong Bow properties.

Mining and milling continued throughout 1959.

SHAFTS, CONIAURUM MINE

	Location	Number of Compartments	Total Depth from Surface
			feet
Bishop shaft	N. ½, lot 7, con. III, Tisdale tp.	3 to 2,000 feet 4 below 2,000 feet	3,666
Bishop subshaft (below 3,250-foot level)		4	5,641
Goldale shaft	SE. ¼ of N. ½, lot 8, con. III, Tisdale tp.	2 to 400 feet 3 below 400 feet	1,020
No. 1 winze (below 2,000-foot level)		2	2,533
No. 2 winze (below 3,000-foot level)		2 to 3,500 feet 3 below 3,500 feet	5,028
No. 3 winze (below 2,000-foot level)		2	2,755

Development work during the year included 3,301 feet of drifting; 2,049 feet of crosscutting; 4,876 feet of raising. Total-development footages to the end of 1959 were as follows: drifting, 113,607 feet; crosscutting, 126,296 feet; raising, 115,643 feet. Diamond-drilling in 1959 consisted of 115 holes from underground totalling 34,597 feet.

The following is taken from the mine manager's report for the year ending December 31, 1959:

Exploration and Development

Exploratory development work was continued throughout the mine, as in previous years, with the total footage of crosscutting, drifting, and raising being 10,410 feet, as compared with 8,189 feet in 1958.

The following list summarizes the more important ore sections in drifting and raising during 1959:

Level	Heading	Vein No.	Length	Width	Grade
			feet	feet	ounces per ton
1,000-foot	Drift	11	162	3.8	0.26
1,000-foot	Drift	72	110	4.8	0.28
1,350-foot	Raise	68	69	4.4	0.22
3,000-foot	Drift	23	196	3.2	0.25
3,150-foot	Raise	23	183	3.2	0.44
3,250-foot	Raise	34	130	3.0	0.26
3,400-foot	Raise	23	55	3.2	0.29
3,500-foot	Raise	33A	50	3.5	0.31
3,500-foot	Raise	23	101	3.3	0.23
3,600-foot	Raise	22	149	3.4	0.32
4,100-foot	Drift	31	62	3.0	0.23
4,250-foot	Raise	31	76	3.2	0.35

GOLD—Continued

A total of 22,773 tons of ore, with an average grade of 0.16 ounces per ton, was broken in development headings.

Waste rock broken in development totalled 11,056 tons, of which 9,832 tons were hoisted to surface; the balance was used as backfill or disposed of underground.

The recent discovery of copper mineralization in the Pearl Lake porphyry on the McIntyre Porcupine property is of interest to Coniaurum. Diamond-drilling of the porphyry, which enters Coniaurum property at the 2,000-foot horizon, was begun in order to explore the possibilities of copper occurrences on this property.

Diamond-Drilling

Underground diamond-drilling for the year totalled 34,597 feet, compared with 29,687 feet in 1958 and 26,821 feet in 1957. In 1959, 175 holes were drilled, compared with 169 in 1958, and 120 in 1957.

In addition to the numerous holes required to continue the development of the producing sections of the mine, a significant amount of drilling was devoted to broader exploration. On the 1,000-foot level 15 holes were completed west of the Coniaurum porphyry and a number of ore-grade intersections were found a short distance above the elevation of this level. A crosscut and raise to reach the zone has been started.

On the 2,000-foot level, a considerable amount of drilling was done in the zones of No. 3 and No. 4 Veins following the driving of M-4 crosscut. On the same level and to the west of the Coniaurum porphyry, a series of holes found scattered veining; several holes showed visible gold over a length of 250 feet and up to 150 feet above the level. A crosscut will be driven to reach the zone.

Stoping

Ore broken in stopes and back-stopes for the year amounted to 91,651 tons with an average grade of 0.221 ounces per ton estimated from sampling.

Distribution of production from the different zones in the mine is given in the following table showing tons of ore trammed to pockets:

Level	Trammed	Tonnage	Value	Value
	tons	percent	ounces	percent
From above 1,000-foot	1,591	1.5	301	1.3
From 1,000- to 3,000-foot	44,173	40.7	10,218	43.5
From 3,000- to 4,500-foot	59,905	55.1	12,531	53.4
From 4,500- to 5,500-foot	2,992	2.7	417	1.8
Total	108,661	100.0	23,467	100.0

Ore Reserves

Broken-ore reserves as at December 31, 1959, are estimated to be 51,094 tons with an average gold content of 0.209 ounces per ton. Compared with 1958 figures, this is a decrease of 5,971 tons and an increase in grade of 0.001 ounces per ton.

Unbroken-ore reserves as at December 31, 1959, are estimated at 58,900 tons having an average grade of 0.226 ounces gold per ton, as compared to 61,500 tons having an average grade of 0.214 ounces gold per ton at the end of 1958.

Milling

During the past year, the 120,345 tons of ore treated in the mill produced 27,595.15 ounces of gold and 5,245.31 ounces of silver. This represented a recovery of 96.5 percent of the gold content of the ore.

The average price received for gold produced in 1959, not including cost-aid, was $33.57 per ounce compared to $33.95 during 1958.

General

The average number of employees was 205: 135 underground, and 70 on surface. W. O. Lafontaine was manager.

Consolidated Mosher Mines Limited

New Mosher Longlac Mines Limited was incorporated in June 1950 to succeed Mosher Long Lac Gold Mines Limited. In February 1954, the name was changed to Consolidated Mosher Mines Limited. At the same time the authorized capitalization was changed from 5,000,000 shares of $1 par value to

GOLD—Continued

5,000,000 shares of $2 par value; 3,220,410 shares have been issued. The officers and directors were: J. G. Boeckh, president; P. K. Hanley, vice-president; M. C. Maddigan, secretary-treasurer; Thayer Lindsley, T. H. Rea, J. C. L. Allen, and Baptist Johnston, directors. The head office is at 199 Bay Street, Toronto. The mine address is Geraldton.

The main property consists of 20 claims west of the MacLeod-Cockshutt mine in Errington township, District of Thunder Bay. The company also owns the former Hard Rock property, consisting of 17 claims in Errington township.

Operations at the main property continued from April 1 to December 31, 1959. The mine has been developed through a vertical, three-compartment shaft, 2,530 feet deep, known as the No. 1 or Mosher, on claim T.B.10046. In 1957 a second shaft, No. 2, was collared to a depth of 52 feet, on claim T.B.10065, about 3,000 feet west of No. 1 shaft.

Development during the period of operation in 1959 consisted of 438 feet of drifting, and 100 feet of crosscutting. Total-development footages to the end of 1959 were as follows: drifting, 8,976 feet; crosscutting, 5,094 feet; raising, 1,652 feet. The major portion of this work was completed on the 11th, 12th, and 13th levels, at 1,740, 1,890, and 2,040 feet, respectively, below the collar of No. 1 shaft. Diamond-drilling in 1959 consisted of 191 holes from underground totalling 14,842 feet, and 3 holes from surface totalling 318 feet.

New equipment installed was as follows: a compressor (Canadian Ingersoll-Rand, 71 TD, type 30, with 10-hp. motor); a pump with fire hose and nozzles (Terry Machinery); and an oil-fired boiler (Napanee).

A total of 96 tons of ore was hoisted.

H. E. Rudd was general manager, and the operation was carried on by the MacLeod-Cockshutt organization.

Delnite Mines Limited

Delnite Mines Limited was incorporated in October 1934 with an authorized capitalization of 3,000,000 shares of $1 par value, of which 2,978,767 shares have been issued. The officers and directors were: W. V. Moot, president and managing director, K. C. Gray, vice-president in charge of operations; Whitworth Ferguson, vice-president; W. S. Walton, secretary-treasurer; L. R. Gulick, F. R. Burton, and A. F. Osborn, directors. The address of both the head office and mine office is Box 590, Timmins. The secretary's office is at 44 King Street West, Toronto.

The company's property consists of 8 claims in Deloro township, Porcupine area, District of Cochrane, three miles southeast of Timmins.

Mining and milling continued throughout 1959.

There was no shaft-sinking in 1959.

SHAFTS, DELNITE MINE

	Claim No.	Inclination	Number of Compartments	Depth from Surface
				feet
No. 1 shaft (inactive)	T.R.S.825	Vertical	2	391
No. 2 shaft	T.R.S.825	Vertical	3	3,031
No. 3 internal shaft (below 2,875-foot level)	.....	Vertical	4	5,382

GOLD—Continued

Development during the year included 1,814 feet of drifting, 2,629 feet of crosscutting, and 3,112 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 86,659 feet; crosscutting, 44,180 feet; raising, 51,478 feet. Diamond-drilling during 1959 consisted of 103 holes from underground totalling 15,424 feet.

The following is taken from the mine manager's report for the year ending December 31, 1959:

Production

ORE		
Treated	tons	182,746
Gross value		$1,591,629
Value	per ton	$8.709
BULLION		
Gold (43,933.247 ounces at $33.534467)		$1,473,278
Silver (3,227.57 ounces at $0.874364)		$2,822
Total value		$1,476,100
RECOVERY		
Value	per ton	$8.077
Proportion	percent	92.743

Ore and Waste Hoisted

	Ore	Waste	Total
	tons	tons	tons
No. 2 shaft	182,620	.....	182,620
No. 3 shaft	168,749	13,170	181,919

Some 100,950 tons of backfill were placed in stopes (75,823 tons purchased).

Broken-Ore Reserves

Broken-ore reserves are estimated at 16,770 tons; this is an increase of 1,837 tons in the year.

Costs

Distribution	In Full	Per Ton Milled		Per Ounce of Gold Produced, 1959
		1959	1958	
OPERATING COSTS (before cost-aid):				
Development and exploration	$ 83,054	$0.454	$0.198	$ 1.891
Mining	1,113,936	6.096	6.057	25.355
Milling	289,611	1.585	1.479	6.592
General mine charges after deducting sundry revenue	152,912	0.837	0.731	3.480
Administrative expense (partly mine)	49,003	0.268	0.287	1.115
Bullion marketing expense, including mint handling and refining charges	11,536	0.063	0.069	0.263
Total of Operating Costs	$1,700,052	$9.303	$8.821	$38.696
OTHER COSTS:				
Depreciation	$ 15,200	$0.083	$0.086	$ 0.346
Outside exploration	11,503	0.063	0.147	0.262
Shaft-sinking and development write-off	67,667	0.370	0.659	1.540
Provision for Ontario mining taxes	1,700	0.009	.....	0.039
Total Other Costs	$ 96,070	$0.525	$0.892	$ 2.187
TOTAL ALL COSTS	$1,796,122	$9.828	$9.713	$40.883

GOLD—Continued

Development

In all, 1,369 feet of ore of better than average grade and width was developed. Sub-drifting from stopes developed an additional 800 feet of ore.

Mining

Stoping was done on eleven levels including one in the No. 2 shaft-area.

General mine productivity and mill tonnage increased slightly over that of 1958.

The grade of ore was down somewhat from that mined in 1958. About a quarter of this reduction was due to the increased premium on the Canadian dollar which resulted in a lower return per ounce of gold produced.

A progressive change in ore structure and mineralogy occurred below the 4,375-foot level. The sulphide content increased appreciably along with the introduction of gold-bearing pyrrhotite. The typical narrow ribbon-type veining, characteristic of the upper levels, changed with depth to an enriched, irregular, quartz-tourmaline-filled fracture zone. Mining at this depth was accompanied by heavier ground conditions necessitating closer supervision and additional ground support.

Milling

The mill operated continuously throughout the year at an average daily rate of 501 tons compared with 498 tons during the operating period in 1958.

Some progress in the treating of the high-pyrrhotite ore was made and the cyanide circuit was brought into satisfactory balance. The flotation circuit presented a continuing problem. As tonnage from the lower levels increased, the percentages of the sulphides, both pyrite and pyrrhotite, increased. Test work gave some promising leads, and effort was directed toward a better rate of extraction.

General

The conversion, in production mining, from 1¼-inch-diameter bit and ⅞-inch drill-steel to the 1-inch bit and ¾-inch drill-steel was completed early in 1959. This was the largest single factor in stabilization of mining costs during a period of rising labour and material costs during 1957, 1958, and 1959.

At the request, and for the account, of Aunor Gold Mines Limited, Delnite drove 518 feet into Aunor ground on the 3,500-foot level.

The average number of employees was 268: 185 underground, and 83 on surface. G. A. Vary was mine manager.

Dome Mines Limited

Dome Mines Limited was incorporated in July 1923 to succeed Dome Mines Company Limited. The authorized capitalization is 2,000,000 shares of no par value, all of which have been issued; 53,332 shares are held in trust for the company. The officers and directors were: C. W. Michel, chairman and treasurer; J. B. Redpath, president; C. C. Calvin, vice-president and secretary; B. C. Foy, F. W. Fershing, J. L. Carson, H. C. Brunie, A. B. Matthews, and W. F. James, directors. The head office and mine office are at South Porcupine. The secretary's office is at 36 Toronto Street, Toronto.

The company owns 62 claims, and parts of the beds of Porcupine and Simpson lakes, in Tisdale, Whitney, and Shaw townships, Porcupine area, District of Cochrane.

Mining and milling continued throughout 1959.

Development during the year included: 11,510 feet of drifting; 3,444 feet of crosscutting; and 4,208 feet of raising. Total-development footages at the end of the year were as follows: drifting, 379,632 feet; crosscutting, 173,246 feet; raising, 225,128 feet. Diamond-drilling in 1959 consisted of 457 holes from underground totalling 98,593 feet.

New construction included a reinforced-concrete water reservoir (capacity 105,000 gallons) on surface, a mine storage shed, and an addition to the powerhouse.

GOLD—Continued

SHAFTS, DOME MINE

	Location	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft[1]	P.12866	Vertical	3	105
No. 2 shaft[1]	P.12864	Vertical	3	805
No. 3 or main shaft	P.12864	Vertical	4 to 10th level 6 below 10th level	2,456
No. 4 internal shaft (below 13th level)[1]	.....	Vertical	Timber removed	2,052
No. 5 internal shaft (below 16th level) [1, 2]	.....	Vertical	3	3,146
No. 6 internal shaft (below 16th level)[2]	.....	Vertical	5	4,097
No. 1 Dome extension shaft [3]	P.13191	Vertical	Old shaft	222
No. 1 Foley O'Brien shaft[3]	P.13403	Vertical	Old shaft	70
No. 2 Foley O'Brien shaft[3]	P.13403	Vertical	Old shaft	160
No. 3 Foley O'Brien shaft[3]	SW. corner, N.½, lot 2, con. II, Tisdale tp.	Vertical	Old shaft	240

[1]Not being used for hoisting.
[2]Connected with the main shaft on the 16th and 18th levels.
[3]Old shaft, not in use.

The following is taken from the general manager's report for the year ending December 31, 1959:

During the year 712,900 tons of ore were treated in the mill. In the course of mining operations 47,500 tons of waste rock were excavated, most of which was used as fill underground.

The 712,900 tons of ore milled yielded 173,851 ounces of gold, the grade being 0.2439 ounces or 4.88 pennyweight per ton.

All grades of ore will be expressed in pennyweights (dwt.) throughout this report. One pennyweight equals one-twentieth of one ounce troy weight. The price paid by the Royal Canadian Mint is based on $35.00 (United States funds) per ounce, and settlements are made in equivalent Canadian funds at current exchange rates. The average price received for gold was $33.59 per ounce, compared to $33.95 per ounce for the previous year.

Costs

The expenditure on development was $860,993, or $1.21 per ton, as compared with $3,483,138, or $4.92 per ton milled, in 1958.

The total operating charges for the year were $5,539,972 or $7.77 per ton, as compared with $5,631,904 or $7.96 per ton milled, in 1958.

Mining

The 712,900 tons of ore milled during the year were produced as follows:

Source of Ore	Mined	Average Grade
	tons	dwt. per ton
Stopes	622,000	5.21
Development	90,900	3.55
Total	712,900	5.00

The following tabulation is presented to indicate the sections of the mine from which the ore came:

Source of Ore	Mined	Average Grade
	tons	dwt. per ton
5th level to surface	9,628	4.17
Ankerite veins	163,290	4.25
Area serviced by No. 6 internal shaft	277,945	4.67
Remainder of mine	262,037	5.85
Total	712,900	5.00

GOLD—Continued

Ore Reserves

Ore reserves at the close of the year were estimated at 2,494,000 tons with an average grade of 5.21 dwt., as compared with 2,479,000 tons with an average grade of 5.12 dwt. for 1958.

Source	1959	1958
	tons	tons
Unbroken	2,180,000	2,184,000
Broken	314,000	295,000
Total	2,494,000	2,479,000

Of the reserves, 32 percent was ankerite. This ore is more refractory to the milling process than the normal ore in the mine.

Mill

Following are the milling results:

Ore treated	tons	712,900
Average per working day	tons	1,980
Average grade	dwt. per ton	5.00
Extraction	dwt. per ton	4.88
Recovery	percent	97.53

General

During the year the full impact of the conversion from dry sand to hydraulic backfill was evident. At the end of the year 92 percent of the cut-and-fill stopes were using this fill; surface haulage of pit sand had been discontinued.

Total costs and unit operating costs were reduced in spite of higher wage rates, and increases in the price of many supplies and in the cost of certain employee benefits. This reduction was made possible mainly by the use of this new backfill and by increased efficiency throughout the operation. Additional benefits, such as more efficient mine stoping cycles, will be obtained as crews become more proficient in the use of hydraulic backfill. However, it is anticipated that these benefits will be more than offset in 1960 by recent wage increases, and by advances in the price of explosives and other supplies.

Ore milled at 712,900 tons or 1,980 tons per day worked was the highest in the company's history. Improvements in the mill circuit resulted in a further increase in recovery, to 97.53 percent, for the year. It is of interest to note that mill recovery was increased 1.4 percent since 1956. The grade of ore milled decreased slightly as compared with last year and with the lower price received for gold the total value of bullion was lower by $91,500.

Results of development work during the year were satisfactory, and it will be noted that ore reserve tonnage and grade show a modest increase. As mentioned last year, the increase in broken-ore reserve is a temporary condition due to the opening of new shrinkage stopes where ground conditions permit using this method of mining.

Conversion of all plant heating from coal to natural gas will be made early in 1960 with consequent savings in labour and fuel costs.

During the year four mining claims, amounting to 160 acres adjoining the west boundary of the property, were purchased.

A connection was made to the Tisdale township's water main to supply spring water to the residences at Dome and Dome Extension and plant drinking water to replace delivery of water at high labour cost and maintenance of a filtration and chlorination plant.

The average number of employees was 936: 621 underground, and 315 on surface. C. P. Girdwood was general manager.

Golden Algoma Mines Limited

Golden Algoma Mines Limited was incorporated in January 1959 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 1,450,005 shares have been issued. The officers and directors were: E. L. Baxter, president; Gordon McLaughlin, secretary-treasurer; L. J. Whitehouse, G. R. Bellinger, M. L. Mendelow, and J. W. Keywan, directors. The head office is at 372 Bay Street, Toronto. The mine address is Goudreau.

The property consists of 27 claims in Township 28, range 26, District of Algoma. Under former operators it was known as Goudreau, New Goudreau, Amherst, and Algold.

GOLD—Continued

The No. 1, 2-compartment shaft inclined at 68 degrees had been sunk to a depth of 425 feet by former operators. Previous development consisted of 590 feet of drifting and 60 feet of crosscutting on the 100-foot level, 1,050 feet of drifting on the 200-foot level, and 625 feet of drifting on the 400-foot level.

Operations commenced in March and continued to December 1959. The mine was dewatered and sampled. There was neither shaft-sinking nor development work during the year.

New construction consisted of the following: a bunkhouse (18 by 30 by 8 ft.); a cookery (18 by 30 by 8 ft.); a powerhouse (14 by 14 by 8 ft.); a shaft-house (12 by 18 ft.); a core-house (14 by 14 by 8 ft.); a manager's house (28 by 18 ft.); a dryhouse (12 by 18 ft.); and a fuse-and-cap-house (10 by 12 ft.).

New equipment included three pumps and motors, a diesel generator set (General Motors), a portable compressor and drill (Atlas Copco), and a Napanee automatic boiler (International Equipment).

The average number of employees was 8: 3 underground, and 5 on surface. A. LePierre was mine manager.

Hallnor Mines Limited

Hallnor Mines Limited was incorporated in April 1936 with an authorized capitalization of 2,000,000 shares of $1 par value, all of which have been issued. The officers and directors were: J. R. Bradfield, president; H. L. Roscoe, vice-president; C. H. Windeler, secretary; R. G. Rudolph, treasurer; J. Y. Murdoch, F. M. Connell, and L. H. Timmins, directors. The executive office is at 44 King Street West, Toronto. The mine address is Pamour.

The property, consisting of eight claims, is in Whitney township, Porcupine area, District of Cochrane, and adjoins the west boundary of the Pamour Porcupine mine.

Mining and milling continued throughout 1959.

The mine is serviced by the vertical, three-compartment No. 1 shaft, 3,477 feet deep, on the north half of lot 7, concession V, Whitney township. An inclined, two-compartment winze was collared on the 2,230-foot level and had been sunk a distance of 243 feet to establish the 23rd level at the end of the year.

Development during 1959 consisted of 1,398 feet of drifting, 291 feet of crosscutting, and 1,730 feet of raising. Total-development footages at the end of the year were as follows: drifting, 58,808 feet; crosscutting, 15,854 feet; raising 29,748 feet. Diamond-drilling in 1959 consisted of 113 holes from underground totalling 18,181 feet.

The following is taken from the manager's report for the year ending December 31, 1959:

Stoping

Ore broken in stopes amounted to 114,733 tons; ore drawn off was 117,510 which was 2,777 tons in excess of the tonnage broken. The broken-ore reserve was reduced to 6,300 tons.

Of the ore drawn, 92,349 tons came from cut-and-fill stopes, 25,006 tons from shrinkage and open stopes, and 3,289 tons from development headings.

The main orebody, which bottoms at the 8th level, is nearly worked out. The mining of pillars in this orebody, and the narrower widths of the veins being mined in the lavas below the 18th level, as well as the shortage of working places, made it difficult to maintain the mill at full capacity.

Ore Reserves

At December 31, 1959, the ore reserves were 184,500 tons of average cut grade of 0.34 ounces per ton. Ore developed during the year offset the tonnage mined, but was lower in grade.

GOLD—Continued

Mill

The mill was in continuous operation throughout the year except for short shutdowns for repairs, inspections, and statutory holidays. The 8- by 8-foot ball mill was in operation 8,558 hours or 97.7 percent of the possible running time.

The mill-average was 325 tons per day, compared with 345 tons per day in 1958.

The mill treated 118,601 tons of ore averaging 0.398 ounces of gold per ton; with mill recovery at 97.54 percent, the recovery of gold was 46,043 ounces.

To December 31, 1959, the mill has treated 2,598,548 tons of ore from which has been recovered 1,066,608 ounces of gold and 83,566 ounces of silver having a combined value of over $38,800,000.

General

The average number of employees was 194: 118 underground, and 76 on surface. W. J. Marshall was manager.

H. G. Young Mines Limited

H. G. Young Mines Limited was incorporated in January 1946 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 3,773,485 shares have been issued. The directors and officers were: H. G. Young, chairman of the board; B. W. Lang, president; M. A. Cooper, vice-president; J. M. Godfrey, secretary; E. G. Bishop, J. B. Redpath, and J. B. Streit, directors; W. H. Maedel, treasurer. The head office is at 80 Richmond Street West, Toronto. The mine address is Box 130, Balmertown.

The property, consisting of 19 claims, is located in Balmer township, Red Lake area, District of Kenora (Patricia portion). It adjoins part of the east boundary of Campbell Red Lake property and includes part of the land under the water of Balmer Lake.

The vertical, three-compartment shaft, commenced during 1958 on claim K.R.L.20068, was sunk a further 1,012 feet to a total depth of 1,052 feet below the collar. Levels 1 to 6 were established at 259, 385, 509, 634, 784, and 934 feet below the collar.

Development during the year consisted of 2,358 feet of drifting and 3,778 feet of crosscutting, on levels 3, 4, and 6. Some 43 diamond-drill holes, totalling 13,462 feet, were completed from underground.

The headframe and the ore- and waste-bins were enclosed with aluminum sheeting.

A total of 4,262 tons of ore from development was hoisted and stockpiled. Some 34,150 tons of waste was hoisted.

The company employed an average of 14 men on surface. The labour for shaft-sinking and development was supplied by a contractor. G. B. Tribble was manager.

Hollinger Consolidated Gold Mines Limited

Hollinger Consolidated Gold Mines Limited was incorporated in January 1916. The authorized capitalization is 5,000,000 shares of $5 par value, of which 4,920,000 shares have been issued. The officers and directors were: J. R. Timmins, president; L. H. Timmins, vice-president; L. S. Weldon, executive vice-president; P. C. Finlay, secretary; J. I. Rankin, treasurer; A. A. McMartin, N. A. Timmins, Hon. C. D. Howe, Hon. Edouard Asselin, Duncan McMartin, J. A. McDougald, and J. Y. Murdoch, directors. The mine office and head office are at Timmins. The general office is at 44 King Street West, Toronto.

The main property operated by the company is in Tisdale township, Porcupine area, District of Cochrane, and includes part of the ground underlying the town of Timmins. The company has numerous holdings and interests. It owns and operates the Ross mine in Hislop township, District of Cochrane.

GOLD—Continued

HOLLINGER MINE

Mining and milling operations continued throughout 1959.

SHAFTS, HOLLINGER MINE[1]

	Claim No.	Number of Compartments	Total Depth from Surface
			feet
Main shaft	P.13156	3	2,770
Central shaft	P.13157	6	3,195
No. 11 shaft	P.13144	2	2,756
No. 19 shaft	Schumacher veteran lot	3	3,954
No. 25 internal shaft (below 3,800-foot level)	.....	3	5,477
No. 27 internal shaft (below 2,450-foot level)	.....	4	5,277
No. 26 shaft	P.13156	5	3,063
No. 12 shaft	P.13142	2	[2]
No. 21 shaft	P.13157	2	[3]
No. 6 shaft	P.13218	2	[4]

[1]Include the shafts and winzes in use, and four that have been partly filled. All others have been stoped, filled, or otherwise made inaccessible.

[2]Abandoned and filled from surface to the 800-foot level; travelway from the 800- to 1,400-foot level.

[3]Filled from the 1,550- to 2,750-foot level; travelway from the 2,750- to 3,950-foot level.

[4]Abandoned and filled from surface to the 200-foot level; travelway from the 200- to 425-foot level.

Development during the year consisted of: 3,380 feet of drifting; 1,603 feet of crosscutting; and 22,377 feet of rock passes, development, and stope raising. Total-development footages to the end of 1959 were as follows: drifting 1,285,670 feet; crosscutting 678,009 feet; and raising 847,014 feet since 1931. Diamond-drilling in 1959 consisted of 1,048 holes from underground totalling 101,889 feet.

New construction consisted of the main-shaft hoist-house (40 by 45 feet, steel frame on concrete base, corrugated siding).

New equipment included the following: a Heusser gold balance (Mine Assay Supplies); 13 slusher hoists (Joy Manufacturing); 2 air hoists (Gardner-Denver); one Etso 26-inch shaper (A. R. Williams Machine); and machinery for the automation of aerial tramway (Riblet Tramway).

There were 981,149 tons of ore hoisted.

The following is taken from the manager's report for the year ending December 31, 1959:

Operating costs for the year 1959 exceeded bullion production for the first time in the history of the Hollinger mine and resulted from the milling of fewer tons of lower average grade ore for which a lower price of gold was received. The cost of producing a ton of ore was adversely affected by this lower volume, coupled with a wage increase.

PRODUCTION

	1958	1959
Days worked	271	271
Milled ..... tons	1,031,518	980,887
Millhead grade per ton ..... ounces	0.296	0.273
Millhead value per ton	$ 10.10	$ 9.20
Average value of tailings per ton	$ 0.26	$ 0.26
Gold produced ..... ounces	297,746	260,146
Average value received per ounce of gold sold	$ 33.98	$ 33.59
Bullion production	$10,150,293	$8,771,010
Operating cost (before taxes and depreciation)	$ 8,846,845	$9,194,899

GOLD—Continued

COSTS

Distribution	Per Ton	
	1958	1959
Mining	$5.58	$6.03
Milling	0.81	0.87
General	1.04	1.14
Vacation pay, insurance, and other employee benefits	0.47	0.55
Administrative	0.68	0.79
Total	$8.58	$9.38

The millhead value of $9.20 per ton was lower than in 1958 and was $0.63 below the average value milled during the last five years.

The average price received for gold during 1959 was $33.59 per ounce, and was $0.39 per ounce less than in 1958. The price varied from a high of $34.62 per ounce to a low of $33.16 per ounce; at the end of the year it was $33.31 per ounce.

The milling of 980,887 tons of ore depleted the ore reserve by 261,000 tons to a total of 2,603,000 tons. The grade of the reserve was 0.308 ounces of gold per ton as compared with a grade of 0.318 ounces at the end of 1958. The value per ton at the end of 1959 with gold at $35.00 per ounce was $10.77.

During the year, 36.3 percent of the millfeed was obtained from above the 800-foot level; this compares with 33.6 percent during 1958.

The average number of employees was 1,542: 921 underground, and 621 on surface. E. A. Perry was manager.

ROSS MINE

The Ross property, consisting of 456 acres, is located in Hislop township District of Cochrane. The mine address is Holtyre.

Mining and milling continued throughout 1959.

SHAFTS, ROSS MINE

	Location	Inclination	Number of Compartments	Depth from Surface
				feet
No. 1 shaft	N. ½, lot 1, Con. II, Hislop tp.	Vertical	3	1,598
No. 2 winze (below 300-foot level)	.....	Vertical	2	1,535

There was no shaft-sinking in 1959.

Development work during the year consisted of 951 feet of drifting, 136 feet of crosscutting, and 1,014 feet of raising. Total-development footages to the end of the year were as follows: drifting 37,766 feet; crosscutting 30,381 feet; and raising 24,337 feet. Diamond-drilling in 1959 consisted of 78 holes from underground, totalling 18,236 feet.

An extension to the mill building was built, 56 by 12 feet, to house the new grinding unit. The new equipment for the unit consisted of a grinding mill (Allis Chalmers 6 by 16 ft.), a blower (Roots 10 by 15 ft.), and a vacuum pump (Canadian Ingersoll-Rand). Two heating boilers were converted from coal to natural gas.

There were 121,508 tons of ore hoisted. The mill treated 121,217 tons, an average of 348 tons per day.

The following is taken from the manager's report for the year ending December 31, 1959:

The operating cost exceeded the value of bullion production by a larger amount in 1959 than in 1958 because of the lower millhead. A small improvement in cost per ton was made in spite of a wage increase that added an estimated 10 cents per ton to labour cost.

PRODUCTION

	1958	1959
Days worked	348	348
Milled.....tons	120,782	121,217
Millhead grade per ton.....ounces	0.184	0.172
Millhead value per ton	$ 6.60	$ 6.11
Average value of tailings per ton	$ 0.67	$ 0.59
Gold produced.....ounces	19,783	18,654
Average value received per ounce of gold sold	33.93	$ 33.54
Bullion production	$716,276	$669,435
Operating cost (before taxes and depreciation)	$734,047	$728,224

COSTS

Distribution	Per Ton	
	1958	1959
Mining	$2.77	$2.66
Milling	1.90	1.91
General	0.82	0.84
Vacation pay, insurance, and other employee benefits	0.23	0.24
Administrative	0.36	0.36
Total	$6.08	$6.01

During the year, improvements were made to the mill circuit. Capacity was increased from 350 to 400 tons per day, the change-over having been made without incident at the beginning of 1960. The cost of this new plant, including replacement of some worn out equipment, was $55,000. The availability of natural gas in the district has made possible the economic conversion from coal to gas heating.

The milling of 121,217 tons of ore reduced the ore reserve by 6,300 tons to 500,300 tons averaging 0.194 ounces of gold per ton. The value per ton, with gold at $35.00 per ounce, is $6.80 as compared with $6.79 the previous year.

Seven groups of claims were staked in Ontario, and detailed geological and geophysical work was done on them. In each case some diamond-drilling was done and, while no commercial ore was found, the results were interesting enough to justify further work being planned for the summer of 1960.

The average number of employees was 97: 47 underground, and 50 on surface. J. J. Caty was resident manager.

Hugh-Pam Porcupine Mines Limited

Hugh-Pam Porcupine Mines Limited was incorporated in December 1935 with an authorized capitalization of 4,000,000 shares of $1 par value, of which 3,999,399 shares have been issued. The officers and directors were: B. W. Lang, president; J. B. Streit and R. A. Cranston, vice-presidents; W. H. Maedel, secretary-treasurer; J. A. Hackett, director. The head office is at 80 Richmond Street West, Toronto. The mine address is Pamour.

The company owns 15 claims in Whitney township, Porcupine area, District of Cochrane. The mine is operated under the management of Broulan Reef Mines Limited, and the ore is treated in the Broulan mill.

GOLD—Continued

SHAFTS, HUGH-PAM PORCUPINE MINE

	Claim No.	Inclination	Number of Compartments	Depth
				feet
Mulholland shaft	P.12708	Vertical	2	(1)200
Hughes shaft	P.13096	Vertical	2	(1)200
No. 1 winze (below 200-foot level)	.....	70°	2	110

(1)Approximate.

These shafts are not in use. Work is done on the property through extensions of the Reef workings of Broulan Reef Mines Limited. All Hugh-Pam ore is hoisted through the Reef shaft.

There was no shaft-sinking in 1959.

Development in 1959 consisted of 940 feet of drifting, and 568 feet of raising. Total-development footages to the end of 1959 were as follows: drifting, 16,573 feet; crosscutting, 1,464 feet; and raising, 5,400 feet. Diamond-drilling in 1959 consisted of 49 holes from underground totalling 3,714 feet.

The following is taken from the mine manager's report for the year ending December 31, 1959:

Production and Treatment

During the year 62,872 tons of ore were mined and milled.

Production was 10,751.645 ounces of gold valued at $361,243.74. It is estimated that, in addition, $110,473.15 will be received under the terms of the *Emergency Gold Mining Assistance Act.*

Average recovery was 0.171 ounces of gold, or $5.75 per ton milled.

Ore Reserves

Proven ore reserves are calculated to be 53,000 tons having an average uncut grade of 0.43 ounces of gold per ton or a grade cut to 1 ounce of 0.25 ounces per ton.

During the year stopes were operated on the 500-, 650-, 970-, 1,120-, 1,720-, 1,870-, 2,050-, and 2,200-foot levels.

Operating costs, exclusive of charges by Broulan Reef Mines Limited for use of the shaft, plant, etc., were $7.12 per ton, or $8.50 including these charges.

R. F. Dewar was mine manager. The employment figures were included with Broulan Reef Mines Limited report.

Kerr-Addison Gold Mines Limited

Kerr-Addison Gold Mines Limited was incorporated in April 1936 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 4,730,302 shares have been issued. The officers and directors were: J. Y. Murdoch, chairman; W. S. Row, president; H. L. Roscoe, vice-president; R. G. Rudolf, treasurer; G. A. Cavin, secretary; Andre Dorfman, F. M. Connell, K. C. Gray, H. H. Leather, and W. D. Smith, directors. The head office is at 44 King Street West, Toronto. The mine address is Virginiatown.

The company's main property consists of 35 claims in McGarry township, Larder Lake area, District of Timiskaming.

Mining and milling continued throughout 1959.

GOLD—Continued

SHAFTS, KERR-ADDISON MINE

	Claim No.	Inclination	Number of Compartments	Sinking in 1959	Total Depth From Surface
				feet	feet
No. 3 shaft	H.J.B.30	Vertical	5	.....	3,995
No. 4 shaft (collared on 3,850-foot level)	.....	Vertical	3	377	6,022

The sinking of No. 4 internal shaft was completed on April 2, 1959. Levels were established at 5,600, 5,800, and 6,000 feet. A crusher-station level was established at 5,700 feet.

Development during 1959 consisted of 2,208 feet of drifting, 8,320 feet of crosscutting, and 5,544 feet of raising. Total-development footages at the end of the year were as follows: drifting, 192,126 feet; crosscutting, 72,040 feet; and raising, 139,955 feet. Diamond-drilling in 1959 consisted of 329 holes from underground totalling 32,143 feet.

The following new equipment was installed at No. 4 shaft; two 4-ton skip-over-cage combinations (Dorr-Oliver-Long); two 12-man passenger cars (Dorr-Oliver-Long); five 23-horsepower, 2-cylinder locomotives (Hunslet Locomotives); and an Alimak raise platform (Mine Equipment). The following new equipment was installed at No. 3 shaft: 25 mine service trucks (Wabi Iron), eight 25-horsepower, 3-drum electric slushers (Joy Manufacturing), and a pulsometer-turbine centrifugal pump (Laurie & Lamb T6/12). Installed elsewhere was one E outdoor substation (Canadian General Electric, 6,000-kva., 13,200-volt, 25-cycle).

The following is taken from the manager's report for the year ending December 31, 1959:

Cost Summary

Distribution	In Full	Per Ton
Development	$ 823,865.31	$0.496
Stope development	407,792.79	0.245
Mining	3,557,330.61	2.140
Haulage	585,235.70	0.352
Hoisting	393,775.61	0.237
General, at mine	2,165,963.31	1.302
Crushing and conveying	254,257.86	0.153
Milling	1,542,296.17	0.928
General expenses	693,423.58	0.417
Bullion marketing	136,657.59	0.082
Total	$10,560,598.53	$6.352
Net operating profit at mine (before provision for depreciation, taxes, and head office expense)	$ 8,564,431.57	$5.152

In spite of lower costs for development, milling, and general expense, operating costs at the mine increased 11 cents per ton over 1958 owing to the following factors:

1. The 3⅓ percent wage increase, effective September 16, 1958, and amounting to approximately 10 cents per ton, was in effect for the full year.
2. Increases ranging from 2 percent to 15 percent in the prices of some major supply items, including explosives, blasting supplies, zinc dust, manganese liners, and rock drill parts, became effective during the year.
3. Assessment increases, for Workmen's Compensation from 3 percent to 3.5 percent of the payroll, and for silicosis from 3 percent to 4 percent of the payroll.
4. Additional hoisting crews and supervisory and engineering staff were required for operations at No. 4 shaft.

GOLD—Continued

Production

Production in 1959 reached an all-time high in terms of ounces of gold produced, the total dollar-value of production, and average tonnage milled per day. Operating profit also reached an all-time high, although operating costs were again slightly higher. The average value per ounce of gold for the year was $33.71, compared with $33.97 in 1958. The average tonnage milled per day was 4,554.9, compared with 4,553.4 in 1958. The extraction of gold in milling was 97.8 percent, compared with 97.7 percent in 1958. The increase in recovery from the retreatment of cyanide tailings was 5.2 percent, compared with 4.8 percent in 1958. The operating profit from retreatment for the year was $772,971.79 or 46.5 cents per ton milled. An increase in the tonnage produced from the higher-grade lower levels is reflected in the higher average gold content of the ore milled.

SUMMARY OF PRODUCTION FOR 1959

Milled (average per day, 4,554.9 tons)....tons	1,662,534
Total gold recovered....ounces	567,304.80
Total silver recovered....ounces	31,863.99
Average gold recovery per ton (0.3412 ounces at $35)....	$11.9430
Average tailings loss per ton (0.0077 ounces at $35).....	$0.2674
Average mill head value per ton (bullion plus tails) (0.3489 ounces at $35).....	$12.2104
Total realized value of bullion (Canadian Funds).....	$19,125,030.10
Total realized value of bullion per ton (Canadian Funds).	$11.504

Mine Development and Mining

The inclined conveyorway from the 3,850-foot level at No. 3 shaft to the 4,000-foot level at No. 4 shaft was completed in December, and the ore and waste passes from the No. 4 shaft end were started. The conveyorway will accommodate a 36-inch conveyor 2,500 feet in length that will provide for the transfer of broken ore and waste from No. 4 shaft.

Major stope development programs were carried on in the following locations: No. 6 ore-zone on the 1,450-, 1,600-, 1,900-, and 2,500-foot levels; No. 14 ore-zone on the 1,750-, 1,900-, 2,200-, and 2,500-foot levels; No. 16 ore-zone on the 1,150-, 1,300-, 1,750-, 2,200-, and 2,500-foot levels; and No. 21 ore-zone on the 2,050-, 2,200-, 2,650-, 3,400-, and 3,550-foot levels.

The pillar-recovery program continued, and mining of the following pillars was begun: one pillar in the No. 14 ore-zone on the 2,350-foot level; one pillar in the No. 15 ore-zone on the 3,100-foot level; one pillar in the No. 16 ore-zone on the 1,900-foot level; and nine pillars in the No. 21 ore-zone on the 1,450-, 1,750-, 2,050-, 2,200-, 2,350-, and 2,500-foot levels.

Of the 1,662,534 tons of mill feed, 28.0 percent was drawn from ground above the 1,900-foot level, 26.8 percent from the 600-foot block of ground between the 1,900- and 2,500-foot levels, and 45.2 percent from the 1,200-foot block of ground between the 2,500- and 3,700-foot levels. Comparative figures for 1958 were 25.2 percent, 35.3 percent, and 39.5 percent, respectively.

During the year 1,546,056 tons of ore were broken, amounting to 93.0 percent of the mill feed. Of this, cut-and-fill mining accounted for 1,410,262 tons, representing 91.2 percent of the broken and 84.0 percent of the mill feed, a decrease of 14,047 tons from 1958. Shrinkage mining accounted for 108,347 tons, an increase of 33,782 tons over 1958.

Cut-and-fill pillar recovery accounted for 222,133 tons or 15.8 percent of the total cut-and-fill mining, a decrease of 35,850 tons from 1958.

The amount of backfill placed in the mine during 1959 totalled 717,860 cubic yards, a decrease of 43,086 cubic yards from 1958. The backfill placed was made up of 650,105 cubic yards of hydraulic sand from mill tailings and 67,755 cubic yards of development waste. No pit sand was used during the year. Cut-and-fill mining utilized 80.2 percent of the backfill placed.

Ore Reserves

Proven ore reserves were extended to the 3,950-foot horizon in 1958, and ore-development work from No. 4 shaft did not advance sufficiently to permit the further downward extension of proven reserves in 1959. This was the first time in many years that downward extension of proven reserves was not made. The reduction in ore reserves of almost 2,000,000 tons during the year reflected the increase in tonnage milled and the removal, for economic reasons, of some lower grade material from ore classification. This included the revision of ore outlines where additional information was obtained or where a change in mining method was necessary, as well as the elimination of some unrecoverable pillar remnants.

At the end of the year proven ore reserves, after provision for dilution, were as follows: between the surface and the 1,600-foot level there are 962,668 tons having a grade of 0.2692 ounces per ton; between the 1,600-foot and 2,500-foot levels there are 3,616,123 tons having a grade of 0.3133 ounces per ton; between the 2,500-foot and 3,700-foot levels there are 3,510,371 tons having a grade of 0.4197 ounces per ton; and between the 3,700-foot level and the 3,950-foot horizon there are 1,552,775 tons having a grade of 0.5816 ounces per ton.

The total reserve was 9,641,937 tons having an average gold content of 0.3908 ounces per ton. Included in this reserve are 78,848 tons of broken ore having a grade of 0.3042 ounces per ton.

GOLD—Continued

General

Timber consumption amounted to 9.3 million board feet in 1959 as compared with 8.5 million board feet in 1958. Installation of the high-capacity timber-framing machine, purchased in 1958, was completed early in the year, and a total of 26,039 pieces were framed during the summer months. This is sufficient for approximately one year's requirements.

During the year facilities were installed for the handling of cyanide and lime by tank truck in bulk; these facilities lowered the prices and handling charges for these materials.

To provide adequate power for the eventual hoisting, pumping, and mining installations in the No. 4 shaft area, a 6,000-kva. transformer and sub-station was installed on surface, and two 13,200-volt main transmission cables were installed in No. 3 shaft from the surface sub-station down to the 3,700-foot level. Preparations were made to extend the transmission cables to the No. 4 area on the 3,700-foot level.

The average number of employees was 1,418: 968 underground, and 450 on surface. R. J. Beggs was manager.

Kirkland Minerals Corporation Limited

Kirkland Lake Gold Mining Company Limited was incorporated in November 1915 with an authorized capitalization of 5,500,000 shares of $1 par value. In April 1956 the company was reorganized, and the name was changed to Kirkland Minerals Corporation Limited. The authorized capitalization was changed to 5,000,000 shares of $1 par value, 3,100,005 of which have been issued. The officers and directors were: S. G. Taylor, president; I. A. Wallace, vice-president; Myrtle L. Irvine, secretary-treasurer; Camilla Lillico, assistant secretary-treasurer; E. A. Glick, managing director; Robert Martin, and H. L. Pountney, directors. The executive office is at 160 Bay Street, Toronto. The mine address is Box 850, Chaput-Hughes. The mine is under the management of Sulmac Exploration Services Limited.

The company's main property is the former Kirkland Lake gold mine, now known as the Kirkland Minerals mine. It consists of 11 claims in Teck township, Kirkland Lake area, District of Timiskaming. The company also controls Norstar Lake Mines Limited, on which information is given under the company name (p. 49).

Mining and milling at the Kirkland Minerals property continued throughout 1959.

SHAFTS AND WINZES, KIRKLAND MINERALS MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (inactive)	L.1236	Vertical	2	984
No. 2 or main shaft	L.1236	Vertical	3	2,666
No. 1 winze (below 2,475-foot level)	.....	Vertical	4 to 2,975 feet 3 below 2,975 feet	4,952
No. 2 winze (below 4,900-foot level)	.....	Vertical	3	5,897
No. 3 winze (below 3,600-foot level)	.....	Vertical	3	4,487
"1,000" winze (below 1,000-foot level)	.....	Vertical	2	1,134
No. 4 winze (below 4,750-foot level)	.....	Vertical	3	5,886

GOLD—Continued

There was no shaft-sinking in 1959. Underground development during the year consisted of 2,373 feet of drifting, 172 feet of crosscutting, and 778 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 113,346 feet; crosscutting, 39,533 feet; raising, 25,509 feet. Diamond-drilling in 1959 consisted of 92 holes from underground, totalling 10,112 feet.

The following is taken from the general superintendent's report for the year ending December 31, 1959:

The distribution of work for the year (exluding excavation) was as follows:

Work Source	Hoisting Lift		
	First (2,600-foot level to surface)	Second (4,900- to 2,300-foot level)	Third (5,850- to 4,750-foot level)
	percent	percent	percent
Ore hoisting	Nil	5.9	94.1
Development	Nil	5.2	94.8

New Ore Developed During the Year

Level	Length	Average Width	Average Cut Grade (Gold at $35.00 per ounce)
	feet	feet	
47th	37	3.0	$ 7.30
53rd	83.5	3.0	7.10
54th	486.4	3.0	14.47
57th	370.2	3.0	11.69
For all levels	997.1	3.0	$10.15

Ore from development accounted for 13.7 percent of the ore milled during the year; 41.1 percent of drifting was in ore.

Milling

Ore milled	tons	69,624
Average value per ton		$15.317
Gross value		$1,066,430.81
Loss in tailings		$36,448.48
Net value recovered		$1,029,982.23
Daily average drilled	tons per day	190.8
Value in tailings per ton		$0.527
Extraction	percent	96.56

Operating Results

Year	Recovery	Cost	Recovered under E.G.M.A. Act	Profit or Loss
	per ton	per ton	per ton	per ton
1953	$13.22	$14.34	$2.07	+$0.95
1954	11.53	13.58	1.95	− 0.10
1955	9.77	13.15	2.29	− 1.09
1956	10.97	14.51	2.54	− 1.00
1957	11.86	15.89	2.89	− 1.14
1958	16.54	18.34	2.13	+ 0.38
1959	14.79	.....	.....	.....

The above tabulation shows the operating results, including administration and depreciation, but not including taxes.

GOLD—Continued

The following table covers the last eight years and shows the adverse effect on bullion returns, resulting from the difference in exchange between Canadian and United States dollars, also the cost per ounce:

Year	Bullion Produced	Average Price Received per Ounce of Gold	Value of Bullion Recovered	Cost per Ounce
	ounces			
1952	44,827	$34.35	$1,540,202	$33.09
1953	43,173	34.42	1,489,066	35.00
1954	39,572	34.07	1,351,081	37.91
1955	32,101	34.63	1,111,798	44.19
1956	30,072	34.42	1,037,421	45.65
1957	27,697	33.65	933,649	46.86
1958	35,819	33.94	1,218,759	37.73
1959	30,594	33.65	1,029,982	.....

General

Proven ore reserves at the end of 1959 stood at 32,819 tons having a value of $593,070.50, gold taken at $35 an ounce.

The average number of employees was 216: 146 underground, and 70 on surface. L. C. Dixon was general superintendent.

Lake Shore Mines Limited

Lake Shore Mines Limited was incorporated in February 1914 with an authorized capitalization of 2,000,000 shares of $1 par value, all of which have been issued. The officers and directors at the end of 1959 were: R. C. Stanley, Jr., president; J. G. Boeckh, executive vice-president and treasurer; J. C. Adamson, vice-president in charge of operations; Mary C. Maddigan, secretary; H. W. Wright, comptroller; J. C. L. Allen, and S. J. Bird, directors. The head office and mine office are at Kirkland Lake. The executive office is at 199 Bay Street, Toronto.

The company's main property, consisting of about 287 acres, is in Teck township, Kirkland Lake area, District of Timiskaming.

Mining and mill operations continued throughout 1959.

SHAFTS, LAKE SHORE MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (surface to 2,200- foot level)	L.1557	Vertical	3	2,250
No. 1 shaft extension (2,000- to 4,450-foot level)[1]	.....	Vertical	3	4,500
No. 4 shaft (below 4,325-foot level)[2]	.....	Vertical	3	8,176
No. 2 shaft [3]	L.2243	19°	1	[4]200
No. 3 shaft	L.2506	Vertical	5	3,995
No. 5 shaft	L.2506	Vertical	5	3,995
No. 6 shaft (below 3,575-foot level)[5]	.....	Vertical	5	6,098

[1]Not being used.
[2]Hoist at 5,575-foot level.
[3]Used for supplies and timber only
[4]Inclined distance, 632 feet.
[5]Hoist at 3.825-foot level.

GOLD—Continued

There was no shaft-sinking in 1959.

Development during the year consisted of 614 feet of drifting, 1,009 feet of crosscutting, and 947 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 272,564 feet; crosscutting, 105,034 feet; raising, 150,303 feet. Diamond-drilling in 1959 consisted of 111 holes from underground totalling 8,294 feet.

The following is taken from the general manager's report for the year ending December 31, 1959:

Operating and production data for the year ended December 31, 1959, with comparable figures for 1958, are given in the following table:

	1959	1958
Total ore milled.....tons	180,577	188,763
Average milled.....tons per day	495	517
Gold produced.....ounces	66,471.163	69,886.553
Silver produced.....ounces	25,185.420	27,536.503
Average gold content per ton of ore milled.....ounces	0.3681	0.3702
Price received per ounce for gold	$33.54	$33.94
Gross value of production, including estimated E.G.M.A., but less marketing expense	$2,627,378	$2,783,534
Average value per ton of ore milled	$14.65	$14.85
Total operating expense	$2,509,866	$2,549,573
Operating expense per ton of ore milled	$13.899	$13.507
Total operating profit	$117,512	$233,961
Operating profit per ton of ore milled	$0.65	$1.24

During the year the mill also treated 170,220 tons of ore from Wright-Hargreaves mine, in an amount equivalent to 466 tons per day for the period. Additionally 157,917 tons of cyanide tailings from the mill of the Macassa mine were processed in the tailings retreatment plant.

Operating Costs

Costs for the year ended December 31, 1959, with comparable figures for 1958, are tabulated below:

Distribution	In Full 1959	Per Ton Milled	
		1959	1958
Mine development	$ 136,191	0.754	0.781
Mining	1,405,159	7.782	7.517
Milling	372,350	2.062	2.080
Mine office and supervision	167,274	0.926	0.931
General, at the property	360,247	1.995	1.853
Administrative and executive	68,645	0.380	0.345
Total of all costs	$2,509,866	$13.899	$13.507

Development

Development-drifting was carried out in three vein-zones during 1959. The No. 1 vein-zone accounted for 34.6 percent of the total footage, and the No. 2 vein-zone for 55.0 percent; the remaining 10.4 percent represented the drifting done in the No. 4 vein-zone. Ore exposed in 1959 amounted to 43.6 percent of the total drifting advance.

In the last quarter of the year, interesting values over good widths were obtained in two diamond-drill holes at the 7,950- and 8,075-foot levels. At the end of the year a crosscut, driving east from the main crosscut at the 8,075-foot level, had advanced 212 feet of the 700 feet required to reach the favourable zone.

Mining

The mining of the No. 3 shaft pillars was continued as planned throughout 1959 at the 3,075- and 3,200-foot levels; a raise was started in order to open for mining the pillar above the 3,325-foot level. Also, as part of the pillar recovery program, crosscuts totalling 630 feet were driven at the 3,325- and 3,450-foot horizons.

GOLD—Continued

Ore was produced from twenty-five levels in the mine. A tabulation, based on the stages of hoisting required to elevate the ore to surface, follows:

Stages	Quantity	Proportion of Total
	tons	percent
Surface to 3,950-foot level, one-stage hoisting	40,704	22.5
4,075- to 6,075-foot level, two-stage hoisting	94,454	52.3
Below 6,075-foot level, three-stage hoisting	45,419	25.2
Total	180,577	100.0

At the end of the year the total footage of ore, exposed in drifts and available for stoping, was 10,037 feet, grading 0.499 ounces per ton over a width in the drifts, before slashing, of 57.8 inches.

The average number of employees was 469: 273 underground, and 196 on surface. W. T. Robson was general manager.

Leitch Gold Mines Limited

Leitch Gold Mines Limited was incorporated in July 1935 with an authorized capitalization of 3,000,000 shares of $1 par value, of which 2,912,505 shares have been issued. The officers and directors were: K. J. Springer, president; J. H. C. McClelland, vice-president; F. E. Hall, secretary-treasurer; S. H. Robinson and J. R. Cryderman, directors; G. A. McKay, director and mine manager. The head office is at 12 Richmond Street East, Toronto. The mine address is Beardmore.

The main property is in Eva and Summers townships, District of Thunder Bay, about 5 miles from Beardmore by motor road.

Mining and milling continued throughout 1959.

SHAFTS, LEITCH MINE

	Claim No.	Inclination	Number of Compartments	Sinking in 1959	Total Depth from Surface
				feet	feet
No. 1 shaft	H.F.1	Vertical	3	.....	3,006
No. 2 winze (below 2,875-foot level)	.....	Vertical	3	597	4,612

No. 2 winze was sunk 597 feet in 1959, and levels 27, 28, 29, and 30 were established at vertical depths of 4,075, 4,225, 4,375, and 4,525 feet, respectively.

Development during the year consisted of 421 feet of drifting, 833 feet of crosscutting, and 915 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 58,507 feet; crosscutting, 22,442 feet; raising, 26,413 feet. Diamond-drilling in 1959 consisted of two holes from underground totalling 288 feet.

New construction consisted of a concrete-block furnace room, 9 by 15 feet.

The following new equipment was installed: a skip-cage combination (Dorr-Oliver-Long); twenty 1.75-ton side-dump cars (Wabi Iron); a mucking machine (Gardner-Denver); a single-drum hoist (Canadian Ingersoll-Rand, 42 by 30 inches); a Chinook oil-fired furnace (100,000-btu.).

The following is taken from the mine manager's report for the year ending December 31, 1959:

Ore Reserves

Ore reserves are estimated at 93,435 tons, grading 0.786 ounces per ton or 73,438 ounces of gold.

GOLD—Continued

Hoisting

A total of 50,292 tons of ore was hoisted: 397 tons or 0.8 percent from drifts, 1,216 tons or 2.4 percent from raises, and 48,679 tons or 96.8 percent from stopes; 15,687 tons of waste were hoisted.

Milling

A total of 36,861.6 tons of ore was milled after sorting 12,900 tons of waste from the run-of-mine feed. The average milling rate was 102.4 tons per day, based on 360 days of operation during the year. Production for the year was 36,421.797 ounces of gold and 1,547.11 ounces of silver, having a total value of $1,228,052.39. Average recovery was 0.988 ounces of gold per ton milled. Tailings losses averaged 0.0351 ounces per ton milled. Extraction was 96.57 percent.

Costs

Operating costs, per ton milled, for the year were as follows:

Exploration and development	$ 0.80
Drifting	0.39
Raising	0.55
Underground diamond-drilling	0.01
Stoping	15.62
Deferred development (shaft-sinking and station-cutting)	1.36
Milling	5.23
Total operating cost per ton milled	$23.96

Crosscutting and drifting costs were $1.19 per ton milled, compared to $1.50 last year; raising costs were $0.55, compared to $0.74. Stoping costs increased sharply from $12.71 per ton milled to $15.62; milling costs increased from $4.62 to $5.23; rises were due to the smaller tonnage milled. Total operating costs, including one-third of the cost of shaft-sinking and station-cutting, were higher than last year by $4.33 per ton milled.

Unit costs showed an over-all annual increase as indicated in the following table:

Distribution	1957	1958	1959
Crosscutting and drifting, per foot advance	$31.69	$33.25	$33.15
Raising, per foot advance	18.82	21.00	20.93
Mining, per ton broken	10.51	10.60	11.96
Milling, per ton milled	4.48	4.62	5.23

Prices of all commodities used in the mine continued to increase during the year. Labour costs increased by reason of the wage increases and other benefits granted. Mining costs are increasing due to the increasing depth and greater ground support required.

General

The decrease in over-all production from the previous year was caused almost entirely by the lack of production from development in the current year. Production from stopes was substantially the same in both periods. The winze hoist was taxed to capacity by the concurrent sinking and production operations.

An acute shortage of labour was experienced in May with the reopening of bush operations after almost a year's shutdown in the area. Many local residents hired by the mine returned to logging. The shortage persisted throughout the remainder of the year and presented the consequent problem of continually training new men.

Extensive renovations were carried out at the mine dryhouse, and to the pipe boxes serving the mine office, cookery, and mill.

The average number of employees was 133: 68 underground, and 65 on surface. G. A. McKay was mine manager.

Macassa Mines Limited

Macassa Mines Limited was incorporated in April 1926, with an authorized capitalization of 3,000,000 shares of $1 par value, of which 2,678,068 shares have been issued. The officers and directors were: R. A. Bryce, president; J. D. Bryce, executive vice-president; Larmour Soliague, assistant to the president; H. W. Salthouse, secretary-treasurer; C. R. Leonard, C. C. Huston, J. C. L. Allen, and J. G. Boeckh, directors. The head office is at 85 Richmond Street West, Toronto. The mine address is Kirkland Lake.

GOLD—Continued

The company's property consists of 11 claims in Teck township, Kirkland Lake area, District of Timiskaming.

Mining and milling operations continued throughout 1959.

SHAFTS, MACASSA MINE

	Claim No.	Inclination	Number of Compartments	Depth from Surface
				feet
Elliott shaft (inactive)	L.1617	Vertical	2	523
No. 1 or main shaft	L.2837	Vertical	3	3,043
No. 1 winze (below 3,000-foot level)	.....	Vertical	3	4,824
No. 2 shaft	L.4186	Vertical	3	4,070
No. 2 winze (below 4,625-foot level)	.....	Vertical	3	5,756

There was no shaft-sinking in 1959.

Development during the year consisted of 5,517 feet of drifting, 2,323 feet of crosscutting, and 1,371 feet of raising. Total development footages to December 31, 1959, were as follows: drifting, 133,489 feet; crosscutting, 43,467 feet; raising, 27,025 feet. Diamond-drilling in 1959 consisted of 87 holes from underground totalling 13,274 feet.

New equipment in 1959 included the following: a sinking hoist (Canadian Ingersoll-Rand); 2 slushers (Gardner-Denver); 5 rock drills (Atlas-Copco); and 3 stopers.

The following is taken from the mine manager's report for the year ending December 31, 1959:

Production

No assistance under the *Emergency Gold Mining Assistance Act* will be received for 1959 production. None has been received since 1954.

Year	Gross Bullion Value	Tonnage Milled	Recovery per Ton
1959	$2,344,907.97	158,130	$14.83
1958	2,336,325.13	164,262	14.22
1957	2,194,977.41	141,116	15.55

The average price, in Canadian dollars, received per ounce of gold during 1959 was $33.5881; average price per ounce of silver was $0.8743. The corresponding prices for 1958 were $33.954 for gold, and $0.864 for silver.

Milling

Bullion recovery amounted to 69,366.522 ounces of gold and 8,619.66 ounces of silver. The over-all extraction was 94.16 percent.

For the year 158,130 tons of ore were milled giving an average of 433.23 tons per calendar day.

Since the start of milling (October 1933), 1,268,976.57 ounces of gold and 205,772.29 ounces of silver have been recovered from the treatment of 3,091,373 tons of ore. The gross recovered value of this production amounts to $45,614,485.51, equivalent to $14.76 per ton, excluding cost aid.

Development and Exploration

New ore developed amounted to 1,449.5 feet which graded 0.53 ounces per ton over an average width of 6.2 feet.

Development work was concentrated in the block of ground from the 4,750- to the 5,600-foot level. Two thirds of the new ore exposed is in veins caused by the structural conditions associated with the '04 and main breaks. A most significant feature was the development of ore on the main break on the 4,900-, 5,300-, and 5,450-foot levels, on the west side of the mine. The ore-shoot here has been the longest, closest to vertical, and most persistently productive encountered on the main break since the 4,250-foot level. On the 5,450-foot level, 700 feet remains to be explored to the west. Ore associated with the '04 break has been developed on the 5,600-foot level. Development pattern to the west, in this zone, will depend on results of production from ore taken from the 5,450-foot level.

GOLD—Continued

Ore Reserves

From calculations based on results obtained from drifting, raising, and the extension of known veins by stoping operations, the ore reserves as of December 31, 1959, were as shown in the following table:

Source of Ore	Reserve Quantity	Average Grade	Average Value (Gold at $35 per ounce)
	tons	ounces per ton	per ton
Unbroken	852,800	0.455	$15.92
Broken	38,976	0.396	13.86
For all sources	891,776	0.452	$15.82

Note: A dilution factor of 10 percent has been applied to grade only.

Total ore reserves are down 9,351 tons from December 31, 1958. Unbroken-ore reserves in the No. 2 winze area were increased by 2,150 tons. Of the tonnage milled, 89 percent was taken from the No. 2 winze area of the mine.

Costs

Figures on operating and other costs per ton milled and per ounce produced, for 1958 and 1959, are tabulated below for purposes of comparison:

Distribution	Costs, 1959		Costs, 1958	
	69,065.685 Ounces recovered from 158,130 Tons Milled		68,452.403 Ounces recovered from 164,262 Tons Milled	
	Per Ton	Per Ounce	Per Ton	Per Ounce
Development and exploration	$ 1.583	$ 3.608	$ 1.416	$ 3.398
Mining	6.385	14.556	6.059	14.540
Milling	1.838	4.190	1.888	4.530
Undistributed mine-operating charges	0.456	1.038	0.479	1.150
Administration and head office	0.561	1.279	0.595	1.426
Depreciation	0.302	0.688	0.304	0.730
Provision for municipal, provincial, and federal taxes	0.981	2.237	0.926	2.222
Total	$12.106	$27.596	$11.667	$27.996

General

The average number of employees was 334: 223 underground, and 111 on surface. M. R. MacPherson was mine manager.

McIntyre Porcupine Mines Limited

McIntyre Porcupine Mines Limited was incorporated in March 1911 with an authorized capitalization of 800,000 shares of $5 par value, of which 798,000 shares were issued. In December 1959 the authorized capitalization was subdivided on a 3 for 1 basis and increased to 3,000,000 shares without par value, of which 2,299,482 shares have been issued. The officers and directors were: J. D. Barrington, president and managing director; W. B. Dix, vice-president and treasurer; M. L. Urquhart, vice-president, operations; F. T. McKinney, secretary; J. S. D. Tory, chairman of the board; R. S. McLaughlin, J. C. Fraser, Norman D'Arcy, and S. M. Wedd, directors. The address of the head office and the mine office is Schumacher. The executive office is at 25 King Street West, Toronto.

GOLD—Continued

The company has numerous holdings in Ontario, the chief of which is the McIntyre mine, in Tisdale township, Porcupine area, District of Cochrane. In 1959 six claims, comprising 240 acres adjoining McIntyre mine on the east, were purchased from Central Porcupine Mines Limited. During the year all the assets and undertakings of Castle-Trethewey Mines Limited were purchased by McIntyre; the Castle mine is operated as a division of McIntyre.

Mining and milling at McIntyre mine continued throughout 1959.

SHAFTS, MCINTYRE MINE

	Claim No.	Number of Compartments	Total Depth From Surface
			feet
No. 1 shaft (inactive)	P.13307	3	307
No. 2 shaft (inactive)	P.13307	2	183
No. 3 shaft (inactive)	P.13307	2	183
No. 4 shaft (inactive)	P.13307	2	998
No. 5 shaft	P.13307	2 to 1,375 feet 3 to bottom	2,389
No. 6 shaft	P.13710	3 to 1,050 feet 4 to bottom	3,015
No. 7 shaft (inactive)	P.13318	2 to 200 feet 3 to bottom	989
No. 8 shaft (inactive)	P.13318	2	288
No. 9 shaft (inactive)	P.13068	2	204
No. 10 shaft (inactive)	P.13068	2	185
No. 11 or main shaft	P.13318	5	4,130
No. 12 internal shaft (below 3,875-foot level)	.....	4	7,007
No. 14 internal shaft (below 3,750-foot level)	.....	4	7,094

Development during the year consisted of 19,274 feet of drifting, 7,170 feet of crosscutting, and 2,859 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 605,677 feet; crosscutting, 278,749 feet; raising, 57,706 feet. Diamond-drilling in 1959 consisted of 957 holes from underground totalling 163,802 feet.

New equipment included two Eimco B loaders, a Whitcomb locomotive, and a standard DHC-3 Otter landplane.

Total ore hoisted and milled was 779,130 tons, which included 5,150 tons from the Hollinger mine. The mill operated 344 days averaging 2,265 tons daily.

The following is taken from the president's report for the year ending December 31, 1959:

During the year 773,980 tons of ore were milled; 228,373 ounces of gold and 37,364 ounces of silver were shipped to the Royal Canadian Mint.

Value of production amounted to $7,696,676 for an operating profit of $1,196,891, before administration, general expenses, and income taxes; included is an amount of $751,386 received under the *Emergency Gold Mining Assistance Act.*

The price of gold continued to drop, and for 1959 averaged $33.56 per ounce as compared to $33.95 in the previous year. This was the lowest average price received during the past twenty-five years.

Development work amounted to 29,303 feet. This included 19,274 feet of drifting, of which 3,959 feet, or 20.5 percent, was in ore averaging 0.355 ounces per ton over a width of 9.4 feet.

Of the tonnage in the ore reserves, about 75 percent is below the 3,875-foot level and 25 percent is above. It is important that balanced ore extraction be maintained in this same ratio. Now that the No. 14 shaft is operating fully automatically, this objective has been reached with a consequent improvement in efficiency.

GOLD—Continued

The study of the geological structure of the mine mentioned in last year's annual report was actively pursued during 1959. A clearer picture of the structure is gradually unfolding, and it is expected that more definite conclusions will become evident in 1960. One result of the study has been the disclosure, by diamond-drilling, of a copper-bearing zone in the Pearl Lake porphyry. A crosscut, driven through the zone on the 1,625-foot level, shows a well-banded zone of movement mineralized with finely disseminated chalcopyrite and bornite. Analyses to date indicate a grade of roughly 1.2 percent copper and 0.03 ounces of gold per ton over substantial widths from the 1,125-foot level to the 2,375-foot level. The zone has not been delineated either above or below the levels mentioned, and much work remains to be done before the ore-potential of this discovery can be determined accurately.

Six claims, comprising 240 acres adjoining McIntyre on the east, have been purchased from Central Porcupine Mines Limited. The characteristic plunge of known orebodies in Hollinger and McIntyre is to the east; consequently, deep exploration below the 6,825-foot level will be undertaken on these newly acquired claims in the hope of extending the life of the McIntyre mine.

Ore Reserves

Source	1959		1958	
	Tons	Ounces of Gold	Tons	Ounces of Gold
In place, estimated	2,070,185	668,831	2,201,662	696,331
Broken ore	56,114	13,977	61,449	15,360
Total	2,126,299	682,808	2,263,111	711,691
Average grade per ton	.....	0.321	.....	0.314

Revenue and Costs

	1959		1958	
	Total	Per Ounce of Gold	Total	Per Ounce of Gold
REVENUE:				
Gold and silver produced	$7,696,676	$33.70	$7,807,604	$34.10
Emergency gold mining assistance	751,386	3.29	722,266	3.15
Total	$8,448,062	$36.99	$8,529,870	$37.25
COSTS:				
Mine development and exploration	$1,137,987	$ 4.98	$1,144,907	$ 5.00
Breaking and stoping	4,861,586	21.29	4,764,801	20.81
Milling	916,302	4.02	859,897	3.76
Marketing expense	63,491	0.28	63,298	0.28
Royalty under Ontario mining tax act	38,736	0.17	56,454	0.24
Municipal and Provincial taxes and lease rentals	47,431	0.20	52,505	0.23
Depreciation	185,638	0.81	178,343	0.78
Total	$7,251,171	$31.75	$7,120,205	$31.10
OPERATING INCOME:				
Before administration, general expenses, and income taxes	$1,196,891	$ 5.24	$1,409,665	$ 6.15

General

The average number of employees was 1,263: 833 underground, and 430 on surface. N. D. Adams was manager and retired at the end of the year; his successor was P. B. McCrodan.

GOLD—Continued

McKenzie Red Lake Gold Mines Limited

McKenzie Red Lake Gold Mines Limited was incorporated in February 1933 with an authorized capitalization of 3,000,000 shares of $1 par value. In 1956 the capitalization was increased to 5,000,000 shares of $1 par value, of which 2,952,623 shares have been issued. The officers and directors were: S. J. Bird, president; J. G. Boeckh, vice-president; Mary C. Maddigan, secretary-treasurer; J. C. L. Allen and R. C. Stanley, Jr., directors. The address of the head office and mine office is McKenzie Island. The executive office is at 199 Bay Street, Toronto.

The property consists of 12 claims at the north end of McKenzie Island in Red Lake, Dome Township, District of Kenora (Patricia portion).

Mining and milling operations continued throughout 1959.

SHAFTS, MCKENZIE RED LAKE MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft	K.R.L.87	Vertical	3	456
No. 2 winze (below 450-foot level)	.....	36°	3	1,275
No. 4 winze (below 1,250-foot level)	.....	Vertical	3	1,635
No. 5 shaft	K.R.L.87	47½°	3	1,600

The mine is being operated through No. 5 shaft. No. 1 shaft has been abandoned. There was no shaft-sinking in 1959.

Development in 1959 consisted of 3,389 feet of drifting, 368 feet of crosscutting, and 1,990 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 91,089 feet; crosscutting, 25,829 feet; raising, 48,976 feet. Diamond-drilling in 1959 consisted of 107 holes from underground totalling 12,911 feet.

A new bunkhouse, 40 by 18 feet, was constructed.

A vacuum pump (Canadian Ingersoll-Rand, model ES-V) equipped with a 30-horsepower, 550-volt, Lancashire electric motor, was installed.

The following is taken from the mine manager's report for the year ending December 31, 1959:

Production

During 1959 a total of 87,116 tons of ore was hoisted; of this, 79,133 tons were milled, and 7,983 were discarded by sorting.

The 79,133 tons of ore milled yielded 17,572.303 ounces of gold and 4,927.17 ounces of silver. The total value of this bullion, including $180,555 in Emergency Gold Mining Assistance but less marketing cost, was $768,191 or $9.71 per ton milled.

Operating Costs

A substantial increase in development work was responsible for the higher costs in 1959. Total costs for the year, and costs per ton milled for this and the previous year, are given in the following table:

Distribution	1959 In Full	1959 Per Ton Milled	1958 Per Ton Milled
Exploration and development	$115,761	$1.46	$0.42
Mining	311,973	3.94	4.10
Milling	149,188	1.89	1.76
General expense at property	97,377	1.23	0.97
Mine office and supervision	47,151	0.60	0.44
Head office	32,751	0.41	0.39
Total	$754,201	$9.53	$8.08

GOLD—Continued

Exploration

Deep exploratory drilling, from the bottom levels in both the north and south mines, has shown that the main shear continues strongly with depth. This shear, and its associated hanging-wall and foot-wall veins, have produced 2,116,989 tons of ore to date.

Mine Development

Development completed in the year totalled 5,747 feet, compared to 1,817 feet in 1958. The major effort in development was directed toward opening the 1,450-foot level in the south mine. This work produced 648 linear feet of new ore averaging 0.350 ounces per ton across an average width of 3.7 feet. At the end of the year, 1,000 feet of potential ground remained to be explored.

Mining

During the year, the mill was supplied from 35 development headings and 58 stopes. The main source of the ore was the south mine. Broken ore from stopes amounted to 76,645 tons, and broken ore from development amounted to 12,947 tons, for a total of 89,592 tons. After sorting, 79,133 tons milled had an average recovery of 0.2220 ounces per ton.

Ore Position

Exploration and development on and below the 1,450-foot level in the south mine indicate the existence of two year's supply of ore in this area. The results of a program of development directed toward the 1,600-foot level of the south mine will determine the outcome of a shaft-sinking proposal; these results will be made known late in 1960.

General

The average number of employees was 105: 64 underground, and 41 on surface. P. J. McCarthy was mine manager.

MacLeod-Cockshutt Gold Mines Limited

MacLeod-Cockshutt Gold Mines Limited was incorporated in September 1933 with an authorized capitalization of 3,000,000 shares of $1 par value, of which 2,862,490 shares have been issued. Late in 1958 control of the company was acquired by the Little Long Lac Gold Mines Limited interests. At the end of the year the officers and directors were: R. C. Stanley, Jr., president; J. G. Boeckh, vice-president; Mary C. Maddigan, secretary-treasurer; J. C. Adamson, J. C. L. Allen, and S. J. Bird, directors. The head office is at 199 Bay Street, Toronto. The mine address is Geraldton.

The property is in Ashmore and Errington townships, District of Thunder Bay.

Mining and milling continued throughout 1959. There was no shaft-sinking during the year.

SHAFTS, MACLEOD-COCKSHUTT MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft	T.B.10040	Vertical	3	2,250
No. 2 shaft	T.B.10038	Vertical	4	1,921
No. 3 winze (below 11th level; inactive)		45°	4	2,015

Development during the year consisted of 1,619 feet of drifting, 492 feet of crosscutting, and 794 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 103,394 feet; crosscutting, 27,968 feet; raising, 34,332 feet. Diamond-drilling in 1959 consisted of 36 holes from underground totalling 2,440 feet.

GOLD—Continued

New equipment in 1959 included the following: one 3-ton C.G.E. locomotive; twelve 60-cubic-foot Granby-type ore-cars; eight 4-ton Granby ore-cars; one cage-over-skip combination; one 3-phase 60-cycle compensator and control panel; one primary reversing panel; and one Goodman 4-ton trolley locomotive.

A total of 692,307 tons of ore was hoisted; 693,322 tons were milled at an average daily milling rate of 1,915 tons.

The following was taken from the general manager's report for the year ending December 31, 1959:

During 1959 the mine produced 66,616.102 ounces of gold and 6,383.12 ounces of silver from 693,322 tons of ore, averaging 0.096 ounces of gold recovered per ton. Revenue from this production amounted to $2,239,884, or $3.23 per ton, including an estimated $252,268 E.G.M.A., and less marketing expense of $20,555. The total operating revenue was $2,471,597, or $3.56 per ton milled.

Ore reserves were recalculated to provide for increased dilution in this stage of mining and, at the end of the year, were estimated to be 1,663,000 tons averaging 0.114 ounces per ton, entirely within the F zone.

Consolidated Mosher's orebody was being developed and will be available to be treated in the mill on a custom basis when MacLeod-Cockshutt reserves have been depleted.

The eleventh level has been connected to Consolidated Mosher's 1,740-foot level, and two more connections on the 12th and 13th levels will be completed early in 1960.

During 1959 the mill treated 5.3 percent more ore than in 1958, operating for 362 days at an average rate of 1,915 tons per working day.

Costs

Distribution	In Full	Per Ton
Mine development	$ 89,858	$0.129
Mining	1,157,478	1.669
Milling	523,426	0.755
Mine office and supervision	95,514	0.138
General expense at property	208,570	0.301
Administration and corporate expense	49,508	0.071
Ontario Royalty tax	1,800	0.003
Total	$2,126,154	$3.066

Outside Exploration

Diamond-drilling on the Isis group of claims north of Longlac, which the company holds jointly with Kerr-Addison on a 60-40 basis, was completed early in 1959. Low copper values were encountered, and sufficient work has been recorded to retain thirty-seven claims in good standing.

General

The average number of employees was 297: 128 underground, and 169 on surface. H. E. Rudd was general manager.

Madsen Red Lake Gold Mines Limited

Madsen Red Lake Gold Mines Limited was incorporated in March 1935 with an authorized capitalization of 5,000,000 shares of $1 par value. On June 6, 1940, the capitalization was reduced to 3,500,000 shares by the cancellation of 1,500,000 unissued shares. The number of shares issued at the end of 1959 stood at 3,499,-528. The officers and directors were: Joseph McDonough, president; F. R. Marshall, vice-president; Margaret Masterson, secretary-treasurer; Marius Madsen, H. H. Mackay, H. G. Young, A. H. Seguin, and S. J. Bird, directors. The head office is at 55 Yonge Street, Toronto. The mine address is Madsen.

The company's main property is in Baird and Heyson townships, Red Lake area, District of Kenora (Patricia portion). It is about 7½ miles southwest of the Howey mine and may be reached by road from Red Lake.

Mining and milling operations continued throughout 1959.

GOLD—Continued

SHAFTS, MADSEN RED LAKE GOLD MINE

	Claim No.	Inclination	Number of Compartments	Sinking in 1959	Depth from Surface
				feet	feet
No. 1 shaft (inactive)....	K.R.L.11505	Vertical	2	.....	573
No. 2 shaft.....	K.R.L.12528	Vertical	3	365	3,875

No. 2 shaft was sunk 365 feet in 1959; level 23 was established at a vertical depth of 3,775 feet below the collar.

Development in 1959 consisted of 2,824 feet of drifting, 2,489 feet of crosscutting, and 4,691 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 114,595 feet; crosscutting, 20,585 feet; raising 47,910 feet. Diamond-drilling in 1959 consisted of 216 holes from underground, totalling 52,485 feet.

New equipment included the following: one 80-cubic-foot underground loading pocket (Dorr-Oliver-Long); one raise machine (Alimak-Verken); and one diesel locomotive (Hudson-Hunslet, 38-hp.).

A total of 302,120 tons of ore was hoisted; 301,999 tons were milled at an average daily rate of 827.4 tons.

The following was taken from the general manager's report for the year ending December 31, 1959:

Summary

The establishment of the No. 3 ore-zone in the east section of the mine was confirmed by diamond-drilling from the 16th-level drift.

The mine operating profit was $1,076,036.21, or $3.56 per ton of ore milled. This was $1.67 per ton lower than in the previous year. The drop in profit was due to the lower grade of ore treated, together with the influence of the above-par value of the Canadian dollar, the increased lateral development program, and increased operating costs.

There were no payments received under the *Emergency Gold Mining Assistance Act* for the year.

The shaft-sinking program was concluded at a depth of 3,875 feet from surface. A program of work was commenced, to develop the new lower levels.

The grade of the ore reserve was maintained, while 261,959 tons of new ore were disclosed. This tonnage of new ore replaced all but 40,000 tons of the ore milled during the year.

Production

The mine produced 301,999 tons of ore that were milled to yield 118,804.674 ounces of gold and 20,276.860 ounces of silver. The total value of this bullion was $4,019,616.83. This was a recovery of $13.31 per ton of ore milled.

The average value, Canadian funds, received for gold, at $33.68 per ounce, was $0.26 lower than the average price received in the previous year.

The cumulative production from the mine up to December 31, 1959, since milling began in August 1938, amounted to $46,173,667.60 from the 4,603,398 tons of ore put through the treatment plant. The average recovery for this period of time was $10.03 per ton of ore milled.

Costs

Mining costs were up $0.61 per ton milled during the year owing to the increased tonnage of ore broken, the smaller size of ore-bodies being mined, and the operation of an additional surface hoist to develop the lower section of the mine.

The amount of lateral development work undertaken on the completion of shaft-sinking caused an increase of $0.28 per ton milled in the account for development and exploration.

The establishment of employee pension plans caused an increase in the accounts for mine general and head office expense, through the combined write-off of one-tenth of the prepaid past service payment and the current service contributions, to the extent of $43,351.90 or $0.144 per ton of ore milled.

A decrease of $0.03 per ton milled occurred in the marketing charges owing to the selling of gold in the free market.

The foregoing and other changes in costs caused the total operating costs per ton of ore milled to be increased, by the amount of $1.041, to $9.747 per ton after $126,957.06 of the monies spent for shaft work were transferred to a deferred development account.

GOLD—Continued

OPERATING COSTS

Distribution	In Full		Cost per Ton Milled	Cost per Ounce Produced
Development and exploration	$662,828.46			
less portion deferred	126,957.06			
		535,871.40	$1.774	$ 4.511
Stope preparation		102,167.47	0.338	0.860
Stoping		995,917.01	3.298	8.383
Mucking, tramming, and hoisting		452,334.80	1.498	3.807
Crushing and conveying		84,915.93	0.281	0.715
Milling		361,734.44	1.198	3.045
Mine general expense		320,615.10	1.062	2.699
Head office expense		63,034.80	0.209	0.530
Marketing charges		26,989.67	0.089	0.227
Total		$2,943,580.62	$9.747	$24.777

Ore Developed

The extensions to working places, and diamond-drilling in other locations, disclosed 261,959 tons of ore that were taken into the ore reserve to partially replace the 301,999 tons of ore milled during the year.

Diamond-drilling from the extension of the 16-east drift confirmed the establishment of a new ore-zone in that section of the mine. To date, four ore-bodies have been indicated by diamond-drilling. These contain an estimated 56,000 tons of ore averaging 0.28 ounces per ton between the 17th and 15th levels. This ore was not included in the ore-reserve figure given for December 31, 1959.

Ore Reserve

The calculated ore reserve was as follows:

Source	December 31, 1958			December 31, 1959		
	Tons	Ounces	Grade	Tons	Ounces	Grade
7th level to surface	25,230	7,340	0.291	28,930	9,112	0.315
11th level to 7th level	27,010	7,984	0.295	57,200	16,777	0.293
From 50 feet below 17th level to 11th level	494,220	166,963	0.338	413,040	140,845	0.339
Broken reserve	97,730	30,296	0.310	104,980	32,544	0.310
Total	644,190	212,583	0.330	604,150	199,278	0.330

All high assays were reduced to 1.00 ounce, and a dilution factor of 10 percent was allowed in the calculation of grade and tonnage of the ore reserve.

Milling

The details of the mill operation are shown in the following summary, in which, for comparative purposes, figures are given for the two previous years' operations and for the total operating life of the mine:

	Year Ending			Aug. 11, 1938 to Dec. 31, 1959
	Dec. 31, 1957	Dec. 31, 1958	Dec. 31, 1959	
Dry tons treated....tons	305,300	302,200	301,999	4,603,398
Operating time of total time....percent	98.16	97.64	97.42	95.77
Ore treated, average per calendar day..tons	836.4	827.9	827.4	589.2
Average gold assay of heads....ounces	0.3541	0.4310	0.4190	0.3001
Average gold assay of tails....ounces	0.0161	0.0224	0.0256	0.01745
Recovery....percent	95.45	94.81	93.90	94.18

During the year, difficulty was experienced in extracting the gold, which was extremely fine and was disseminated throughout the ore. This had a downward effect on the average recovery for the year.

GOLD—Continued

General

The average number of employees was 376: 238 underground, and 138 on surface. E. G. Crayston was general manager.

New Dickenson Mines Limited

Dickenson Red Lake Mines Limited was incorporated in November 1944 with an authorized capitalization of 3,500,000 shares of $1 par value. In June 1947 the capitalization was increased to 4,000,000 shares. In June 1949 the company was reorganized, and the name was changed to New Dickenson Mines Limited. The capitalization was reduced to 3,750,000 shares of $1 par value. The number of shares issued at the end of 1959 stood at 2,755,900. The officers and directors were: A. W. White, president and treasurer; C. R. Diebold, vice-president; R. B. Law, secretary; L. W. McIlmurray, assistant secretary; H. R. Heard, assistant treasurer; R. A. Jodrey, S. C. Smith, M. L. Urquhart, and L. I. Ross, directors. The head office is at 145 Yonge Street, Toronto. The mine address is Balmertown.

The company's main holding is the New Dickenson mine consisting of 31 claims in Balmer township, Red Lake area, District of Kenora (Patricia portion).

Mining and milling continued throughout 1959.

SHAFTS, NEW DICKENSON MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft	K.R.L.19497	Vertical	3 to 8th level 4 to bottom	2,969
Detta shaft (inactive)	K.R.L.19502	Vertical	3	280

In 1959, 2,573 feet of drifting, 4,135 feet of crosscutting, and 3,317 feet of raising, were completed. Total-development footages to December 31, 1959, were as follows: drifting, 47,077 feet; crosscutting, 36,467 feet; raising, 27,644 feet; 274 diamond-drill holes from underground, totalling 51,959 feet, were completed in 1959.

New construction consisted of a mill addition (77 by 42 feet) to house a regrind unit.

The following new plant equipment was purchased during 1959: 1 rod mill (Allis Chalmers, 8 by 12 feet) with 350-horsepower synchronous motor, 3-phase, 60-cycle; 1 cyclone (Krebs, model D-15-B); 1 automatic separator (Wilkerson); 1 automatic spray system (Farval); one 6-ton crane (Hepburn); 10 side-dump mine-cars (Hudson, 48-cubic-foot); 1 rocker shovel (Eimco, Model 21–55); 3 transformers (Supreme, 150-kva. 60-cycle, 2,300 to 575 volts); 1 double-drum slusher (Joy, FF-211); 1 single-drum tugger (Joy, DW-111).

The following is taken from the general manager's report for the year ending December 31, 1959:

Production

Totals of 171,302 tons of ore and 30,215 tons of waste were hoisted. The waste was distributed as yard fill. The ore was sent directly to the mill bins.

The 171,227 tons of ore milled yielded 85,851.268 ounces of gold and 8,125.90 ounces of silver. The total value of this bullion was $2,906,804.12, giving a recovery-value of $16.976 per ton milled. No benefits were received under the *Emergency Gold Mining Assistance Act* because the cost per ounce of gold produced was lower than the amount required to qualify for such payments under the Act. Average values for the year were: gold, $33.776 per ounce; silver, 87.4 cents per ounce.

GOLD—Continued

To date, the mine has produced 631,780.512 ounces of gold and 52,986.01 ounces of silver. The total value of this bullion was $21,774,220 for an average value of $34.39 per ounce of gold and 86.6 cents per ounce of silver. Total tons milled to date amount to 1,340,316 for a recovery of 0.471 ounces of gold per ton.

Costs

Distribution	1959		1959	1958
	In Full	Per Ton Milled	Per Ounce	Per Ounce
Shaft deepening	$ 66,115	$ 0.39	$ 0.77	$ 1.685
Exploration and development	385,860	2.25	4.49	4.310
Mining	676,165	3.95	7.88	7.514
Milling	409,489	2.39	4.77	4.705
Mine general	286,688	1.67	3.34	2.893
Head office	62,017	0.36	0.72	0.668
Marketing	29,417	0.17	0.34	0.317
Total	$1,915,751	$11.18	$22.31	$22.092

Mining

Broken ore totalling 151,448 tons remained in the stopes; this is a decrease of 11,005 tons from the previous year.

Of the 171,302 tons of ore hoisted, 16,369 tons were obtained from development and 154,933 tons were obtained from stoping and stope preparation.

Stoping operations in the three main ore-zones, North C, South C, and D, were confined to the upper thirteen levels. Of the total ore hoisted, proportions by zones were: North C, 34.7 percent; South C, 40.4 percent; D, 19.5 percent; miscellaneous (B, E, and F), 5.4 percent.

The shrinkage-stope method of mining was continued. Rock broken per rock-drill shift, in stopes and back stopes, was 42 tons, compared to 49.0 in 1958. The average stoping width was 6.0 feet, compared to 6.1 feet the previous year.

Exploration and Development

Development during 1959 consisted largely of the driving of the seventeenth- and nineteenth-level main crosscuts, the completion of the No. 3 loading pocket at 68 feet below the nineteenth level, and the completion of the ore and waste passes from the No. 3 loading pocket to the seventeenth level.

The seventeenth-level main crosscut reached the projected location of the F zone in November; by the end of December, 126.7 feet of ore, grading 0.54 ounces per ton across 5.0 feet, were developed in the F zone at the seventeenth level. This was a considerably improved grade when compared with the ore of the F zone development above this area at the fifteenth-level horizon.

At the end of the year, the seventeenth- and nineteenth-level main crosscuts had approximately 179.0 feet and 670.0 feet, respectively, to go to reach the projected location of the South C zone.

Three diamond-drill holes drilled downward from the fifteenth level at distances of 300 feet, 570 feet, and 850 feet, respectively, west of the east boundary, intersected mineable ore between the seventeenth- and nineteenth-level horizons in the projected locations of the D and South C zones. This is the most easterly orebody that is indicated on the property.

A total of 917.7 linear feet of ore, grading 0.50 ounces per ton across a width of 6.0 feet, was opened up by drifting in four ore-zones.

Exploration Department

Thirty-eight properties were examined, thirty-five being gold, one copper-gold, one iron, and one nickel. A total of 57 claims were staked on five of the gold properties examined, and preliminary diamond-drilling was done on two of these; no samples of economic value were found in the diamond-drill cores. However, surface prospecting on two claim-groups indicated interesting gold occurrences; more work is planned.

Robin Red Lake Mines Limited

The diamond-drilling program, in progress on the Robin property at the end of 1958, was completed. The work-site was located at the face of the crosscut, 600 feet within the Robin property and on the New Dickenson Mines Limited fifteenth level; three holes, totalling, 2,362 feet, were drilled. Small amounts of widely disseminated gold were found, but no ore was intersected in this drilling.

GOLD—Continued

Ore Reserves

At December 31, 1959, the total positive ore reserves, both broken and in place, were calculated to be 511,257 tons having an average grade of 0.558 ounces of gold per ton. This compares with 565,956 tons grading 0.542 ounces per ton, at December 31, 1958.

Milling

Details of the milling operations during the year, with figures for the previous year for comparison, are summarized in the following table:

	1959	1958
Ore treated during the year.....tons	171,227	162,659
Operating time.....percent	98.97	98.61
Mill-average.....tons per day	469.1	445.6
Average content of mill heads.....ounces of gold per ton	0.561	0.612
Assay of mill tails.....ounces of gold per ton	0.059	0.068
Extraction.....ounces of gold per ton	0.502	0.544
Recovery.....percent	89.4	88.8

General

Operating costs, at $11.18 per ton milled, are down $0.83 from 1958 owing mainly to reductions both in shaft-sinking expense and tonnage of broken-ore reserve.

The 8- by 12-foot Canadian Allis-Chalmers regrind ball mill was put into operation in August. Results at the end of the year were gratifying; the recovery was increased approximately 3 percent to a total of 92 percent; the daily average of the mill's rated capacity was raised from 450 to 470 tons.

The average number of employees was 251: 130 underground, and 121 on surface. F. A. Fell was general manager.

Norstar Lake Mines Limited

Norstar Lake Mines Limited was incorporated in September 1956, with an authorized capitalization of 3,000,000 shares of $1 par value; 2,525,397 shares have been issued. The company is controlled by Kirkland Minerals Corporation Limited. The directors and officers were: S. G. Taylor, president; I. A. Wallace, vice-president; E. A. Glick, managing-director; Robert Martin and H. L. Pountney, directors; Mrs. M. L. Irvine, secretary-treasurer; Mrs. Camilla Lillico, assistant secretary-treasurer. The operation was managed by Sulmac Exploration Services Limited. The head office is at 160 Bay Street, Toronto. The mine address is Crerar.

The company has an option on a copper-gold prospect consisting of 7 claims in Davis township, District of Sudbury, about 15 miles north of Markstay. The property includes the former Mount Aetna gold mine.

Former operators had sunk a vertical, two-compartment shaft to a depth of about 110 feet, and had driven an adit about 100 feet long, in the northeast quarter of lot 10, concession III, Davis township.

A vertical, three-compartment shaft (No. 2) was sunk, in 1958, to a depth of 277 feet on the northeast quarter of lot 10, concession III, about 200 feet north of the old shaft. Levels were established at 125 and 250 feet. Operations continued from January 1 until March 21, 1959; during this time 330 feet of drifting and 239 feet of crosscutting were completed. Total-development footages at No. 2 shaft, to December 31, 1959, were as follows: 270 feet of drifting and 195 feet of crosscutting on the 125-foot level; 300 feet of drifting and 175 feet of crosscutting on the 250-foot level. Diamond-drilling in 1959, consisted of 69 holes from underground totalling 7,937 feet.

A total of 2,000 tons of ore was hoisted and stockpiled.

Work was done by a contractor; an average of 4 men was employed. G. A. Kelly was engineer in charge.

GOLD—Continued

Pamour Porcupine Mines Limited

Pamour Porcupine Mines Limited was incorporated in March 1934. The authorized capitalization is 5,000,000 shares of no par value, all of which have been issued. The officers and directors were: J. R. Bradfield, president; R. V. Porritt, vice-president; C. H. Windeler, secretary; R. G. Rudolf, treasurer; J. R. Timmins, L. H. Timmins, J. Y. Murdoch, H. L. Roscoe, and W. S. Row, directors. The executive office is at 1700 Bank of Nova Scotia Building, 44 King Street West, Toronto. The head office and mine office are at Pamour.

The company's main property, totalling 33 claims, is in Whitney and Murphy townships, Porcupine area, District of Cochrane. It includes the former LaPalme Porcupine, Three Nations, and Porcupine Grande properties.

Mining and milling continued throughout 1959.

SHAFTS, PAMOUR MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (inactive)	P.13793	Vertical	2	110
No. 2 shaft (inactive)	P.13793	Vertical	2	220
No. 3 shaft	P.13783	Vertical	5	3,144
No. 4 internal shaft (below 600-foot level)	.....	Vertical	3	2,437

Development during the year consisted of 3,759 feet of drifting, 1,191 feet of crosscutting, and 173 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 149,924 feet; crosscutting, 32,287 feet; raising. 77,927 feet. Diamond-drilling in 1959 consisted of 331 holes from underground totalling 56,478 feet.

The following is taken from the manager's report for the year ending December 31, 1959:

Stoping

Stoping progressed in both the east and west sections of the mine. Fourteen percent of the ore produced was from lava stopes. The east end provided 67 percent of the ore broken and 70 percent of the ore milled.

Cut-and-fill stopes provided 7 percent of the ore broken, slusher stopes 8 percent, blast-hole stopes 30 percent, and shrinkage stopes the remainder.

Ore Reserves

Source	Broken		In Place		Broken and In Place	
	Tons of ore	Gold, oz. per ton	Tons of ore	Gold, oz. per ton	Tons of ore	Gold, oz. per ton
East end	566,597	0.087	488,226	0.117	1,054,823	0.101
West end	136,216	0.117	416,529	0.127	552,745	0.124
Total	702,813	0.092	904,755	0.115	1,607,568	0.105

Allowance for normal dilution has been made in calculating the tonnage and grade of ore reserves.

After milling 637,403 tons, total ore reserves were increased by 1,931 tons with a slight increase in grade. Broken-ore reserves were increased by 194,474 tons.

GOLD—Continued

Milling

The average was 1,756 tons per day; the average grade of ore milled was 0.106 ounces of gold per ton. Production by quarters is tabulated below:

Quarter	Milled	Mill Head Assay	Recovery	Recovery		Gross Value Bullion Shipped
				Gold	Silver	
	tons	ounces per ton	percent	ounces	ounces	
First	160,555	0.1033	90.98	15,091	2,038	$ 513,993
Second	153,423	0.1011	90.92	14,110	1,890	475,914
Third	161,190	0.1047	90.97	15,346	1,651	513,844
Fourth	162,235	0.1141	91.95	17,027	2,832	562,602
Total 1959	637,403	0.1059	91.23	61,574	8,411	$2,072,176
Total 1958	647,127	0.1035	90.06	60,335	8,439	$2,055,066

General

A jaw crusher (36 by 48 inches) was purchased for installation on the 2,900-foot level.

The average number of employees was 377: 210 underground, and 167 on surface. F. E. Patton was manager.

Pantan Mines Limited

Pantan Mines Limited was incorporated in February 1951 with an authorized capitalization of 3,000,000 shares of $1 par value, of which 2,282,834 had been issued to February 27, 1959. The officers and directors were: J. N. Plexman, president; Blanchard Ariko, vice-president; F. J. Ainsborough, secretary-treasurer; Jack Haynes, and Joseph Tessis, directors. The head office address is 73 Adelaide Street West, Toronto. The mine address is Dyment.

Pantan Mines Limited leased from Tabor Lake Gold Mines Limited the property consisting of 15 claims, formerly called Clarke Gold Mines, located immediately south of the south boundary of Melgund township, District of Kenora.

Previous work on the property included the sinking of a three-compartment, vertical shaft to a depth of 280 feet on claim K.912. Lateral work from this shaft consisted of 32 feet of drifting on the 68-foot level, 134 feet of crosscutting and 134 feet of drifting on the 125-foot level, and only station-cutting on the 250-foot level.

In the early part of 1959, 185 feet of drifting and 185 feet of crosscutting were completed on the 250-foot level.

Surface mapping of the property was carried out. At the end of the year, a crew of men was on the property constructing a mill and sheeting-in the headframe.

J. N. Plexman, president, was in charge of operations at the property. Two contractors employed an average of seven men.

Paymaster Consolidated Mines Limited

Paymaster Consolidated Mines Limited was incorporated in February 1930 with an authorized capitalization of 9,000,000 shares of $1 par value, of which 8,629,090 shares have been issued. The officers and directors were: C. E. Cook, president and managing director; W. C. Ringsleben, vice-president; A. C. Buckley,

GOLD—Continued

secretary-treasurer; H. D. Rothwell, L. G. Sams, Marshall Stearns, S. A. Caldbick, and A. J. Feuer, directors. The head office and mine office are at South Porcupine.

The main property, 23 claims, in Deloro and Tisdale townships, Porcupine area, District of Cochrane, consists of amalgamated holdings of former operating companies.

Mining and milling continued throughout 1959.

SHAFTS, PAYMASTER CONSOLIDATED MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (inactive)	T.R.S.776	Vertical	2	80
No. 2 shaft (inactive)	T.R.S.776	Vertical	2	814
No. 3 shaft (inactive)	T.R.S.776	Vertical	4	400
No. 4 shaft (inactive)	H.S.747	Vertical	2	253
No. 5 shaft	P.14115	Vertical	3	4,316
No. 5 winze (below 2,075-foot level)	.....	Vertical	3	4,212
No. 6 winze (below 4,075-foot level)	.....	Vertical	3	4,501
No. 1050-1 winze (below 1,050-foot level); (inactive)	.....	75°	2	1,212
No. 1050-2 winze (below 1,050-foot level); (inactive)	.....	Vertical	2	1,632
No. 1050-3 winze (below 1,050-foot level); (inactive)	.....	Vertical	2	2,120
No. 6 shaft (inactive)	P.13128	60°	2	482
No. 400-4 winze (below 400-foot level); (inactive)	.....	Vertical	2	1,080
No. 7 shaft (inactive)	P.14114	Vertical	filled	75
No. 8 shaft (inactive)	P.14115	Vertical	filled	185
No. 9 shaft (ventilation)	P.14115	Vertical	1	185

The sinking of No. 6 winze, begun in 1958, was continued 380 feet farther in 1959 to a total depth of 4,501 feet from surface. The 4,225- and 4,375-foot levels were established.

Development during the year consisted of 3,599 feet of drifting, 2,675 feet of crosscutting, and 1,855 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 175,236 feet; crosscutting, 77,388 feet; raising, 55,158 feet. Diamond-drilling in 1959 consisted of 5 holes from surface totalling 1,325 feet, and 185 holes from underground totalling 16,181 feet.

New equipment installed included 2 simplex Lilly controllers and auxiliary equipment (Canadian Ingersoll-Rand), and 2 duplex adjustable-stroke diaphragm pumps (4-inch, Denver Equipment).

A total of 207,920 tons of ore was hoisted; 207,830.6 tons were milled. The daily mill-average was 607.7 tons.

The following is taken from the general manager's report for the year ending June 30, 1960:

Mining

Underground development was done on the levels from No. 5 shaft, No. 6 winze, and No. 5 winze.

From No. 5 shaft the south crosscut on the 3,300-foot level was completed, and exploration of the Nos. 36 and 37 ore-zones was commenced by drifting and diamond-drilling. On the 4,075-foot level, drifting was done along the Nos. 25 and 36 veins.

From the No. 6 winze, on the 4,225-foot level, the crosscut was driven a total of 977 feet to reach the No. 36 ore-zone where a total of 666 feet of drifting was done to the east and the west. On the 4,375-foot level, 825 feet of crosscutting was done to reach the No. 36 zone, and a total of 1,357 feet of drifting was done to the east and the west at this horizon. On these two new levels the total length of ore developed was 989 feet; this had an average width of 112 inches and an average cut grade of 0.267 ounces; all but 44 feet of this was along the No. 36 vein. Development

GOLD—Continued

and exploration, by drifting and diamond-drilling, continues on both levels. Stoping operations were commenced on the 4,375-foot level. At the east end of the No. 36 vein on the 4,375-foot level, an interesting copper content was found in the gold-bearing ore. Extensive sampling east of, west of, and above, and below this zone has failed to outline a copper orebody of commercial significance; this occurrence is considered to be a local enrichment of chalcopyrite in the sulphides associated with the Nos. 36 and 37 veins.

From the levels of No. 5 winze, drifting was done in the following locations: along the No. 18 vein on the 3,700-, 3,825-, 3,950-, and 4,075-foot levels; along the No. 23 vein on the 2,075-foot level; along No. 24 vein on the 3,450- and 3,575-foot levels; along No. 31 vein on the 3,450-foot level; and along the No. 34 vein on the 3,950-foot level.

New ore developed during the fiscal year totalled 1,612 feet having an average width of 98 inches and an average cut grade of 0.27 ounces per ton.

Stoping operations proceeded in the following locations: from the levels of No. 5 winze between the 2,825- and 3,950-foot levels on the Nos. 8, 18, 24, 31, and 34 veins; from the levels of No. 5 shaft between the 3,600- and 4,075-foot levels on the Nos. 25, 36 and 37 veins; and from the levels of No. 6 winze on the No. 36 vein.

Sources of ore during the fiscal year were as follows: development, 6 percent; levels of No. 5 winze, 57 percent; levels of No. 5 shaft and No. 6 winze, 37 percent.

Ore Reserves

Source	Quantity	Average Grade
	tons	ounces per ton
Probable	38,648	0.221
Positive	353,132	0.237
Broken	13,099	0.195
Total	404,879	0.234

Ore reserves show a decrease of 17,329 tons from the amount at June 30, 1959; the over-all grade is down from 0.240 to 0.234 ounces per ton.

Milling

During the fiscal year, 209,983.9 tons of ore were milled. The average milling rate was 573.7 tons per calendar-day, compared with 556.4 tons per calendar day in the previous fiscal year.

Costs

The mining cost per ton of ore broken was $5.62. The following gives an analysis of the operating costs:

Distribution	In Full	Per Ton Milled
Diamond-drilling	$ 24,518.91	$0.12
Drifting	114,476.61	0.55
Crosscutting	58,763.00	0.28
Raising	55,837.45	0.27
Mining	1,117,528.80	5.32
Ore transportation	20,591.93	0.10
Crushing	46,313.79	0.22
Milling	284,622.99	1.35
General expense	152,132.74	0.72
Total of all costs	$1,874,786.22	$8.93

General

The average number of employees was 313: 222 underground, and 91 on surface. L. K. Walkom was general manager.

GOLD—Continued

Pickle Crow Gold Mines Limited

Pickle Crow Gold Mines Limited was incorporated in January 1934 with an authorized capitalization of 3,500,000 shares of $1 par value, of which 3,386,850 shares have been issued. In April 1959 the capitalization was increased to 5,000,000 shares; the number of shares issued stood at 3,554,869 at the end of the year. The officers and directors were: N. B. Keevil, president; C. G. MacIntosh, vice-president; R. M. Butler, secretary and director; J. M. Bland, treasurer; J. C. Perry and W. A. Robinson, directors. The head office is at 11 Adelaide Street West, Toronto. The mine office is at Pickle Crow.

The property consists of 96 claims in Connell and McCullagh townships, Pickle Lake area, District of Kenora (Patricia portion).

Mining and milling continued throughout 1959.

SHAFTS, PICKLE CROW MINE

	Claim No.	Number of Compartments	Total Depth from Surface
			feet
No. 1 main shaft (Howell vein)	P.A.747	3 to 1,200 feet 4 from 1,200 to 2,450 feet 3 from 2,450 feet to bottom	3,042
No. 2 winze (below 750-foot level; inactive)		3	1,547
No. 3 shaft (5,000 feet NE. No. 1)	P.A.2062	3 to 1,554 feet 4 from 1,554 to 2,600 feet 3 from 2,600 feet to bottom	3,031

Development during the year consisted of 4,052 feet of drifting, 5,404 feet of crosscutting, and 2,718 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 61,002 feet; crosscutting, 48,827 feet; raising 35,631 feet. Diamond-drilling in 1959 included 119 holes from underground totalling 22,866 feet, and 6 holes from surface totalling 251 feet. A number of old surface trenches were cleaned out.

The following is taken from the mine manager's report for the year ending December 31, 1959:

Stoping

A total of 112,310 tons of ore was hoisted; stopes supplied 97,822 tons of this total.

In the No. 1 shaft-area, 5,436 tons of ore came from No. 1 vein, 20,611 tons from No. 5 vein, and 463 tons from No. 9 vein. In the No. 3 shaft-area, 30,437 tons came from No. 2 vein, 31,801 tons from No. 6 vein, 8,711 tons from No. 8 vein, and 363 tons from No. 10 vein. Back-fill, in the amount of 28,978 tons, was placed in stopes.

Milling

The following is a summary of some of the figures from milling operations:

Ore milled	tons	112,045
Gold recovered	ounces	32,432
Grade of ore	ounces per ton	0.2895
Recovery	percent	98.47

GOLD—Continued

Costs

Distribution	In Full	Per Ton	Per Ounce
Development (not including $20,620 for deferred development)	$ 414,621	$ 3.70	$12.78
Mining	765,758	6.83	23.61
Milling	216,986	1.94	6.69
General mine expense	211,893	1.89	6.53
Depreciation	75,564	0.67	2.33
Total of all costs	$1,684,822	$15.03	$51.94

Ore Reserves

	Jan. 1, 1960	Jan. 1, 1959
Total ore reserves.....tons	473,206	470,326
Estimated value of gold content.....per ton	$13.07	$13.37

Approximately 60,120 tons of the reserve are in surface and shaft pillars.
All values recorded are based on gold at $35, Canadian funds, per ounce.

General

Ore-passes were driven from the 2,900-foot level to the 2,600-foot level at No. 1 shaft. At No. 3 shaft ore-passes were driven from the 2,850-foot level to the 2,600-foot level and from the 550-foot level to the 400-foot level.

A waste-pass was driven from the 1,900-foot level to the 1,750-foot level in the No. 3 shaft-area.

The remaining surface plant at the Central Patricia Mine was purchased early in the year. Six dwellings were moved to Pickle Crow. Another building was converted into six apartments. An addition to the change-house was built with salvaged materials.

An electric steam-generator was installed to heat the surface plant at No. 1 shaft.

A 1,250-cfm. compressor was installed at No. 3 shaft.

Additions to underground equipment included 2 mucking machines, 2 battery trammers, 2 battery charging units, 13 mine-cars, and 10 rock-drills.

The average number of employees was 243: 144 underground, and 99 on surface. A. E. Cave was appointed manager when A. G. Hattie retired.

Pitchvein Mines Limited

Pitchvein Mines Limited was incorporated in March 1953 with an authorized capitalization of 5,000,000 shares, of $1 par value, of which 2,929,760 shares have been issued. The officers and directors were: D. F. Hurd, president and general manager; T. R. Rowe and J. V. Driscoll, vice-presidents; J. R. McDougall, secretary-treasurer; E. F. Carr, director. The head office and mine address is 82 Government Road West, Kirkland Lake.

The property, formerly known as Melba Gold Mines, consists of 11 claims located in Melba township, District of Timiskaming, about 12 miles north of Kirkland Lake. The two-compartment shaft, located on claim L.59506 and inclined at 55 degrees, had been sunk by the former owners to a distance of 246 feet, with a level at 225 feet, vertical depth.

In 1959, three buildings on the property were repaired; about 3,000 feet of surface stripping averaging 3 feet in depth was completed, and the underground workings were dewatered.

D. F. Hurd, president, was in charge; an average of 3 men was employed.

GOLD—Continued

Preston East Dome Mines Limited

Preston East Dome Mines Limited was incorporated in January 1911 and reorganized by supplementary letters patent in February 1936. In September 1957 the company was again reorganized, and the capitalization was increased from 3,000,000 shares of $1 par value to 7,000,000 shares of $1 par value; 6,728,000 shares have been issued. The company is controlled by Rio Tinto Mining Company of Canada Limited. The officers and directors were: W. H. Bouck, president; G. B. Langford, vice-president; R. D. Lord, managing director; G. Baker, secretary; D. A. MacFarlane, treasurer, G. A. Roy, assistant-treasurer; and S.A. Hayden, D. R. Derry, W. B. Malone, G. A. Fallis, E. B. Gillanders, and J. H. Hirshhorn, directors. The head office is at 335 Bay Street, Toronto. The mine office is at South Porcupine.

The company's main property is the Preston East Dome mine, consisting of 7 claims immediately south and east of the Dome mine, in Tisdale township, Porcupine area, District of Cochrane. Early in 1959 the company acquired the property of Midcamp Mines Limited, consisting of 355 acres adjoining the Paymaster and Preston East Dome mines. Further details on Midcamp are given in the annual report of Ontario Department Mines for 1954, Volume LXIV, Part 2, page 63.

Mining and milling operations continued throughout 1959.

SHAFTS, PRESTON EAST DOME MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (escape)	P.13151	63°	2	95
No. 2 shaft	P.13151	Vertical	5	2,388
No. 3 internal shaft (below 18th level)		Vertical	3 from 18th level to 69 feet above 28th level, 4 to bottom	4,170
No. 4 shaft (inactive)	P.12971	Vertical	3	400

Development during the year consisted of 2,197 feet of drifting, 6,981 feet of crosscutting, and 1,871 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 111,814 feet; crosscutting, 134,410 feet; raising 55,888 feet. Diamond-drilling in 1959 consisted of 760 holes from underground totalling 96,112 feet.

New equipment included a hydraulic-fill plant, ten 3-ton Granby ore-cars, and 1 Eimco rocker shovel.

The following was taken from the mine manager's report for the year ending December 31, 1959:

Milling

Milled	tons	223,460
Daily average milled	tons	750
Average of mill heads	ounces per ton	0.265
Average net recovery	ounces per ton	0.259
Average gold in tailings	ounces per ton	0.006
Average recovery	percent	98.0
Gold produced	ounces	57,877.95
Silver produced	ounces	7,027.25

The reduction in tonnage was due to the exhaustion of some of the larger stopes and to the diversion of development crews to the long-range program then in progress to reach the indicated orebodies of the newly acquired Midcamp property.

GOLD—Continued

Mining

The following table shows the production by zones:

Mining Zone	Trammed	Proportion of Total	Grade	
			Uncut	Cut
	tons	percent		
Preston porphyry	9,893	4.5	0.31	0.21
West porphyry	112,071	50.6	0.23	0.17
Porphyry greenstone	61,148	27.7	0.29	0.17
North greenstone	20,285	9.2	0.23	0.12
West greenstone	2,577	1.2	0.13	0.13
Development	15,145	6.8	0.32	0.12
Total from all zones	221,119	100.0	0.26	0.16

Operating Costs

The operating costs, per ton milled, at the mine before charging administration expenses, depreciation, taxes, and write-offs, were as follows:

	Per Ton
Development and diamond-drilling	$1.96
Mining	5.45
Milling	1.27
Total of all costs at the mine	$8.68

These costs, 32 cents higher than the previous year, were influenced by a wage increase and by the development program requiring that most of the advance be in waste.

Ore Reserves

Ore developed during the year amounted to 1,367 linear feet, which graded 0.47 ounce per ton uncut, and 0.29 ounce per ton cut grade. The average width of developed ore-veins was estimated to be 5.9 feet. A new producing-zone has been named "the west greenstone area" in order to identify distinctly those orebodies on the Midcamp ground that are associated with the flows.

The ore reserves at December 31, 1959, totalled 467,550 tons. The estimated grade was 0.25 ounce per ton. The decrease in tonnage from that of the previous year was 13,337 tons. In addition to the above reserves, a considerable tonnage was indicated by diamond-drilling on the Midcamp ground extending from the 12th level to the 21st level. This orebody was partly developed on the 12th level, and mining was in progress. Results so far have been encouraging.

General

Owing to the exhaustion of the waste dump, a hydraulic-fill plant was installed; no gravel fill was purchased. At the end of the year the plant was ready for operation.

Labourers were in plentiful supply throughout the year. A wage-contract, of one year's duration and signed with the United Steelworkers on June 16, 1959, provided for an additional $0.05 per hour increase for hourly-rated personnel, and an additional statutory holiday.

The average price received for gold was $33.57 per ounce compared to $33.97 for the previous year.

The compensable-injury frequency for the year was 15.4 per million man-hours, a decrease of 11 for the year; this compares with an average of 26.4 for the group of mines in the area.

The average number of employees was 344: 242 underground, and 102 on surface. G. F. Greenacre was mine manager.

Renabie Mines Limited

Renabie Mines Limited was incorporated in January 1941 with an authorized capitalization of 1,500,000 shares of $1 par value, of which 1,050,005 shares have been issued. The company is a subsidiary of Macassa Mines Limited. The officers and directors were: R. A. Bryce, president; Larmour Soliague, assistant to the

GOLD—Continued

president; J. D. Bryce, executive vice-president; H. W. Salthouse, secretary-treasurer; G. A. Howes, and C. C. Huston, directors. The head office is at 85 Richmond Street West, Toronto. The mine address is Renabie.

The property is in Rennie and Leeson townships, District of Sudbury.

Mining and milling continued throughout 1959.

SHAFTS, RENABIE MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft	S.34314 (Leeson tp.)	Vertical	3	281
No. 2 shaft	S.34317 (Leeson tp.)	Vertical	3	2,229

Development during the year consisted of 1,547 feet of drifting, 2,365 feet of crosscutting, and 2,256 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 24,534 feet; crosscutting, 11,591 feet; raising 15,681 feet. Diamond-drilling in 1959 consisted of 79 holes from underground totalling 12,351 feet.

New construction included: a 24- by 12-foot addition to the mill to house the vacuum pumps; a 20- by 12-foot addition to the shaft-house for a mine-rescue room; a 14½- by 24-foot building to combine the refinery storage and the mill office; and a 30- by 12-foot all-frame building to house the planing mill.

A wooden 5-inch inside-diameter, water-supply pipeline, 6,740 feet in length, was replaced. A single-deck vibrating screen, 13 by 6 feet, was installed in the mill.

The following was taken from the mine manager's report for the year ending December 31, 1959:

Production

The following are production figures for 1959, and comparable figures for 1958 and 1957:

Year	Value of Bullion Recovered	Ore Milled	Gross Value of Recovery
	per ton	tons	
1959	$6.27	195,898	$1,228,560.22
1958	5.37	177,475	952,880.21
1957	6.32	167,133	1,056,830.07

The average mint-settlement value per ounce of gold was $33.54 for this year, compared to $33.94 in 1958. The average price received for silver was $0.87 per ounce. It was estimated that the company was entitled to receive, under the provisions of the *Emergency Gold Mining Assistance Act*, an amount of $222,014.12 for 1959, compared to $246,938.94 for 1958; for 1959, the amount was $1.133 per ton milled, or $6.108 per ounce of gold recovered.

Milling

The daily average milled in 1959 was 536.7 tons as compared with 486.2 tons in 1958. The extraction for the year was 93.2 percent. Bullion recovered comprised 36,349.963 ounces of gold and 10,579.37 ounces of silver.

From the commencement of milling operations in July 1947, 1,891,931 tons of ore have been milled. From this tonnage, 413,589.852 ounces of gold and 127,876.42 ounces of silver have been recovered, returning a gross value of $14,506,207.84; this is equivalent to $7.667 per ton milled, exclusive of cost-aid.

The over-all milling costs were reduced from $1.510 per ton in 1958 to $1.460 per ton in 1959. The 1959 figure of 195,898 tons milled was the highest since the plant started. Recovery improved toward the end of the year.

GOLD—Continued

Ore Reserves

The technical position of ore reserves at the end of the year, allowing for dilution, after elimination of any doubtful or marginal ore, and without including any ore below the 1,550-foot level, was as follows:

Source	Ore	Grade	Value (gold at $35 per ounce)
	tons	ounces per ton	per ton
Unbroken ore	238,404	0.203	$7.11
Broken ore	24,134	0.276	9.66
Total	262,538	0.210	$7.35

Costs

The operating and other costs per ton and per ounce of gold recovered were as follows:

Distribution	1959		1958	
	36,349.963 ounces recovered from 195,898 tons milled		27,857.4 ounces recovered from 177,475 tons milled	
	Per Ton	Per Ounce	Per Ton	Per Ounce
Development and exploration	$1.200	$ 6.469	$1.122	$ 7.146
Mining	2.888	15.562	2.689	17.131
Milling	1.663	8.962	1.691	10.775
Undistributed operating charges, including administration and head office	0.382	2.057	0.509	3.243
Depreciation	0.509	2.741	0.692	4.410
Provision for municipal, federal, and provincial taxes	0.029	0.161	0.046	0.294
Total	$6.671	$35.952	$6.749	$42.999

General

The average number of employees was 188: 81 underground, and 107 on surface. W. A. Moore was mine manager.

Sylvanite Gold Mines Limited

Sylvanite Gold Mines Limited was incorporated in June 1913 with an authorized capitalization of 3,300,000 shares of $1 par value, of which 3,299,500 shares have been issued. The officers and directors were: W. V. Moot, president and managing director; K. C. Gray, vice-president and general manager; Whitworth Ferguson, vice-president; W. S. Walton, secretary-treasurer; F. R. Burton, L. R. Gulick, and A. F. Osborn, directors. The executive office is at Erie County Bank Building, Buffalo, N.Y. The secretary's office is at 44 King Street West, Toronto. The head office and mine office address is Box 670, Kirkland Lake.

The main property is in Teck township, Kirkland Lake area, District of Timiskaming.

Mining and milling continued throughout 1959. There was no shaft-sinking during the year.

GOLD—Continued

SHAFTS, SYLVANITE MINE

	Claim No.	Number of Compartments	Total Depth from Surface
			feet
No. 1 shaft (inactive)	L.2226	2	125
No. 2 shaft	L.2100	3	3,642
No. 3 shaft (inactive)	L.2227	2	118
No. 4 shaft	L.2101	2	1,762
No. 5 winze (below 3,150-foot level)	.....	4	5,605

During the year a total of 962 feet of drifting, 112 feet of crosscutting, and 2,464 feet of raising was completed. Total-development footages to December 31, 1959, were as follows: drifting, 231,327 feet; crosscutting, 70,274 feet; raising, 72,096 feet. Some 91 diamond-drill holes, totalling 6,641 feet were completed from underground during 1959.

A 5- by 4-inch, AC-SRL, pump with 25-horsepower motor as a stand-by unit, and a 5- by 6-inch Smart-Turner triplex pump were installed in the mill.

The following is taken from the report of the vice-president and general manager for the year ending December 31, 1959:

Production

During the year 146,401 tons were milled producing 39,306.337 ounces of gold and 8,257.08 ounces of silver with a total value of $1,326,910. The mill averaged 401.1 tons per day, which is 46.5 tons less per day than in the previous year. Details are listed, for the past five years, in the following table:

Year	Milled	Gold Produced	Average Price per Ounce	Total Revenue from Gold and Silver	Gold, Average Recovery
	tons	ounces			ounces per ton
1955	171,926	53,751.465	$34.54	$1,863,573	0.31
1956	153,666	49,392.961	34.45	1,709,119	0.32
1957	149,135	47,025.236	33.58	1,587,190	0.32
1958	163,356	46,296.810	33.95	1,580,096	0.28
1959	146,401	39,306.337	33.57	1,326,910	0.27

Broken-Ore Reserves

Broken-ore reserves were 35,247 tons at the end of the period, a decrease of 12,182 tons for the year.

Costs

Distribution	In Full	Per Ton Ore Milled	Per Ounce of Gold Produced
Development and exploration	$ 129,767	$0.886	$ 3.302
Mining	893,200	6.101	22.724
Milling, including tailings disposal	255,110	1.743	6.490
General charges (after deducting sundry revenue)	65,299	0.446	1.661
Administration	57,550	0.393	1.464
Bullion expense, including insurance, shipping, and mint refining charges	2,471	0.017	0.063
Mint handling charges	7,861	0.054	0.200
Total	$1,411,258	$9.640	$35.904

GOLD—Continued

Mining

Year	Ore, Broken in Stopes	Ore, from Development	Ore, Total Broken	Waste, Broken and Used for Backfill	Total Ore and Waste, Broken
	tons	tons	tons	tons	tons
1957	126,595	14,953	141,548	13,210	154,758
1958	133,657	12,375	146,032	10,097	156,129
1959	126,727	7,872	134,599	7,198	141,797

General

The average daily tonnage milled decreased 46.5 tons, compared to the previous year; the average recovery dropped to 0.27 ounces per ton.

The tonnage milled again exceeded the tonnage developed. Although it is impossible to specify an exact length of time, as of December 31, 1959, the foreseeable ore will give approximately one year's profitable operations.

The average price received per ounce of gold dropped to $33.57 in 1959. This is the lowest average price per ounce since 1933, a period of 26 years.

The average number of employees was 293: 196 underground, and 97 on surface. W. S. Maguire was general superintendent.

Teck-Hughes Gold Mines Limited

Teck-Hughes Gold Mines Limited was incorporated in March 1923 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 4,807,144 shares have been issued. The officers and directors were: N. B. Keevil, chairman of the board; J. C. Perry, president; R. M. Butler, secretary; J. W. Stephenson, treasurer; W. H. Keith, R. E. Metz, D. A. Perigoe, and W. A. Robinson, directors. The head office address is Woodstock. The executive office is at 11 Adelaide Street West, Toronto. The mine address is Kirkland Lake.

The main property is in Teck township, Kirkland Lake area, District of Timiskaming.

Operations continued throughout 1959.

SHAFTS, TECK-HUGHES MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
South shaft	16625	Vertical	4	3,690
South shaft extension (below 30th level)	.....	Vertical	4	5,546
10th level winze (below 10th level) (inactive)	.....	Vertical	3	2,020
No. 2 winze (below 30th level) (inactive)	.....	60°	3	4,900
No. 3 winze (below 40th level)	.....	60°	3	6,182
No. 4 winze (below 30th level)	.....	Vertical	3	4,538
Central shaft	16626	Vertical	4	3,014
Central shaft extension (below 25th level) (inactive)	.....	Vertical	3	3,625
No. 1 shaft (inactive)	L.1238	Vertical	2	490
No. 1 winze (below 5th level) (inactive)	.....	Vertical	2	1,150

There was no shaft-sinking in 1959. Hoisting operations have been discontinued in the south shaft extension between 32nd and 36th levels. A double-drum air hoist was installed on the 36th level to service the levels to the bottom, or 45th level.

GOLD—Continued

During the year 517 feet of drifting, 358 feet of crosscutting, and 1,492 feet of raising was completed. Total-development footages to the end of the year were as follows: drifting, 140,114 feet; crosscutting, 54,129 feet; raising, 85,421 feet. Some 90 diamond-drill holes from underground, totalling 2,959 feet, were completed during 1959.

The following is taken from the manager's report for the year ending December 31, 1959:

During the year 184,170 tons of ore from the mine were milled. Recovery of bullion amounted to 25,149.069 ounces of gold and 3,290.98 ounces of silver. The value of bullion production was $1,070,109.43 or $5.81 per ton, which includes estimated cost-aid of $223,236.31. Income from general investments amounted to $43,109.31, making a total revenue of $1,113,218.74 or $6.04 per ton. Operating costs amounted to $1,074,628.17 or $5.83 per ton, leaving a profit of $38,590.57 or $0.21 per ton.

Income from dividends on shares of Lamaque Gold Mines Limited amounted to $486,280.00. Net profit for the fiscal year was $524,870.57.

Operating Costs

Operating costs increased by 35 cents per ton, owing principally to the lower tonnage, the higher average wage in 1959, and the extra expenditures on recovery operations. A comparison follows:

Distribution	In Full		Per Ton of Ore Treated		Per Ounce of Gold Produced	
	1959	1958	1959	1958	1959	1958
Development	$ 120,053.06	$ 139,280.19	$0.65	$0.71	$ 4.773	$ 5.341
Mining	609,402.95	604,494.28	3.31	3.06	24.232	23.179
Milling	265,740.48	269,388.29	1.44	1.36	10.567	10.330
General expense	79,055.86	69,960.99	0.43	0.35	3.143	2.683
Depreciation	375.82	536.88	.....	0.00	0.015	0.021
Total	$1,074,628.17	$1,083,660.63	$5.83	$5.48	$42.730	$41.554

Ore Reserves

Ore reserves at December 31, 1959, compared with those of the previous year, are as follows:

Source	Quantities of Ore		Gold Content		Average Grade	
	1959	1958	1959	1958	1959	1958
	tons	tons	ounces	ounces	dwt. per ton	dwt. per ton
Positive Ore:						
Blocked	65,425	65,147	24,557	25,178	7.51	7.73
Broken	43,802	41,440	8,638	8,533	3.94	4.12
Total	109,227	106,587	33,195	33,711	6.08	6.33
Potential Ore:						
Blocked	7,778	6,090	3,610	2,888	9.28	9.49
Broken	10,830	16,190	4,116	5,055	7.60	6.24
Total	18,608	22,280	7,726	7,943	8.30	7.13
Totals for all sources	127,835	128,867	40,921	41,654	6.40	6.46

Company policy has been to apply the term "potential" to proven ore which may not be recovered due to the expense or hazard involved. When any potential ore becomes accessible and is judged mineable, it is transferred to positive ore.

GOLD—Continued

Mining

The sources of ore milled during the years 1959 and 1958 are shown in the following table:

Source	Total		Gold Content		Average Grade	
	1959	1958	1959	1958	1959	1958
	tons	tons	ounces	ounces	dwt. per ton	dwt. per ton
Levels 0–10	.....	14,064	.....	1,140	.....	1.62
Levels 10–20	55,707	35,330	9,969	6,185	3.58	3.50
Levels 20–30	94,572	115,462	10,826	13,267	2.29	2.30
Levels 30–40	33,891	31,672	5,820	6,969	3.43	4.40
Levels 40–41	.....	1,227	.....	97	.....	1.58
Total	184,170	197,755	26,615	27,658	2.89	2.80

Of the above production in 1959, 1.8 percent of the ore and 3.8 percent of the gold came from branch veins in the hanging wall. Corresponding figures for 1958 were 2.5 and 6.1 respectively.

Operating results for the past five years are shown in the following table:

Year	Average Milled	Average Grade	Value of Bullion Production	Investment Income	Operating Costs	Profit
	tons per day	dwt. per ton	per ton	per ton	per ton	per ton
1955	616	3.22	$5.89	$0.35	$5.45	$0.79
1956	537	3.45	6.32	0.35	5.93	0.74
1957	498	2.97	5.79	0.43	6.00	0.22
1958	542	2.80	5.60	0.37	5.48	0.49
1959	505	2.89	5.83	0.23	5.83	0.23

Total costs were about the same as in 1958 but, owing to lower tonnage treated, unit costs increased from $5.48 to $5.83 per ton. A large proportion of the underground expense was incurred in recovery operations between levels 33 and 37 following the severe rockburst of November 1958. This laborious and time-consuming work is nearing completion, and the pillar-area adjoining the abandoned section of the south shaft-extension is being currently explored and developed for active mining. This area contains nearly half of the unbroken, blocked, ore reserves.

Elsewhere, conventional stoping was confined to a few pillars and remnants between levels 23 and 33 and to a small narrow vein above level 17. Most of the production came from slough and long-hole blasts between levels 17 and 25 and from level 33-west.

General

Buildings and plant were kept in good repair.

The new tailings-dam of rock-filled timber cribbing was raised an additional six feet; this should provide storage for another two years.

An area over the first-level stopes near the east end of the property was judged unsafe, and was fenced off with permanent wire-link fencing.

All of the 1959 bullion production was sold to the mint at Ottawa at average prices of $33.55 for the gold content and 87.56 cents for the silver content. Corresponding prices in 1958 were $33.94 and 86.25 cents respectively. The lower gold price represents a reduction in earnings of $9,810.

The average number of employees was 185: 117 underground, and 68 on surface. G. G. Gilchrist was manager.

Thorncliffe Mines Limited

Thorncliffe Mines Limited was incorporated in September 1958 with an authorized capitalization of 2,000,000 shares of $1 par value, of which 1,500,000 shares have been issued. The officers and directors were: H. L. Pountney, president; C. E. Logan, vice-president; R. W. Davies, secretary; F. W. Burback, treasurer; and E. R. Schack, director. The head office is at 320 Bay Street, Toronto. The mine address is P.O. Box 11, Schumacher.

GOLD—Continued

The property consists of 24 claims in Garrison township, District of Cochrane, and was formerly called Buffonta Mines Limited. Further details on Buffonta are given in the annual report for 1949, Volume LVIII, part 4, pages 20–22.

Operations progressed from October 1, to December 22, 1959.

During this period a vertical, three-compartment shaft was sunk on claim L.21753(P) to a depth of 111 feet, with the first level having been established at 100-foot depth. New construction included the following: a headframe 60 feet high; a shaft-house, 40 by 40 feet; and a combined hoistroom, 20 by 30 feet, and compressor-room, 16 by 30 feet. All buildings were enclosed with sheet metal.

New equipment consisted of the following: a General Electric diesel locomotive (200-kva.), a double-drum hoist with a 100-horsepower electric motor; and a compressor (50-cfm.).

C. W. Miller was general manager during the period of operation; 35 men were employed.

Upper Canada Mines Limited

Upper Canada Mines Limited was incorporated in April 1929 with an authorized capitalization of 3,500,000 shares of $1 par value, of which 3,314,827 shares have been issued. The officers and directors were: J. A. W. Brown, chairman of the board; T. J. Day, president; J. W. McBean, vice-president; K. H. Larkin, secretary-treasurer; Jenkin Evans and J. A. Dickson, directors; J. H. Botsford, director and general manager. The head office is at 250 University Avenue, Toronto. The mine address is Dobie.

The company's property, consisting of 47 claims, is in Gauthier township, Kirkland Lake area, District of Timiskaming.

Mining and milling continued throughout 1959.

SHAFTS, UPPER CANADA MINE

	Claim No.	Inclination	Number of Compartments	Depth from Surface
				feet
No. 1 shaft	L.6314	Vertical	3 to 1,750-foot level 4 to bottom	4,540
No. 2 shaft	L.6321	Vertical	3	1,877

During the year 5,274 feet of drifting, 2,484 feet of crosscutting, and 791 feet of raising, were completed. Total-development footages to December 31, 1959, were as follows: drifting, 122,837 feet; crosscutting, 29,786 feet; raising, 29,641.

Some 546 diamond-drill holes, totalling 50,015 feet, were drilled from underground.

The following is taken from the general manager's report for the year ending December 31, 1959:

Exploration and Development

For the first year, development results, on the six new levels below the 3,625-foot horizon, were excellent. Over 2,000 feet of the drifting was in ore that graded much higher than average for the L zone. Slashing of drift-walls and development of parallel orebodies will add considerable tonnage of lower grade material. Results on the bottom, or 4,525-foot level, which was driven ahead of the other levels in order to gain advance information on depth conditions, indicate a lengthening of the productive zone with no loss in grade.

The eastern L zone, discovered on the 3,625-foot level last year, was opened for a length of 600 feet in good structural conditions; here a length of 305 feet of ore, grading $8.53 per ton, was developed. This zone has not yet been reached by the drifts on the lower levels.

GOLD—Continued

Three short sections of ore were developed on the main L zone above the 3,625-foot level; drifting at No. 2 shaft on the 1,625-foot C sublevel has disclosed two short ore lengths.

Owing to the strength of ore on the 4,525-foot level, the decision was taken to utilize the full capacity of the sinking-plant and thereby continue the shaft another two levels.

Mine Production

Source	Ore		Bullion
	Quantity	Grade	Value (Gold at $35 per Ounce)
	tons	per ton	
No. 1 SHAFT			
B zone	32,146	$ 8.28	$ 266,236.00
L zone	112,216	11.64	1,306,193.00
Total for No. 1 shaft	144,362	$10.89	$1,572,429.00
No. 2 SHAFT			
C zone	12,481	$ 7.58	$ 94,657.00
B zone	22,006	6.65	146,437.00
L zone	21,924	9.68	212,219.00
Total for No. 2 shaft	56,411	$ 8.04	$ 453,313.00
Total for the mine	200,773	$10.09	$2,025,742.00

The improvement in the grade of developed ore was reflected in the mill heads for the year; at $10.09, these were sixty-two cents higher than in the previous year.

although close interlevel exploration continues to reveal small orebodies in the No. 2 shaft-area, at the present rate of mining, the main orebodies above the 1,750-foot level will be exhausted by the end of this year. The downward extension of these orebodies will be handled from No. 1 shaft, as will any ore remaining in the C or K zones. Concentration of mining operations at the No. 1 shaft should result in some increase in mine efficiency.

Total tons hoisted, 200,773, is the highest in the mine's history.

Bullion production, amounting to 52,264.218 ounces of gold and 29,663.43 ounces of silver, is also at a new high.

Milling

Daily average milled was 550.1 tons. Recovery was 91.58 percent, and total tailings-loss $0.85.

The program of mill-research continued during the year. Tests were made concerning the milling characteristics of the lower-level orebodies; studies continued on the problem of erratic extraction from ore currently milled. Results were somewhat inconclusive, and although some additions to the mill circuit may be necessary, no major change in the process was anticipated.

Operating Costs and Profits

Cost per ounce of gold produced before depreciation, taxes, etc., was $33.82. Operating costs, per ton milled, for the past four years are tabulated below.

Distribution	Per Ton Milled			
	1959	1958	1957	1956
Mine exploration and development	$1.53	$1.24	$1.48	$1.38
Mining	5.02	4.85	4.75	3.92
Milling	1.26	1.27	1.30	1.21
General and head office	0.99	0.94	0.93	0.90
Total	$8.80	$8.30	$8.46	$7.41

Higher charges for development and hoisting were mainly responsible for the increase in the cost per ton. The larger amount of broken ore contributed to the rise in mining costs.

The price received per ounce of gold declined from $33.941 in 1958 to $33.536 in 1959. This was the lowest average price received in any one year. The effect of this drop was to decrease revenue by $21,137.68. Had the price received for gold been $35 per ounce, the revenue would have been higher by $76,485.49 or 38 cents per ton.

GOLD—Continued

General

With the transfer of operations from No. 2 shaft to No. 1 shaft-area, and the development of substantial tonnage on the lower levels, it has become necessary to greatly increase the capacity of the No. 1 hoisting plants. A 10-foot-diameter hoist, easily capable of handling all tonnage from the 3,625-foot level, has been purchased along with a 125-foot steel headframe. Construction work, now progressing on the new hoistroom and headframe, is scheduled for completion late in 1960. Also planned is an underground hoisting plant that will be able to carry operations to a depth of 6,000 feet below surface.

Capital account totalled $122,694.61, of which $108,150.00 represented the cost of the new hoist.

The contract with the United Steel Workers of America was extended for three years, with wage increases of 4 cents, 2½ cents, and 3 cents.

Some gold and base metal properties were investigated by company geologists, but none warranted further expenditure.

The average number of employees was 279: 187 underground, and 92 on surface. J. H. Botsford was general manager.

Wright-Hargreaves Mines Limited

Wright-Hargreaves Mines Limited was incorporated in June 1916 with an authorized capitalization of 5,500,000 shares of $1 par value, all of which have been issued. The officers and directors were: R. C. Stanley, Jr., president; J. G Boeckh, executive vice-president and treasurer; M. W. Hotchkin, vice-president in charge of operations; Mary C. Maddigan, secretary; J. C. L. Allen, S. J. Bird, and N. O. Seagram, directors. The head office is at 199 Bay Street, Toronto. The mine address is Kirkland Lake.

The company's main property, consisting of four claims, is in Teck township, Kirkland Lake area, District of Timiskaming.

Mining operations continued throughout 1959.

SHAFTS, WRIGHT-HARGREAVES MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (ventilation)	L.1829	Vertical	2 to 2,000 feet 3 to bottom	2,285
No. 2 shaft (sand pass)	L.1830	Vertical	2	319
No. 3 shaft	L.1829	Vertical	3 to 1,200 feet 4 to bottom	4,089
No. 4 shaft	L.1829	Vertical	3	4,000
No. 5 winze (below 3,600-foot level)	.....	Vertical	4 to 6,450 feet 3 to bottom	7,272
No. 6 winze (below 7,200-foot level)	.....	Vertical	2	8,358

During the year a total of 3,828 feet of drifting, 1,599 feet of crosscutting, and 2,297 feet of raising was completed. Total-development footages to December 31, 1959 were as follows: drifting, 254,045 feet; crosscutting, 90,892 feet; and raising, 76,617 feet. Some 59 diamond-drill holes, totalling 14,780 feet, were drilled from underground.

The following is taken from the general manager's report for the period ending December 31, 1959:

Production

During the year, 170,220 tons of ore averaging 0.421 ounce of gold per ton were milled, from which were recovered 69,000.996 ounces of gold and 17,338 ounces of silver. Included in these totals are 710.272 ounces of gold and 168 ounces of silver recovered from 1,970 tons of ore mined in Kirkland Townsite property under lease to Wright-Hargreaves.

GOLD—Continued

The gross value of production was $2,329,133 and the total of operating revenue, after including $318,158 estimated Emergency Gold Mining Assistance but less marketing expense, was $2,627,985 or $15.44 per ton milled.

The premium on Canadian funds continued at a high rate in 1959 and, since the Mint price for gold is set at U.S. $35 per ounce, the average price received by the company for gold was $33.535 (Canadian) which was the lowest average annual price received in any year since 1933. This disparity in exchange rates resulted in a revenue loss of $101,086 or 59.5 cents per ton milled, and it is important to note that the Mint price for gold is not a factor in calculating emergency gold-mining assistance.

Mining

Stopes were worked on 36 of the 51 main levels down to the 7,200-foot level, and mining commenced on all six of the new levels below the 7,200-foot level.

As in the last few years, a considerable part of the ore produced from above the 7,200-foot level was mined in small remnants and tail-ends of ore-shoots left in various portions of the mine over the years.

Of the total ore milled, 24,780 tons or 14.5 percent of the total was obtained from development and mining on the six new levels opened from No. 6 winze, and the substantially higher gold content of this ore accounts for the improvement in average grade of ore milled in 1959 to 0.421 ounce per ton from 0.393 in 1958.

The broken-ore reserve was reduced by 12,088 tons to a total of 63,521 tons at the end of the year.

Origin of ore hoisted in 1959 is shown in the following tabulation:

Source	From Stopes	From Development
	tons	tons
Surface to 3,900-foot level (one hoisting stage)	89,958	3,733
4,050-foot level to 7,200-foot level (two hoisting stages)	49,945	1,804
7,350-foot level to 8,100-foot level (three hoisting stages)	14,260	10,520
Total	154,163	16,057

Milling

Ore produced by Wright-Hargreaves continued to be treated in the Lake Shore mill under the joint milling agreement.

Average daily milling rate was 466.4 tons compared to 491.9 tons in 1958, and recovery was 96.4 percent of contained gold compared to 96.3 percent.

Disposal of mill equipment continued at a slow rate because of slack demand. To the end of 1959, $54,495.36 had been realized from sales of such equipment.

Development

Again in 1959 the major effort was directed to exploration and development on the six new levels opened from No. 6 winze below the 7,200-foot level. Of the 3,173 feet of drifting done on these levels, 953 feet, or 30 percent of the total, was in ore that averaged 0.674 ounce of gold across drift width. Development of the known favourable structures below the 7,200-foot level was virtually completed, and further work to be done is largely exploratory in nature. It is interesting to note that from December 1957, when development work on these levels commenced, to the end of 1959, 3,494 feet of ore averaging 0.615 ounce of gold across drift width has been opened by drifting.

Development on upper levels of the mine resulted in exposing 232 feet of new ore averaging 0.498 ounce of gold across drift width.

Towards the end of the year, negotiations with Sylvanite Gold Mines Limited resulted in agreement to undertake a joint exploration project of importance to both companies. This project involves the exploration and development of a block of ground lying below the 5,550-foot level down to the 8,100-foot level and comprising all Sylvanite claims and Wright-Hargreaves claims generally east of Nos. 5 and 6 winzes. A small portion of this ground has been explored incompletely and inconclusively by only a few widely-spaced drill holes all of which intersected vein-structures having a low content of gold. Initial work under the agreement was started in January 1960.

Ore Reserves

After the milling of 168,250 tons of ore in the year (not including Kirkland Townsite Lease), the developed and available unbroken- and broken-ore reserves were reduced by 18,118 tons to a total, on January 1, 1960, of 296,471 tons containing 0.411 ounces of gold per ton.

The total reserve at the end of the year, including probable ore and ore that is at present unavailable for mining, stood at 363,121 tons averaging 0.405 ounce per ton. The reduction in grade from a year ago is due to a revaluation of grade of ore remaining in upper parts of the mine

GOLD—Continued

Kirkland Townsite Lease

There was no development or diamond-drilling in the Kirkland Townsite property in 1959.

The mining of a relatively small ore shoot in a subsidiary structure of the Wright-Hargreaves south vein-system was completed late in the year. This work produced 1,970 tons of ore from which 610.27 ounces of gold, and 168 ounces of silver were recovered.

Operating Costs

Total operating expense in 1959, not including provisions for depreciation and deferred development, was $2,342,732; this amount is equivalent to $13.76 per ton of ore milled and $33.95 per ounce of gold recovered, compared with $12.98 per ton milled and $34.32 per ounce of gold recovered in 1958.

The only capital expenditure of note in 1959 was for the purchase and installation of two 100-horsepower gas-fired boilers to replace the old coal-fired boilers for plant heating. Cost of the new equipment, including installation and necessary changes to existing steam and water lines, was $28,171.42; this expenditure will be recovered in about two years through savings in labour and fuel costs.

General

The average total working force was 423 compared to 447 in 1958. Due to lessened activity in other branches of the mining industry there was less difficulty in retaining experienced workers, and labour turnover, mostly involving unskilled workers, was only slightly higher than in 1958.

The warehousing department was consolidated with that of the Lake Shore mine; this has resulted in a reduction of $78,427 in the value of operating supplies carried in stock, as well as a saving in warehouse operating expense. The accounting department was also consolidated with that of Lake Shore, thereby effecting a further reduction in expense.

The average number of employees was 423: 297 underground and 126 on surface. Frank Buckle was general manager.

GYPSUM

Canadian Gypsum Company Limited

Canadian Gypsum Company Limited was incorporated in September 1907. The authorized capitalization is 3,000 shares of $100 par value, of which 2,710 shares have been issued. The officers and directors were: O. M. Knode, president; F. L. Stellner, secretary-treasurer and director; G. A. Long, J. E. MacLeish, Edward Rembert, H. F. Sadler, and C. H. Shaver directors. The head office is at Windsor, Nova Scotia. The executive office is at 790 Bay Street, Toronto. The mine address is Hagersville.

The company operates a gypsum mine and plant in lots 14 and 15, concession XIV, Oneida township, Haldimand county.

The mine is operated through the three-compartment, No. 1 vertical shaft, 102 feet deep, in lot 15. There is a vertical two-compartment ventilation and escapement shaft, 90 feet deep, known as No. 2, in lot 14. In 1959, No. 3 vertical two-compartment, ventilation and escapement shaft was completed at a depth of 85 feet below the collar. The room-and-pillar method of mining is used.

The mine and mill operated throughout 1959.

A new mill building of steel and transite construction, and having a floor area of 9,100 square feet, was built. New mill equipment included 1 calciner (Canadian Allis-Chalmers, 9 by 140 feet, 37-tph. capacity); 1 Raymond grinding mill (Combustion Engineering, 18-tph. capacity); 1 tube mill (Hardinge, 9- to 10-tph. capacity). Forty 2-ton mine cars (Wabi Iron Works) were added to the underground equipment.

A total of 297,031 tons of ore was hoisted; 248,043 tons were milled. The mill averaged 827 tons daily.

The average number of men employed, excluding the mill, was 86: 69 underground, and 17 on surface. C. F. Gloeckner was works manager.

GYPSUM—Continued

Gypsum, Lime and Alabastine Limited

Gypsum, Lime and Alabastine, Canada Limited was incorporated in July 1927 with an authorized capitalization of 500,000 shares of no par value. In May 1956, the capitalization was increased to 1,000,000 shares. In February 1959, the name was changed to Gypsum, Lime and Alabastine Limited with an authorized capitalization of 100 shares of $10 par value, all shares being issued. The directors and officers were: W. N. Hall, chairman of the board; P. N. Gross, president; D. S. Thomas, vice-president and treasurer; S. A. Kerr, secretary and assistant treasurer. The head office is at 2240 Sun Life Building, Montreal, Que. The executive office is at 50 Maitland Street, Toronto. The mine address is Caledonia.

The company has two gypsum properties and a mill in Seneca township, Haldimand county. The old mine, in lot 10, range 1 west, has been abandoned. Operations at the new mine in lot 8, range 2 west, continued throughout 1959. The room-and-pillar method of mining is used.

The underground crushing and screening addition, which was commenced in 1958, was completed and put into operation. This installation included the following equipment: 1 jaw-crusher (Pennsylvania Crusher Company, type KU, size 95); 1 Symons 4-foot standard cone-crusher (Nordberg Manufacturing); 1 Universal Wobbler feeder (Federal Equipment); 1 channel frame, 58 feet long (Federal Equipment); 1 underground Limberroller conveyor, 944 feet long, 24 inches wide, capacity 200 tons per hour (Joy Manufacturing); 1 conveyor belt, 4-ply, 1,986 feet long, 24 inches wide (Dominion Rubber).

Some 17 diamond-drill holes, totalling 2,217 feet, were completed from surface.

During the year a total of 163,973 tons of ore was hoisted, and 143,720 tons were milled. The mill treated a daily average of 452 tons.

The average number of employees, excluding the mill, was 29; 26 underground, and 3 on surface. G. H. Hunt was mine superintendent.

IRON

Algoma Ore Properties Limited

Algoma Ore Properties Limited was incorporated in February 1936 with an authorized capitalization of 50,000 shares of no par value, of which 42,751 shares have been issued. The directors and officers were: D. S. Holbrook, president; J. B. Barber, vice-president and comptroller; G. C. Bateman, H. S. Hamilton, Douglas Joyce, G. W. MacLeod, and Gordon McMillan, directors; H. G. MacAdam, secretary; C. E. McLurg, treasurer. The head office is at 503 Queen Street East, Sault Ste. Marie. The mine address is Wawa.

The company, a wholly-owned subsidiary of Algoma Steel Corporation Limited, holds various iron properties in the District of Algoma, including the Helen, Victoria, and Alexander mines, the Sir James mine located three miles east of the Helen, and the Goudreau Pyrite property.

IRON—Continued

HELEN MINE
(Helen, Victoria, and Alexander orebodies)

Operations continued throughout 1959.

SHAFTS, HELEN MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (inactive)	R.737	Vertical	3	428
No. 2 shaft (inactive)	R.737	60°	3	375
No. 2 shaft (inactive)	R.737	Vertical	3	682
No. 3 shaft	D.J.22	Vertical	3	921
No. 4 winze (below 2nd level)	.....	Vertical	2	1,778
No. 5 shaft	D.J.31	Vertical	3	2,066

There is also a 20-degree inclined tramway, collared on claim D.J.31, 4,877 feet in length. A ropeway drift, 254 feet long, was established from the end of the tramway, at a vertical depth of 1,560 feet from surface.

During the year, 8,909 feet of drifting, 2,186 feet of crosscutting, and 6,154 feet of raising was completed. Total-development footages to December 31, 1959, were as follows: drifting, 126,362 feet; crosscutting, 23,306 feet; and raising, 48,750 feet.

A total of 127 diamond-drill holes was completed in 1959: 17 from surface totalling 4,009 feet, and 110 from underground totalling 21,301 feet.

New construction included the following: 1 hospital standby generator house, 6 by 8 feet; 1 warehouse building, 60 by 70 feet; 5 residences, 21 by 40 feet; a sleep camp, 24 by 80 feet; 1 ropeway drive station; 1 scale foundation,14 by 60 feet; 1 scale house, 6 by 8 feet.

New equipment was installed, at the Helen mine: 1 bus (G.M.C., 29-passenger), 2 gasoline-driven welding machines (Onan, 300-amp.), 1 fire truck (G.M.C., 3-ton), 3 trucks (G.M.C., ½-ton), 1 Alimak raise platform, and an aerial ropeway (Breco); at the ore preparation plant: 1 dry-type sprinkler system (Grinnell Co.); 2 electronic beltmeters (Transweight Co., 300-tph); at the sinter plant: 1 rail-car and truck-weigh bridge (Fairbanks-Morse, 200-ton); and at the Lady Dunn hospital: 1 gasoline-driven standby generator (Onan, 5,000-watt).

A total of 1,672,523 tons of ore was hoisted; 1,427,168 tons was concentrated producing 1,177,910 tons of concentrate, which was treated in the sinter plant; 240,151 tons was sintered without concentration. A total of 960,950 tons of sinter was produced.

SIR JAMES MINE

The Sir James mine commenced production of ore in 1958. It is expected that about 10,000,000 tons of ore will be mined by the open-pit method. A spur railway line from the Helen mine was built to provide service to the operation and to carry ore to the treatment plant. A conveyor tunnel, 610 feet long, was driven at an angle of 14 degrees to house the conveyor carrying ore from the crusher to the railway loading-point. The crusher room was cut at a point 124 feet vertically below surface.

Four diamond-drill holes totalling 699 feet, were completed from surface during 1959.

New construction included a 32- by 40-foot, steel with metal siding, extension to the dry house, and a frame-constructed, 12- by 12-foot, pump-house.

IRON—Continued

New equipment consisted of the following: 1 mobile drop-ball crane (Lorain); 1 tractor (Michigan 280); 1 Euclid truck (Blackwood-Hodge, 40-ton); 1 sprinkler system (Grinnell Co.); 1 gasoline-driven fire pump (S.A.C. centrifugal, 500-gpm.); 1 diesel road grader (Caterpillar Co.).

A total of 1,236,695 tons of ore was hoisted and conveyed; 118,291 tons was stockpiled; 791,210 ton was concentrated, producing 673,832 ton of concentrate that was treated in the sinter plant; 436,596 tons was sintered without concentration. A total of 774,473 tons of sinter was produced.

Totals of 3,222,997 tons of back waste and 165,857 tons of face waste were removed during 1959.

GOUDREAU PYRITE PROPERTY

Algoma Ore Properties Limited awarded a contract for the mining of pyrite ore from the Rand No. 1, and Bear groups of claims. The property consists of 10 claims, located in Township 27, range 26, in the Sault Ste. Marie mining division. Plant and equipment used in the operation is owned and provided by the contractor.

The pyrite is used primarily as fuel in the sintering process.

Some 87 diamond-drill holes, totalling 4,571 feet, were completed from surface.

A total of 171,646 tons of pyrite was mined; 147,445 tons was sintered without concentration producing 103,063 tons of sinter. Total waste removed was 194,219 tons

General

The average number of employees was 858: 425 underground and 433 on surface. The sintering plant at Wawa employed 182 men. C. M. Beck was general manager, and R. F. Palmer was mine manager, for Algoma Ore Properties Limited operations. The contractor employed an additional 17 men at the Goudreau operation.

Anaconda Iron Ore (Ontario) Limited

Anaconda Iron Ore (Ontario) Limited was incorporated in November 1957 with an authorized capitalization of 5,000,000 shares of $3 par value, of which 3,000,000 shares have been issued. The directors and officers were: J. B. Knaebel, president and managing director; J. S. Vanderploeg, M. Lewis, and J. J. Gourd, vice-presidents; W. T. Swensen, assistant vice-president; P. E. Riverin, J. Monette, R. S. Newlin, and C. J. Parkinson, directors; A. R. McGinn, secretary-treasurer. The head office and mine address is 198 North Cumberland Street, Port Arthur.

The property consists of 504 claims, in the Kowkash Mining Division, about 40 miles north of Nakina. Surface exploration, geophysical work, and diamond-drilling have indicated large tonnages of low-grade, open-pit, concentrating ore.

During 1959 a road was completed from Cavell to the property, and to the Nakina-Geraldton road. Construction of a permanent camp and a pilot mill commenced late in the year. Equipment was purchased for road-building, for bulk-sampling on a large scale, and for the assembling of a 100-ton pilot mill.

The average number of employees on surface was 60. J. B. Knaebel, president and managing director was in charge at the property.

IRON—Continued

Caland Ore Company Limited

Caland Ore Company Limited was incorporated in November, 1957, with an authorized capitalization of 100,000 shares of $50 par value of which 1,020 shares have been issued. It is a wholly-owned subsidiary of Inland Steel Company, of Chicago. The directors and officers were: P. D. Block Jr., chairman; C. B. Jacobs, president; R. D. Satterley, vice-president and general manager; H. M. Graff, vice-president; P. P. Ribotto, manager; Graydon Megan, secretary; J. L. Block, L. B. Hunter, J. F. Smith Jr., H. W. Johnson, and R. L. Peters, directors; W. B. Cummings, treasurer; W. H. Lowe, assistant treasurer; J. C. Carter, assistant secretary. The head office is at 30 West Monroe Street, Chicago, Ill. The mine address is Atikokan.

The property consists of 66 claims, including 31 held on a 99-year lease from Steep Rock Iron Mines Limited. The lease covers a section of the C orebody at the east end of Steep Rock Lake.

Dredging operations continued on the C orebody in the Steep Rock range near Atikokan.

The Falls Point mine is serviced by the vertical, eight-compartment shaft, 1,333 feet deep, located on claim F.F.3513.

Development during 1959 consisted of 2,275 feet of crosscutting and 508 feet of raising. Total-development footages to December 31, 1959, were 3,725 feet of crosscutting and 533 feet of raising on the 800-, 1,000- and 1,200-foot levels. Three diamond-drill holes, totalling 1,275 feet, were drilled from underground in 1959.

The screening and loading plant, and the Falls Point mine headframe and service building, all commenced in 1958, were completed during 1959. A truck-maintenance garage, 62 by 190 feet, 28 feet high, with galvanized-steel insulated siding and roof, was completed.

New equipment was installed or added in four locations. To the Falls Point surface plant was added: 2 four-rope friction skip-hoists (120-inch diameter, 82.5-ton maximum loading, with 1,350-hp. dc. motor and 1,400-hp. M.G. set, A.S.E.A. Sweden); 1 four-rope friction cage-hoist (110-inch diameter, 67.5-ton maximum loading, 600-hp. dc. motor and 650-hp. M.G. set, A.S.E.A.); 2 bottom-dump skips (180-cu. ft., Dorr-Oliver-Long); 1 double-deck cage (25,000-pound capacity, Manitoba Bridge); 2 reciprocating air compressors (R-19, 4,000-cfm., with 800-hp. motors, Belliss and Norcum); 2 forced-draft, low-pressure, oil-fired boilers (250-hp., Darling). To the equipment at the Falls Point mine, underground, was added: 1 mucking machine (Eimco 21B), and 1 mucking machine (Eimco, 630). At the Lime Point open-pit mine, the new equipment was: 1 electric shovel (6-cu. yd., P&H, 1,600); 2 electric shovels (6-cu. yd., Bucyrus-Erie, 150B); 1 diesel shovel (3-cu. yd., Bucyrus-Erie, 71B); 1 rotary drill (Bucyrus-Erie, 40B): 7 trucks (40-ton, Euclid); 2 bulldozers (Caterpillar D8); 2 bulldozers (Caterpillar D7); 1 scoopmobile (2-yd. bucket); 1 service truck (International Harvester); 1 water wagon (22-ton, Euclid); 1 compressor (600-cfm., LeRoi); 1 dumptor (Koehring, No. 60). To the open-pit conveyor system was added the following: 1 jaw-crusher (Traylor, 42- by 48-inch); 1 pan-feeder (Stephens-Adamson 22- by 5-foot); 1 vibrating screen (Tyler, 6- by 10-foot, F-900); 3 vibrating screens (Tyler, 6- by 14-foot, F-900).

A total of 10,800 tons of development waste was hoisted.

The average number of employees was 80: 36 underground, and 44 on surface. The two contractors, for the dredging and for the shaft-sinking operation, together employed about 244 men. R. D. Satterley was general manager, and P. P. Ribotto was manager.

IRON—Continued

Canadian Charleson Limited

Canadian Charleson Limited, incorporated in 1955, is a wholly-owned subsidiary of Charleson Mining Company of Hibbing, Minn. The directors and officers were: Frank Skubic, president; A. T. Steele, treasurer; Edward Skubic, J. J. Dwyer, B. L. Knudsen, and C. H. Remer, directors; Anasa Wheeler, secretary. The head office is at Room 2400, 25 King Street West, Toronto. The executive office is at 2127 Sixth Avenue, Hibbing, Minn. The mine address is Box 1510, Atikokan.

The company holds a lease on about 1,000 acres in Freeborn township, Steeprock Lake area, District of Rainy River. The property, which includes the Mathieu and Pattison groups of claims, lies between Atikokan and the Steep Rock iron mines.

Operations in the open-pit continued throughout 1959. The concentrator operated from May 1 to November 5.

Four diamond-drill holes, totalling 342 feet were completed from surface in 1959. A welding shop (Armco Prefab, 20 by 24 feet) was constructed.

A total of 1,587,167 tons of ore was transported from which 251,913 tons was discarded. The concentrator treated 1,335,254 tons, averaging 7,050 tons daily, and produced a washed, sized, and screened gravel as a byproduct.

The average number of employees was 66. G. H. McLeod was general superintendent.

Lowphos Ore Limited

Lowphos Ore Limited, incorporated in July 1941, is a subsidiary of National Steel Corporation and operates under the direction of the Hanna Iron Ore Division of that corporation. The directors and officers were: G. W. Humphrey, president; W. A. Marting, and R. W. Whitney, vice-presidents; S. L. Engel, secretary; R. E. Beal, treasurer; F. W. Bennett, assistant secretary; F. E. Teske, assistant treasurer. The head office is at 1300 Leader Building, Cleveland 14, Ohio. The mine address is Capreol.

Lowphos Ore Limited has a lease on the Moose Mountain iron property, containing 5,421 acres, about 35 miles north of Sudbury, in Hutton township, District of Sudbury.

The open pit operated from March 2, to December 31, and the concentrator from April 2, to December 31, 1959.

Some 19 diamond-drill holes, totalling 5,607 feet, were drilled from surface.

A total of 829,249 tons was mined in the open pit, from which 821,973 tons was milled. Some 272,416 cubic yards of material was removed by stripping.

The average number of employees was 143: 81 in the open pit, and 62 on surface. S. A. Mahon was superintendent.

Marmoraton Mining Company Limited

Marmoraton Mining Company Limited is a wholly-owned subsidiary of Bethlehem Steel Corporation. It was incorporated in the State of Delaware in November 1950. The authorized capitalization is 205,000 shares of $100 each, of which 200,500 have been issued. The directors and officers were: A. F. Peterson, president; B. D. Brooker, secretary; F. R. Brugler, comptroller; N. Berkeley and R. E. McMath, vice-presidents; E. W. Morris, treasurer; H. O. Olsen, vice-president and general superintendent; P. B. Entrekin, W. H. Johnstone, P. S. Killian, and E. P. Leach, vice-presidents. The head office and mine offices are at Marmora. The executive office is at Wilmington, Del.

IRON—Continued

The company owns an iron property in Marmora and Rawdon townships, Hastings county, a short distance east of Marmora.

The company was affected by the general steel strike in the U.S.A. and, during 1959, lost a total of 116 days' production.

A total of 854,319 tons of ore was mined, from which 243,854 tons was discarded. The mill treated 610,465 tons, averaging 2,760 tons daily, and produced 352,825 tons of pelletized iron. A total of 1,261,678 tons of waste was removed.

The average number of employees was 304: 70 in the open-pit, and 234 on surface. H. O. Olsen, vice-president and general superintendent, was in charge of operations at the property.

Multi-Minerals Limited

Multi-Minerals Limited was incorporated in December, 1953, with an authorized capitalization of 6,000,000 shares of $1 par value of which 3,400,014 shares have been issued. The directors were: E. F. Carr, president; B. N. Apple, secretary; M. Osborne, treasurer; F. Cannon, R. Glass, E. S. Guilford and W. C. Ringsleben, directors. The head office is at 25 Adelaide Street West, Toronto. The mine address is Nemegos.

The property, acquired from Nemegos Uranium Corporation, consists of 57 claims in Lackner and McNaught townships, District of Sudbury.

Work at the property in 1959 consisted of drilling ten diamond-drill holes on the magnetite-apatite showing, totalling 9,776 feet from surface.

E. F. Carr, president, was in charge of operations.

North American Rare Metals Limited

North American Rare Metals Limited was incorporated in June 1955 with an authorized capitalization of 4,000,000 share of $1 par value, of which 2,310,007 shares have been issued. The directors and officers were: W. D. McCoy Sr., president; G. E. Buchanan, treasurer; W. A. Carter, general manager; Rt. Hon. Lord Lovat, L. F. Simon, R. J. Murphy, and L. J. Buck, directors; J. T. Symons, secretary. The head office is at 100 Adelaide Street West, Toronto. The mine address is Cummings Lake, via River Valley.

The property, consisting of 86 claims, is located in Scholes township, west of Timagami, in the District of Nipissing.

A vertical, three-compartment shaft was sunk to a depth of 621 feet, on claim T.37963 in 1959. One diamond-drill hole, 1,210 feet in length, was completed from underground.

New construction included the following: a hoistroom, 28 by 33 feet; a powerhouse, 28 by 50 feet; a machine-shop, 20 by 20 feet; a dryhouse, 20 by 48 feet; an office and warehouse, 20 by 40 feet; a cookery, 22 by 54 feet; a detonator storehouse, 6 by 12 feet; a powder magazine, 16 by 20 feet.

The following equipment was installed: 1 mine hoist (Canadian Ingersoll-Rand, 60- by 36-inch, 14,000-pound rope-pull, 920-fpm., with 200-hp., 60-cycle, 550-volt, 3-phase motor); 3 diesel generators (G.M.C., 250-kva. 3-phase, 60-cycle); 1 diesel generator (G.E., 550-volt); 2 air compressors (C.I.R., 670-cfm.).

Operations were suspended in October, and a watchman was placed on the property.

A. C. A. Howe was resident engineer in charge during the sinking operations. The shaft contractor employed an average of 10 men.

IRON—Continued

Steep Rock Iron Mines Limited

Steep Rock Iron Mines Limited was incorporated in February 1939. Early in 1955 the authorized capitalization of 30,000 shares of preferred stock of $100 par value and 10,000,000 shares of common stock of $1 par value was changed to 10,000 shares of preferred stock of $100 par value and 10,666,666 shares of common stock of $1 par value. The 20,000 previously-issued shares of preferred stock were converted into 666,666 shares of common. The number of shares issued at December 31, 1959, was: common, 8,045,110; preferred, none. The officers and directors were: C. S. Eaton, chairman of the board; M. S. Fotheringham, president and general manager; Neil Edmonstone, vice-president and secretary-treasurer; W. R. Daley, J. G. Cross, Hon. G. E. Allen, Mark McKee, John Paterson, F. H. Black, D. D. Hogarth, and C. J. Burchell, directors. The head office and mine office are at Steep Rock Lake.

The company holds about 7,000 acres in Freeborn and Schwenger townships, Steep Rock Lake area, District of Rainy River.

Operations continued throughout 1959. The amount of ore mined during the year is shown in the following table

	Tons
A orebody (open pit)	2,417,013
B orebody (underground)	379,583
Total	2,796,596

A total of 2,746,849 tons of ore was shipped.

A (HOGARTH) OREBODY

Open-pit mining continued throughout 1959, during which 2,417,013 tons of ore was mined.

Some 50 diamond-drill holes, totalling 17,127 feet, were drilled from surface.

A storage shed, 56 by 40 feet, was constructed.

Preparations for underground mining were continued.

SHAFTS, A (HOGARTH) OREBODY

	Claim No.	Inclination	Number of Compartments	Depth from Surface
				feet
No. A-1 (inactive)	F.F.3183	Vertical	3	845
No. A-2	F.F.3660	Vertical	4	1,480

There was no shaft-sinking in 1959.

Development consisted of 968 feet of drifting and 190 feet of raising. Total-development footages to December 31, 1959, were 1,336 feet of drifting and 592 feet of raising.

New equipment installed included the following: 1 skip dump pocket at 75-foot level (Dorr-Oliver-Long, 110 tons); 1 waste conveyor (Stephens-Adamson, 42-inch, 500-tph.) 75-foot level to surface; 4 Plurovane pumps, (Mather and Platt, 5-stage, 1,000-gpm., with Westinghouse motors) at the 900-foot level.

IRON—Continued

B (ERRINGTON) OREBODY

Underground mining on the B (Errington) orebody continued throughout 1959.

SHAFTS, B (ERRINGTON) OREBODY

	Claim No.	Inclination	Number of Compartments	Depth from Surface
				feet
No. B1 Errington (Float Ore Island) shaft	G.629	Vertical	3	1,263
Mosher Point (Drainage Tunnel) shaft	F.F.3664	Vertical	2	283

There was no shaft-sinking in 1959.

Development consisted of 2,535 feet of drifting. Total-development footages to December 31, 1959, were as follows: drifting, 27,663 feet; crosscutting, 12,893 feet; raising 6,908 feet.

Seven diamond-drill holes, totalling 1,665 feet, were drilled from underground.

Total ore hoisted was 379,583 tons.

G OREBODY

The G orebody lies between the A and B orebodies. Dredging was resumed in 1959 with open-pit mining scheduled to commence in 1961.

C OREBODY

Caland Ore Company Limited, a Canadian subsidiary of Inland Steel Company, of Chicago, holds a 99-year lease on a section at the east end of Steeprock Lake, in C zone. Further details appear in this report under Caland Ore Company Limited.

The following is taken from the president's report for the year ending December 31, 1959:

Shipments of high-grade iron ore in 1959 totalled 2,746,849 tons. Operating profits equalled $12,102,000 before interest and write-offs. Net profits, after all charges, totalled $9,049,000, equivalent to $1.13 per share.

Open-pit production totalled 2,389,796 tons; 357,053 tons came from underground.

Both of the new beneficiating plants operated during 1959. The high-quality iron concentrates produced by these plants were readily accepted by customers. Changes were made in other loading plants to permit classification of direct-shipping ores by size to meet various and special requirements of customers.

Expansion Program

Dredging operations on the G ore-zone were resumed. Although dredging will not be completed until 1962, open-pit mining is scheduled to commence on the G ore-zone in 1961.

Work on the Hogarth undergrond mine included the completion of a number of plant installations and the construction of underground stations, in preparation for crosscutting to the orebody for lateral development.

Expenditures on the expansion program totalled $2,907,000 in 1959, in comparison with $8,200,000 in 1958. Some $2,723,000 was budgeted for continuation of the program in 1960.

Caland Ore Company, Inland Steel Company's wholly-owned Canadian subsidiary, will begin production in 1960 on the C ore-zone, which it leases on a royalty basis. As Caland shipments increase progressively from an expected total of 750,000 tons this year to a minimum ultimate annual output of 3,000,000 tons, the substantial revenues from royalties will rise correspondingly.

Exploration

One of the properties acquired, after careful examination, is expected to become a major attraction to consumer interests in the immediate future. This property appears capable of an annual production of 3,000,000 tons of pellets, from which an important royalty income should be realized without the necessity of making any large capital expenditures. Several other promising prospects are under examination.

IRON—Continued

Product and Market Development

The product-research staff continued to work closely with industrial consumers of Steep Rock iron ores during the year, and to apply the valuable first-hand information thus obtained to the production of ores specially suited to meet the requirements of the individual customer. In addition, basic research continued on methods to increase recovery of high-grade products from lean material associated with direct-shipping ores.

The average number of employees was 852: 456 underground, and 396 on surface. M. S. Fotheringham, president and general manager, was in charge of operations.

MAGNESIUM

Dominion Magnesium Limited

Dominion Magnesium Limited was incorporated in February 1941 with an authorized capitalization of 500,000 shares of no par value, of which 476,270 shares have been issued. The directors and officers were: R. J. Jowsey, president; C. C. Calvin, vice-president; John Thomson, general manager; J. G. Weir, L. M. Pidgeon, F. E. Jowsey, G. T. N. Woodrooffe, and J. M. Mortimer, directors; H. B. Clearihue, secretary-treasurer; M. Crabtree, assistant secretary. The head office is at 320 Bay Street, Toronto. The mine address is Haley.

Dominion Magnesium Limited holds exclusive patent-rights to the Pidgeon magnesium-production process. Operations continued throughout 1959 at the company's quarry and plant about 3 miles from Haley, in concessions V and VI, Ross township, Renfrew county.

The melt-plant addition, commenced in 1958, was completed and additions were made to plant equipment.

The following is taken from the president and general manager's report for the year ending December 31, 1959:

Magnesium production-rate was maintained at half capacity with five furnaces until October, when a sixth furnace was placed in operation. World demand for magnesium and its alloys increased during the year but, owing to large producer-inventories, prices remained depressed. By the end of the year the stockpile of magnesium was disposed, and a slight increase in price was established. The seventh furnace was prepared for operation early in 1960. Shipments of magnesium for the year amounted to 6,300 tons, compared with 3,300 tons in 1958.

The demand for calcium and zirconium was down from the previous year, but production and sale of thorium increased.

The main research effort has continued on a program to improve reduction-furnace design and operating technique. Limited research was continued on titanium, thorium, and special alloys.

A total of 53,203 tons of dolomite was mined in the open pit which, after treatment, produced 8,321,529 pounds of magnesium metal crowns.

The average number of employees was 318: 308 in the plant and 10 in the open pit. D. J. McPhail was plant manager.

NEPHELINE SYENITE

American Nepheline Limited

American Nepheline Limited was incorporated in January 1945 with an authorized capitalization of 4,500,000 shares of 50 cents par value, of which 4,100,000 shares have been issued. The directors and officers were: A. L. A. Richardson, president; Ernest Craig, vice-president and managing director;

NEPHELINE SYENITE—Continued

H. R. Deeth, vice-president and sales manager; Thayer Lindsley, C. J. Koenig, C. R. Archibald, F. D. Hart, W. H. Woods, and M. F. Goudge, directors; D. D. Anderson, secretary-treasurer. The head office is 25 King Street West, Toronto. The mine address is Nephton, via Lakefield.

The property, consisting of approximately 2,200 acres, is located in concession IX, Methuen township, Peterborough county.

Operations continued throughout 1959 in the open pit on the Cabin Ridge section of the property. A 1½-yard power-shovel (Northwest Engineering) was added to the open-pit equipment.

A total of 185,664 tons of ore was mined, of which 978 tons was discarded. The mill treated 182,735 tons, averaging 746 tons daily.

The average number of employees was 133: 102 in the plant, and 31 in the pit. E. B. Wright was resident manager.

International Minerals and Chemical Corporation (Canada) Limited (Canadian Flint and Spar Department)

Canadian Flint and Spar Company Limited was incorporated in March 1930. In December 1955 the name was changed to International Minerals and Chemical Corporation (Canada) Limited. The company is wholly owned by International Minerals and Chemical Corporation, Chicago, Ill. The directors and officers were: T. M. Ware, president; A. R. Cahill, vice-president and treasurer; N. J. Dunbeck, L. W. Gopp, G. B. Hamilton, D. J. Stark, and J. D. Zigler, vice-presidents; N. C. White, director; C. M. Edwards, secretary; R. E. Swanson, controller; B. R. Carlson, assistant controller; C. E. Gable, and J. W. York, assistant secretaries. W. H. Wood is general manager. The head office is at 77 Metcalfe Street, Ottawa. The mine address is Box 158, Havelock.

The company owns six claims, about 400 acres, in Methuen township, Peterborough county. The present operation is in lots 19, 20, and 21, concession VI, at the northeast end of Blue Mountain. The property is known as the Blue Mountain nepheline syenite mine.

Mining and milling continued throughout 1959.

New equipment installed was as follows: 1 air separator (Gayco, 14-ft.); 2 cyclones (72-in.); 2 Hummer screens; 2 crushing rolls (Exolon, 14-by 24-in.); 1 separator (Dings).

The open-pit operation produced 117,716 tons of ore. The mill treated 83,509 tons, an average of 300 tons daily.

The average number of employees was 43: 37 in the plant, and 6 in the pit. L. F. McDonnell was plant superintendent.

NICKEL AND COPPER

Falconbridge Nickel Mines Limited

Falconbridge Nickel Mines Limited was incorporated in August 1928 with an authorized capitalization of 5,000,000 shares of no par value, of which 3,756,472 shares have been issued. The directors and officers were: H. J. Fraser, president; R. Campbell, vice-president and secretary; C. F. H. Carson, O. D. Cowan, W. F. James, Thayer Lindsley, J. D. Barrington, James Stewart, and R. B. West, directors: R. C. Mott, vice-president-production; G. S. Jewett, vice-president.

NICKEL AND COPPER—Continued

sales; A. W. Coome, treasurer; J. L. Matthews, assistant secretary. The head office is at 44 King Street West, Toronto. The mine address for the properties in the Sudbury area is Falconbridge.

The company has nickel-copper mines and concentrating and smelting operations in the Sudbury area, and operates a refinery at Kristiansand, Norway.

The average number of employees, excluding employees of contractors, employed in mining operations was 2,800. R. M. Oliver was manager; J. H. Fraser was general superintendent at the Falconbridge, East, and McKim mines; G. A. Allen was general superintendent at the Hardy, Longvack, Boundary, Onaping, and Fecunis mines.

The company financed the development of Norduna Mines Limited. Further information is given in this report under Norduna Mines Limited.

SHAFTS, FALCONBRIDGE NICKEL COMPANY'S MINES

	Inclination	Number of Compartments	Sinking in 1959	Total Depth from Surface
			feet	feet
FALCONBRIDGE				
No. 1 shaft	Vertical	3	.....	2,848
No. 5 shaft	Vertical	6	.....	4,347
No. 7 shaft	Vertical	3	.....	1,692
No. 9 shaft (winze, below 4,025-foot level)	Vertical	6	419	6,564
EAST MINE				
East shaft	Vertical	3	.....	3,942
MCKIM				
No. 1 shaft	Vertical	3	.....	1,421
No. 2 winze, (below 1,000-foot level)	Vertical	3	308	2,420
MOUNT NICKEL (inactive)				
Mount Nickel shaft	Vertical	3	.....	327
HARDY				
Hardy shaft	Vertical	3	.....	1,427
No. 1125 winze, (below 1,000-foot level)	36½°	.....	.....	1,163
BOUNDARY				
Boundary shaft (internal, below Hardy 1,000-foot level)	Vertical	3	.....	1,951
ONAPING				
No. 1 shaft	Vertical	5	.....	3,148
FECUNIS LAKE				
No. 1 shaft	Vertical	6	.....	4,183
No. 2 shaft	Vertical	4	.....	3,243
LONGVACK				
Longvack shaft	17½°	2	.....	854

FALCONBRIDGE MINE

No. 9 shaft (winze, below 4,025-foot level) was deepened 419 feet to a total depth of 6,564 feet below the collar; new levels were established at 6,050-, 6,125-, 6,200-, and 6,325-feet.

During the year, 2,693 feet of drifting, 1,414 feet of crosscutting, and 1,697 feet of raising were completed. Total-development footages to December 31, 1959, were as follows: drifting, 178,889 feet; crosscutting, 36,327 feet; raising, 97,682 feet. A total of 176 diamond-drill holes, totalling 17,352 feet, was completed in 1959 from underground; an additional 27 surface holes, totalling 73,375 feet, were outside exploratory holes drilled on Sudbury Basin properties.

NICKEL AND COPPER—Continued

New construction included: a building, 44 by 46 feet, 32 feet high, for the tailings sand-fill plant; a tank, 33 feet in diameter and 36 feet high, for settled storage; and a building, 30 by 60 feet, 12 feet high, for the storage of geological equipment.

New equipment installed at No. 9 shaft was as follows: 1 loading pocket (9-ton, Dorr-Oliver-Long); 2 bottom-dump skips (80-cu. ft., Dorr-Oliver-Long); 2 cages (Dorr-Oliver-Long) for 6- by 13-foot compartments; and 2 cages (double-deck, Dorr-Oliver-Long) for 5- by 6-foot compartments. At the 6,125-foot level, the following new equipment was installed: 2 Pulsometer, TL4, 12-cell centrifugal pumps (Laurie and Lamb); two 300-horsepower motors (Orenda Industrial) for pumps. On the 200-foot level the following new equipment was installed: one 60-inch Vanaxial fan (Sheldon Engineering); one 100-horsepower motor (Tamper Limited) for fan.

A total of 657,531 tons of ore was hoisted.

The average number of employees was 857: 660 underground and 197 on surface. R. R. Holmes was mine superintendent.

EAST MINE

During the year, 490 feet of drifting, 1,301 feet of crosscutting, and 1,182 feet of raising was completed. Total-development footages to December 31, 1959, were as follows: drifting 25,687 feet; crosscutting, 6,307 feet; raising, 11,779 feet. Some 78 diamond-drill holes, totalling 5,776 feet, were drilled from underground during 1959.

An Alimak drilling platform (Mine Equipment) was added to underground equipment.

A total of 263,743 tons of ore was hoisted.

The average number of employees was 147: 135 underground, and 12 on surface. M. J. Chesser was mine superintendent.

McKIM MINE

No. 2 winze (below 1,000-foot level) was sunk 308 feet to a depth of 2,420 feet below surface. Two new levels, at 2,150 and 2,300 feet, were established.

During the year, 265 feet of drifting, 275 feet of crosscutting, and 243 feet of raising was completed. Total-development footages to December 31, 1959, were as follows: drifting, 13,304 feet; crosscutting, 9,448 feet; raising, 9,896 feet. Some 74 diamond-drill holes, totalling 8,904 feet, were completed during 1959 from underground.

A total of 92,901 tons of ore was hoisted; 93,724 tons was shipped.

The average number of employees was 117; 97 underground, and 20 on surface. J. A. MacMillan was mine superintendent.

HARDY MINE

During the year, 1,063 feet of drifting, 183 feet of crosscutting, and 146 feet of raising was completed. Total-development footages to December 31, 1959, were as follows: drifting, 14,203 feet; crosscutting, 17,816 feet; raising, 12,912 feet. Diamond-drilling during 1959 consisted of 24 holes from underground totalling 2,240 feet, and 2 holes from surface totalling 711 feet.

New construction included a cement plant for stope-floor building, 10 by 10 feet, 10 feet high.

An Alimak drilling platform (Mine Equipment) was added to underground equipment.

NICKEL AND COPPER—Continued

A total of 407,623 tons of ore was hoisted; 407,373 tons was milled.

The average number of employees at the mine and concentrator was 352: 137 underground, and 215 on surface. J. Bardswich was mine superintendent.

BOUNDARY MINE

During the year, 148 feet of drifting and 64 feet of crosscutting was completed Total-development footages to December 31, 1959, were as follows: drifting, 7,177 feet; crosscutting, 1,739 feet; raising, 560 feet. Two diamond-drill holes, totalling 165 feet, were completed from underground.

A total of 4,824 tons of development-waste was hoisted.

The average number of employees was 8: 7 underground, and 1 on surface. J. Bardswich was mine superintendent.

ONAPING MINE

During the year, 2,499 feet of drifting, 1,548 feet of crosscutting, and 572 feet of raising was completed. Total-development footages to December 31, 1959, was as follows: drifting, 3,846 feet; crosscutting, 7,725 feet; raising, 572 feet. Some 66 diamond-drill holes from underground, totalling 16,750 feet, were completed during 1959.

A waste-rock bin, 14 by 16 feet, 32 feet high, was constructed.

A total of 10,422 tons of ore was hoisted; 9,464 tons was milled.

The average number of employees was 50: 30 underground, and 20 on surface; J. Bardswich was mine superintendent.

LONGVACK MINE

During the year, 447 feet of drifting, 207 feet of crosscutting, and 293 feet of raising were completed. Total-development footages to December 31, 1959 were as follows: drifting, 4,340 feet; crosscutting, 1,136 feet; raising, 2,903 feet. Some 15 diamond-drill holes, totalling 1,055 feet, were drilled from underground during 1959.

A total of 329,000 tons of ore was hoisted from which 1,114 tons was discarded; 266,166 tons was delivered for milling.

The operation of the mine was contracted to Temiskaming Inspiration who employed an average of 87 men; 63 underground and 24 on surface. G. M. Proudfoot, development supervisor, was in charge for Falconbridge, and the company supplied 4 men.

FECUNIS LAKE MINE

During the year, 802 feet of drifting, 4 feet of crosscutting, and 59 feet of raising, was completed. Total-development footages to December 31, 1959, were as follows: drifting, 16,130 feet; crosscutting, 13,395 feet; raising, 11,943 feet. Some 27 diamond-drill holes from underground, totalling 5,988 feet, were drilled during 1959.

New underground equipment was as follows: twenty 110-cubic foot Granby-type mine-cars (Wabi Iron); 10 Hudson supply-cars (Patricia Engineering); six 3-drum slusher hoists (Canadian Ingersoll-Rand); five 2-drum slusher hoists (Canadian Ingersoll-Rand).

A total of 552,955 tons of ore was hoisted; 547,415 tons was delivered for milling. The International Nickel Company of Canada Limited mines the Fecunis ore, and delivers it underground to the Fecunis shaft for hoisting and subsequent treatment.

The average number of employees at the Fecunis mine and concentrator was 115: 29 underground, and 86 on surface. G. M. Proudfoot was development supervisor.

NICKEL AND COPPER—Continued

CONCENTRATORS

Falconbridge Rockhouse

During the year a total of 930,570 tons of ore was milled producing 109,082 tons of concentrate. The concentrator averaged 2,550 tons daily.

H. T. Berry was superintendent of plants.

Hardy Concentrator

During the year a total of 374,102 tons of ore was milled, and 69,794 tons of concentrate was produced. The concentrator averaged 1,440 tons daily.

K. C. Mott was mill superintendent

Fecunis Concentrator

During the year a total of 700,702 tons of ore was milled, and 105,465 tons of concentrate was produced. The concentrator averaged 2,249 tons daily.

J. K. Weglo was mill superintendent.

SMELTER

Falconbridge Smelter

New construction included: an addition to the sinter plant, 32 by 45 feet, 45 feet high, and a building to house the sinter fan, 22 by 22 feet, 16 feet high.

New equipment installed included: 1 sinter fan (40,000 cfm., Canadian Sirocco), and 2 pelletizing discs (Haines Engineering), in the sinter plant; 1 briquette press (20½-inch diameter, Komareck-Greaves), in the briquetting plant and one 60-ton hot-metal weigh-scale (Canadian Fairbanks-Morse) in the convertor aisle.

The smelter treated concentrates from the Falconbridge, Hardy, and Fecunis concentrators, producing 62,617 tons of nickel matte.

The average number of employees was 1,120.

H. T. Berry was plants superintendent.

The following is taken from the company's annual report for the year ending December 31, 1959

Metal Deliveries

Deliveries of the principal metals, nickel and copper, were substantially higher in 1959 than during any previous year. Nickel deliveries totalling 58,413,000 pounds were 9,904,000 pounds above the record deliveries in 1958, and copper deliveries totalling 32,728,000 pounds were 1,832,000 pounds above the previous record in 1958.

Cobalt deliveries totalling 732,000 pounds were about 24,000 pounds below 1958 deliveries and about 45,000 pounds below the record deliveries in 1957. New records were set for shipments of the platinum-group metals and sulphur dioxide.

The quoted market price for nickel, which was established in December 1956, did not change during 1959. The market price for cobalt dropped 12½ percent, or 25 cents a pound, on February 1, 1959, and no further change took place during the year. Copper prices sagged in the middle of the year but these prices rose later in the year as a result of long and widespread strikes. Platinum and palladium prices moved up strongly during the year.

Mines

	1959	1958
Ore delivered from company mines.....tons	2,232,937	2,087,180
Development advances.....feet	19,221	27,904
Diamond-drilling.....feet	129,747	133,985

The tonnage of ore delivered to treatment plants from the company's mines in 1959 was about 7 percent higher than in 1958. In addition, ore receipts from the Norduna mine increased from 64,303 tons in 1958 to 141,112 tons in 1959.

NICKEL AND COPPER—Continued

The increase in ore deliveries from the company's mines reflects the coming into production of the Fecunis mine in the latter half of the year. For the first time the year's production from the northern-area mines, Hardy, Longvack, and Fecunis, exceeded that of southern-area mines, Falconbridge, East, and McKim. The Company's mines are now capable of producing sufficient ore to meet the normal requirements of the treatment plants.

Development was on a lower scale in 1959 than in 1958. The program for development in the Falconbridge mine between the 4,000- and 6,000-foot levels, which has been in progress since 1956, was marked by completion of the sinking and equipping of the internal shaft that will serve 12 new levels in this section of the mine. Lateral development from this shaft had already begun by the end of the year. In the East mine, lateral development was carried out below the 2,800-foot level and, at the end of the year five of the seven proposed crosscuts had been completed from the shaft to the ore-zone. At McKim, an internal shaft was deepened to make available a small orebody located near the boundary of the property. Innovations at the Hardy mine included the successful introduction to North America of a machine designed for driving raises, and the development of a method of mixing cement and prepared-fill for the flooring of cut-and-fill stopes. Development at Onaping mine disclosed narrowing of the orebody which reduced the indicated tonnages of ore. However, development in the Longvack mine indicated additional ore.

Treatment Plants

COMPARATIVE TREATMENT DATA

	1959	1958
	tons	tons
Ores delivered to treatment plants	2,374,049	2,151,483
Ores milled to produce concentrates	2,005,374	1,721,360
Ores and concentrates smelted	658,432	661,101

The tonnage of ore treated in 1959 exceeded the previous record of 1958 by more than 10 percent.

Continuing implementation of the metallurgical program of up-grading the smelter-feed by removing more waste in the concentrating process, improved the feed to the smelter; tonnages of concentrates were increased, and tonnages of ore were reduced. The total tonnage smelted in the year was slightly less than in 1958, although the production of nickel in matte increased more than 17 percent. Since concentrates require agglomeration before being fed to the smelter, the increased production of concentrates placed a strain on the agglomeration facilities. The problem was met in part by installation of ancilliary equipment in the sinter plant.

Ore Reserves

Although 2,313,752 tons of ore were extracted from the company's mines during the year, reserves of developed and indicated ore increased approximately 2,300,000 tons. This brings the total to over 46,000,000 tons, estimated to contain approximately the same proportion of nickel as last year and a slightly higher proportion of copper. Total reserves at the end of the year were the highest reported in the company's history.

Diamond-drilling on a large scale at the Strathcona property during the past eighteen months yielded excellent information, and a major orebody has been indicated; consequently a substantial tonnage was added to the indicated ore reserves of the company. A decision was made at the end of the year to begin underground exploration in order to develop and outline this important orebody.

Summary of Ore Reserves at Year's End

	Quantity	Nickel	Copper
	tons	percent	percent
DEVELOPED ORE			
Falconbridge, East, Hardy, McKim, Longvack, Onaping, and Fecunis	22,200,050	1.56	0.87
INDICATED ORE			
Sudbury district only	23,982,400	1.34	0.77
Total	46,182,450	1.45	0.82

Research

Research, and process-improvement activites, at Falconbridge continue to be directed chiefly toward further improvements in milling, concentrating, and smelting, with the object of maintaining over-all recovery of metals at reduced cost per pound of metal. Other activities of continuing

NICKEL AND COPPER—Continued

importance were related to operation of the pyrrhotite pilot plant, shipping and handling of concentrate, evaluation of ores sampled by exploratory methods, dust collection, and general process-control factors.

At the Richvale laboratory, metallurgical studies progressed toward the development of a process for treatment of lateritic nickel ores. Research on, and development of, spectrographic and chemical analytical methods, particularly instrumental methods, continued to be a major activity at Richvale. Mineralogical and crystallographic studies were intensified in the examination of samples related to geological and metallurgical problems.

Fatima Mining Company Limited

Fatima Mining Company Limited was incorporated in May 1956 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 3,000,005 shares have been issued. The directors and officers were: E. F. Carr, president; H. L. Garvie, vice-president; B. N. Apple, secretary; H. J. Lisack, and E. S. Guilford, directors; M. Osborne, treasurer. The head office is at 25 Adelaide Street West, Toronto. The mine address is Box 285, Timmins.

The property consists of 26 claims in Geikie and Bartlett townships, District of Timiskaming.

Operations commenced on June 1 under contract and were continuing at the end of the year.

A vertical, three-compartment shaft was sunk 790 feet below the collar on claim P.36102. The 1st, 2nd, 3rd, 4th, and 5th levels were established at 150-, 300-, 450-, 600-, and 742-foot depths respectively. A total of 108 feet of cross-cutting had been completed on the 3rd and 5th levels by the end of the year.

New construction included a hoist building, 20 by 20 feet; a compressor and diesel-electric garage, 40 by 12 feet; a machine shop, 20 by 30 feet; a dryhouse, 20 by 30 feet; a cookery, 20 by 35 feet; a bunkhouse, 20 by 40 feet; and an office, 8, by 12 feet, all fir-ply construction.

The contractor employed an average of 13 men. J. M. Kilpatrick was resident engineer for Fatima Mining Company Limited.

International Nickel Company of Canada Limited

International Nickel Company of Canada Limited was incorporated in 1916 under Dominion of Canada charter. Early in 1957 all issued preferred shares of stock were redeemed for cash, and all authorized but unissued preferred shares were cancelled. The authorized capitalization is now 15,000,000 common shares of no par value, of which 14,584,025 have been issued.

The officers, as of March 2, 1959, were: J. F. Thompson, chairman of the board; H. S. Wingate, president; J. R. Gordon, executive vice-president; R. D. Parker, vice-president in charge of Canadian operations; L. H. Cooper, vice-president; W. F. Kennedy, secretary; F. M. A. Noblet, treasurer; W. A. McCadden, comptroller.

The executive office is at 67 Wall Street, New York 5, N.Y., U.S.A., and the general offices are at Copper Cliff. The Toronto office is at 55 Yonge Street.

R. H. Waddington is assistant to the vice-president and general manager, Ontario Division; Frederic Benard is assistant to the vice-president and assistant general manager, Ontario Division; H. J. Mutz is assistant to the general manager, Ontario Division; T. M. Gaetz is manager of mines and assistant to the general manager; R. R. Saddington is manager of reduction plants; J. M. Lilley is superintendent of smelters.

NICKEL AND COPPER—Continued

The company and its subsidiary companies operate the following, in Ontario: hydro-electric plants at High Falls, Big Eddy, Wabageshik, and Nairn Falls; nickel-copper mines in the Sudbury district; a smelter, refinery, and iron ore recovery plant at Copper Cliff; and a refinery at Port Colborne. Operations outside the province include: refineries at Acton, England, and Clydach, Wales; rolling mills at Birmingham, England, at Huntington, West Virginia, U.S.A., and at Glasgow, Scotland; and a foundry at Bayonne, New Jersey, U.S.A. The development of a new nickel-mining project at Thompson, Manitoba, was in progress.

The company employed, excluding employees of contractors, an average of 17,767 persons at mining, milling, smelting, and refining operations in Ontario.

SHAFTS, INTERNATIONAL NICKEL COMPANY'S MINES, SUDBURY AREA

	Inclination	Number of Compartments	Sinking in 1959	Total Depth from Surface
			feet	feet
CREAN HILL				
No. 1 shaft	57° to 305 ft. 71° to bottom	3	.....	797
No. 2 shaft	Vertical	5	.....	2,115
CREIGHTON				
No. 2.0 shaft [1]	65°	2	.....	314
No. 3 shaft	55°	5	.....	1,946
No. 4 shaft (internal, collar 1,448 feet below collar of No. 3 shaft)[1]	50°	5	.....	2,702
No. 5 shaft	Vertical	6	.....	4,074
No. 6 shaft (internal, collar 3,821 feet below collar of No. 5 shaft)	Vertical	5	.....	5,562
No. 7 shaft	Vertical	3	.....	2,056
No. 65 winze (collar 3,819 feet below collar of No. 5 shaft)[2]	65°	3	.....	4,320
No. 8 shaft (internal, collar 5,017 feet below collar of No. 5 shaft)	Vertical	3	698	6,351
FROOD-STOBIE				
No. 1 shaft [3]	77° to 1,300 ft. 61° to bottom	2	.....	3,097
No. 3 shaft	Vertical	6	.....	3,040
No. 4 shaft[4]	Vertical	3	.....	3,928
No. 6 shaft (internal, collar 2,872 feet below collar of No. 3 shaft	Vertical	3	.....	3,391
No. 7 shaft	Vertical	5	.....	3,105
No. 8 shaft	Vertical	3	535	2,491
GARSON				
No. 1 shaft[5]	Vertical	3	.....	1,457
No. 2 shaft	Vertical	5	.....	4,243
LEVACK				
No. 1 shaft[2]	65°	3	.....	983
No. 2 shaft	Vertical	6 to 2,915 ft. 4 to bottom	.....	3,915
No. 3 shaft (internal, collar 1,594 feet below collar of No. 2 shaft)	Vertical	3	.....	3,716
MURRAY				
No. 1 shaft[6]	36°	3	.....	593
No. 1 winze (below 476-foot level of No. 1 shaft)[6]	36°	2	.....	775
No. 2 shaft	Vertical	5	.....	3,298

[1]Abandoned for hoisting purposes.
[2]Abandoned for hoisting purposes; used as a fresh-air intake.
[3]Abandoned and filled above the 600-foot level; the lower part continues to serve as a fresh-air intake.
[4]Abandoned above the 600-foot level; now serves as an inside shaft for lower levels of the Frood-Stobie mine.
[5]Abandoned for hoisting purposes; used as an escapeway.
[6]Now used as a main return airway.

NICKEL AND COPPER—Continued

CREAN HILL

Operations commenced on August 1 and continued until December 13, 1959.

Development during the period of operation consisted of 3,026 feet of drifting and crosscutting, and 1,236 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting and crosscutting, 37,924 feet; raising, 7,631 feet. Some 106 diamond-drill holes, totalling 31,932 feet, were completed during the year from underground.

Construction was begun on a crushing plant, bins, and conveyor system in the open pit, and a feeder building and conveyor gallery on surface.

Some 11,135 tons of waste was hoisted and used for yard fill.

The contractor employed an average of 41 men. T. M. Gaetz, manager of mines, was in charge for International Nickel, which supplied 6 men.

CREIGHTON MINE

The No. 8 internal shaft, collared at 5,017 feet, was sunk a further 698 feet to a total depth of 6,351 feet below surface; the new No. 72 level was established.

Development during the year consisted of 6,058 feet of drifting and crosscutting and 3,250 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting and crosscutting, 386,903 feet; raising, 194,967 feet. Some 173 diamond-drill holes, totalling 62,940 feet, were completed in 1959 from underground.

New equipment included the following: 1 loader (Pettibone-Mulliken, Model 54); 4 hoists (Pikrose No. 3); 1 diamond-drill (BB5-2U6 Boyles Bros.); 3 pumping units (BB4-7, Boyles Bros.).

A total of 4,234,132 tons of ore was hoisted and shipped for treatment.

The average number of employees was 1,908: 1,503 underground, and 405 on surface. E. E. Mumford was superintendent.

FROOD-STOBIE MINE AND OPEN PIT

The No. 8 shaft was sunk 535 feet to a total depth of 2,491 feet below surface in 1959; the new 2,000-foot level was established.

Development during the year consisted of 9,227 feet of drifting and crosscutting, and 2,783 feet of raising. Total-development footages to December 31, 1959, were: drifting and crosscutting, 475,103 feet; raising, 185,834 feet. Some 144 diamond-drill holes, totalling 39,434 feet, were drilled from underground in 1959.

New equipment added included a Pettibone-Mulliken loader, model 54, and an Alimak raise platform.

A total of 4,850,615 tons of ore was hoisted and shipped for further treatment.

The average number of employees was 2,519: 2,021 underground, and 498 on surface. S. J. Sheehan was superintendent.

A total of 1,518,021 tons of ore was mined in the open pit and trucked to the rockhouse.

The average number of employees was 189: 78 in the open pit, and 111 on surface. C. H. Stewart, assistant to the manager of mines, was in charge.

GARSON MINE

Development during the year consisted of 6,655 feet of drifting and crosscutting, and 4,569 feet of raising. Total-development footages to December 31, 1959, were: drifting and crosscutting, 211,289 feet; raising, 86,849 feet. Some 146 diamond-drill holes, totalling 55,560 feet, were drilled from underground in 1959.

NICKEL AND COPPER—Continued

New equipment included 1 Pettibone-Mulliken loader, model 54; 1 Alimak raise platform; and 3 pumping units (BB4-7, Boyles Bros.).

A total of 1,113,006 tons of ore was hoisted and shipped for further treatment.

The average number of employees was 1,003: 823 underground, and 180 on surface. B. T. King was superintendent.

LEVACK MINE

Development during the year consisted of 11,193 feet of drifting and crosscutting, and 5,333 feet of raising. Total-development footages to December 31, 1959, were: drifting and crosscutting, 231,473 feet; raising, 65,141 feet. Some 234 diamond-drill holes, totalling 77,208 feet, were drilled from underground in 1959.

New equipment included the following: 53 tugger hoists of various types (Canadian Ingersoll-Rand); 1 electric hoist, (HKK, J. Bertram and Sons); 1 motor (CDR ST2, serial N, Fairmount Rly. Motor); 1 motor (battery type, T125-6R6/6, Amalgamated Electric); 1 raise platform (Alimak); 1 diamond-drill (CP65, Canadian Pneumatic); 1 diamond-drill (BBS-2UG, Boyle Bros.); 1 lathe (model 300-EA, D. R. Williams Machinery).

A total of 1,578,822 tons of ore was hoisted; 1,558,608 tons was shipped for further treatment.

The average number of employees was 1,735: 1,395 underground, and 340 on surface. F. M. McAteer was superintendent.

MURRAY MINE

Operations were resumed on February 2, and continued throughout the balance of the year.

Development during this period included 8,297 feet of drifting and crosscutting, and 2,207 feet of raising. Total-development footages to December 31, 1959, were: drifting and crosscutting, 153,656 feet; raising, 33,495 feet. Some 82 diamond-drill holes, totalling 36,144 feet, were drilled from underground in 1959.

New equipment included the following: 1 raise platform (Alimak); 1 diamond-drill (BBS-2UG, Boyles Bros.); 2 pumping units (BBU-7, Boyles Bros.); 1 hoist (KSNM2G, Canadian Ingersoll-Rand).

A total of 2,041,822 tons of ore was hoisted and shipped for further treatment.

The average number of employees was 473: 370 underground, and 103 on surface. H. W. Smith was superintendent

VICTOR MINE

Operations commenced at the property on October 15 and were continuing at the end of the year.

A vertical, three-compartment shaft had reached a depth of 132 feet below the collar at the end of the year.

Some 1,726 tons of waste was hoisted and used for yard fill.

The shaft contractor employed an average of 8 men. T. M. Gaetz, manager of mines, was in charge.

LAWSON QUARRY

The quarry is operated to supply quartzite rock used as a flux in Sudbury smelting operations. The quarry address is Willisville.

A total of 471,771 tons of quartzite was mined and delivered to the rockhouse; 471,111 tons was shipped.

The average number of employees was 41. W. G. Tilston was superintendent.

NICKEL AND COPPER—Continued

CONCENTRATORS

Creighton Mill

The Creighton mill treated 3,837,721 tons of ore, averaging 10,400 tons daily, to produce concentrates that were pumped to the Copper Cliff smelter.

The average number of employees was 104. E. McMullen was superintendent.

Copper Cliff Concentrator

The Copper Cliff concentrator treated 9,178,019 tons of ore, averaging 25,145 tons daily, to produce concentrates.

New equipment included: 1 transformer (175-kva.); 1 magnetic separator; 1 fan (tube-axial, 27-in.); and 5 pumps of various sizes.

The average number of employees at the Copper Cliff plants (concentrator, smelter, and iron-ore plant) was 6,252. J. Lee was superintendent at the concentrator.

Levack Mill

The Levack mill commenced operations on June 1 and continued to the end of the year.

New equipment added included the following: 2 welders, (SAE-400, *Lincoln* Electric); 3 drying ovens (33 by 26, 78 ins. high, Kipp-Kelly); 1 air dryer (Kemp model 50E, Williams and Wilson); 2 pulverizers (Masco-McCool, 9-in., Williams and Wilson); 4 cyclones (Krebs Model D-306, Technequip Co); 1 chlorinator (automatic, 100 lb. per 24 hrs., Wallace and Tiernan).

A total of 900,000 tons of ore was milled at an average of 4,455 tons daily.

The average number of employees was 54. G. H. Morrison was superintendent.

SMELTERS

Coniston Smelter

The Coniston smelter treated 601,436 tons of concentrate, producing 48,885 tons of Bessemer matte.

New equipment installed included the following: 2 motors (250-hp., 3-phase, 1,800-rpm., Worthington); 1 engine (Waukesha, 252-bhp., model 6); 2 fans (64-in., DIW-Type MD); 1 fuel tank (12,000 gals.); 1 chlorinator (automatic, 100 lb. per 24 hrs.)

F. G. Murphy was superintendent.

Copper Cliff Smelter

The production from the smelter was 195,962 tons of nickel matte, 13,909 tons of nickel oxide sinter, and 146,254 tons of converter copper.

New construction consisted of the following: revert-crushing plant addition, 25 by 13 feet, 10 feet high; car-shaker house over 4 existing bins, 20 by 56 feet, 24 feet high; conveyor gallery, 39 by 13 feet, 14 feet high; coal and sand storage bins; thaw-shed and heater-house.

New equipment installed included the following: 1 electric hoist (3-ton); 2 hoists (5½-ton, Hewitt-Robins); 1 hoist (HU, Canadian Ingersoll-Rand); 3 car-shakeouts (heavy duty, Hewitt-Robins); 2 heaters (model S-2000, Calorific Ltd.).

J. N. Lilley, superintendent of smelters, was in charge.

NICKEL AND COPPER—Continued

Iron Ore Recovery Plant

The iron-ore recovery plant produced 170,031 tons of iron ore, averaging 478 tons daily.

New equipment installed included the following: 1 tank (12 by 12 feet, Standard Steel Construction); 1 pellet feeder (Hamment Car and Engineering); 1 Payloader (Hough, HA); 1 electric hoist (1-ton).

E. Bracken was superintendent.

REFINERIES

Copper Cliff Refinery

The Copper Cliff refinery produces copper cathodes and shapes, nickel sulphate, gold, silver, tellurium, selenium, and semi-refined platinum metals.

New equipment included: 1 semi-automatic saw (Wagner) for cutting copper shapes; 1 steam generating unit (capacity 80,000 lb. per hr., 12,000-sq. ft. heating surface, Babcock-Wilcox Goldie and McCulloch); 1 Ferranti transformer, (1,500-kva., Packard Electric).

The average number of employees was 889. W. R. Koth was manager.

Port Colborne Refinery

The Port Colborne refinery produces: nickel cathodes, shot, ingots, and oxides; cobalt cathodes; and elemental sulphur.

Operations commenced in the integrated pilot-plant to permit the study of improved methods for the refining of metals; commenced in 1958. The plant was completed in 1959.

The average number of employees was 2,009. J. W. Freeman was manager.

The following was taken from the company's annual report for the year ending December 31, 1959.

DELIVERIES OF METALS

	1959	1958	1957
	pounds	pounds	pounds
Nickel			
In refinery products	239,560,000	142,880,000	207,610,000
In rolling-mill and foundry products	73,350,000	59,670,000	78,780,000
In salts and chemicals	4,130,000	3,250,000	3,660,000
Total	317,040,000	205,800,000	290,050,000
	pounds	pounds	pounds
Copper	252,450,000	210,570,000	280,810,000
Cobalt	2,400,000	2,170,000	2,400,000
	ounces	ounces	ounces
Platinum metals	384,600	145,400	339,400
Gold	36,300	44,000	43,400
Silver	1,200,000	1,155,000	1,450,000
	long tons	long tons	long tons
Iron ore	162,000	122,000	113,000

NICKEL AND COPPER—Continued

Sudbury Mines

The production rate at the Sudbury mines was low during the opening months of 1959 because operations were just being resumed following the end of the strike in 1958. As soon as possible, however, the maximum production rate was attained and thereafter held for the remainder of the year. The tonnage of ore mined, with comparative data for the two previous years, is shown in the following table:

	Ore Mined		
	1959	1958	1957
	tons	tons	tons
Underground	13,798,000	8,863,000	14,948,000
Open pit	1,518,000	594,000	1,101,000
Total	15,316,000	9,457,000	16,049,000

Total ore mined during the last half of the year was at the rate of 16,500,000 tons per year.

Underground development in the operating mines in 1959 totalled 66,000 feet, reaching a cumulative total of 2,364,000 feet, or about 450 miles.

Ore shipments were resumed in January 1959 from the Murray mine, where operations had been suspended in July 1958. The Crean Hill mine-development and underground-construction program, suspended in February 1958, was resumed in August 1959. Also in 1959, a new and improved method of mining continued to be actively developed for areas in mines where difficult ground conditions are encountered. This method, using hydraulic sand fill, gives promise of more efficient mining and of improved working conditions in such areas.

Ore Reserves

Proven ore reserves stood at 264,864,000 short tons at December 31, 1959. This compares with 264,628,000 short tons at the end of 1958. The nickel-copper content at the end of the year was 7,964,900 short tons, compared with 7,960,300 short tons at December 31, 1958.

The ore reserves given above do not include Manitoba ore. Priority has been given to the underground development necessary to bring the mine into operation; and the further drilling required for the determination of proven ore reserves by the long-established procedures has therefore been deferred.

Plant and Process Improvements

In addition to building the new plants for the processing of the ore from the Thompson mine in Manitoba, the Company is continually improving its plants in Ontario and the United Kingdom. It is also actively continuing process-research to improve the efficiency of all operations, and new or modified processes capable of dealing with different types of ores are under study in several pilot plants.

Following long-term study, the research staff has developed an improved fluid-bed process for roasting nickel sulphide. At the end of the year, construction had begun on a $5,000,000 plant at Copper Cliff, which will utilize the new method and will largely replace existing sintering facilities.

Other developments in the Sudbury District included: completion of the new Levack concentrator, which went into operation June 1; completion of a new 375-foot chimney and a pumping station for the Coniston smelter; and completion of a natural gas distribution system serving some of the Copper Cliff operations.

Nickel Mining and Smelting Corporation

Eastern Mining and Smelting Corporation Limited was incorporated in December 1955. It is an amalgamation of Eastern Smelting and Refining Company Limited, and Quebec Nickel Corporation Limited. The name was changed to Nickel Mining and Smelting Corporation with the authorized capitalization increased to 8,500,000 shares of no par value, of which 4,087,087 shares have been issued. The directors and officers were: A. W. Johnston, president; W. C. Campbell, vice-president; Wm. McKee, secretary-treasurer; T. J. Day, H. B. Hicks, Eliot Janeway, and Robert Lafleur, directors; W. M. O'Shaughnessy, assistant secretary-treasurer. The head office is at 100 Adelaide Street West, Toronto. The mine address is Kenora, c/o Ontario Central Airlines.

NICKEL AND COPPER—Continued

The company owns the nickel-copper property known as the Gordon Lake mine, previously called the Quebec Nickel mine. The property is in the Werner Lake area, District of Kenora (Patricia portion).

Operations at the property were resumed, commencing August 1, and were continuing at the end of the year.

SHAFTS, GORDON LAKE MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft	K.R.L.19096	Vertical	3	360
No. 2 shaft	K.R.L.31831	Vertical	3	1,297

No. 2 shaft, which will be the production shaft, is about 2,500 feet west No. 1 shaft.

In 1959, during the period of operation, 149 feet of drifting and 697 feet of crosscutting had been completed. Total-development footages to December 31, 1959, were as follows: drifting, 9,569 feet; crosscutting, 5,898 feet; raising, 497 feet. Some 22 diamond-drill holes, totalling 6,380 feet, were completed during 1959 from underground.

A total of 60 tons of ore and 4,434 tons of waste was hoisted.

C. D. N. Taylor was manager; the average number of employees was 9.

Norduna Mines Limited

Norduna Mines Limited was incorporated in January 1953 with an authorized capitalization of 3,000,000 shares of no par value, of which 1,043,860 shares have been issued. The company is controlled and financed by Falconbridge Nickel Mines Limited. The directors and officers were: H. J. Fraser, president; J. A. H. Paterson, vice-president; R. C. Mott, Reginald Campbell, and N. C. Urquhart, directors; A. W. Coome, secretary-treasurer; T. R. Caldwell, assistant treasurer. The head office is at Room 1506, 44 King Street West, Toronto. The mine address is Box 353, Falconbridge.

The property, consisting of two claims located in Falconbridge and Kenogaming townships, District of Sudbury, is a short distance east of the Falconbridge plant.

Mining operations continued throughout the year through the No. 1, vertical, three-compartment shaft, sunk to a depth of 725 feet in 1957.

During the year, 659 feet of drifting, and 111 feet of crosscutting was completed. Total-development footages to December 31, 1959, were as follows: drifting, 3,446 feet; crosscutting 1,702 feet; raising 907 feet. Sixty-seven diamond drill holes, totalling 2,992 feet, were completed during 1959 from underground.

A total of 141,162 tons of ore was hoisted and delivered to the Falconbridge mill.

The average number of employees was 55: 34 underground, and 21 on surface. R. C. Staveley was mine superintendent.

NIOBIUM (COLUMBIUM)

Nova Beaucage Mines Limited

Beaucage Mines Limited was incorporated in February 1953 with an authorized capitalization of 3,000,000 shares of $1 par value. In September 1956 the capitalization was increased to 5,000,000 shares; in September 1958 the name was changed to Nova Beaucage Mines Limited, on a 1 for 3 share basis. The authorized capitalization remained at 5,000,000 shares of $1 par value of which 1,045,481 shares have been issued. The directors and officers were: D. D. Thomson, president; Karl Graber, vice-president; R. S. Woodford, manager; Mrs. J. Forbes secretary-treasurer; F. L. Hallam, John Kennedy, John Rook, J. E. Shepherd, and C. M. Tetrault, directors. The head office and mine office address is 170 Regina Street, North Bay.

The company holds a license of occupation on the Manitou Islands and surrounding waters in Lake Nipissing, District of Nipissing.

Three deposits carrying niobium and uranium were discovered on the islands several years ago. On Newman Island there is a vertical, four-compartment shaft, 425 feet deep, with levels at 275 and 400 feet. On the 275-foot level there was 77 feet of drifting; on the 400-foot level there was 1,142 feet of drifting and 1,287 feet of crosscutting. The underground workings were allowed to flood in March 1957.

The 50-ton pilot-flotation mill, located on the mainland, was operated between June 15 and August 8, 1959, making short experimental runs for recovery of niobium from stockpiled ore.

R. S. Woodford was manager.

QUARTZ CRYSTALS

Quartz Crystals Mines Limited

Quartz Crystals Mines Limited was incorporated in July 1951 with an authorized capitalization of 3,000,000 shares of $1 par value, of which 1,678,180 shares have been issued. The directors and officers were: G. W. Bauerschaefer president and general manager; L. J. Davidson, vice-president and treasurer; J. P. Arnott and W. D. Pelley, directors: R. C. Stelk, secretary. The head office is at 366 Bay Street, Toronto. The mine is at Lyndhurst.

The property consists of 50 acres, in Rear of Leeds and Lansdowne townships, Leeds county.

Work proceeded in the open pit from early April to late December. A total of 5,610 tons of rock was removed, and some quartz crystals were recovered.

J. B. Steele was superintendent, and 6 men were employed.

SALT

Canadian Rock Salt Company Limited

Canadian Rock Salt Company Limited was incorporated in September 1952 with an authorized capitalization of 50,000 shares of no par value, of which 3,140 shares have been issued. The directors and officers were: Daniel Peterkin Jr., president; N. C. Hobson, and J. F. Eurtch, vice-presidents; F. B. Common Jr., H. R. Milner, W. D. Mahaffy, and E. G. Smith, directors; F. A. Clarke, secretary-treasurer. The head office is at 30 Prospect Avenue, Windsor. The mine address is Ojibway.

The company's property is in concession 1, Sandwich West township, Essex county, on the shore of the Detroit River.

Operations continued throughout 1959.

SHAFTS, CANADIAN ROCK SALT MINE

	Inclination	Number of Compartments	Sinking in 1959	Total Depth
			feet	feet
No. 1 shaft	Vertical	4	.....	1,082
No. 2 shaft	Vertical	3	395	1,025

No. 2 shaft was sunk a further 395 feet to a depth of 1,025 feet below the collar in 1959. The headframe was covered with asbestos siding.

A 4-rope friction hoist (52-inch drum-diameter, 25,000-pounds rated capacity, 1,000-fpm. hoisting speed, Canadian Ingersoll-Rand) with motor and controls was installed in the headframe. An elevator was installed for service between shaft-collar elevation and the hoist installation.

A bag-handling system and compaction-unit with heaters, elevators, and conveyors, was installed in the mill.

The mining level is at 975 feet. Mining is done by the room-and-pillar method, employing trackless haulage. The salt is crushed underground and, after hoisting, is screened for different products.

Development in 1959 consisted of 5,210 feet of drifting, 5,450 feet of crosscutting, and 16,860 feet of rooms. Total-development footages to December 31, 1959, were as follows: drifting, 25,600 feet; crosscutting, 15,300 feet; rooms, 45,230 feet.

A total of 1,375,716 tons of salt was hoisted and milled. The mill treated a daily average of 4,000 tons.

The average number of employees was 189: 108 underground, and 81 on surface. W. M. Rice was mine manager.

All work connected with No. 2 shaft was contracted. James Tripp was engineer-in-charge, employing an average of 32 men.

Sifto Rock Salt Limited

Astrea Company Limited was incorporated in March 1956 under Dominion charter. In December 1956 the name was changed to Dominion Rock Salt Company Limited, and in July 1959 to Sifto Rock Salt Limited. The company is a wholly-owned subsidiary of Dominion Tar and Chemical Company Limited.

SALT—Continued

The authorized capitalization is 100,000 shares of no par value, of which 25,000 shares have been issued. D. S. Thomas and S. A. Kerr are directors. The head office and mine office is at Goderich.

The 16-foot-diameter shaft, collared in 1957, was completed by contract to a depth of 1,867 feet. The main station was cut at 1,764 feet, ore passes excavated, and the shaft timbered before the end of August. The project was then turned over to the Sifto Company who installed the cables, loading-pockets and combination skip-cages.

While the shaft work was in progress, the various contractors proceeded with the surface work, which mainly involved the completion of the mill and storage buildings, machine shop, stores, change-room, hoist building, office and ship-loading facilities. Yard work, including railway sidings and yard-paving, was also completed during this period. Shipping facilities for boats, trains, and trucks, have been provided.

The principal equipment in use underground at the end of the year consisted of: a single-roll impact crusher (Universal Engineering, 42- by 56-in. opening); an undercutter fitted with one auger-drill (Joy Universal); a front-end loader (Michigan, model 175, capacity 2¼ yards); and a front-end loader (Pettibone Mulliken, capacity 2½ yards).

During the early stages of the underground operation, the primary crusher was set up over the ore-passes. The Joy undercutter was used to undercut and drill the salt before blasting. The explosive used was 40-percent stopeite. Blasted salt was transported from the faces, and fed to the crusher, by front-end loaders.

When sufficient space is provided a Joy drill-jumbo, fitted with four drills and capable of drilling a face 45 feet high and 30 feet wide in one set-up, will be used. Diesel-powered, 25-ton capacity trucks will be used to haul the salt to the crusher. The crusher will be relocated to permit the salt to be dumped directly from the trucks. The crushing, screening, and storage facilities, will be installed underground when space permits.

The mining follows the room-and-pillar method. Rooms are 60 feet wide, and pillars are 210 feet square. Rooms advanced a total length of 1,338 feet during the period of operation. Mining commenced in October, and by the end of the year 90,000 tons of salt had been hoisted.

The average number of employees was 20: 5 underground, and 15 on surface. W. G. Muir was mine manager. The major contractor employed an average of 41 men: 39 underground, and 2 on surface. J. G. S. Hynd was engineer-in-charge.

SILVER AND COBALT

Agnico Mines Limited

Cobalt Consolidated Mining Corporation Limited was incorporated in January, 1953, with an authorized capitalization of 3,500,000 shares of $1 par value. In October 1957 the company was reorganized, and the name was changed to Agnico Mines Limited. The capitalization was increased to 5,000,000 shares of $1 par value, of which 2,125,000 shares have been issued. The directors and officers were: Andrew Robertson, president; Denison Denny, executive vice-president; R. D. Bell, secretary; E. H. Pooler, J. Koza, J. F. Paxton, and S. A.

SILVER AND COBALT—Continued

Perry, directors; Louis Pancer, vice-president; G. E. Buchanan, treasurer; G. D. Pattison, assistant secretary. The head office is at Suite 405, 25 Adelaide Street West, Toronto. The mine address is Box 140, Cobalt.

The company has acquired properties formerly held by Silanco Mining and Refining Company Limited, Cobalt Lode Silver Mines Limited, Penn-Cobalt Silver Mines Limited, Gilgreer Mines Limited, Keylode Cobalt Silver Mines Limited, Hellens Mining and Reduction Company Limited, and others in the Cobalt, South Lorrain, and Gowganda areas, District of Timiskaming. A group of mines in Coleman township, including the Beaver and Temiskaming mines was acquired in 1955, and the O'Brien mine was acquired in 1958. The company also owns, or has an interest in, a number of claims in the Blind River area, District of Algoma, and in Strathcona township, Timagami area, District of Nipissing.

All mining operations in 1959 were confined to the company's properties in the Cobalt area.

AGAUNICO MINE

Operations at the Agaunico property continued throughout 1959.

SHAFTS, AGAUNICO MINE

	Claim No.	Inclination	Number of Compartments	Depth from Surface
				feet
No. 1 shaft	Parcel 195	Vertical	2	400
No. 2 winze (below 275-foot level)	697	Vertical	2	458
No. 1 incline haulageway (below 275-foot level)	697	−20°	2	325

Development in 1959 consisted of 539 feet of drifting and 705 feet of crosscutting. Total-development footages to December 31, 1959, were as follows: drifting, 9,375 feet; crosscutting, 3,234 feet; raising, 3,630 feet. Some 82 diamond-drill holes were completed in 1959, totalling 15,301 feet, from underground.

A total of 25,350 tons of ore was hoisted; 22,578 tons was milled.

CHRISTOPHER MINE

The Christopher mine adjoins the south boundary of the Cobalt Lode mine, in lot 2, concession III, Coleman township. The operation continued throughout 1959, under lease from Christopher Silver Mines Limited.

SHAFTS, CHRISTOPHER MINE

	Claim No.	Inclination	Number of Compartments	Depth from Surface
				feet
No. 1 shaft	1970	Vertical	2	295
No. 2 shaft	106	Vertical	2	415

These shafts are not used in the present operation. There is a connection between the Christopher workings and the Cobalt Lode workings on the 400- and 600-foot levels. Cobalt No. 1 shaft is used for all mining operations on the Christopher property.

Development during the year consisted of 1,456 feet of drifting, 406 feet of crosscutting, and 1,469 feet of raising. Total-development footages to December

SILVER AND COBALT—Continued

31, 1959, were as follows: drifting, 6,672 feet; crosscutting, 2,395 feet; raising, 6,592 feet; mainly on the 400-, 490-, 600-, and 650-foot levels. Diamond-drilling in 1959 consisted of 45 holes, totalling 5,457 feet, from underground.

A total of 39,550 tons of ore was hoisted; 45,290 tons was milled.

FOSTER MINE

The Foster, Crown Reserve, Kerr Lake, and Penn-Canadian mines are part of a group in lots 3 and 4, concession IV, Coleman township, held under lease from Penn-Cobalt Silver Mines Limited.

The only underground work done on the mines in this group during 1959 was on the Foster property. The vertical, three-compartment No. 5 shaft was used.

SHAFTS, FOSTER MINE

	Claim No.	Inclination	Number of Compartments	Depth from Surface
				feet
No. 1 shaft	66	Vertical	2	55
No. 2 shaft	66	Vertical	2	69
No. 3 shaft	66	Vertical	2	115
Air shaft	66	Vertical	2	80
No. 5 shaft	66	Vertical	3	225
No. 6 shaft	66	Vertical	2	88

Operations were resumed on March 20 and continued to the end of the year. During the period of operation, 442 feet of subdrifting, 72 feet of crosscutting, and 48 feet of raising were completed. Total-development footages on the 70-, 140-, and 210-foot levels to December 31, 1959, were as follows: drifting and subdrifting, 4,587 feet; crosscutting, 1,840 feet; raising, 3,103 feet.

A total of 1,418 tons of ore was hoisted; 1,194 tons was milled.

NIPISSING MINE

Development in 1959 consisted of diamond-drilling only. Some 12 holes, totalling 3,358 feet, were completed during the latter part of the year from underground.

O'BRIEN MINE

Nipissing-O'Brien Mines Limited was incorporated in January, 1952. The company acquired the properties of M. J. O'Brien Limited, and Nipissing Mines Company Limited, in concession V and VI, Coleman township, District of Timiskaming.

Nipissing-O'Brien Mines Limited operated the property until June 1958, when it was purchased by Agnico Mines Limited. Mining operations continued throughout 1959.

SHAFTS, O'BRIEN MINE

	Location	Inclination	Number of Compartments	Depth from Surface
				feet
Main shaft	R.L.403	Vertical	3	345
No. 615 winze (below 340-foot level)	R.L.403	Vertical	2	460
No. 2 shaft	R.L.403	Vertical	2	250
No. 6 shaft	R.L.403	Vertical	2	300
No. 14 shaft	R.L.403	Vertical	2	176

SILVER AND COBALT—Continued

Operations are carried on through the main shaft to the 340-foot level, and No. 615 winze to the 460-foot level.

Development in 1959 consisted of 243 feet of drifting, 550 feet of crosscutting, and 100 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 5,647 feet; crosscutting, 1,955 feet; raising, 4,128 feet. Some 116 diamond-drill holes, totalling 14,533 feet, were completed in 1959 from underground.

A total of 38,089 tons of ore was hoisted; 33,939 tons was milled.

PENN MILL (FOSTER PROPERTY)

The Penn mill operated throughout the year, treating ore from the four producing mines.

An assay office was completely equipped at the mill.

The mill treated a total of 102,820 tons, averaging 340 tons daily.

The average number of employees at all operations was 163: 98 underground, and 65 on surface. H. E. Cawley was manager.

Cairngorm Mines Limited

Cairngorm Mines Limited was incorporated in November 1955 with an authorized capitalization of 4,000,000 shares of no par value, of which 1,440,006 shares have been issued. The directors and officers were: Lorna M. McWilliams, president; L. F. Mendendorp, vice-president; S. A. McWilliams, M. P. Salmon, and S. K. Shanklin, directors; D. I. McWilliams, secretary; P. K. E. McWilliams, treasurer; Doris C. Lill, assistant secretary-treasurer. The head office and mine address is 160 Bay Street, Toronto.

The property consists of 19 claims in O'Connor, Scoble, and Gillies townships, District of Thunder Bay; it includes the old Beaver mine, located about 26 miles south of Port Arthur.

The Beaver underground workings were being dewatered for examination, sampling, and diamond-drilling. Four diamond-drill holes, totalling 343 feet, were drilled from surface in 1959.

Two temporary buildings were constructed, and a 500-cfm. compressor installed.

P. G. Thoday, consulting engineer, was in charge.

Coballoy Mines and Refiners Limited

Coballoy Mines and Refiners Limited was incorporated in August 1952, with an authorized capitalization of 5,000,000 shares of $1 par value, of which 1,700,000 shares have been issued. J. J. Gray was president, J. F. Stirrett was vice-president, and C. L. Murray was secretary-treasurer. The secretary-treasurer's office is at 719 Yonge Street, Toronto.

The company acquired, by purchase and lease, a number of properties, including several former producing mines, in Coleman township and the Gillies Limit, District of Timiskaming. It also bought the Colonial mill from Cobalt Consolidated Mining Corporation Limited.

All mining operations in 1959 were confined to the company's Mensilvo mine in the Cobalt area.

SILVER AND COBALT—Continued

SHAFTS, MENSILVO MINE

	Inclination	Number of Compartments	Depth Below Surface
			feet
No. 1 shaft	Vertical	2	75
No. 2 shaft	Vertical	2	108
No. 4 shaft	Vertical	2	45
No. 7 shaft	Vertical	2	209
Winze (below 70-foot level)	Vertical	1	100

Development in 1959 consisted of 742 feet of drifting, 248 feet of crosscutting, and 402 feet of raising. Total-development footages to December 31, 1959, on the 40-, 70-, 140-, and 200-foot levels were as follows: drifting, 3,454 feet; crosscutting, 1,893 feet; raising, 865 feet. Diamond-drilling in 1959 consisted of 25 holes from underground totalling 5,816 feet, and 7 holes from surface totalling 3,895 feet.

A complete diamond-drilling outfit (Longyear Straitline), and a 200-cfm. electric fan with ducts (Combustion Engineering), were added as new equipment.

A total of 2,538 tons of ore was hoisted and milled. The mill operated several months, averaging 45 tons daily.

The average number of employees was 14: 9 underground, 5 on surface. R. W. Christoph was mine manager.

Deer Horn Mines Limited

Deer Horn Mines Limited was incorporated in December 1950, with an authorized capitalization of 5,000,000 shares of $1 par value, of which 3,160,005 shares have been issued. The directors and officers were: Denison Denny, president; J. G. Pierdon, vice-president; Lawrence Murphy, treasurer; P. H. Chubb and J. H. Westall, directors: Margaret B. Smith, secretary. The head office is at 100 Adelaide Street West, Toronto. The mine address is Cobalt.

Deer Horn Mines Limited leased the Cross Lake O'Brien property from Agnico Mines Limited. The property consists of 14 claims in Coleman township, District of Timiskaming, about 1½ miles east of Cobalt.

The main shaft is 595 feet deep; there are two winzes, one of which extends to a depth of 800 feet below surface.

The shaft was dewatered to the 450-foot level in early 1959. A total of 174 feet of drifting, 186 feet of crosscutting, and 111 feet of raising was completed on the 270- and 450-foot levels. Some 49 diamond-drill holes, totalling 7,007 feet, were drilled from underground.

New construction included: a headframe 65 feet in height; a shafthouse, 45 by 28 feet, with 10-foot walls; and a hoist-house and switch-room, 40 by 16 feet. An air hoist (Canadian Ingersoll-Rand, single-drum, 10 by 12), and 3 transformers (50-kva.) were installed.

A total of 638 tons of ore was hoisted and stockpiled.

J. E. Armstrong was manager; the average number of employees was 6.

SILVER AND COBALT—Continued

Langis Silver and Cobalt Mining Company Limited

Langis Silver and Cobalt Mining Company Limited was incorporated in February 1953 with an authorized capitalization of 300,000 shares of $1 par value. In May 1957 the capitalization was increased to 5,000,000 shares of $1 par value; 3,800,015 shares have been issued. The directors and officers were: A. W. White, president; D. F. Burt, vice-president; H. R. Heard, secretary-treasurer; K. J. Benner, and J. E. Armstrong, directors. The head office is at 145 Yonge Street, Toronto. The mine address is New Liskeard.

The property consists of 20 claims in Casey and Harris townships, District of Timiskaming, and includes the former Casey Cobalt property.

SHAFTS, CASEY COBALT PROPERTY

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (inactive)	T.354	75°	2	270
No. 3 shaft	T.354	Vertical	2	295
No. 4 shaft (inactive)	T.1474	Vertical	2	150
No. 6 shaft	T.1110	Vertical	2	396
No. 4 winze (below 260-foot level)	T.1110	Vertical	2	310

Development in 1959 consisted of 2,315 feet of drifting, 821 feet of crosscutting, and 997 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 12,008 feet; crosscutting, 13,083 feet; raising, 1,950 feet. Diamond-drilling in 1959 consisted of 63 holes from underground totalling 6,203 feet, and 28 holes from surface totalling 6,591 feet.

A frame building, 20 by 40 feet, was moved and renovated for a dryhouse.

New equipment included: 1 diamond-drill (Boyles Brothers, Bazooka); 1 hot-air heating-unit (Chinook, S-90, 90,000-btu.); 1 filter (Dino, 5F-12); 2 centrifugal pumps (Monarch, 64- and 100-gpm.).

A total of 21,811 tons of ore was hoisted and milled.

The average number of employees was 65: 43 underground, and 22 on surface. J. E. Jerome was manager.

McIntyre Porcupine Mines Limited (Castle Division)

Castle-Trethewey Mines Limited was incorporated in January 1922 with an authorized capitalization of 3,000,000 shares of $1 par value, of which 2,709,002 shares have been issued. In December 1959 the assets of Castle-Trethewey Mines Limited were purchased by McIntyre Porcupine Mines Limited and became the Castle division of McIntyre. The directors and officers were: J. S. D. Tory, chairman of the board; J. D. Barrington, president and managing director; W. B. Dix, vice-president and treasurer; Norman D'Arcy, J. C. Fraser, R. S. McLaughlin, and S. M. Wedd, directors; M. L. Urquhart, vice-president, operations; F. T. McKinney, secretary. The address of the head office and mine office is O'Brien. The executive office is at 25 King Street West, Toronto.

The property, consisting of 45 claims, is located in Haultain and Nicol townships, Gowganda area, District of Timiskaming. The property is in two mining sections: the Castle; and the Capitol. In recent years all major operations have been in the Capitol mine.

SILVER AND COBALT—Continued

SHAFTS, CASTLE AND CAPITOL MINES

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
CAPITOL MINE				
Capitol shaft	H.S.351	Vertical	2	819
Capitol winze (below 800-foot level)	H.S.351	Vertical	2	1,188
Inclined haulageway (below 1,125-foot level)	H.S.351	—27°	2	1,425
Capitol Cobalt shaft (inactive)	H.S.351	Vertical	1	38
CASTLE MINE				
Ng. 1 shaft (inactive)	R.S.C.106	Vertical	.....	460
No. 2 shaft (inactive)	R.S.C.101	Vertical	.....	160
No. 3 shaft	R.S.C.101	Vertical	2	850

The No. 3 shaft was sunk 151 feet in 1959, and the 775- and 850-foot levels were established. Some 3,547 feet of drifting, 417 feet of crosscutting, and 884 feet of raising was completed. Total-development footages to December 31, 1959, were as follows: drifting, 24,901 feet; crosscutting, 13,081 feet; raising, 6,197 feet.

An auxiliary solenoid emergency brake was installed on No. 3 hoist.

A total of 17,639 tons of ore was hoisted; 19,892 tons were milled, from which 1,084,630 ounces of silver and 14,195 pounds of cobalt were recovered for a gross value of $958,942. Operating profit amounted to $195,775, compared with $24,086 in 1958. The broken-ore reserve at December 31, 1959, was estimated at 3,390 tons grading about 48 ounces of silver per ton. At the end of 1958 the comparative figures were 2,800 tons averaging 40 ounces per ton. The mill operated from May 1 to December 23, averaging 90.42 tons daily.

The average number of employees was 85: 55 underground, and 30 on surface. G. D. McLeod was manager.

Silver-Miller Mines Limited

Silver-Miller Mines Limited was incorporated in January 1946 with an authorized capitalization of 3,000,000 shares of $1 par value. In 1952 the number of shares was increased to 4,000,000, and in 1953 to 5,000,000, of which 4,960,181 shares have been issued. The directors and officers were: Murray Cooper, president; R. K. Hart, vice-president; M. C. Hill, J. D. Streit, Murray Watts, F. A. Fell, and E. F. Dodge, directors; J. M. Wainberg, secretary-treasurer. The head office is at 357 Bay Street, Toronto. The mine address is Box 230, Cobalt.

The company owns a number of properties in Coleman and Lorrain townships and in the Gillies Limit, District of Timiskaming. Claims owned by the Kerr Lake Mining Company and located south of the Lawson mine were acquired in 1959.

BRADY LAKE MINE

The Brady Lake property, which has also been called the Silver-Miller mine, is in lots 2 and 3, concession III, Coleman township. It includes the old Lumsden, Rochester, Gillies, Cobalt Central, and Coleman Development (Pan Silver) mines.

Operations continued throughout 1959.

SILVER AND COBALT—Continued

SHAFTS, BRADY LAKE PROPERTY

	Location	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft (Lumsden)	Claim No. 367	Vertical	2	400
No. 4 winze (below 200-foot level) (Lumsden)	.....	Vertical	2	270
No. 2 shaft (Rochester)	Claim No. 119	Vertical	2	75
No. 3 shaft (Rochester)	Claim No. 119	Vertical	2	75
No. 4 shaft (Pan Silver)	SW.¼, N.½, lot 2, con. III, Coleman tp.	Vertical	2	632
No. 1 winze (below 285-foot level) (Pan Silver)	.....	Vertical	2	447
No. 3 winze (below 610-foot level) (Pan Silver)	.....	Vertical	2	746

Operations were conducted through No. 4 shaft from surface to the 610-foot level, and through No. 3 winze from the 610-foot to the 725-foot level.

Development in 1959 consisted of 1,959 feet of drifting, 125 feet of crosscutting, and 1,051 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting and subdrifting, 31,943 feet; crosscutting, 7,505 feet; raising, 9,567 feet. Diamond-drilling in 1959 consisted of 123 holes from underground totalling 31,520 feet.

A total of 3,031 tons of ore was hoisted; 1,920 tons was milled.

LA ROSE MINE

Mining operations at the La Rose mine in Coleman township were suspended in early March.

SHAFTS, LA ROSE MINE

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
Main shaft	J.S.14	Vertical	2	250
No. 240 winze (below 240-foot level)	J.S.14	Vertical to 500 feet; inclined to bottom	2	665
No. 3 shaft (inactive)	J.S.14	Vertical	2	165
Discovery shaft (inactive)	J.S.14	Vertical	1	85

During the period of operation, development consisted of 14 feet of drifting. Five diamond-drill holes, totalling 589 feet, were drilled from underground. Total-development footages to December 31, 1959, were as follows: drifting and subdrifting, 23,469 feet; crosscutting 2,609 feet; raising, 3,155 feet.

Some 155 tons of ore was hoisted and milled.

LAWSON MINE

Operations at the Lawson mine in Coleman township continued throughout 1959.

SHAFTS, LAWSON MINE

	Location	Inclination	Number of Compartments	Depth
				feet
No. 8 shaft	SW.¼ of N.½, lot 3, con. IV, Coleman tp.	Vertical	2	410
Main shaft	SW.¼ of N.½, lot 3, con. IV, Coleman tp.	Vertical	2	195

SILVER AND COBALT—Continued

Development in 1959 consisted of 575 feet of drifting, 83 feet of crosscutting, and 604 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 19,459 feet; crosscutting, 2,816 feet; raising 4,960 feet. Diamond-drilling in 1959 consisted of 32 holes from underground totalling 7,501 feet.

A total of 2,286 tons of ore was hoisted; 2,007 tons was milled.

KERR LAKE FRACTION

Development at the Lawson mine has progressed into the recently acquired Kerr Lake property on the 300- and 400-foot levels. Some 117 feet of drifting on the 300-foot level, and 15 feet on the 400-foot level, was completed from October 1 to the end of the year.

The average number of employees at all operations was 44: 27 underground, and 17 on surface. E. A. Pearson was mine manager.

Siscoe Metals of Ontario Limited

Siscoe Metals of Ontario Limited is a wholly-owned subsidiary of Siscoe Mines Limited. It was incorporated in October 1946. The officers and directors are: J. B. Lynch, chairman of the board; M. F. Nicholson, president; C. M. Masterman, secretary-treasurer; J. G. Ahern, W. A. Arbuckle, N. S. Beaton, J. P. Crete, and Auguste Desilets, directors. The head office is at 421 Dominion Square Building, Montreal, Que. The mine address is O'Brien.

The company owns and operates the Siscoe Metals property, formerly the Miller Lake O'Brien mine, consisting of fourteen claims, about 547 acres, in Nicol and Haultain townships, Gowganda area, District of Timiskaming.

Mining and milling continued throughout 1959. Work was carried on through No. 6 shaft, which was created in 1956 by raising No. 6 winze to surface.

SHAFTS, SISCOE METALS MINE[1]

	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 6 shaft	R.S.C.91	Vertical	2	844
No. 2 shaft (inactive)	R.S.C.91	75°	2	452
No. 1 winze (below 350-foot level)	R.S.C.91	75°	2	457
No. 2 winze (below 350-foot level)	R.S.C.91	82°	2	460
No. 3 winze (below 350-foot level)	R.S.C.91	76°	2	405
No. 4 winze (below 350-foot level)	R.S.C.91	82°	2	525
No. 5 winze (below 525-foot level)	R.S.C.91	Vertical	2	650
No. 7 winze (below 730-foot level)	R.S.C.91	75°	2	908
No. 8 winze (below 730-foot level)	R.S.C.92	68°	2	790
No. 9 winze (below 730-foot level)	R.S.C.91	Vertical	3	908
No. 11 winze (below 850-foot level)	R.S.C.92	Vertical	2	1,359
No. 20 shaft	R.S.C.94	76°	2	163

[1]This table includes only the shafts and winzes that have been used in the present company's operations.

Development in 1959 consisted of 4,173 feet of drifting, 298 feet of crosscutting, and 793 feet of raising. Total-development footages, by present operators, to December 31, 1959, were as follows: drifting, 58,428 feet; crosscutting, 15,666 feet; raising, 4,383 feet. Diamond-drilling in 1959 consisted of 195 holes from underground totalling 18,801 feet.

SILVER AND COBALT—Continued

New construction included: a bunkhouse; a tractor garage, 20 by 22 feet; a refinery building, 32 by 36 feet; an assay-office building, 34 by 38 feet; and five houses, 32 by 22 feet.

New equipment included: a stoper rock-drill; 2 aluminum cages; and 10 side-dump mine-cars, 24-cubic foot capacity.

A total of 61,401 tons of ore was hoisted and milled. The mill treated an average of 234 tons per operating day.

The average number of employees was 104: 64 underground, and 40 on surface. G. Shartner was mine manager.

TALC

Canada Talc Industries Limited

Canada Talc Industries Limited was incorporated in July 1951, with an authorized capitalization of 1,000,000 shares of no par value, of which 850,007 shares have been issued. The officers are: H. L. Roscoe, president; N. C. Urquhart, vice-president; C. H. Windeler, secretary-treasurer. The head office and mine office are at Madoc.

The company's property in Huntingdon, Elzevir, and Madoc townships, Hastings county, includes the Conley and Henderson mines.

Operations continued throughout 1959. Mining is done through No. 2 shaft of the Conley mine, and No. 3 shaft of the Henderson mine.

SHAFTS, CANADA TALC PROPERTIES

	Location	Inclination	Number of Compartments	Total Depth from Surface
				feet
CONLEY MINE				
No. 1 shaft (inactive)	Huntingdon tp. Lot 15, con. XIV	Vertical	2	431
7th level winze (below 420-feet) (inactive)	Lot 15, con. XIV	Vertical	2	451
Escapement raise (inactive)	Lot 15, con. XIV	Vertical	1	185
No. 2 shaft	Lot 15, con. XIV	Vertical	3	420
HENDERSON MINE				
No. 3 shaft	Huntingdon tp. Lot 14, con. XIV	Vertical	2	456

The No. 2 shaft at the Conley mine was sunk 37 feet, and the 2nd level was established at the 400-foot horizon. Development in 1959 consisted of 366 feet of drifting, and 170 feet of crosscutting. Total-development footages to December 31, 1959, were as follows: drifting, 13,079 feet; crosscutting, 4,027 feet; raising, 3,768 feet. Five diamond-drill holes, totalling 1,320 feet, were completed from underground.

A total of 9,924 tons of ore was hoisted; 1,097 tons was sold as crude talc; 8,827 tons was milled at an average of 50 tons daily.

The average number of employees was 22: 11 underground, and 11 on surface. H. E. Roscoe was manager.

THORIUM

Rio Tinto Dow Limited

Rio Tinto Dow Limited was incorporated in January 1958 with an authorized capitalization of 200,000 shares of $10 par value, of which 35,000 shares have been issued. The directors and officers were: Hon. R. H. Winters, president; L. D. Smithers, vice-president; J. D. Head, general-manager; D. R. Derry, H. D. Doan, E. B. Gillanders, Roger Jeanty, and J. L. Smart, directors; George Baker, secretary; B. A. Howard, treasurer. The head office is at 335 Bay Street, Toronto. The plant address is Box 190, Elliot Lake.

The new plant was completed; operations commenced on January 26. The plant is designed to produce a thorium concentrate from treatment of the Algom Quirke mill tailings, using a solvent extraction-process.

During the period of operation, a total of 54.5 tons of thorium was recovered as crude cake.

The average number of employees was 21. E. N. Banks was resident manager.

URANIUM

Algom Uranium Mines Limited

Algom Uranium Mines Limited was incorporated in July 1953 with an authorized capitalization of 6,000,000 shares of $1 par value, of which 4,344,797 shares have been issued. The directors and officers were: W. H. Bouck, president; Roger Jeanty, vice-president; W. P. Arnold, managing director; C. C. Calvin, H. L. Roper, J. H. Hirshhorn, F. R. Joubin, Sen. S. A. Hayden, and Hon. R. H. Winters, directors; George Baker, secretary; D. A. MacFarlane, treasurer. The head office is at 335 Bay Street, Toronto. The address for the two mines of the company is Elliot Lake.

The company holds about 25,400 acres in the Blind River area, District of Algoma. Two mines, the Algom Nordic and the Algom Quirke, are being operated.

ALGOM NORDIC MINE

Mining and milling operations continued throughout 1959 at the Algom Nordic mine at Elliot Lake, in Townships 143, 149, and 155.

The vertical, six-compartment, Nordic No. 1 shaft, located on claim S.66619, in Township 149, was sunk a further 360 feet in 1959, to a depth of 1,331 feet. A crusher station, loading and spill pockets, and a bottom sump, were established. Development consisted of 9,925 feet of drifting, 1,997 feet of crosscutting, and 23,123 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 51,897 feet; crosscutting, 7,608 feet; raising, 76,051 feet.

New construction during the year included the following: an oil storage building, 21.5 by 52 by 12.7 feet; a penthouse, 28.5 by 28 by 18.7 feet, on the pachuca building roof to house filters; extensions, 10 by 25 feet, to seven townsite houses; the moving of two dormitories from Elliot Lake Townsite and their alteration for single men's quarters; the moving, relocating, and modifying of a building, 18 by 20 feet, to house the new exhaust-fan accessories.

URANIUM—Continued

New equipment installed was as follows: 1 Vanaxial exhaust-fan (84-in. diameter, 250,000-cfm., 300-hp. motor, Sheldon Engineering) in the west exhaust-raise; all equipment necessary to convert from steel-ball grinding to pebble grinding; 1 ammonia-storage tank (1,264-cu. ft., Toronto Iron Works) outside the concentrator building; 1 ammonia compressor (250 psi., Corkens Inc., model 291-KC-AA) in the compressor building; 1 leach disc-filter (8.5-ft. diameter, 8 discs, Dorr-Oliver-Long) in the penthouse of the pachuca building; 2 vacuum cleaning systems (Canadian Hoffman), one for the crushing-and-screening building and one for the drying-and-packaging plant; 1 automatic lubricating system (Farval Corp.) for 16 drum-filters in the concentrator building; five 3-drum electric slushers (50-hp. motors, 8,200-lb. rope-pull, 200-fpm., Joy Mfg.); 1 diesel locomotive (7-ton, Ruston-Hornsby) for underground haulage; 1 jumbo rock-drill (track-mounted, Gardner-Denver) for underground work; 1 high-pressure air compressor (29 by 18 by 14.5 ins., 2,815 cfm. at 100 psi., Canadian Ingersoll-Rand).

A total of 1,072,961 tons of ore was hoisted; 1,041,300 tons was milled at a daily average of 2,975 tons.

ALGOM QUIRKE MINE

The Algom Quirke mine in Township 150 adjoins the north boundary of the Consolidated Denison property.

The vertical, five-compartment Quirke No. 1 shaft, on claim S.66899, was sunk 348 feet in 1959, to a depth of 1,208 feet below the collar. The 9th, 10th and 11th levels were established at depths of 928, 1,036 and 1,150 feet respectively. The vertical two-compartment pilot-shaft, collared on the 8th level (829-foot) and used for raising No. 1 shaft, was sunk 45 feet to a depth of 404 feet (1,233 feet below surface) for use as a waste pass.

Development in 1959 consisted of 8,767 feet of drifting, 3,934 feet of crosscutting, and 23,901 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting 64,745 feet; crosscutting, 15,210 feet; raising 83,203 feet. Diamond-drilling in 1959 consisted of 94 holes from underground totalling 6,557 feet.

New construction included two dormitories, 30 by 110 feet, with concrete foundations.

All equipment necessary to change from ball-mill grinding to autogenous or pebble grinding was installed. Anhydrous ammonia replaced caustic soda in the precipitation process.

A total of 996,240 tons of ore was hoisted; 909,579 tons was milled at a daily average of 2,492 tons.

The following is taken from the company's annual report for the year ending December 31, 1959:

In May 1959 the company entered into an extension contract with Eldorado Mining and Refining Limited for the delivery of 2,456,000 pounds of U_3O_8 at a price of $8.00 (U.S.) per pound between the date of completion of the original contract and March 1962. By December 31, 1959, approximately 13,605,000 pounds of U_3O_8 had been delivered to Eldorado out of the contract total of 22,256,000 pounds.

The year 1959 was one of steady progress in the operation of the company's two mines at Nordic and Quirke. Shaft-sinking continued at both properties and new levels were opened together with the necessary ore-passes, loading stations, and services. Further improvements in

URANIUM—Continued

recovery were recorded owing mainly to the benefits of a full year's operation of the pachuca leaching plants and further research and cost-control. Production is summarized in the following table:

	Nordic		Quirke	
	1959	1958	1959	1958
Total milled.....tons	1,041,300	1,108,380	909,579	963,835
Average daily mill rate.....tons	2,975	3,037	2,492	2,641
Average calculated heads (U_3O_8 per ton).....pounds	2.40	2.49	2.45	2.43
Average recovery based on average calculated heads.....percent	95	94	95	93

Operating costs per ton of ore milled, before administration expense, interest, Ontario mining tax and amortization, but after deducting the revenue from sales of ore to Northspan Uranium Mines Limited, were $9.71 at Nordic and $9.67 at Quirke in 1959 compared with $11.33 at Nordic and $11.59 at Quirke in 1958. Further economies are expected from the installation of autogenous grinding. By the end of the year, installation of this equipment was complete at Nordic and nearly complete at Quirke.

The ore reserves at October 31, 1959, were:

	Nordic		Quirke	
	Quantity	Content U_3O_8 per ton	Quantity	Content U_3O_8 per ton
	tons	pounds	tons	pounds
Proven ore[1].....	562,856	2.34	614,070	2.56
Probable ore:				
Disclosed by underground development[1]	580,224	2.54	615,119	2.39
Disclosed by diamond-drilling[2].....	6,286,433	2.33	11,189,147	2.50

[1]Includes dilution based on experience.
[2]Tonnages and grades undiluted.

It should be mentioned that the drop in ore-reserve tonnage over the past year is greater than the tonnage mined during the same period. This negative difference is due mainly to two facts: (1) underground work during the year showed that, on the margins of the ore shoots, the grade and thickness diminished to the point where mining would be uneconomic; (2) pillar tonnages included in the ore-reserve statement of the last annual report have now been excluded from the ore reserve as unlikely to be mined.

Development consisted of 36,219 feet at Nordic that produced 199,843 tons of ore, and 38,474 feet at Quirke that produced 126,951 tons of ore. Stoping operations produced 909,195 tons at Nordic and 861,811 tons at Quirke.

The main capital expenditures during the year were for the installation of the pebble grinding plant, which cost approximately $285,000 at Nordic and $279,000 at Quirke, and for further shaft-sinking at a cost of approximately $445,000 at Nordic and approximately $516,000 at Quirke.

Labour relations remained harmonious and new contracts have now been negotiated with the United Steelworkers of America effective January 1, 1960, for a two-year period.

Under an agreement, entered into at mid-year, for the sale of broken ore to Northspan Uranium Mines Limited, 34,761 tons were supplied by Nordic and 89,238 tons by Quirke. In addition, Northspan continued to mine ore from adjoining Algom claims on a royalty basis, with Lacnor taking 748,261 tons and Panel 501,796 tons. In both cases, the Algom claims are easily accessible to the underground workings and shafts on the Northspan properties, while being well over a mile from any Algom shaft.

Despite slightly lower tonnages milled and a shorter number of hours worked, the results of operations for the year were better than in 1958. The consolidated net profit for 1959 was $12,912,429, after deducting amortization of $15,195,136 as compared with $9,334,198 in 1958 after amortization of $14,270,744. Working capital increased by $5,179,898.

The continued successful operation of the mines enabled the company to declare and pay its first dividend in December, at the rate of $2.50 per share and amounting in total to $10,841,993.

The average number of employees at the Algom Nordic mine was 896: 442 underground, and 454 on surface. M. W. Airth was mine manager.

The average number of employees at the Algom Quirke mine was 875: 467 underground, and 408 on surface. G. M. Godfrey was mine manager.

URANIUM—Continued

Bicroft Uranium Mines Limited

Bicroft Uranium Mines Limited was formed in April 1955 as an amalgamation of Centre Lake Uranium Mines Limited and Croft Uranium Mines Limited. The authorized capitalization is 4,000,000 shares of $1 par value, of which 3,057,475 shares have been issued. The officers and directors were: R. A. Bryce, president; J. D. Bryce, executive vice-president; S. A. Perry, vice-president; G. D. Pattison, secretary-treasurer; H. W. Salthouse, assistant secretary-treasurer; J. H. Crang, E. D. Scott, and R. A. Cranston, directors. The head office is at 25 Adelaide Street West, Toronto. The executive office is at 85 Richmond Street West. Toronto. The mine address is R.R. 3, Bancroft.

The Croft properties are in Cardiff township, Haliburton county, and in Faraday and Herschel townships, Hastings county. The Centre Lake property is in Cardiff township.

Operations at the Centre Lake property continued throughout 1959.

SHAFTS, CENTRE LAKE MINE

	Location	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 shaft.....	Claim E.O.5936, N.½, lot 27, con. XI, Cardiff tp.	Vertical	3	234
No. 2 shaft.....	S.½, lot 28, con. XI, Cardiff tp.	Vertical	5	1,314

Development in 1959 consisted of 9,617 feet of drifting, 5,878 feet of crosscutting, and 11,179 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 44,211 feet; crosscutting, 37,251 feet; raising 33,055 feet. Diamond-drilling in 1959 consisted of 461 holes from underground totalling 76,065 feet, and 5 holes from surface totalling 1,254 feet.

New equipment installed included an electronic sorting-unit (capacity 30 tons per hour, K. and H. Equipment), and a salt lixator, 12 by 27 by 9 feet.

The following is taken from the mine manager's report for the year ending December 31, 1959:

Production was maintained at approximately the same reduced rate as that established in the second half of 1958, following governmental limitations on contract deliveries. Average daily tonnage milled at 1,162 tons was below the 1,255 ton rate for the second half of 1958. However, this was generously offset by the better grade of ore milled.

Value of production at $8,288,699.54 was more than double the value of production ($4,085,057.97) in the second half of 1958.

This pace of production enabled the company to produce a modest excess over contract requirements. At the end of 1959, production in excess of allowable shipments totalled 95,000 pounds of U_3O_8. This stockpile is available for either sales outside the contracts or for final shipments to fill the existing contracts.

Stoping

The shrinkage-stoping method continued in general use. Filling of mined-out stopes was initiated during the year, utilizing both sorter-plant discard rock and development waste.

A new method of cleaning-down stopes was successfully developed and has reduced the cost and improved the efficiency of this important operation.

A total of 389,496 tons of ore was broken during the year. Broken reserves in stopes at the end of the year totalled 75,382 tons, a decrease of 14,492 tons.

Stopes supplied 85.1 percent of the mill feed; the balance came from development (9.3 percent) and surface stockpiles (5.6 percent).

One hundred and sixty-eight stopes were worked during the year; the total number of stopes worked to date is three hundred, of which two hundred and thirty-five have been completed. Eighty-seven new stopes were started during the year.

Stoping lengths range between 20 feet and 300 feet, and average 68 feet. Stoping widths normally range between 3 and 10 feet, and average 6 feet.

URANIUM—Continued

Production

The data tabulated below summarizes operating results in 1959 and also provides comparative data for the two preceding years.

	1959	1958	1957
Value of Production	$8,288,699.54	$8,850,454.11	$7,156,693.04
Total hoisted.....tons	471,321	[1]472,709	414,024
Average hoisted.....tons per day	1,291	[1]1,295	1,134
Total discarded.....tons	46,948	[1]8,029	.....
Average discarded.....tons per day	129	[1]75	.....
Total milled.....tons	424,373	464,680	414,024
Average milled.....tons per day	1,162	1,273	1,134
Value of recovery.....per ton	19.53	19.05	17.28
Proportion of recovery.....percent	92.9	92.1	91.4
Mill head value.....per ton	$21.02	$20.68	$18.92

[1]Sorting with one unit 3½ months only.

New ore-lengths totalling 5,699 feet were developed during the year. Forty-four percent of the drifting done was in ore. Owing to the nature of the orebodies, the amount of development that is necessary continues to be high in relation to the tonnage being mined and the footage of ore being developed.

Ore Reserves

Due to the nature of the orebodies, it is difficult to make accurate estimates of possible, probable, and positive, ore reserves. On the basis of the tonnage extracted to date, on the upper levels, the average tonnage-potential of orebodies, that are now developed along a strike-length of 3,500 feet, is 1,850 tons per vertical foot. On that basis, and with due allowance for pillars and sills, the possible- and probable- ore reserves lying above the ninth level, as of December 31, 1959, are estimated to total 698,000 tons, grading two pounds of U_3O_8 per ton. This figure includes 75,382 tons in broken-ore reserves underground.

Ore reserves are sufficient to fill all existing contracts.

The work done to date on the lower levels indicates that the structure of the ore-zone itself has remained relatively unchanged; continuation to depth is therefore indicated.

Milling

Ore was hoisted at an average rate of 1,291 tons per calendar day. The sorting plant processed 17.4 percent of this and discarded 57.2 percent as waste, for an average discard-rate of 129 tons per day. Various improvements in screening arrangements, and in operating controls, completed in the second half of the year, increased to 20 percent the proportion of ore going through the sorting plant.

The mill operated at an average daily rate of 1,162 tons of sorted ore.

It is now evident that, under favourable marketing conditions for the product, the sorting plant in combination with the mill could handle 1,600 tons of mine ore per day.

Over-all recovery, at 92.9 percent, again showed improvement over previous years.

General

Various improvements were made in mill facilities and techniques, particularly in reagent handling. These improvements, in combination with sorting, effected economies which made it possible to keep milling cost below those in the previous year in spite of the lower operating rate and increases in both labour costs and the cost of supplies.

The average number of employees was 552: 326 underground, and 226 on surface. J. M. Thompson was mine manager.

Can-Met Explorations Limited

Can-Met Explorations Limited was incorporated in April 1944 with an authorized capitalization of 5,000,000 shares of $1 par value. In December 1957 the number of shares was increased to 5,500,000, of which 4,687,650 have been issued. The officers and directors were: S. B. Roman, president; B. E. Willoughby, vice-president; J. C. Puhky, secretary-treasurer; Murray Axmith, Dr. W. H. Gifford, G. C. Knowles, J. G. Pickard, F. W. Boulger, and L. P. Chalmers, directors. The head office is at 360 Bay Street, Toronto. The mine address is Box 908, Spragge.

URANIUM—Continued

The company's main holdings consist of 35 claims, adjoining the eastern part of the south boundary of the Consolidated Denison property, in Townships 144 and 150, Blind River area, District of Algoma.

SHAFTS, CAN-MET MINE

	Location	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 (service)	S.67833	Vertical	2	2,127
No. 2 (production)	S.67839	Vertical	3	2,395

Development in 1959 consisted of 12,079 feet of drifting, 1,185 feet of crosscutting, and 140 feet of raising, all on the 2,100-foot level. Total-development footages to December 31, 1959, were as follows: drifting 31,745 feet; crosscutting 2,591 feet; raising 602 feet; all on the 2,100-foot level except 180 feet of raising on both the 150- and 2,260-foot horizons. Diamond-drilling in 1959 consisted of 11 holes from underground totalling 3,341 feet.

An underground conveyor (48-in. belt, 770 ft. long, 400-tph., 25-hp. motor, Joy Limberope) was installed.

A total of 938,387 tons of ore was hoisted; 936,863 tons was milled at an average of 2,567 tons daily.

The average number of employees was 939: 590 underground, and 349 on surface. R. D. Lindberg was mine manager.

Canadian Dyno Mines Limited

McLellan Gold Mines Limited was incorporated in 1951. In June 1953 the name was changed to Dyno Mines Limited. In December 1956 the name was further changed to Canadian Dyno Mines Limited. The authorized capitalization is 3,000,000 shares of $1 par value, of which 2,546,000 shares have been issued. The officers and directors were: S. A. Perry, president; Louis Pancer, vice-president and managing director; G. D. Pattison, secretary-treasurer; R. D. Bell, assistant secretary-treasurer; C. A. Campbell, Hon. C. P. McTague, L. P. Chalmers, G. C. Knowles, and H. H. Wright, directors. The head office is at 25 Adelaide Street West, Toronto. The mine address is R.R. 3, Bancroft.

The company's principal holding consists of 26 claims in concessions VII, VIII, IX, XI, XII and XIII, Cardiff township, Haliburton county.

The vertical, three-compartment, No. 1 shaft was sunk 722 feet in 1959, to a total depth of 1,719 feet below the collar. New levels were established at 1,080, 1,230, 1,380, 1,530, and 1,680 feet. No. 2 and No. 3 loading pockets were established at 1,184 and 1,604 feet respectively.

Development during the year consisted of 6,879 feet of drifting, 9,557 feet of crosscutting, and 5,516 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 19,209 feet; croscutting, 28,960 feet; raising, 16,786 feet. Diamond-drilling in 1959 consisted of 506 holes from underground totalling 91,296 feet.

New equipment installed included, 1 mine air-heater (Arkose oil-fired, 2,000,000 btu. per hour); 2 double-drum slusher hoists (Gardner-Denver, model EE); 2 Slushmaster scrapers (30-in.); 1 pump (Canadian Ingersoll-Rand, 200-gpm, 550-ft. head, 40-hp. motor); 1 turbine pump (7.5-hp. motor, 3,500 rpm., Bryan Jackson); 1 air locomotive (Eimco 401); 1 diesel locomotive (4.5-ton

URANIUM—Continued

Ruston Hornsby, model L.B.U.); 2 timber cages (Dorr-Oliver-Long); 2 loading-station assemblies (Dorr-Oliver-Long); thirty-six 50-cubic-foot and twelve 80-cubic-foot mine cars.

A total of 363,300 tons of ore was hoisted; 365,650 tons was milled at a daily average of 1,046 tons.

The following is taken from mine manager's report for the year ending July 31, 1959:

The quantity of ore treated increased through the year from a low of 872 tons per day in August to a high of 1,166, for an average of 1,046 tons per day. The grade of ore that was treated showed a slight improvement over that of the previous year. Of the ore treated, 6.74 percent came from the surface stockpile, which was completely used up during the year.

Three shipments of concentrate, each consisting of two 20,000-pound lots, were made to the United Kingdom Atomic Energy Authority; the balance of production was shipped to the Atomic Energy Commission in the United States.

Production

Production for the year totalled 452,636.5 pounds of uranium oxide having a value of $4,799,155.

Milling

The mill treated a total of 381,750 tons for a daily average of 1,046 tons. The mill-operating time was 94.5 percent of the maximum possible.

Continuous research throughout the year by the mill staff resulted in an improvement in both operational efficiency and costs. Costs were reduced to the lowest in the industry while the proportion of recovery was increased 2.05 percent.

The following table summarizes the mill-operating data; figures are given for the three-month operating period in 1957-58, 1958-59, and to date:

	To Date	1958-59	1957-58
Ore milled.....tons	451,559	381,750	69,809
U_3O_8 content.....pounds per ton	1.228	1.233	1.204
Daily average milled.....tons	967	1,046	684.4
Extraction.....percent	96.29	96.49	95.00
Soluble loss.....percent	0.62	0.54	1.10
Recovery.....percent	95.67	95.95	93.90
Cost.....per ton	$2.45	$2.40	$2.75
Precipitate grade.....percent U_3O_8	77.02	77.56	73.82

Development

During the year, work concentrated on opening up the A zone on the third and fifth levels, and the E zone on the third, fourth, and fifth levels. Development of the B and E zones was completed during the year to the fifth level. The main crosscut was started on the sixth level towards the B zone. Development continued in the D zone on the third, fourth and fifth levels.

The total length of ore opened up by drifting was 3,993 feet, with an average width of 5.3 feet.

Mining

During the year, mining was active on all levels to the fifth or 780-foot level. The number of stoping sections available increased from 34 in August 1958, with a combined length of 1,779 feet, to 58 in July 1959, with a combined length of 3,183 feet. Seventy new stopes were started during the year while 46 were completed. To date 115 stopes have been worked. A total of 324,279 tons of ore including dilution was broken in stoping during the year.

The percentage of ore taken from stopes increased to 82.0 percent from 61.1 percent for the previous year; the balance of the mill feed was made up of 11.3 percent from development and 6.7 percent from the surface stockpile.

Ore-grade has indicated that the true mine grade is about 1.30 pounds U_3O_8; this is considerably lower than was originally estimated. The drop in grade is due entirely to dilution as a result of irregular walls and an irregular and unpredictable content in the ore dikes. Constant grade-control measures remain in effect at all times in order to improve this situation.

URANIUM—Continued

Ore Reserves

Owing to the complex nature of the orebodies, it was impossible to calculate reserves with any degree of accuracy. For this reason, as in previous years, no calculation of ore-in-place was made.

Broken-ore reserves at the end of the year stood at 61,493 tons of which 1,171 were on the surface stockpile.

Lateral and vertical development, and diamond-drilling to the end of the year, indicated an additional 12 months' ore-supply above the fifth level, if rated mill-capacity is maintained.

Operating Costs

Operating costs showed a steady improvement during the year. The following table gives a comparison between costs for the past year and those for the three-month operating-period in 1957-58, on a ton-milled basis. No allowance has been made for administration costs, debenture interest, provincial tax, and write-offs.

Distribution	1958-9	1957-8
Mining	$3.57	$4.34
Milling	2.40	2.75
Development	2.21	4.27
Marketing	0.01	0.01
General	0.48	1.05
Total	$8.67	$12.42

The average number of employees was 437: 288 underground, and 149 on surface. P. S. Cross was mine manager.

Consolidated Denison Mines Limited

Denison Copper Mines Limited was incorporated in November 1936. It was succeeded in 1946 by Denison Nickel Mines Limited. In 1949 the name was changed to North Denison Mines Limited. In March 1954 it was changed to Consolidated Denison Mines Limited. The authorized capitalization is 6,000,000 shares of $1 par value, of which 4,451,265 have been issued. The directors and officers were: S. B. Roman, president; A. W. Stollery, vice-president; J. C. Puhky, secretary-treasurer; F. H. Jowsey, B. E. Willoughby, Joseph Sedgwick, J. S. Williams, G. C. Knowles, and Murray Axmith, directors; H. A. Willis, vice-president; E. B. McConkey, assistant secretary-treasurer. The head office is at 360 Bay Street, Toronto. The mine address is Spragge.

The company's main holding consists of 88 claims in Townships 144 and 150, Blind River area, District of Algoma.

SHAFTS, CONSOLIDATED DENISON MINE

Shaft	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1	S.86071	Vertical	5	1,856
No. 2	S.86118	Vertical	8	2,776

Development in 1959 consisted of 30,425 feet of drifting, and 401 feet of raising. Total-development footages on a single plane to December 31, 1959, were as follows: drifting, 88,076 feet; raising, 1,611 feet. In 1959, 1,818 diamond-drill holes, totalling 43,130 feet, were completed from underground.

URANIUM—Continued

New construction included: an addition (1,170 sq. ft.) to the rubber shop; an inflammable-solution and paint-storage building (265 sq. ft.); an addition (1,812 sq. ft.) to the grinding plant; and a security gatehouse (136 sq. ft.).

All the necessary equipment was installed to convert from steel-ball grinding to autogenous or pebble grinding. Some 2,415 feet of conveyor was installed underground, bringing the total to 7,022 feet. The two 1,250-horsepower skip-hoists at No. 2 shaft were equipped with semi-automatic push-button remote-control.

The following is taken from the general manager's report for the year ending December 31, 1959:

An intensive program of supervision, engineering, and planning was conducted throughout the entire operation to ensure maximum efficiency. The success of this program is confirmed by a drop of $1.53 per ton in operating costs for the year.

The improvement in mining efficiencies was due principally to the development of single-entry panels, the establishment and accentuation of budget-controls for labour, equipment, and supplies, and the installation of belt conveyors as a low-cost method for the transportation of run-of-mine ore. Savings resulted also from the centralization of working places and a reduction of indirect labour. The mechanization of mine and plant was still being evolved; future progress in this field will result in additional reductions in over-all costs.

Positive planning for 1960 demands the introduction and development of a method whereby ore can be scraped from stopes directly on to conveying belts. With the elimination of the intermediate cycle of haulage from a stope to a conveying belt, a reduction in the number of haulage vehicles is anticipated; this will bring a corresponding drop in labour and maintenance.

Substantial savings in labour and materials, through improvements in work procedures, metallurgy, and recovery, spurred progress in the extraction plant. A changeover is nearly completed from conventional grinding with steel balls to that with pebbles. A reduction in operating and other related costs is indicated in the elimination of steel balls and a consequent decrease in the consumption of sulphuric acid and lime.

Production

	1957	1958	1959
Ore broken.....tons	621,444	1,897,870	2,189,316
Milled.....tons	612,676	1,861,229	2,046,250
Average milled per day.....tons	2,676	5,101	5,672
Recovery.....percent	89.71	92.37	93.55
U_3O_8 produced.....pounds	1,353,947	4,239,761	4,916,108
Average U_3O_8 per ton, mill heads.....pounds	2.63	2.46	2.56

Mining

Mining and development continue to feature successfully the transportation of ore by belt conveyors and the use, where adaptable and economic, of trackless drilling-loading methods. As a result of studies dealing with stress concentrations as a function of opening-width to pillar-size, stope widths have been increased in successive increments from 25, 35, 45, and 60 feet and finally, in selected areas, to 100 feet. These greater widths, in conjunction with direct scraping to panel conveyors connected to main-line arteries, are expected to bring reductions in costs after the elimination of ore-carrying vehicles.

A total of 2,090,490 tons was hoisted from both shafts with a grade of 2.56 lb. U_3O_8 per ton, of which 1,040,576 tons were from No. 1 shaft having a grade of 2.59 lb. U_3O_8 per ton, and 1,049,914 tons from No. 2 shaft with a grade of 2.52 lb. U_3O_8 per ton.

A total of 80,399 feet of linear development was done, of which 46,585 feet were in pilot openings, 8 by 8 feet in size. This work not only prepared the tonnage moved during the year, but also developed a further 2,000,000 tons of positive grade. Only 8,575 tons of waste were broken during the year.

During the year, and at No. 1 shaft, the north-east conveyor was extended a further 805 feet and the south-west conveyor a further 930 feet. A flight of 680 feet was placed in the centre section between the two shafts to move ore to No. 2 shaft. In addition, 2,400 feet of conveyor was erected east of No. 2 shaft.

URANIUM—Continued

General

The over-all betterment in the safety record, and a corresponding reduction in injuries throughout the plant, is most pleasing to report. Compensable cases decreased by 26 percent, injuries by 34 percent, one-to-four-day injuries by 53 percent and medical aid by 28 percent.

Supervisors were given training in job instruction and job-relations safety. Safety-inspections were carried out during the year on a two-shift basis underground and led to improved work methods and safer conditions. The First-Aid team of Denison employees placed first among eight competing teams in the first District Competition. The Mine Rescue team placed second among eleven competing teams.

The average number of employees was 1,538: 803 underground, and 735 on surface. John Kostuik was general manager; M. J. de Bastiani was mine manager.

Faraday Uranium Mines Limited

Faraday Uranium Mines Limited was incorporated in June 1949 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 4,405,910 shares have been issued. The directors and officers were: A. W. Johnston, president; E. T. Donaldson, vice-president; A. B. Whitelaw, secretary; William McKee, W. C. Campbell, G. L. Jennison, and J. K. McCausland, directors; W. M. O'Shaughnessy, treasurer. The head office is at 100 Adelaide Street West, Toronto. The mine address is Bancroft.

The company holds about 2,600 acres in concessions A, B, IX, X, and XI, Faraday township, Hastings county.

SHAFTS, FARADAY MINE

	Location	Inclination	Number of Compartments	Sinking in 1959	Total Depth below Adit Level
				feet	feet
No. 1 shaft.....	Lot 16, con. XI, Faraday tp.	Vertical	3 to 750 feet 4 below 750 feet	371	1,455
No. 2 shaft.....	Lot 17, con. XI, Faraday tp.	Vertical	3	.....	196

The mine is being developed through an adit and two shafts. The deepening of No. 1 shaft commenced in 1958, was continued for 371 feet to 1,455 feet below adit-level elevation. New levels established were the 8th and 9th, at 1,211 and 1,381 feet respectively.

Development in 1959 included 11,727 feet of drifting, 6,747 feet of crosscutting, and 8,817 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 39,186 feet; crosscutting, 26,421 feet; raising, 27,251 feet. Diamond-drilling in 1959 consisted of 586 holes from underground totalling 104,780 feet, and 15 holes from surface totalling 3,790 feet.

New construction consisted of No. 2 ventilation building, 22.6 by 10.5 feet, and a mine-dry extension, 104.5 by 14.5 feet.

New equipment added included: 1 shop lathe (Ensign); 1 resuscitator (Safety Supply); 6 double-drum slushers (Gardner-Denver); 7 scrapers (42-inch, Lecky Machinery); 1 car monitor (Electronic Assoc.); 6 drills (Holman); 2 mucking machines (Eimco); 8 stoper drills (Gardner-Denver); 2 locomotives (Titan, Mancha Loco.); and 4 underground pumps (35-, 125-, and 500-gpm.).

The following is taken from the mine manager's report for the year ending December 31, 1959

The operating program was affected by two changes in conditions during the year. Greyhawk Uranium Mines terminated its operations in April, necessitating an increase in Faraday production to fulfill the contract within the specified time. This required an increase in labour force to a maximum of 565, additional mining equipment, and an addition to the mine-dry. By drawing on broken reserves, and by working considerable overtime, a maximum milling rate of 1,650 tons per day was reached in October.

On November 6, the decision of the United States Atomic Energy Commission to drop options on future production, along with the stretch-out policy advocated by Eldorado Mining and Refining Ltd., altered the situation. To take the greatest of economic advantages of the new conditions, it was decided to reduce development and continue at the maximum milling rate until the end of the tax-free period in April 1960. After April the tonnage would be reduced to the most efficient rate for the mine.

Production

Production totalled 895,980 pounds of U_3O_8 having a value of $9,465,685. Of this, Faraday contributed 885,046 pounds having a value of $9,351,644, and Greyhawk, 10,934 pounds having a value of $114,041.

Milling

The mill treated a total of 537,594 dry tons for a daily average of 1,473 tons; of this, Faraday produced approximately 99 percent. The following table summarizes mill-operating data for Faraday ore only, with figures for 1958 and for the eight-month operating period of 1957 supplied for comparison:

Faraday Ore	1959	1958	1957
	percent	percent	percent
Heads, U_3O_8	0.087	0.092	0.086
Tails, U_3O_8	0.0040	0.0056	0.0068
Recovery	95.34	94.0	91.9
Precipitate Grade, U_3O_8	75.66	70.5	67.1

The slight decrease in ore-grade, as compared with the previous year, may be attributed to the additional development and stope preparation necessitated by the increased tonnage rate.

The mill's research staff has been constantly engaged in efforts to improve metallurgical efficiency. This work has resulted, during the year, in a 1.3 percent increase in recovery and an improvement of better than 5 percent in precipitate grade. These increases followed a number of small changes in procedure. The work continues.

Mining

Mining was continued on all levels in an area 3,000 feet west and 1,000 feet east of No. 1 shaft. Tonnage was evenly distributed between levels with 20 percent of the ore being broken in the new Northwest zone. Stoping accounted for 93 percent of the mill feed; the balance was from development. The average tonnage broken in stopes was 1,200 tons per day, from an average of 26 active breaking-stopes per month. Mining methods were unchanged, with 70 percent of the ore having been supplied from shrinkage-stopes.

Development

Exclusive of shaft-sinking, development costs amounted to $2.12 per ton milled. It now appears that, by continuing the normal development rate for one year longer sufficient ore will be developed to complete the Eldorado contract on the date anticipated. Thereafter, this cost should be substantially reduced. However, it is neither possible nor desirable to attempt to stop development at the exact point where sufficient ore is in sight. Therefore, at the completion of the contract, the company expects to have sufficient remaining ore reserves to justify acceptance of any new sales contract that may be offered.

Of particular importance during the year was the development of the new Northwest zone on the adit-, 150-, and 300-foot levels; this added substantial tonnages of hitherto unknown ore of a grade better than mine average. Toward the end of the year, a new high-grade zone was disclosed near the shaft on the 450- and 600-foot levels. This is currently being explored and, while being highly irregular in its occurrence, it will contribute a worthwhile amount of ore that will have a grade of six or seven pounds to the ton.

Deepening of the main production-shaft was completed during the year, thus providing four additional levels at 150-foot intervals below the 600-foot horizon. Because of new ore-discoveries on the older levels, particularly in the Northwest zone, lateral development on the new deep levels was not undertaken during the year; however, the necessary ore-and-waste-pass systems, sumps, and other ancillary works, were pushed ahead and at the end of the year were virtually completed.

URANIUM—Continued

Diamond-drilling from the 600-foot level has already indicated continuation of the ore downward to the 750-foot horizon and close to the shaft. While large and favourable areas on the upper levels remain to be explored, these are becoming remote from the shaft; therefore, it is planned to concentrate, in the coming year, on the development of new levels from which the ore can be extracted more economically.

Costs

Operating costs show a substantial improvement over those of the past two years. In part, this may be attributed to the larger tonnage handled and, in part, to a reduction in the amount of broken reserves. More particular experience has been gained; consequently, more efficient methods have been adopted in all phases of the operation.

The following table, covering Faraday operations only, gives a comparison between costs per ton for the past year and those for the eight-month operating period of 1957 and for all of 1958. Administrative cost, debenture interest, provincial mining tax, and write-offs are not included:

Distribution	Per Ton		
	1959	1958	1957
Development	$2.12	$ 2.54	$ 2.34
Mining	3.96	4.41	3.77
Milling	3.00	3.05	3.69
Ore conveyance	.....	.....	0.25
Total	$9.08	$10.00	$10.05

Greyhawk

Shipments from Greyhawk Uranium Mines Limited totalled 8,195 tons of an average grade of 0.072 percent U_3O_8. No ore was received from Greyhawk after April 1959 and, since that time, Greyhawk has been in receivership.

The average number of employees was 507: 304 underground, and 203 on surface. D. R. Wilson was mine manager.

Greyhawk Uranium Mines Limited

Goldhawk Porcupine Mines Limited was incorporated in September 1944 with an authorized capitalization of 4,000,000 shares of $1 par value. In 1954 the capitalization was increased to 5,000,000 shares. In 1955 the name was changed to Greyhawk Uranium Mines Limited. In October 1957 the capitalization was increased to 6,000,000 shares, 5,850,000 of which had been issued at the end of 1958. The officers and directors are: E. K. Fockler, president; G. W. Bowcock, vice-president; H. B. Clearihue, secretary-treasurer; C. J. Brackley and H. J. Jeths, directors. The head office is at 320 Bay Street, Toronto. The mine address is Bancroft.

The company's main holding is a uranium property in Concessions A, B, XI, XII, XIV, and XV, Faraday township, Hastings county.

The mine was serviced by the vertical, three-compartment, No. 1 shaft, 402 feet deep, in lot 10, concession XI. A winze, collared on the third level, extends for 375 feet (at −16°), and serves the 390- and 425-foot levels.

The following table shows the development during 1959, and the totals to March 31, 1959:

Level	Drifts		Crosscuts		Raises	
	1959	Total	1959	Total	1959	Total
	feet	feet	feet	feet	feet	feet
1st (100-foot)	.....	1,727	.....	453	.....	828
2nd (200-foot)	.....	2,550	.....	590	.....	705
3rd (325-foot)	.....	1,351	.....	365	.....	523
4th (390-foot)	.....	.....	.....	18	.....	.....
5th (425-foot)	208	337	175	229	225	238

URANIUM—Continued

The mine produced about 125 tons of ore per day which was milled at the Faraday Uranium mill. Further details on Greyhawk are given in this volume under Faraday Uranium Mines Limited.

Production at the mine ceased on March 31, 1959. The mine was stripped of all salvable materials which, with the plant, were sold later in the year.

The average number of employees was 21: 14 underground, and 7 on surface. W. J. Salisbury replaced R. A. Freberg as manager on March 1, 1959.

Milliken Lake Uranium Mines Limited

Milliken Lake Uranium Mines Limited was incorporated in October, 1952, with an authorized capitalization of 6,000,000 shares of $1 par value. In February, 1957, the capitalization was increased to 7,000,000 shares, of which 6,684,800 have been issued. The officers and directors are: W. H. Bouck, president; George Baker, secretary; D. A. Macfarlane, treasurer; J. Van Netten, assistant treasurer; R. D. Lord, managing director; D. F. Burt, J. G. Edison, and D. J. McParland, directors. The head office is at 335 Bay Street, Toronto. The mine address is Elliot Lake.

The company's main holding consists of 24 claims, immediately east of Elliot Lake in Township 149, District of Algoma.

SHAFTS, MILLIKEN LAKE MINE

Shaft	Location	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 (service)	S.80247	Vertical	2	3,071
No. 2 (production)	S.80247	Vertical	3	3,400

During 1959 the new 2,760-foot level was established from No. 1 shaft at 2,751 feet below the collar. An incline-raise was driven 461 feet to serve four recently-established levels remote from the shaft.

Development in 1959 consisted of 11,576 feet of drifting, 3,854 feet of crosscutting, and 35,850 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 27,700 feet; crosscutting, 7,884 feet; raising, 64,875 feet.

New construction consisted of a curling rink (corrugated iron on wood frame, 36 by 196 feet).

New equipment added was as follows: 2 diesel locomotives (7- and 4.5-ton, Ruston-Hornsby); 1 triple-deck cage for No. 1 shaft (86-man, Dorr-Oliver-Long); 2 vibrating screens (4 by 8 ft., Hewitt-Robins); conversion of ball mills to pebble mills (Dominion Engineering); and conversion of a low-pressure compressor to high pressure (2,030-cfm., 100-psi., Canadian Ingersoll-Rand).

The following is taken from the annual report for the year ending December 31, 1959:

By December 31, 1959, approximately 3,169,600 pounds of U_3O_8 had been delivered to Eldorado Mining and Refining Limited; the contract total is 9,143,300 pounds.

Throughout this first full year of the company's production, performance at the mine continued to improve. Development, totalling 56,578 feet, increased the proven-ore reserves and produced 18 percent of the ore milled. As soon as development had advanced beyond production requirements, mine layouts were adjusted to suit local conditions and a more efficient stoping-cycle was attained. As the orebody was entered, grade was found to vary only moderately and generally good ground conditions were experienced.

URANIUM—Continued

Principal production statistics, compared with those of the previous year, are listed below:

	1959	1958
Milled.....tons	1,057,847	738,942
Average daily mill rate.....tons	3,048	2,575
Average calculated heads.....lb. U_3O_8 per ton	2.09	1.80
Average recovery, based on average calculated heads.....percent	93.7	92.0

Improvements in the mill included introduction of ammonia precipitation, high density leaching, pebble-grinding and better ion-exchange practice.

Operating costs, per ton of ore milled, before administration expense, interest, Ontario mining tax, and amortization, were $10.36 compared with $11.32 in 1958.

Proven- and probable-ore reserves were recalculated as at October 31, 1959, and they are given below:

	Tons	Pounds U_3O_8 per ton
Proven ore[1]	578,600	2.08
Probable ore:		
Disclosed by underground development[1]	766,300	2.07
Disclosed by diamond-drilling[2]	7,728,578	2.12

[1]Includes dilution based on experience.
[2]Tonnage and grade undiluted.

The Milliken ore-reserve figure is larger than that published in the last annual report. This is due to the gaining of greater knowledge of the continuity of the orebody from mining in the area over the past two years. Experience has justified the inclusion in the ore reserve of ore below the present bottom-level of the mine and disclosed by early drill holes from surface, but not included previously in published ore-reserve statements.

Capital expenditures for the year covered acquisition of additional underground equipment and hoisting improvements, pebble-grinding installation, and the improvement of camp accommodation for single employees.

As the working force stabilized, training was carried out with favourable results. Employee relations remained harmonious, and new labour contracts were signed with the United Steelworkers of America early in 1960 for a two-year period starting January 1, 1960.

Profit for the year was $1,090,225 after deducting amortization of $7,819,890. During the year the company's debt was reduced by $7,589,286. It is expected that the balance of the 5¾ percent notes outstanding, in the amount of $4,285,714, will be repaid during the first half of 1960; this will leave outstanding, the $16,000,000 principal amount of 6 percent bonds.

The average number of employees was 848: 448 underground, and 400 on surface. M. A. Upham was mine manager.

Northspan Uranium Mines Limited

Northspan Uranium Mines Limited was incorporated in June 1956 by a merger of Lake Nordic Uranium Mines Limited, Spanish American Mines Limited, and Panel Consolidated Uranium Mines Limited. The authorized capitalization is 10,000,000 shares of $1 par value of which 7,219,966 have been issued. The officers and directors are: E. B. Gillanders, president; W. B. Malone, vice-president; George Baker, secretary; D. A. MacFarlane, treasurer; E. G. Lambert, assistant treasurer; W. P. Arnold, managing director; J. B. Aird, J. N. V. Duncan, Ian Douglas, E. T. Donaldson, and R. H. Winters, directors. The head office is at 335 Bay Street, Toronto. The address for each of the company's mines is Elliot Lake.

The company's properties include the Lacnor mine (formerly called the Lake Nordic) and the Buckles property in Township 149, the Panel mine in Township 144, and the Spanish American mine in Township 150, all in the Blind River area, District of Algoma.

URANIUM—Continued

The Buckles property closed in October, 1958, when all available ore had been removed.

LACNOR MINE

Operations continued throughout 1959 at the Lacnor (formerly called Lake Nordic) mine, comprising 29 claims, in Township 149.

SHAFTS, LACNOR MINE

Shaft	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1	S.80071	Vertical	4	3,510
No. 2	S.80064	Vertical	4	2,970

No. 1 shaft was sunk 748 feet in 1959 to a depth of 3,510 feet below the collar. Eight new levels, the 9th to the 16th inclusive, were established at 2,638, 2,715, 2,785, 2,855, 2,925, 2,995, 3,065, and 3,135 feet respectively. The crusher-level was established at 3,342 feet and the lower loading pocket at 3,510 feet. No. 2 shaft was sunk 250 feet to a depth of 2,970 feet. Five new levels, the 9th to the 13th inclusive, were established at 2,637, 2,714, 2,784, 2,854, and 2,924 feet respectively.

Development in 1959 consisted of 15,685 feet of drifting, 6,068 feet of crosscutting, and 51,464 feet of raising. Total-development footages to December 31, 1959, was as follows: drifting, 48,381 feet; crosscutting, 11,600 feet; raising, 89,100 feet. Diamond-drilling in 1959 consisted of 45 holes from underground totalling 4,469 feet. Some 27,701 feet of test-hole drilling was completed.

New construction included two disc-filter penthouses, 28 by 30 feet, 12.8 feet high, and a weighscale building, 60 by 14 feet, 14 feet high.

New equipment installed included the following: 2 compressors (24 by 14.5 by 12, 1,750-cfm., Canadian Ingersoll-Rand); 1 rectangular magnet (42 by 48 ins., 2,790-watt, dc., Dings Magnetic Separator Company); 1 set of scales (60 by 10 feet, 50-ton, Howe Scale Company); 5 disc- and drum-filters (Eimco) various sizes in mill.

A total of 1,273,885 tons of ore was hoisted; 1,395,230 tons was milled at a daily average of 3,823 tons.

PANEL MINE

Operations at the Panel mine, in Township 144, continued throughout 1959. The mine is being developed through two shafts that were sunk on two islands close to the north shore of Quirke Lake. The No. 1 island has now been joined to the mainland by a causeway.

SHAFTS, PANEL MINE

	Claim No.	Inclination	Number of Compartments	Sinking in 1958	Total Depth from Surface
				feet	feet
No. 1 shaft (production)	S.67629	Vertical	6	626	1,836
No. 2 shaft (ventilation)	S.67630	Vertical	3	.....	1,250

Development in 1959 consisted of 12,391 feet of drifting, 12,081 feet of crosscutting, and 21,454 feet of raising. Total development footages to December 31, 1959, were as follows; drifting, 29,586 feet; crosscutting, 19,231 feet; raising, 35,905 feet. Diamond-drilling in 1959 consisted of 30 holes from underground totalling 5,311 feet, and 4 holes from surface totalling 3,183 feet.

URANIUM—Continued

New construction included: an addition (61 by 24 ft., 12 ft. high) to the recreation hall; an addition (28 by 16 ft., 20 ft. high) to the mine compressor building; and a chain-link security fence (750 feet long, 6 feet high).

New equipment installed was as follows: 1 high-pressure compressor (29 by 18 by 14.5, 28,000-cfm., Canadian Ingersoll-Rand, with 500-hp. motor, General Electric); 1 low-pressure compressor (17 by 17 by 10, 1,700-cfm., Canadian Ingersoll-Rand; with 200-hp. motor, English Electric); 1 standby generator (750-kw., Fairbanks-Morse; with diesel engine, 12-cylinder, 1,425-bhp., General Motors); 1 crusher (36 by 48 ins., Traylor, type H) with 1 chain feeder (capacity 307-tph., Ross), and 1 filter-plant (10,000-cfm. Rabson), at 12th-level crusher station; 1 clarifier (7 by 5, 200-gpm., Whitco); 1 lime-grinding mill (3.3 by 3 feet), and 1 magnesium oxide precipitation unit, in the mill; 2 tailings pipelines; and semi-automatic push-button remote-control on the ore-skips.

A total of 1,109,729 tons of ore was hoisted; 1,110,029 tons was milled at an average daily rate of 3,041 tons.

SPANISH AMERICAN MINE

Operations at the Spanish American mine in Township 150 were discontinued in February 1959. The surface-shaft and ventilation openings were sealed with thick concrete slabs, and the workings were allowed to flood.

SHAFTS, SPANISH AMERICAN MINE

Shaft	Claim No.	Inclination	Number of Compartments	Total Depth from Surface
				feet
No. 1 (production)	S.68305	Vertical	3 to 3,097 feet 4 to bottom	3,476
No. 2 (service)	S.68303	Vertical	3	3,163

All mining operations were conducted on the 3,100-foot level. At the time of closing, totals of 7,056 feet of drifting, 4,286 feet of crosscutting, and 6,797 feet of raising had been completed. The following is taken from the annual report for the year ending December 31, 1959.

NORTHSPAN URANIUM MINES LIMITED

By December 31, 1959, approximately 9,587,500 pounds of U_3O_8 had been delivered; the company's contract with Eldorado Mining and Refining Limited is for 26,673,500 pounds.

After many difficulties, which Northspan had to face in the earlier years of its operations, 1959 marked a definite turning point. By the end of the year the two mines, in operation after the closing of the Spanish American mine in February, were producing sufficient ore to provide all the Company's needs. However, during the year approximately 33 percent of the mill-feed was mined from the adjoining claims of Algom Uranium Mines Limited, and a further 9 percent was purchased from Algom under an agreement which terminated at the end of 1959. Output per man-shift, particularly at Lacnor, rose sharply.

Upon the approval of the amalgamation plan by the shareholders of the amalgamating companies, shaft-deepening at Lacnor was halted at a depth of 3,663 feet at No. 1 and 3,380 feet at No. 2 shafts. Conversion to track-mining has largely been completed at both mines. Development at Lacnor and Panel amounted to 76,306 feet and 47,266 feet respectively for the year.

Principal production results are given in the table below:

	Lacnor		Panel	
	1959	1958	1959	1958
Milled.....tons	1,395,230	1,268,939	1,110,029	776,913
Average daily milling rate.....tons	3,823	3,476	3,050	2,395
Average calculated heads..lb. U_3O_8 per ton	2.058	1.89	2.38	1.95
Average recovery, based on average calculated heads.....percent	93.3	91.5	94.12	92.37

URANIUM—Continued

Both operations came into full production in mid 1958, and improvements made since then have been due to increased technical and mechanical efficiency.

In 1959 operating costs per ton milled, before administration expense, interest, Ontario mining tax and amortization, were reduced significantly to $10.91 at Lacnor, and to $12.06 at Panel, compared with $11.61 and $13.45, respectively, for the six-month period ending December 31, 1958.

The proven and probable ore reserves given below are taken at October 31, 1959:

Source	Lacnor		Panel	
	tons	pounds U_3O_8 per ton	tons	pounds U_3O_8 per ton
Proven ore[1]	551,623	2.12	299,847	2.30
Probable ore:				
Disclosed by underground development[1]	1,027,119	2.11	946,216	2.23
Disclosed by diamond-drilling[2]	5,202,054	2.22	9,016,654	2.28

[1]Includes dilution based on experience.
[2]Tonnages and grades undiluted.

No figures have been included for the Spanish American property, owing to the suspension of operations there. The reserves include ore under lease from Algom in adjoining claims.

In considering the above-quoted Lacnor ore-reserve figures, it should be mentioned that the drop in tonnage over the past year is greater than the tonnage mined during the same period. This is mainly due to two facts: (1) underground work has shown certain sections to be uneconomic to mine; (2) pillars included in the ore-reserve statement of the last annual report have now been excluded as unlikely to be mined.

At the Panel mine a larger tonnage has been mined from stoped areas than had been estimated to exist by surface-drilling methods. The greater tonnage in the orebody was due to (a) the thickness of ore being found to be greater than estimated and (b) the extension of ore of satisfactory grade beyond the limit originally assumed.

In addition, surface drilling carried out during the year increased the "probable ore as disclosed by diamond-drilling" in the area under lease from Algom Uranium Mines Limited.

Labour relations continued harmoniously, and new two-year labour contracts, effective from January 1, 1960, have been signed with the United Steelworkers of America.

During the year, operations had improved to the extent that, after $22,340,668 had been provided for amortization, the net loss for the year was $2,352,722, compared with a loss for the last six months of 1958 of $5,067,085 after amortization of $11,886,017.

Current liabilities (excluding the portion of long-term debt maturing within one year) were reduced during the course of the year from $17,975,607 at December 31, 1958, to $6,303,946 at December 31, 1959.

The average number of employees at the Lacnor mine was 1,086: 650 underground, and 436 on surface. G. L. Hatherly was mine manager.

The average number of employees at the Panel mine was 965: 555 underground, and 410 on surface. G. A. Jewett was mine manager.

The average number of employees at the Spanish American mine was 112: 36 underground, and 76 on surface. G. M. Godfrey was mine manager.

Pronto Uranium Mines Limited

Pronto Uranium Mines Limited was incorporated in June 1953 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 2,710,713 shares have been issued. The directors and officers were: W. H. Bouck, president; R. D. Lord, vice-president and managing director; J. H. Hirshhorn, D. S. Beatty, J. S. Gairdner, Roger Jeanty, and S. B. Randolph, directors; George Baker, secretary; D. A. Macfarlane, treasurer. The head office is at 335 Bay Street, Toronto. The mine address is Algoma Mills.

The company holds 139 claims in Long and Spragge townships, District of Algoma.

URANIUM—Continued

SHAFTS, PRONTO MINE

	Claim No.	Inclination	Number of Compartments	Sinking in 1958	Total Depth from Surface
				feet	feet
Adit	S.S.M.23537	26°	.....	.....	55
No. 1 shaft	S.S.M.23523	Vertical	4	301	974

Development during the year consisted of 4,907 feet of drifting, 2,152 feet of crosscutting, and 380 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 24,350 feet; crosscutting, 10,103 feet; raising 5,305 feet. Diamond-drilling in 1959 consisted of 191 holes from underground totalling 9,976 feet, and 41 holes from surface totalling 16,704 feet. Some 200 feet of trenching was completed on surface.

New construction included a mine-rescue building, having a concrete floor, asbestos siding, asbestos and tar roof.

New equipment added was as follows: 1 new type E stoker, and ash-disposal system, on No. 3 boiler; 1 screen (4 by 8 ft., Nordberg), and 1 feeder (4 by 7 ft., Syntron), in crusher-house; 2 slushers (30-hp., Sala), 1 mucking machine (Eimco B21), and 44 stoper and jack-leg drilling-machines, for underground.

The following is taken from the annual report for the year ending December 31, 1959:

In May 1959 the company entered into an extension-contract with Eldorado Mining and Refining Limited for the delivery of 1,508,000 pounds of U_3O_8 at a price of $8.00 (U.S.) per pound between the date of completion of the original contract and March 1962. By December 31, 1959, approximately 4,279,000 pounds had been delivered to Eldorado; the contract total is 7,008,000 pounds.

The plant operated continuously and at capacity throughout the year. Various operational improvements were effected, and resulted in a considerable increase in earnings. A slightly lower mill-feed grade than last year was offset by improved recovery in the mill and by lower operating costs for the year. Production is summarized in the following table:

	1959	1958
Milled ..... tons	576,690	549,976
Average daily milling rate ..... tons	1,580	1,507
Average calculated heads ..... lb. U_3O_8 per ton	2.29	2.36
Average recovery based on average calculated heads ..... percent	93.3	91.5

Operating costs per ton of ore milled, before administration expense, interest, Ontario mining tax and amortization, were $10.83 compared with $11.59 in 1958. Improved productivity in all operating departments, and studies in the use of reagents, brought about the reduced operating costs.

Proven- and probable-ore reserves which, in view of the proposed amalgamation, were re-calculated as of October 31, 1959, are set out below:

Source	Quantity	U_3O_8 per Ton
	tons	pounds
Proven ore[1]	535,844	2.49
Probable ore:		
Disclosed by underground development[1]	137,142	2.39
Disclosed by diamond-drilling[2]	647,685	2.57

[1]Includes dilution based on experience.
[2]Tonnage and grade diluted.

URANIUM—Continued

A limited program of diamond-drilling was carried out on surface during the year and, except for minor additions in the eastern extension of the main zone, results were negative.

There were no major changes in plant and equipment; capital expenditures were at a minimum. During the year the company acquired, by the issue of 186,666 treasury shares to Pater Uranium Mines Limited, the property and assets of that company with a view to utilizing Pronto equipment and facilities in the mining and milling of the Pater copper ore indicated by previous diamond-drilling and underground work.

Employee relations continued harmoniously, and new labour contracts were negotiated with the United Steelworkers of America, effective January 1, 1960, for a one-year period.

During the year the company distributed $2,710,713 to shareholders in two dividends totalling $1.00 per share; a further dividend of 60 cents per share was declared payable on April 20, 1960. In addition, the working capital of the company showed an increase of $2,000,000 for the year. Net profit after amortization was $3,336,226, or $1.23 per share, compared with $1.00 per share for the previous year computed on the number of shares issued as at December 31, 1959. The company's period of exemption from federal and provincial corporation taxes ended on April 30, 1959. However, owing to application of allowances under the income tax act, no liability for income tax has been estimated for the period to December 31, 1959.

Mortage debentures in the principal amount of $1,174,500 were purchased for cancellation during the year, leaving an outstanding amount of $679,000 for retirement in 1960.

Several innovations at the property contributed to operating improvements and the completion of a successful year.

The average number of employees was 504: 288 underground, and 216 on surface. P. E. Young was mine manager.

Stanleigh Uranium Mining Corporation Limited

Stanleigh Uranium Mining Corporation Limited was incorporated in August 1954 with an authorized capitalization of 5,000,000 shares of $1 par value, of which 3,930,075 shares have been issued. The directors and officers were: W. C. Pitfield, president; R. C. Payn, J. I. Crookston, J. H. Shepherd, F. Armstrong, G. H. Cohen, R. C. Mott, W. C. Cochrane, and E. R. Thomas Jr., directors: R. C. Ashenhurst, secretary-treasurer. The head office is at 85 Richmond Street West, Toronto. The mine address is Elliot Lake.

The property consists of 108 claims in Townships 148 and 155, Blind River area, District of Algoma.

SHAFTS, STANLEIGH MINE

Shaft	Claim No.	Inclination	Number of Compartments	Total Depth
				feet
No. 1	S.75393	Vertical	4 to 3,792 feet 3 from 3,792 to 3,846 feet	3,846
No. 2	S.75393	Vertical	3	3,650

No. 1 shaft was sunk 54 feet to a total depth of 3,846 feet below the collar, and the 14th level established at 3,606 feet. The 9th level was established at 3,531 feet in No. 2 shaft.

Development during the year consisted of 21,347 feet of drifting, 4,514 feet of crosscutting, and 30,289 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 25,580 feet; crosscutting, 10,788 feet; raising, 31,800 feet. Some 675 diamond-drill holes, totalling 20,654 feet, were completed from underground during 1959.

New equipment added was as follows: 1 tractor (Caterpillar, D6); 5 diesel locomotives, (4.5-ton, Ruston-Hornsby); 5 mucking machines (Eimco, 21); 23 aerofoil fans (Woods, No. 19 JTK); 30 slusher hoists (Sala); 6 transformers (1,000-kva., Canadian General Electric); and a vacuum pump was converted to a 2,000-cfm. compressor.

URANIUM—Continued

A total of 952,773 tons of ore was hoisted; 949,120 tons was milled at an average daily rate of 2,600 tons.

The following is taken from the mine manager's report for the year ending June 30, 1959:

All 108 mining claims held by the company in the Elliot Lake area remained in good standing. Surface rights to a parcel of about 15 acres adjoining highway No. 108 were sold during the year to the Improvement District of Elliot Lake. Approximately 19 acres were added to the Stanleigh property by the settlement of a disputed claim-fraction along the south boundary. This fraction is thought to lie within the ore-zone.

Production

The tonnage of ore treated during the year from July 1, 1958, to June 30, 1959, was 846,347 tons, from which was produced 1,688,039 pounds of uranium oxide. Mill-head grade was 2.082 pounds per ton and recovery was 95.76 percent, giving a yield of 1.994 pounds per ton.

Mining

Operations now extend about 2,600 feet along strike and about 2,400 feet up the dip from No. 2 shaft. Mine grade has continued to meet expectations, and indeed, has exceeded the forecasts which were made from the original surface-drilling.

The following figures summarize mining operations for the fiscal year 1958-59:

	Tons
Ore hoisted	841,843
Waste hoisted	159,914
Ore broken	848,321

Source of ore:

	Percent
Trackless mining	62.9
Conventional stoping	21.5
Conventional development	15.6

The efforts of the mining department for the major portion of the year were concerned with the problem of effecting the change-over from trackless mining to conventional mining without a serious drop in tonnage. This was accomplished by shifting the emphasis gradually from one method to the other. Although some ore was derived from conventional development in July, production from the stopes did not begin until October, when less than 13 percent of the ore came from conventional mining. This figure was raised to 65 percent by the following June.

A rise in mill-head grade accompanied the conversion. During the first three months of the fiscal year, heads ran 2.056 pounds per ton. The corresponding figure for the last three months was 2.150, consisting of ore from trackless methods grading 2.026 and conventional ore grading 2,246 pounds per ton. This difference is due to the greater selectivity inherent in conventional methods.

Trackless-mining operations were concentrated during the latter months of the year on pillar recovery in previously mined-out areas. In June, some virgin ground in the northwestern portion of the mine was laid out for trackless operations. Here the dips and bed-thicknesses are suitable for the method, and it is believed that under such conditions the mining costs will be no greater than conventional mining because no waste development is necessary.

Milling

Milling operations during the year were dominated by a number of flow-sheet changes that produced marked improvements in the efficiency and economy of operations. These included the addition of an ion-exchange regeneration plant in August, and an increase in pulp density in the leaching section in November. In January, precipitation by means of anhydrous ammonia instead of caustic soda was adopted on a permanent basis; this promptly induced decreased operating costs and improvements in the grade and quality of the final product.

The plant was operated continuously throughout the year, and no undue difficulty was experienced with any of the equipment.

Plant and Equipment

In July 1958 only a few minor items of plant construction remained to be completed. These, finished during the past year, consisted of revisions to the machine shop, the change house, and the office; conversion of temporary buildings into bunkhouses; the construction of oil storage facilities; and exterior painting.

The only major plant addition was the provision of a surface-bin for waste-handling. This was in operation at the end of August.

URANIUM—Continued

Costs

Operating costs at the property, which were higher during the first part of the year, declined to $5.61 per pound by the end of the year; further reductions may be expected as efficiencies improve.

The average number of employees was 944: 605 underground, and 339 on surface. C. E. Powker was mine manager.

Stanrock Uranium Mines Limited

Stanrock Uranium Mines Limited was incorporated in March 1956 with an authorized capitalization of 5,000,000 shares of $1 par value. In 1958 the number of shares was increased to 6,000,000, of which 4,963,286 have been issued. The directors and officers were: Hugh Fulton, president; N. C. Steenland, V. V. Jacomini, John Dunning, E. V. Huggins, J. C. Ward, and D. S. Robertson, directors; Harmon Duncombe, secretary; D. C. Marshall, treasurer. The head office is at 121 Richmond Street West, Toronto. The mine address is Box 1700 Elliot Lake.

The company holds 22 claims in Townships 144 and 150, Blind River area, District of Algoma.

Mining operations in Township 144 continued throughout 1959.

SHAFTS, STANROCK MINE

	Claim No.	Inclination	Number of Compartments	Total Depth
				feet
No. 1 shaft	S.82324	Vertical	3	3,379
No. 2 shaft	S.82323	Vertical	3	2,953
Service raise	S.82323	Vertical	3	220

The shafts are about 800 feet apart. There is a main level from No. 1 shaft at a depth of 3,277 feet, and a main level from No. 2 shaft at a depth of 2,909 feet. A connection between these two was made in 1958. There are also two adits, one leading to each shaft, in a steep hillside near the shafts. The crushing and grinding equipment and a fine-ore bin are located in chambers excavated inside the hill. The crushing and grinding operation began on February 15, 1958.

Development during the year consisted of 30,621 feet of drifting, 2,391 feet of crosscutting, and 2,042 feet of raising. Total-development footages to December 31, 1959, were as follows: drifting, 62,825 feet; crosscutting 2,391 feet; raising 2,481 feet. Some 117 diamond-drill holes, totalling 5,478 feet were completed from underground during 1959.

New construction included a Cochrane Dunlop prefabricated H-shaped building, comprising two buildings 141 by 8 feet, joined by a 20- by 28-foot building.

New equipment installed consisted of a rope suspension conveyor (1,550 ft. long, Goodman) underground, and an auxiliary mine-air-heating unit (2,000,000 btu., Reznor).

A total of 1,019,236 tons of ore was hoisted; 1,016,493 tons was milled at a daily average of 2,785 tons.

The average number of employees was 926: 441 underground, and 485 on surface. F. R. Jones was mine manager.

METALLURGICAL WORKS

Algoma Steel Corporation Limited

Algoma Steel Corporation Limited was incorporated in December 1934. The authorized capitalization was changed in 1957 to 15,099,880 shares of no par value, of which 5,766,180 shares have been issued. The directors and officers were: D. S. Holbrook, president; J. B. Barber, Hon. T. A. Crerar, Sir Philip Dunn, H. S. Hamilton, W. H. Howard, T. R. McLagan, Gordon McMillan, James Muir, J. S. D. Tory, and Wilhelm Zangen, directors; Douglas Joyce, vice-president in charge of operations; H. G. MacAdam, secretary; C. E. McLurg, treasurer. The head office and plant is at Sault Ste. Marie.

Operations continued throughout 1959. No. 1 blast furnace has been dismantled, No. 2 furnace was idle.

PRODUCTION OF IRON, ALGOMA STEEL CORPORATION

Furnace	1958		1959	
	Months of Operation	Production	Months of Operation	Production
		tons		tons
No. 3	7	120,281	11	227,654
No. 4	7	74,236	9	149,565
No. 5	12	436,025	12	473,765
No. 6	9	396,617	12	579,310
Total	12	1,027,159	12	1,430,294

The relining of No. 5 blast furnace in-wall was commenced at the end of the year.

The installation of a 175,000-pounds-per-hour steam generating plant and an 85,000-cubic-foot-per-minute turbo-blower, both commenced in 1958, was completed.

The average number of employees in the blast furnace division was 524. W. Dowhaniuk was superintendent.

Canadian Furnace Company Limited

Canadian Furnace Company Limited was incorporated in June 1950 to succeed Canadian Furnace Limited. The authorized capitalization is 50,000 shares of no par value, of which 25,000 have been issued. The directors and officers were: D. S. Holbrook, president; Gordon McMillan, vice-president; J. B. Barber, vice-president, finance; Douglas Joyce, and T. R. McLagan, directors; O. H. Hugill, general manager; H. G. MacAdam, secretary; C. E. McLurg, treasurer. The head office address is c/o Algoma Steel Corporation Limited, Sault Ste. Marie. The plant is at Port Colborne.

The No. 1 blast furnace operated a total of 242 days during the year producing 122,135 tons of pig iron. In 1958, during 160 days of operation, 82,762 tons of pig iron was produced.

The average number of employees was 148. Thomas Cordner was superintendent.

METALLURGICAL WORKS—Continued

Canadian Industries Limited

The new No. 2 sulphuric acid plant of Canadian Industries Limited commenced operation in March 1958. It was constructed to produce sulphuric acid from the stack gas of International Nickel Company's iron-ore recovery plant. The No. 1 and No. 2 sulphuric acid plants, and the liquid sulphur dioxide plant, all located at Copper Cliff, resumed operations in mid-January, having been closed earlier owing to the strike at International Nickel Company of Canada Limited.

No. 1 plant produced 56,345 tons of acid, averaging 157.3 tons daily.

No. 2 plant produced 125,385 tons of acid, averaging 353.2 tons daily.

The liquid sulphur dioxide plant produced 72,720 tons.

The average number of employees was 98. A. A. Perley was works manager.

Deloro Smelting and Refining Company Limited

The Deloro Smelting and Refining Company Limited was incorporated under Dominion charter in July 1916. In November 1936 it was converted to a private company by supplementary letters patent, with an authorized capitalization of 15,000 shares of $85 par value, of which 11,900 shares have been issued. The directors and officers were: B. A. O'Brien, president; Alan Scott, vice-president; R. G. Walsh, general manager; M. J. O'Brien, W. S. Kirkpatrick, J. S. Carter, and M. J. Murray directors: R. F. Burns, secretary-treasurer. The head office and plant is at Deloro.

Production of Metals

Metals		1958	1959
Silver	ounces	3,526,413	4,128,601
Arsenic	pounds	1,730,140	1,175,766
Nickel, nickel oxide	pounds	172,026	181,960
Cobalt metal powder and shot	pounds	447,198	176,344
Cobalt oxide, black	pounds	162,951	278,946
Cobalt oxide, grey	pounds	13,933	13,680
Cobalt carbonate	pounds	6,754	3,508

A carbon determinator was added to plant equipment.

The average number of employees was 200. J. N. Cram was resident manager.

Dominion Foundries and Steel Limited

Dominion Foundries and Steel Limited was incorporated in May 1917. The authorized capitalization was 51,731 preferred shares of $100 par value and 5,000,000 common shares of no par value, of which 41,435 preferred and 3,516,079 common shares have been issued. The directors and officers were: F. A. Sherman, chairman; A. G. Wright, vice-chairman; F. H. Sherman, president; F. A. Loosley and D. F. Hassel, vice-presidents; A. C. Anderson, and R. R. Craig, vice-presidents, sales; D. O. Davis; vice-president, engineering; D. A. Lindsey, vice-president, purchases; J. G. Sheppard, secretary and comptroller. The head office and plant is at Hamilton.

The construction of No. 3 blast furnace and accessory installations was commenced. No. 3 furnace will be similar to the two existing blast furnaces; however, revisions in design are expected to bring improved operating efficiency.

METALLURGICAL WORKS—Continued

The company uses pipelines to supply the adjoining Cyanamid of Canada plant with such byproducts as nitrogen gas, coke-oven gas, blast-furnace gas and steam at 400 psi., all of which are used in the Cyanamid plant to produce urea.

No. 1 and 2 blast furnaces operated throughout 1959, producing a total of 746,241 tons of pig iron. Production in 1958 amounted to 633,939 tons.

The average number of employees in the blast furnace division was 190. H. C. Taylor was superintendent; Lloyd Thomas was assistant superintendent.

Noranda Mines Limited

Noranda Mines Limited was incorporated in May 1922 with an authorized capitalization of 6,000,000 shares of no par value, of which 4,479,544 shares have been issued. The directors and officers were: J. R. Bradfield, president; R. V. Porritt, vice-president and general manager; F. M. Connell, Hon. G. B. Foster, J. Y. Murdoch, J. I. Rankin, Jean Raymond, H. L. Roscoe, L. H. Timmins, J. R. Timmins, and N. C. Urquhart, directors; C. H. Windeler, secretary; R. G. Rudolf, treasurer. The head office is at 44 King Street West, Toronto.

SULPHUR-IRON DIVISION
(Port Robinson Plant)

The company's sulphur-iron plant near Port Robinson, in Stamford township, Welland county, adjoining the Welland plant of Cyanamid of Canada Limited, closed on February 6, 1959.

The following table shows the number of tons of material received and processed during the period of operation:

	Tons
Pyrite	5,555
Calcine	161
Pyrrhotite	1,453

The following table shows the production during the period of operation:

	Tons
Iron sinter	5,424
Sulphur	nil
Sulphur dioxide	4,189

The average number of employees was 15. J. C. McDonald was plant manager.

SULPHURIC ACID DIVISION
(Cutler Plant)

The company's sulphur-iron division located on the north shore of Lake Huron, in the Serpent River Indian Reserve, Lewis township, District of Algoma, operated throughout 1959.

The plant supplies a large part of the sulphuric acid used in the leaching of the uranium ore in the Elliot Lake area.

New construction during the year included a 30- by 70-foot Coseley warehouse storage building, and a 30- by 34-foot concrete-block extension to the administration building.

METALLURGICAL WORKS—Continued

The following table shows the number of tons of material received and processed during the year:

	Long Tons
Pyrite	177,679
Pyrrhotite	40,478

The following table shows the production during the year:

	Long Tons
Sulphuric acid (60° B)	372,000
Iron sinter	82,874
Iron calcine	59,187

The average number of employees was 304. T. R. Wearing was plant manager.

Quebec Metallurgical Industries Limited

Quebec Metallurgical Industries Limited was incorporated in December 1945. The authorized capitalization is 6,000,000 shares of no par value, of which 5,060,100 shares have been issued. The directors and officers were: N. B. Davis, president; W. J. Tough, vice-president; J. R. Tolmie, secretary; A. G. Fulton, A. J. Anderson, B. G. Edward, and Senator N. M. Paterson, directors: C. van Eeden, assistant-secretary and treasurer. The head office is at 88 Metcalfe Street, Ottawa. The Toronto office is at 25 King Street West.

The company is controlled by Frobisher Limited and Ventures Limited; it operates its metallurgical laboratory on Albion Road, Ottawa, and the refinery of the former Cobalt Chemicals Limited, in the Gillies Limit, District of Timiskaming, about six miles south of Cobalt. Operations at the refinery during the year were very limited and, on December 30, it was sold.

Experimental work continued at the research laboratory throughout the year.

The average number of employees was 13. R. P. Bailey was manager.

The Steel Company of Canada Limited

The Steel Company of Canada Limited was incorporated in June 1910 with an authorized capitalization of 2,000,000 preferred shares of $5 par value, and 3,000,000 common shares of no par value. In April 1953 the capitalization was changed to 5,133,328 common shares of no par value, 4,338,338 of which have been issued. The directors and officers were: H. G. Hilton, chairman and chief executive officer; V. W. T. Scully, president; E. G. Baker, G. R. Ball, Allan Graydon, G. A. R. Hart, Frederick Johnson, R. A. Laidlaw, L. L. Lang, R. H. McMaster, H. Greville Smith, and W. Taylor-Bailey, directors: R. B. Taylor, vice-president and treasurer; N. J. Brown, vice-president and comptroller; L. T. Craig, H. M. Griffith, H. M. Mawhinney, and H. J. Clawson, vice-presidents; W. C. Chick, secretary and assistant treasurer; J. G. Collinson, assistant secretary; A. S. Marshall, and B. M. Kinnear, assistant treasurers; R. E. Karr, assistant comptroller. The address of both the head office and the blast furnace division is Wilcox Street, Hamilton.

METALLURGICAL WORKS—Continued

PRODUCTION, THE STEEL COMPANY OF CANADA, 1958 AND 1959

Furnace	1958		1959	
	Operated	Pig Iron Produced	Operated	Pig Iron Produced
	days	tons	days	tons
A	223	63,103	304	97,441
B	270	212,189	362	272,306
C	269	301,949	285	350,207
D	258	364,161	288	566,086
Total	.....	941,402	.....	1,286,040

Production was curtailed owing to time lost in rebuilding the blast furnaces as follows: A furnace, 61 days; C furnace, 76 days; and D furnace, 68 days.

A study is in progress to increase sinter-plant facilities in order to augment the production of calcined or self-fluxing sinter used for blast furnace feed. The self-fluxing sinter produces a comparable grade of pig iron at increased production rates, with decreased coke consumption and flue-dust loss.

The average number of employees in the blast furnace division was 526. J. S. McMahan was superintendent, J. A. Peart, assistant superintendent.

Strategic-Udy Metallurgical and Chemical Processes Limited

Strategic-Udy Metallurgical and Chemical Processes Limited is a subsidiary of Strategic Materials Corporation. The directors and officers were: J. C. Udd, president and treasurer; S. D. Lunt, R. O. Denman, G. S. Diamond, M. C. Udy, and R. D. Weldon, directors: G. C. Monture, vice-president; E. H. Damon, secretary. The head office and plant is at 3527 Stanley Avenue, Niagara Falls.

The company is engaged in research and development of metallurgical processes. Work was continued during the year on the reduction and recovery of iron and ferro-manganese alloys from manganiferous ores, and on the recovery of iron and the selective reduction of lateritic ores for the production of ferro-nickel, ferro-chromium, and steel.

The average number of employees was 96. F. C. Senior was general manager, J. D. Mooney was superintendent.

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ONTARIO
DEPARTMENT OF MINES

HON. JAMES A. MALONEY, *Minister* H. C. RICKABY, *Deputy Minister*
M. E. HURST, *Provincial Geologist*

Geology of the Saganash Lake–Wakusimi River Area

By

R. C. McMURCHY

Volume LXIX, Part 3, 1960

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KEY MAP

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Key map showing the location of the Saganash Lake–Wakusimi River area	1

COLOURED GEOLOGICAL MAP

Map No. 1960a—Saganash Lake Area, District of Cochrane, Ontario. Scale, 1 inch to 1 mile ..... *map case*

Geology of the Saganash Lake–Wakusimi River Area

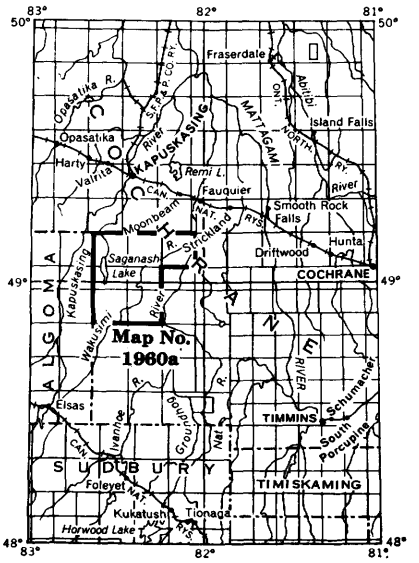
BY

R. C. McMurchy[1]

INTRODUCTION

This report deals with the geology of Staples, Fenton, Seaton, Casselman, Slack, Griffin, and Macvicar townships, District of Cochrane. The area is between latitude 48° 51′N. and 49° 11′N., longitude 82° 06′W. and 82° 39′W. The eastern part of Macvicar township was not mapped.

The area is about 16 miles due south of Kapuskasing, the nearest large town, which is on the northern branch of the Canadian National railway.



Key map showing the location of the Saganash Lake–Wakusimi River area, District of Cochrane. Scale, 1 inch to 50 miles.

Present Report

Since very little was known about this part of the province, an area that included eighteen townships was chosen to be surveyed in 1958. To facilitate this work and mineral exploration the Ontario Department of Mines arranged for an air magnetometer survey to be made early in 1958; maps showing the results were issued in May of the same year.

Magnetometer maps for each of the eighteen townships surveyed were published. The seven townships forming the subject of this report make up the western section of the area surveyed magnetically. Iron formation, discovered about 1945 in Fenton township, was explored by a syndicate in 1946 and 1947. The syndicate's claims were later allowed to lapse, but in March, 1958, many of them were restaked by Harry Isaacs of Toronto.

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[1]Consulting geologist, Toronto.

The magnetometer maps were found to be of great assistance by the author, particularly in areas where outcrops are rare. In many places the nature of the underlying rocks can be inferred with confidence by using the magnetic data in conjunction with known geology.

Also of great value to the survey party were the forestry maps of Spruce Falls Power and Paper Company. These not only show the type of tree present and other features of indirect value to the survey but also show the location of rock outcrops observed by timber cruisers.

Air photos on the scales of 1 inch to ¼ mile and 1 inch to 1 mile were found to be of little use. Only prominent ridges of rock showed clearly, and since most of the area is extremely flat very little could be gained by using a stereoscope. Glacial features, however, often showed up very well; linears showing direction of movement of ice, eskers, and beaches are quite definite.

The geological party consisted of the author, one senior assistant, and two junior assistants. It operated in pairs, the senior assistant doing independent work.

Mapping was done on a scale of 1 inch to ¼ mile. Traverses were directed towards areas of known outcrop, areas where outcrops were likely to occur, and areas where it was particularly desirable to obtain information. Many large sections believed to lack outcrops were not traversed. In many cases the geology can be inferred from the magnetic maps.

The amount of outcrop varies greatly within the map area. Fenton and Seaton townships have the most exposed rock. A ridge containing bands of iron formation has a high proportion of outcrop for a distance of 4 miles and a width of 1 mile in Fenton, and for a distance of 6 miles and a width of ¼–½ mile in Seaton township. Staples and Griffin townships have the least outcrop; the former having only four known outcrops, and the latter having outcrop on the shores of Griffin Lake and over an area 1 mile by 1 mile in the south-central part of the township.

Means of Access

The area surveyed may be reached by road, air, or water, but no single means of transportation is practical. A combination of travel by truck, airplane, and canoe was employed within the area.

An all-weather gravel road crosses the area in a southwesterly direction through Casselman, Fenton, and Seaton townships. This private road of the Spruce Falls Power and Paper Company joins a township road about 6 miles south of highway No. 11. The township road joins the highway just west of Moonbeam, a small town about 12 miles east of Kapuskasing.

The gravel road, known as the Chain-of-Lakes road, was used extensively. This and two short branch roads are shown on the geological map. (No. 1960a, in map case.)

Since the hauling of pulpwood is mostly done in winter, other roads are fit for travel in that season only. In summer, although they facilitate travel on foot, these roads are generally wet.

Another means of reaching parts of the area is by pole tracks on which small trucks operate. Spruce Falls Power and Paper Company has a number of these tracks by which they service some of their camps in summer.

Only a few lakes are suitable for landing pontoon-equipped aircraft. The usual point of departure is Remi Lake, 4 miles north of Moonbeam. The Department of Lands and Forests and a private company operate from bases on this lake.



.ir Photograph of Part of Seaton Township. Numerous Outcrops Form a Ridge
'ending North-South Across the Area Just East of Seaton Lake.
ıe Ridge Consists Mainly of Hornblende Schist

Kapuskasing River flows past the west side of the area in a general northerly direction, and the Groundhog River flowing in the same direction passes near the east side. Spruce Falls Power and Paper Company operates a tug boat on the former. From Kapuskasing the river is ascended to Big Beaver Falls a distance of about 10 miles. From there a private railway runs south some 15 miles to Camp 15. A branch line of the railway runs southeast to old Camp 33 on the north shore of Saganash Lake. This lake, in Staples and Fenton townships, served the field party as a base of operations for a few days.

The Groundhog River may be ascended from highway No. 11 or from the Canadian National railway at Fauquier or descended from the branch of the same railway that runs through Capreol, Foleyet, and Hornpayne. It is a difficult river to travel due to rapids and logging operations.



Truck and trailer on pole tracks, Seaton township. Note the recent burn.

Previous Geological Work

Until 1947 little if any geological work had been done in this area. In the summer of that year Nelson Hogg of the Ontario Department of Mines spent several weeks mapping part of Fenton township. Interest in the area at that time was due to exploration for iron by a syndicate composed of employees of Spruce Falls Power and Paper Company. Mr. Hogg's findings were published as a preliminary report and map.[1]

The territory immediately north of the present author's map area was surveyed in 1935 and 1936 by parties under the direction of L. J. Weeks for the Geological Survey of Canada. A map (No. 411A—Hearst-Kapuskasing area (east sheet)) with descriptive notes was published in 1938. No rock is shown immediately adjoining the author's map area.

[1]Nelson Hogg, *Geology of Portion of Fenton Township, District of Cochrane,* Ont. Dept. Mines, Prelim. Report, P.R. 1948-1, 1948.

Topography

Except for the main areas of rock outcrop, the surface of most of the area mapped is monotonously flat. Large, flat areas are generally covered by spruce or swamp. Lack of relief results in poor drainage and uniform wetness. This in turn means it is expensive to build roads suitable for summer travel by car, but cheap to build winter roads and pole tracks.

Relief caused by rock outcrop, such as the ridge through Fenton township, seldom exceeds 30 feet and is often only 10–15 feet. The valley of a small stream entering Saganash Lake at the south end is up to 70 feet deep, and the east wall steep or precipitous in places. Where ridges of rock occur, the trend is north or northeast following the strike of the bedding and schistosity.

Relief due to glacial action may be caused by the deposition of material or by the scouring action of the ice. The former may be up to 50 feet high, the latter generally less than 10 feet. Esker complexes with pot-hole lakes are conspicuous on the ground and in air photographs. Glacial features are dealt with in a later section.

Streams cutting through clay and sand have made banks up to 25 feet high, but generally less.

Drainage

As the area is very flat with few streams and lakes, it is poorly drained. The Wakusimi River, the only river navigable by canoe for more than a few miles, flows northeastward through the area. Its course is interrupted at a few places by boulder rapids and rock falls. Rains cause sudden fluctuations in the level of this river.

Saganash Lake, which drains into the Kapuskasing River, is 9 miles long and is the largest lake in the area. A dam at its outlet is used to help control the level of the Kapuskasing River to facilitate logging operations.

Some of the pot-hole lakes, such as occur along the Chain-of-Lakes road, have no outlets and therefore do not contribute to the drainage of the area.

The regional drainage is north to Hudson Bay.

Natural Resources

FORESTS

The map area is entirely within the limits of Spruce Falls Power and Paper Company. This company has extensive holdings, and in 1958 operations were being conducted in the map area at Camps 75, 92, 60, and 81.

There are many good stands of spruce within the area. These trees are considered the most desirable by the paper company. Small amounts of balsam and poplar are also cut. Birch and cedar are common and often of good size. A few pine were seen in the southern part of the map area.

Knolls and ridges of glacial origin, even if only a few feet higher than the surrounding ground, show a change in tree type. Such changes are conspicuous on the ground and on air photos.

WATER POWER

There being no large rivers or extensive water basin within the area there is no development of hydro-electric power.

Outside the map area power is generated on the Kapuskasing and Mattagami rivers.

FISH AND GAME

Since there are few lakes and rivers, fishing is not of much importance. Shack, Pratt, Esmee, and Keenoa lakes are near the Chain-of-Lakes road and are the fishing grounds of the inhabitants. Pickerel and pike are found in these lakes and also in Saganash and Griffin lakes. The latter is less accessible than the other lakes, and pickerel appear to be more plentiful there.

Moose are numerous throughout the area. Bear are common, and deer are found on higher ground.

Ruffed grouse, spruce partridge, and duck are common but not seen in great numbers.



Air view looking east from the Chain-of-Lakes road, showing Pratt and Esmee lakes, Seaton township.

Acknowledgments

The results of Nelson Hogg's work in Fenton township are incorporated in this report. Some generalization of rock types and outcrops has been done to conform with the present work. The previous work was found to agree well with the author's findings and was of considerable help in the present survey.

Assistants for the season were: W. W. Hutchison, N. R. Fisher, and W. R. Rouse. All three gave energetic and efficient help, which contributed to the success of the project. Mr. Hutchison, the senior assistant, carried out independent work most of the time.

The author wishes to acknowledge the many courtesies and valuable assistance extended to the party by F. N. Wiley, manager of Woodlands for Spruce Falls Power and Paper Company, and his staff. They provided information on rock outcrops that saved the party many miles of fruitless traversing and thus enabled it to gather more data in the time available than would have been possible otherwise. The use of the company's camps and transportation facilities was also of great help.

The author wishes to thank the officers of the Department of Lands and Forests for courtesies and assistance received during the summer. On several occasions the party was able to use the Department's aircraft.

GENERAL GEOLOGY

Except for unconsolidated rocks of Pleistocene and Recent age the rocks of the area are all of Precambrian age. They are chiefly of igneous origin and of both intrusive and extrusive nature. The extrusive or volcanic rocks are now dominantly hornblende schist and quartz-hornblende schist. With them is amphibolite, some greenstone, and minor amounts of sedimentary types and volcanics, sediments, or tuffs.

The volcanic and sedimentary rocks have been folded and metamorphosed by the intrusive rocks and are now mainly schists, but some are gneisses. In one place the rock is identified as metaporphyry and in another place as metagabbro.

The iron formation is a member of this group.

The rocks of the volcanics-sediments group are not listed in chronological order since there is more than one band of each, and all are interbedded. Amphibole is so abundant that the group is sometimes referred to as the amphibole rocks.

No contacts were found between the granodiorite and the biotite granite so their relative ages cannot be given. The granites, pegmatite, diorite, granodiorite, and diabase all intrude the volcanics-sediments group of rocks.

TABLE OF FORMATIONS

CENOZOIC	
RECENT:	Lake, stream, and swamp deposits.
PLEISTOCENE:	Glacial till, boulders, glaciofluvial sand, gravel, and clay.
	Great Unconformity
PRECAMBRIAN	
PROTEROZOIC:	
Intrusive:	Diabase.
	Intrusive Contact
ARCHEAN:	
Intrusives:	Granodiorite and diorite. Granite complex. Biotite granite and pegmatite.
Metamorphosed Equivalents of Volcanic and Sedimentary Group:	Metaporphyry with some amphibolite. Metagabbro with some amphibolite.
Volcanic and Sedimentary Group:	Hornblende schist, quartz-hornblende schist, and amphibolite (in part intrusive). Iron formation. Greenstone, greenstone schist, and greenstone tuffs. Quartzite and quartz-mica schist.

Archean

VOLCANIC AND SEDIMENTARY GROUP

The dominant member of this group is hornblende schist. This grades into quartz-hornblende schist and gneissic phases. Amphibolite and iron formation are conspicuous members of the group.

Most of the rocks of the group are considered to be of volcanic origin, but where alteration has been intense the original characteristics have been destroyed. Definite flow structures such as pillow forms were only seen in a few places. Good banding was seen in some outcrops identified as tuffs, but little was found in the quartzite and quartz-mica schist. The amphibolite appears to be intrusive in part, but good evidence of this was seldom found.

On the geological map, figures and letters are used to indicate the rock type where this has been established.

Hornblende Schist

The hornblende schist is uniformly fine- to medium-grained and strongly schistose. Garnets are abundant in some zones of the schist and are often conspicuous on weathered surfaces. They are about $\frac{1}{10}$–$\frac{1}{2}$ inch in size.

The schist is dark green in colour with no distinguishing features to indicate its original nature. It is thought that greenstone tuffs could readily be altered to form the hornblende schist, but lack of variation in most of it suggests that it may have been originally greenstone flows.

Quartz-Hornblende Schist

This is similar to the hornblende schist except that quartz is more abundant and may be prominent. Where the amount of quartz is roughly equal to the amount of the ferromagnesian mineral, the rock is greyish rather than green. It is generally homogeneous and exhibits very little banding, but where the rock is medium-coarse, and quartz is abundant, it is somewhat gneissic in appearance. Biotite is present in some phases, and garnets are occasionally prominent.

Amphibolite

This rock is dark green to almost black and in the hand specimen appears to be composed almost entirely of hornblende. It ranges in texture from fine to coarse and generally has the appearance of an intrusive. The contacts are sharp between it and the schist. It is usually conformable with the schists but in a few places was seen to transect them. The rock is considered to be formed mainly from basic flows.

There are numerous small bodies of amphibolite. Due to their number, their random occurrence, and lack of good exposures, it was considered impracticable to attempt to map amphibolite as a separate unit. Similar amphibolite is found in the metaporphyry, the metagabbro, and as inclusions in the granite complex.

Garnets sometimes occur in small pod-like masses of amphibolite in the hornblende schist.

Iron Formation

The iron formation occurs in a number of zones within the amphibole rocks. Each zone may be divided into sections containing iron formation alternating with sections of hornblende schist. The iron formation section is either a rusty quartz with a small amount of magnetite or a banded schist with dark bands having various amounts of magnetite and light bands that are non-magnetic. In the iron formation seen, individual black, magnetite-bearing bands are seldom more than 2 inches wide, and sections with alternating bands of magnetic and non-magnetic material are seldom more than a few feet wide. Of the four diamond-drill holes drilled in Fenton township the longest section reported was 44 feet in a hole drilled at a dip of 55 degrees. Most sections in the holes were less than 10 feet. This is dealt with further in the section on iron.

Greenstone, Greenstone Schist, and Greenstone Tuffs

These rocks form only a small part of the volcanics-sediments group. Where alteration has not been intense some characteristics of volcanic rocks can be discerned. At a few places, pillow outlines have been preserved. The tuffs are more readily identified because of their banding. Those seen have alternate bands about ½ inch thick of light and dark minerals; the former being partly feldspar and quartz, the latter dominantly hornblende and chlorite.

Quartzite and Quartz-Mica Schist

These are the only rocks identified as of sedimentary origin, but some of the outcrops mapped may not belong to this group. The quartzite is light coloured and of rather a sugary texture with occasionally a little fine banding. Some contains enough feldspar to be called arkosic quartzite. The quartz-mica schist is slightly foliated and generally uniform in appearance. These rocks are too sparse to be mapped as a separate unit and are moreover closely associated with the volcanics, tuff, and amphibolite.

METAMORPHOSED EQUIVALENTS OF THE VOLCANIC AND SEDIMENTARY GROUP

Metaporphyry and Amphibolite

This rock is amphibolite and feldspathized forms of amphibolite. Three phases of it were seen: amphibolite, amphibolite with coarse feldspars, and amphibolite with coarse and medium feldspar metacrysts. These types were fairly definite, but if more rock were exposed, gradational types would no doubt be found. The amphibolite without feldspar metacrysts is the same as that described in the previous section.

The amphibole appears to be hornblende and is medium- to coarse-grained. The feldspar metacrysts are up to ¼ inch long and about equidimensional. Since the amphibole part of the rock is the same in the metaporphyry as in the amphibolite, it is assumed that in the formation of the metaporphyry the feldspar has been added.

Metagabbro and Amphibolite

These rocks are exposed over an area ¼ by ½ mile in Seaton township and in one small outcrop on Seaton Creek. Amphibolite similar to that already described occurs as a number of small dike-like bodies in the metagabbro.

Although the metagabbro strongly resembles a gabbro in general appearance it is believed to be a highly metamorphosed member of the volcanic and sedimentary group. If it is a true gabbro, it is probably older than the biotite granite and granodiorite, since it does not look as fresh as these do. Amphibolite being associated with the metagabbro suggests it corresponds to the volcanic and sedimentary group. Moreover there is some change in composition and texture within it, and it is not as homogeneous as would be expected of a body of true gabbro.

INTRUSIVES

Biotite Granite

This rock varies greatly from place to place as might be expected from an intrusive that has assimilated various amounts of various kinds of other rocks. The phase considered typical weathers pale pink and contains feldspar, quartz, and biotite. However, there are grey phases, and some of these contain hornblende as well as the above three minerals. This type resembles the granodiorite; the texture is generally granitic, but in some areas it is gneissic. On the east side of Saganash Lake it has a sheeted structure.

About midway along the west shore of Saganash Lake, granite with many inclusions of schist is exposed. The inclusions are more numerous than elsewhere on the lake, and it is noticeable that the magnetic readings are slightly higher in this locality and run south from it to the southwest corner of Seaton township. Numerous inclusions were noted in the vicinity of Camp 75 in the northwestern part of Seaton township. They are about ½–2 feet in diameter. Their abundance in the zone of the low magnetic anomaly suggest a similar situation to that found in the eastern part of the map area and discussed in a later section dealing with the granite complex. However in this instance there is only one diabase dike known and none of the fine-grained diabasic material.

In the vicinity of Camp 75 the granite is intruded by numerous pegmatite dikes.

Pegmatite

Pegmatite dikes occur cutting the biotite granite and, rarely, the amphibole rocks. None were observed cutting the granodiorite. Only two bodies of sufficient size were seen to map separately. One mapped by Hogg is about ½ mile south of the south end of Saganash Lake, the other is about 2 miles south.

The pegmatite is composed of pink feldspar, quartz, biotite, and muscovite. In the southwestern part of Macvicar township, magnetite and a green mineral possibly arfvedsonite, were seen as accessory minerals; here feldspar crystals up to 3 by 6 inches were seen. Near Saganash Lake some of the pegmatite has a graphic texture.

The pegmatite is presumably related to the biotite granite.

Granite Complex

This division is mainly granite, part of which is gneissic. Included in the granite are many xenoliths of the older schist and gneiss. No large exposure of granite was seen without these inclusions, which range in size from less than one to several feet and are generally equidimensional.

Intruding this mixture are numerous diabase dikes. Not all of these were checked for texture, and some may be gabbroic rather than diabasic. They are discussed further in a later section.

A distinctive feature of the complex is its magnetic quality. The diabase and most of the inclusions in the granite are definitely magnetic. Many tests were made with a pocket magnet in checking this feature.

None of the many inclusions examined were identified as iron formation. It is thought that their magnetism may have been caused by emanations from the diabase or by metamorphism induced by heat and pressure accompanying the intrusion of the granite. Evidence for the former theory is found in the frequent occurrence of dense, black, very fine-grained magnetic material in the vicinity of the diabase dikes. This material appears to be part of the diabase intrusion because of its close areal relationship, its general appearance, its magnetic quality, and its silica composition as determined by chemical analysis.

The diabase dikes strike about north-south and as far as was determined, all have steep-to-vertical dips. They are very abundant in Macvicar township near, and east of, Macvicar Lake.

The area mapped as being underlain by the complex has a distinctive magnetic pattern as shown by the magnetometer survey. Approaching the area from the northwest and the southeast, the magnetic readings rise sharply and then flatten out giving a plateau effect in profile. The explanation of this pattern is believed to be well enough established to justify extending the geological boundaries considerable distances without geological data.

Granodiorite

This rock is grey in colour and granitic in texture. Very little variation in mineral content, texture, or colour was found in it. It consists of feldspar, hornblende, and quartz and has some biotite; but generally only the hornblende was noticed in hand specimens. The feldspar is dominantly oligoclase with only minor amounts of orthoclase and microcline.

In contrast to the biotite granite, little included material was seen in the granodiorite. It is also free of diabase dikes so far as was seen except for a body of coarse gabbroic diabase on the north shore of Esmee Lake.

The age of the granodiorite, relative to the biotite granite occurring to the east and west, cannot be established since no contacts of the two were found.

Diorite

Only two small areas were mapped as diorite; these are adjacent to the granodiorite and are probably phases of it. There is little or no quartz in the diorite, and the feldspar, although not identified under the microscope, appears to be more basic in the diorite than in the granodiorite. Assimilation of some of the amphibole rocks by the granodiorite could conceivably have resulted in the formation of the diorite.

Proterozoic

INTRUSIVES

Diabase

This is the youngest of the Precambrian rocks, and in other areas similar rocks are said to be of Keweenawan age. It intrudes both the volcanic and sedimentary group of rocks and the plutonic igneous rocks. Characteristically it occurs as dikes 20–75 feet wide with a general north-south trend and steep to vertical dips.

The texture of nearly all the dikes seen is diabasic with good laths of feldspar surrounded by the ferromagnesian mineral or minerals. They commonly exhibit chilled margins in which the feldspar crystals are still distinguishable as very tiny laths. Little baking of intruded rocks was seen.

The outcrop of this group occurring on a point on Esmee Lake near its outlet has a gabbroic appearance, although some laths of feldspar can be seen. Only the west side of the mass was seen and it may have a greater width than is usual for the diabase dikes. It may be a plug or small stock. Adjacent to the granodiorite it has a chilled margin indicating it is intrusive into the granodiorite.

The diabase dikes sometimes stand out as low knolls or hog-back ridges. This is particularly noticeable east of Macvicar Lake in Macvicar township.

As mentioned in the section on the granite complex the diabase is quite magnetic. Where the dikes intrude non-magnetic granite they may give rise to low magnetic anomalies. In the complex the proportion of the magnetic attraction attributable to the diabase is uncertain. The dense, black, very fine-grained material associated with the diabase but not part of the dikes in the Macvicar Lake area and on Griffin Lake is also quite magnetic. Some of this material was found in Fenton and Seaton townships but not always near outcrops of diabase dikes.

Pleistocene

Although Pleistocene deposits are widespread in the area, there are few vertical sections where detailed examination is possible. The best sections are shallow roadcuts and sand and gravel pits along the Chain-of-Lakes road. Banks of lakes and streams occasionally afford opportunities for study.

Data from two diamond-drill borings where the nearby surface of Pleistocene material is a flat plain are as follows: at Camp 92 of Spruce Falls Power and Paper Company a hole drilled for water is reported to have penetrated 150 feet of sand before reaching bedrock; in Fenton township a diamond-drill hole put down by the Bonnie Prince Mining Syndicate entered bedrock at 63 feet vertically after passing through sand.

The Chain-of-Lakes road follows an esker complex for part of its length in the map area. Sand and gravel pits along this road show sorting into bands of sand, gravel, and boulders. A pit near the Seaton radio telephone shows the following sequence from the bottom upwards: 14 feet of medium-coarse sand, 1 foot of gravel with fragments ½–1½ inches in diameter, and 2 feet of boulders mostly 6–12 inches in diameter.

A pit at mileage 33.4 on the Chain-of-Lakes road shows 12 feet of sand with a covering of boulders. At mileage 33.7 another pit shows 15 feet of gravel and gravel with small boulders. There appears to be sudden changes in material both horizontally and vertically.

Associated with the sand and gravel ridge of the esker complex are a number of kettle lakes, which are generally elongated in the direction of the ridge. This situation is well shown in Seaton township.

Other esker complexes occur in Griffin township. One north of Griffin Lake has several kettle lakes; another south of the lake has a deltaic form.

The direction of glacial action is shown by glacial striae on bedrock, gouges in the unconsolidated material, and low ridges of glacial drift or till. Only one good set of striae was seen. This was near mileage 21 on the Chain-of-Lakes road, and its direction of movement was S.52°E. Gouges are often remarkably straight for distances up to 2 miles and, even if only a few feet deep, show up well on air photographs; as stream valleys they are conspicuous on topographic maps. Glacial ridges other than the esker type are usually only a few feet high and 100–200 feet long. These and the gouges have similar trends over most of the area, being about S.60°E.

Recent

There has been little accumulation in recent times other than vegetable matter.

Near Camp 75 in Seaton township weathering of granite and pegmatite was noticed. Where the rocks were exposed a thin coating of weathered feldspar, quartz, and mica up to ⅓ inch thick was seen. Examination of surfaces under a shallow covering of moss showed the same feature. Spalling due to a bush fire may have caused this.

On the east side of Saganash Lake, at the north end, there is about 4 miles of good sand beaches. Several sand beaches were also noted on Griffin Lake; these are probably reworked glacial material.

STRUCTURAL GEOLOGY

Folding

The volcanics-sediments or amphibole group of rocks has been intensely folded, the angle of inclination being generally from 70 degrees to vertical. Where both bedding and schistosity were observed they have the same strike. Where schistosity only was seen, it is thought that the bedding at that locality would be the same.

There is one main band of rocks of this group. Beginning near the east side



Esker Complex or Beach with Delta-like Feature, Griffin Township. Outcrops of the Granite-Gneiss-Diabase Complex are Seen in the Light-Coloured Area

of Seaton Lake, in Seaton township, they trend west of north for a short distance, then north to Fenton township. The trend across Fenton township is roughly northeast except near the east boundary where part of the band trends easterly into Slack township. The general northeast trend is continued northeast of Fenton across Casselman township, Here, aeromagnetic readings indicate the band may be split into two parts with a zone of granite between.

The part of the amphibolite band that trends east from Fenton into Slack township contains rocks that are less amphibolitic and less altered than the



Drag-folding in banded iron formation on scarp face near south side of Fenton township.

average and are identified as volcanic and sedimentary types. The structure is more complicated as is shown by the divergence of strikes and dips, and even with the help of magnetic data the general pattern is uncertain.

In the eastern part of Seaton township a belt about 2 miles wide by 10 miles long has been mapped as metaporphyry on the basis of a few outcrops in the vicinity of Pratt and Esmee lakes and magnetic readings. This mapping is open to doubt, but the rocks are probably related to the volcanics-sediments group thus giving nearly complete encirclement of the granodiorite by rocks of the volcanic and sedimentary group. These rocks are, in turn, encircled by the biotite granite. Since the granodiorite was not seen in contact with the biotite granite, the relative ages of the two intrusives are uncertain.

Shearing and Brecciation

The rocks in the amphibolite band are nearly all schistose to some degree and generally are very schistose. The schistosity was probably developed at the time the rocks were folded. No pronounced shear zones were observed.

A little brecciation, from one to several feet wide, was seen at a few places at about the same horizon in Seaton and Fenton townships. The best examples of this were seen ¼ mile north and ¼ mile southwest of Camp 92 in Seaton township. Outcrops have a rusty surface due to weathering of iron carbonate. Fragments of schist are cemented and partially replaced by felsitic material containing iron carbonate.

A sheeted structure occurs in the granite along the east side of Saganash Lake near the south end and close to the contact with the amphibole rocks.

Faulting

Only one fault is shown on the geological map. This is east of the south end of Saganash Lake. Here, geological and magnetic data indicate a fault trending N.65°W. In this area the trend of the group of amphibole rocks swings from north to northeast going from Seaton to Fenton townships. About ¼–¾ mile south of the fault several rock ridges have scarp faces on their west sides. These may indicate subsidiary faults. Here drag folding is evident in iron formation on the side of one of the ridges. Other evidence of the main fault is found in the distribution of rock outcrops and the stream pattern. Displacement and dip of the fault are not known, but magnetic data suggest a vertical movement.

Other faults are indicated by magnetic data but lack geological evidence and are not shown on the map.

ECONOMIC GEOLOGY

There has been very little prospecting in the area except exploration of the iron formation in Fenton township in 1946 and 1947 and that done in the summer of 1958. The former is described by Nelson Hogg[1] who mapped part of Fenton township in 1947:

> In the outcrops and trenches examined, the iron formation is a banded type with alternating bands of granular magnetite and sugary textured white quartz, and in some places bands of dark, cherty quartz.
>
> The widest exposure opened up to date is on claim S.47982, where trenching and stripping reveals a width of 140 feet of iron formation. At this point the siliceous bands predominate and there are also narrow rusty shear zones.
>
> Farther east, on claim S.47983, the iron formation appears to have narrowed and split into at least two bands. A trench at this point reveals the following assemblage of rock from north to south:

	Width feet
Black, crystalline hornblende schist	6
Red, rusty, schist with garnets	3
Banded iron formation with approximately 30 percent magnetite by volume	18
Rusty hornblende schist	2
No rock	3
Hornblende-garnet schist	1
No rock	3
Banded iron formation	9
Medium-textured, massive amphibolite	6

[1]Nelson Hogg, *Geology of Portion of Fenton Township, District of Cochrane*, Ont. Dept. Mines, Prelim. Report, P.R. 1948-1, 1948.

Another rather good exposure has been opened up by trenching on the line between claims S.43482 and 43483. At this point the iron formation strikes N.50°E., and the trench shows a true width of approximately 40 feet. It appears to be delimited to the south but may have greater width to the north. The bands of magnetite reach widths of half an inch but average about an eighth of an inch and are separated by comparable widths of sugary quartz. In the pure iron formation more than 50 percent by volume is magnetite, but this is reduced over the entire formation by included bands of rusty, granular quartz-hornblende-garnet schist and narrow dikes with a maximum width of 3 feet. The iron formation at this point shows a considerable amount of distortion. The north end of the trench ends in 2 feet of hornblende schist, which passes under the clay; but 80 feet farther north, a second trench exposes more iron formation. In this case the iron formation is a minor band about 12 feet wide, which is associated with a granitic dike 6 feet wide and 15 feet of amphibolite. To the south, the iron formation passes into rusty quartz for 10 feet, which is followed by an acid dike 10 feet wide.

The extension of the same band of iron formation has been developed by trenching in the southwest corner of claim S.43483. At this point the sequence from north to south is as follows:

	Width feet
Fine-grained amphibolite	18
Rusty, siliceous schist	12
Banded iron formation	4
No rock	1½
Hornblende schist	1
No rock	12
Hornblende-garnet schist	4
Fine-textured granitic dike	2
Banded iron formation	23
Amphibolite	2

The 23 feet of iron formation exposed at this point would probably carry from 40 to 50 percent magnetite by volume. Bands of granular magnetite as much as an inch in thickness are present with intervening sugary-textured quartz.

Iron formation is exposed in various other parts of the property, but none of the other showings examined are as high in iron content as the few described on claims S.43482 and 43483.

Where the iron formation is exposed at the surface, its iron content is not sufficiently high to constitute iron ore. As previously stated, however, magnetic readings were much higher over some of the swampy areas where bed rock cannot be reached by trenching, and exploration by the Bonnie Prince Mining Syndicate is being carried out with the object of determining the nature of the iron formation at the points where the magnetic attraction is greatest.

In the summer of 1958, a party from International Nickel Company of Canada Limited carried out geological work, geophysical work, trenching, and diamond-drilling in the northern part of the area. This party used a helicopter on which geophysical equipment was installed. The results of this work are not known to the author.

In March 1958 most of the claims formerly held by the Bonnie Prince Mining Syndicate in Fenton township were re-staked by Harry Isaacs of Toronto.

Iron

The presence of iron formation in Fenton township was first noted by timber cruisers of Spruce Falls Power and Paper Company. They found considerable magnetic attraction in the course of their work. Some employees of the company formed the Bonnie Prince Mining Syndicate and proceeded to explore an area of some 104 claims in the east-central part of Fenton township in 1946 and 1947. The claims were surveyed, and considerable stripping and trenching were done.

Magnetometer surveying was done along the north-south claim lines in 1946, and more detailed work done on favourable sections in 1947 by the Bonnie Prince Mining Syndicate. Following this, four diamond-drill holes were put down with a total footage of 2,004 feet, but the results were disappointing, and work was discontinued. Assays of a few magnetite-bearing sections showed about 20–25 percent iron. Since the sections of iron formation constitute in general less than half the rock, the average iron content is too low to be of economic importance.

Small amounts of iron formation were seen in other parts of the area. Its

presence is also indicated by the magnetic anomalies shown on the air magnetometer maps published in May, 1958, by the Ontario Department of Mines. The strongest anomalies were obtained in Fenton township.

Sulphides

Some pyrite and pyrrhotite were encountered in drill holes Nos. 3 and 4 of the Fenton drilling. In hole No. 3 it was reported that up to 4½ feet of fine-grained massive-to-banded sulphide was intersected. In hole No. 4, two seams of pyrrhotite a few inches wide were cut. Elsewhere some sulphides were reported in quartz and iron formation sections of core. One section of sulphides assayed is said to have shown negligible values in nickel and copper.

A few outcrops with considerable amounts of rust were seen near magnetic anomalies in north-central Casselman township. Some of this rust may have formed from sulphides, but a search failed to reveal any.

A little pyrite was found in diabase dikes and in a few of the quartz veins. Slight pyrite mineralization was seen in the brecciated rock ¼ mile north of Camp 92 mentioned in the section on shearing and brecciation. Elsewhere in the map area only traces of sulphides were seen. This was generally pyrite and very rarely pyrrhotite or chalcopyrite.

Gold

Quartz stringers and small quartz veins occur sparingly throughout the area. They are lensy in nature and seldom more than 6 inches wide or 10 feet long. They are usually of glassy white quartz and occasionally contain a little pyrite but in most cases are barren. A few of the more promising ones were tested at the Provincial Assay Office for gold, but none was found.

Several samples of diamond-drill core of the Fenton iron formation that contained sulphides were tested for gold, but none was reported.

Sand and Gravel

Deposits of sand and gravel have been discussed in the section on Pleistocene geology. At present the only demand for these in the map area is by the Spruce Falls Power and Paper Company for their private roads.

Future Possibilities

Although exploration of the area did not reveal mineral deposits of economic significance at the time of this survey, it should be remembered that very little prospecting has been done. The few roads and streams, the scarcity of outcrops over most of the area, and the impression that there was very little favourable ground has discouraged prospecting.

The recent survey has shown that the volcanic and sedimentary rocks and their derivatives are more extensive than previously realized and warrant prospecting. The lack of outcrops in much of the area is partly offset by the recent advances in geophysical techniques. Although drift is widespread, it is believed to be generally less than 100 feet thick and penetrable by geophysical means.

The sulphides intersected in the diamond-drilling in Fenton township suggest that deposits of base metals may be present in important amounts. Prospecting for deposits of this kind would appear to offer the best chance of success. The aeromagnetic maps of the area, while generally indicating the presence of iron formation, may in some instances indicate the presence of pyrrhotite, a common associate of nickel and copper minerals.

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Geology of the Bennett–Tanner Area

By

W. L. YOUNG

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COLOURED GEOLOGICAL MAP

Map No. 1960b—Bennett–Tanner Area, District of Rainy River, Ontario. Scale 1 inch to ½ mile ..... *in map case*

Geology of the Bennett–Tanner Area

BY

W. L. Young[1]

ABSTRACT

The Bennett-Tanner Area is in the Rainy River District, northwestern Ontario.

The consolidated rocks are Precambrian. The oldest are steeply dipping and metamorphosed Keewatin formations of tuff-breccia conglomerate (Seine series), lavas and tuffs with intercalated iron formations, and biotite schists derived from the volcanics. All are intruded by quartz-feldspar and hornblende orthogneiss. The youngest rocks are intrusives varying from granite to hornblendite. Pleistocene and Recent deposits mantle areas of the older rocks.

The Keewatin rocks have been tightly folded into an isoclinal syncline, which plunges steeply and splits into a smaller anticline and syncline. Northeasterly and northwesterly right-strike separation faults are prominent.

Many small, barren quartz veins intrude the Keewatin rocks. Sulphides occur in and near the younger basic intrusives and in silicified shears.

INTRODUCTION

The greenstone belt underlying parts of Bennett and Tanner townships has been prospected intermittently during the past 70 years for gold, iron, and more recently, for base metals. During the winter of 1957 the discovery of a zone of massive sulphides 3 miles west of Bennett township started a staking rush that eventually covered the entire belt in the two townships. Since the initial discovery a considerable amount of detailed exploration work has been completed showing that a similar type of mineralization occurs in adjacent localities.

The present survey was carried out during the 1958 field season in order to map the rocks geologically and to evaluate the mineral potential. Mapping was done on perfatrace fitted over air photographs, traversing along ¼-mile intervals. Dip-needle traverses were also done to locate magnetite iron formations.

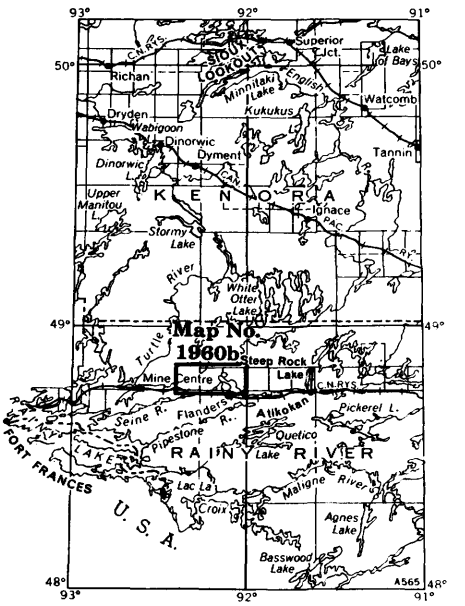
The area mapped consists of Bennett and Tanner townships and some unsurveyed territory extending from Bennett township westward, a distance of 5½ miles. The total area mapped is about 105 square miles.

Location and Access

The map area is located in the District of Rainy River, northwestern Ontario. Its position is approximately, longitude 92° 00′ W. to 92° 27′ W. and latitude 48° 45′ N. to 48° 50′ N. The nearest town is Atikokan, 25 miles east.

[1]Assistant Professor, Department of Geology, Carleton University.

Most of the area is easily accessible by rail, road, air, and water. The transcontinental line of Canadian National Railways, Fort William to Fort Francis division, passes along the south edge of the map area. A second-class private road, the property of Ontario and Minnesota Paper Company, extends from Atikokan to Calm Lake. Many service roads to pulp-cutting camps have been constructed. Most of the lakes and parts of the Seine River are suitable for use by float- or ski-equipped aircraft. The Calm Lake–Seine River drainage system is easily navigable by canoe or skiff. However, the Little Turtle River is barely navigable by canoe, and then only after the annual pulp drive has been completed, usually about the end of July. At present, this river provides the only easy access into the northwest corner of the map area.



Key map showing location of the Bennett–Tanner area. Scale, 1 inch to 50 miles.

Topography

The topography is fairly low and flat, typical of the Canadian Shield peneplane. A few dome-shaped hills, with a local relief of less than 200 feet, rise above the low ground. The variations in elevation are due chiefly to differential weathering. The more resistant granites and other intrusives underlie the higher ground, whereas the softer volcanics and schists underlie the lower ground.

The immediate region is drained by the Seine and Little Turtle river systems, both of which flow west. Rapids and falls are plentiful along the Little Turtle River, and were once numerous along the Seine until a series of dams was constructed, which evened and controlled the flow. Minor creeks are abundant; almost all these have been dammed by beaver, causing extensive flooding of the low-lying areas. There is only one large swamp, which is located 2 miles north of McPherson Lake. This swamp could be drained considerably by breaking the beaver dams at the outlet.

Rock outcrops are very numerous in the north half of the area. In the south half, exposures, although less numerous, are still sufficient for geological mapping, except in the country between Bennett and McPherson lakes.

General Information

There is now virtually no agriculture, although a few abandoned farms along the railway indicate early attempts. What little soil there is, is mostly sandy and stony and generally unsatisfactory for farming.

Pulp is the principal industry. Good stands of spruce, balsam, jackpine, and poplar have been cut for the past 60 years. Heavy rainfall promotes rapid growth, and operators plan on a recut every 30 years. No recent forest fires have hampered the industry.



Ontario and Minnesota Paper Company's dam, Crilly.

Ontario and Minnesota Paper Company maintains two hydro-electric dams along the Seine River, one at the outlet of Calm Lake, and a second downstream at Crilly. (See photo.) Both stations feed their output into the Ontario Hydro-Electric Power Commission network.

Most of the lakes and rivers contain pickerel and northern pike. Deer, bear, beaver, and otter are plentiful, but moose are scarce.

Previous Geological Work

The first geological investigations in this region were by Andrew C. Lawson[1] in 1888, when he mapped the Rainy Lake district, 10 miles west of the present map area.

William McInnes[2] visited this district in 1895 and 1896, but his work was confined to a reconnaissance of the geology along some of the waterways.

Lawson[3] later revisited this country and extended his work into Bennett township, but only in the immediate vicinity of the railway.

---

[1]Andrew C. Lawson, "Report on the Geology of the Rainy Lake Region," *Annual Report*, Geol. Surv. Can., Vol. III, 1888, Report F.

[2]William McInnes, "Report on the Geology of the Area Covered by the Seine River and Lake Shebandowan Map Sheets," *Annual Report*, Geol. Surv. Can., Vol. X, 1899, Report H.

[3]Andrew C. Lawson, *The Archaean Geology of Rainy Lake Re-Studied*, Geol. Surv. Can., Memoir No. 40, 1913.

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Thanks are also extended to the Ontario and Minnesota Paper Company, whose kind co-operation and assistance was greatly appreciated.

GENERAL GEOLOGY

The rocks discussed in this report are located near the west end of a long, narrow belt of highly contorted and metamorphosed Precambrian volcanics and sediments, which strikes approximately east-west for 130 miles. The discovery, before the turn of the century, of gold, copper, iron, and other minerals, led to the early realization that this belt of Precambrian rocks was economically important. Consequently for many years this area has been of interest to geologists. A selected bibliography follows:

SELECTED BIBLIOGRAPHY

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A. W. JOLLIFFE, "Geology and Iron Ores of Steep Rock Lake," *Economic Geology*, Vol. 50, 1955, pp. 373–98.

Almost all these geologists have recognized two very difficult and important geological problems: the stratigraphic relationship between the Coutchiching, Seine, Steeprock, and Keewatin lava formations; and the relative ages of the various intrusive rocks. A full discussion of these problems is beyond the scope of this report, but evidence that bears directly on the problems and conclusions drawn from this evidence, will be given.

Because of differences of opinion as to stratigraphic sequence and date of intrusions, the Tables of Formations of geologists differ. In the accompanying table, Tables of Formations of other writers are presented beside that now proposed by the author.

Keewatin

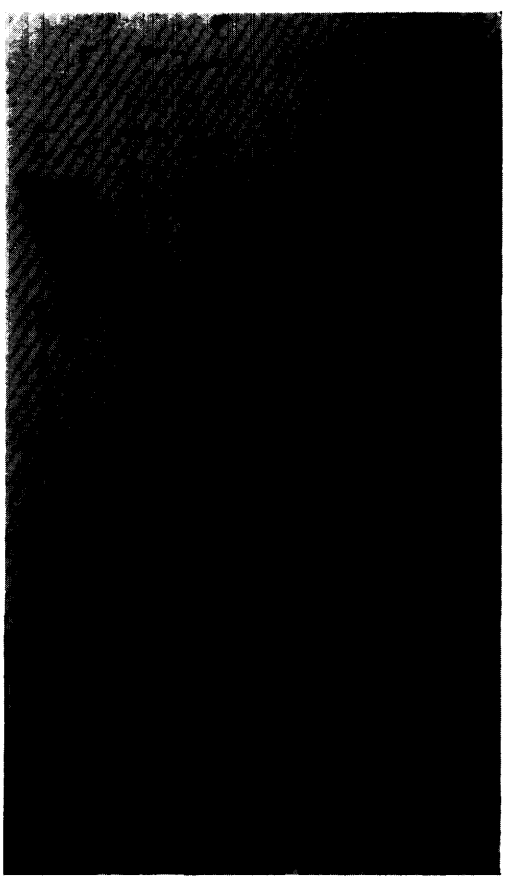
As stated above, one major problem in the over-all belt concerns the stratigraphic relationship between the Coutchiching, Seine, and Keewatin lava formations. Information obtained in the preparation of this report strongly suggests:

COMPARATIVE TABLE OF FORMATIONS

DISTRICT OF RAINY RIVER

	Lawson (1913) Rainy Lake	Parsons (1918) Rainy Lake	Hawley (1930) Sapawe and Steeprock Lakes	Bartley (1939) Steeprock Lake	Young (1958) Bennett-Tanner Area
CENOZOIC					
RECENT:			River silts.	Soil and alluvium.	Silts, soil.
PLEISTOCENE:			Morainic and fluvio-glacial deposits.	Drift, soil, gravel.	Glaciofluvial deposits.
				Erosional Interval	
PRE-PLEISTOCENE:				Hematite.	
					Great Unconformity
PRECAMBRIAN					
KEWEENAWAN:	Diabase dikes.				
	Unconformity (Eparchaean Interval)				
ALGOMAN:	Granites, gneisses, etc.	All granites, gneisses, etc.	Red biotite granite, and gneiss.	(?) Diorite, gabbro, granite, gneiss.	Post Keewatin: Red biotite granite, diorite, hornblendite, etc.
	Intrusive Contact		*Intrusive Contact*	*Intrusive Contact* (?)	
UPPER HURONIAN:	Seine series.	Seine series.	Seine series, Coutchiching Post-Steeprock Lake intrusives.	Timiskaming type: Seine and Steeprock series.	
	Unconformity		*Intrusive Contact*		*Intrusive Contact*
LOWER HURONIAN:	Steeprock Lake series.		Steeprock Lake series.		
	Unconformity		*Unconformity*	*Unconformity* (?)	
LAURENTIAN:	Granites, gneisses, etc.		Hornblende gneisses, etc.	(?) Granite; gneiss.	Hornblende orthogneiss, quartz-feldspar orthogneiss.
			Intrusive Contact Altered gabbro, diorite.		
	Intrusive Contact		*Intrusive Contact*	*Intrusive Contact*	*Intrusive Contact*
KEEWATIN:	Volcanics.	Anorthosites. Greenstones.	Volcanics.	Iron formation, volcanics.	Chlorite schist, lava, tuff, biotite schist (Coutchiching of McInnes), iron formation. Seine tuff-breccia conglomerate.
COUTCHICHING:	Metasediments.		Listed as Seine.		





Two photos showing Seine tuff-breccia conglomerate. Rounded material is detrital boulders and pebbles. Lens-shaped material is volcanic fragments. Fine-grained material is chlorite schist.

(a) a genetic relationship between the Seine series and the Keewatin lavas; (b) that the Seine series are older, and (c) the biotite schists in the vicinity of Calm Lake, previously mapped as Coutchiching by McInnes, are meta-lavas of Keewatin age.

SEINE SERIES

All previous investigators considered the Seine series as a sedimentary group consisting of conglomerate, arkose, quartzite, greywacke, slate, and phyllite.

In the area mapped, rocks with the appearance of conglomerates and phyllites occur along the south edge, from the west boundary to a point south of Laseine Station, where the series strikes out of the map area. This formation is at least 5,000 feet thick in the west. Its thickness in the east was not determined because the south contact is beyond the map area.

In the map area, conglomerate members of the Seine series are divisible into three facies, each based on a characteristic lithological feature. The facies are: (1) boulder, (2) volcanic fragment, and (3) chlorite schist. Commonly the various facies are intermixed as follows: almost always (2) and (3) with (1); and (3) with (2); occasionally (2) with (3); but never (1) with (3).

The boulder facies has abundant, well-rounded, unsorted boulders and pebbles of granite, chert, quartz and iron formation, with volcanic fragments, in a matrix of fine-grained chlorite schist. (See photos.) The granite boulders are mostly leucocratic granite consisting of highly sericitized oligoclase feldspar, and quartz, with minor chlorite and accessory minerals. The boulders may be as large as 2 feet in diameter and are usually slightly elongated and fractured. Frequently the long axis has been turned so that the boulders lie at right angles to the strike. The boulder content dies out both across and along the strike, and the boulder facies changes to the volcanic fragment and chlorite schist facies.

The volcanic fragment facies has abundant volcanic fragments in a fine-grained chloritic groundmass. The facies generally lacks granitic pebbles. The fragments have been greatly stretched; some are 1 foot long by 3 inches wide, and the long axis is always parallel to the strike.

The chlorite schist facies is a fine-grained, light-green to brownish chlorite schist and in hand specimen appears to consist principally of chlorite and ferruginous carbonate with a little quartz. This rock does occur as a unit but it generally forms the groundmass for the boulder conglomerate and volcanic fragment facies. As such, the schist can be seen to flow around the boulders and fragments. The lack of sorted, fine-grained clastic material in the schist is always evident.

In the field mapping, it was seen that one facies would quickly give way to another, making it extremely difficult to follow any one facies. However, taken as a whole the three facies can be followed along a fairly regular belt.

As seen under the microscope, the conglomerate matrix and the chlorite schist consist of a few rounded nodules of quartz, some of which appear to be detrital, but the lack of corroded rims and strain shadows suggests that much of this quartz may be secondary and non-detrital in origin. Laths of oligoclase-andesine feldspar occur as metacrysts here and also in the fine-grained groundmass. Most of the feldspars are highly sericitized, particularly those of the groundmass where only remnants of the original feldspar remain. The laths are sharply angular, suggesting that the feldspars are primary and of igneous origin. In addition, the groundmass consists of finely shredded chlorite, quartz, sericite, and some biotite. Ferruginous carbonate veinlets cut across the rock, and carbonate replacement exists along the shear planes.

Lavas and tuffs directly overlying the Seine series were also examined under the microscope and were found to contain oligoclase-andesine feldspar, quartz, chlorite, biotite, and sericite. The quartz commonly occurs as nodules, and the feldspar as angular laths in a fine-grained groundmass of feldspar, quartz, chlorite, biotite, and sericite. The more basic lavas contain medium-sized laths of oligoclase-andesine feldspar, quartz, and hornblende, in a finer groundmass of sericitized feldspar, chlorite, and biotite.

In thin section, as in hand specimen, the matrix of the conglomerate bears a strong similarity in mineralogy and texture to the lavas and tuffs. Several specimens of the conglomerate matrix and the volcanics were submitted for trace-element analysis. The average trace-element content of these specimens is given in the accompanying table.

AVERAGE TRACE-ELEMENT CONTENT OF CONGLOMERATE MATRIX AND VOLCANICS[1]
(Spectrographic Analyses by Provincial Assay Office, Ont. Dept. Mines, 1958)
(ND = not detected by the method used)

	Conglomerate Matrix (4 samples)	Chloritic Schist (5 samples)	Massive Lava (4 samples)
Antimony	ND	ND	ND
Arsenic	ND	ND	ND
Beryllium	0.0001	0.0001	ND
Bismuth	ND	ND	ND
Cadmium	ND	ND	ND
Cerium	ND	ND	ND
Chromium	0.013	0.044	0.02
Cobalt	0.001	0.0007	0.004
Copper	0.004	0.005	0.008
Gallium	0.001	0.003	0.002
Germanium	ND	ND	ND
Lead	0.003	0.001	ND
Lithium	ND	ND	ND
Manganese	0.07	0.03	0.10
Mercury	ND	ND	ND
Molybdenum	ND	ND	ND
Nickel	0.004	0.001	0.01
Niobium	ND	ND	ND
Silver	ND	ND	ND
Strontium	0.03	0.027	0.04
Tantalum	ND	ND	ND
Tellurium	ND	ND	ND
Thorium	ND	ND	ND
Tin	ND	ND	ND
Titanium	0.5	0.50	0.60
Tungsten	ND	ND	ND
Uranium	ND	ND	ND
Vanadium	0.008	0.003	0.02
Yttrium	ND	ND	ND
Zinc	ND	ND	ND
Zirconium	0.01	0.03	0.007

[1]Values shown are averages based on spectrum line intensities and indicate approximate relative percentage concentrations.

The analyses indicate a close similarity between the trace-element percentages of the volcanics and the matrix of the conglomerate. It seems reasonable to assume that these rocks have a common origin, which must be volcanic since some of these rocks can be identified as volcanics. Whether the matrix is an original volcanic, or a sediment derived from a volcanic, is still undetermined. The lack of sorting of the detritals; chemical, mineralogical, and textural similarity to the volcanics; extreme thickness; and structural relations; suggest that the matrix is volcanic. The presence of the coarse detrital material is the strongest evidence in favour of a sedimentary origin.

This structural, petrographic, and chemical evidence leads to the conclusion that the Seine series, at least in the map area, is actually a sheared volcanic tuff-breccia, which during deposition picked up and incorporated boulders and finer detrital material, somewhat in the manner postulated for the Sudbury volcanic-breccia by Thomson and Williams.[1]

Most investigators place the Seine series in the Upper Huronian, that is, the Seine overlies unconformably all the older rocks, including the Keewatin lavas. However, the unconformity with the Keewatin has never been observed, a condition for which Hawley[2], after a study of the regional structure postulated a fault contact between the two. Gill[3] seriously questions the structural interpretations of Hawley. Lawson[4] states that the contact between the Bad Vermillion granite and the Seine in the vicinity of Shoal Lake is unconformable. Parsons[5] disagrees; he believes this contact to be intrusive because the edge of the Seine is granitized. The author has checked this contact and agrees with Parsons.

Without proof, therefore, the age of the Seine series is still uncertain. In the map area, the relationship between the Seine and Keewatin was studied. The Seine strikes easterly and the dip averages 80°N., conforming to the strike and dip of the lavas to the north. Thus the Seine appears to underlie the Keewatin. Furthermore, the majority of drag folds in the Seine indicates that it is on the south limb of a regional syncline. Some shearing in the Seine, possibly similar to that which Hawley believes was caused by faulting along the contact, was seen, but in view of the similar mineralogical and chemical content of the rocks on either side, the shear zone is thought to have been formed by stretching of the outer beds during the formation of the syncline.

Therefore, because of the structural and genetic relations between the Seine volcanic breccia-conglomerate and the Keewatin lavas, the Seine is believed to be older than, and to underlie, the Keewatin lavas. It is not proposed to separate the two formations, since the Seine is considered to be the lowermost member of the Keewatin in this area. The term Seine is retained because the volcanic breccia-conglomerate is readily distinguished from the overlying lavas and is a valuable marker formation.

KEEWATIN LAVAS

The lavas change considerably in appearance and composition. The variations are transitional, and no definite contacts can be drawn. There is, nevertheless, a distinct north-south regional zoning, which is chiefly due to different grades of metamorphism. Along the south edge of the lava belt, the rocks are schistose, highly chloritized and carbonatized lavas, and possibly tuffs; grading to fairly fresh, unaltered lavas in the middle; to silicified lavas, to biotite schists, and biotite gneisses in the north.

The schistose, chloritic variety can be traced from the west edge of the map area to the Calm Lake power line. In this section the schists lie between the

[1]Jas. E. Thomson and Howel Williams, *Sudbury Volcanology.* A paper presented at the joint session of the Geological Association of Canada and the Geology Division, Can. Inst. Min. Met., April 11, 1956.

[2]J. E. Hawley, *Geology of the Sapawe Lake Area,* Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6, p. 16.

[3]James E. Gill and J. E. Hawley, " 'Seine' or 'Coutchiching', by J. E. Hawley: A Discussion," *Journal of Geology,* Vol. XXXIX, 1931, pp. 655–69.

[4]Andrew C. Lawson, *op. cit.,* p. 54.

[5]Arthur L. Parsons, *Mineral Developments in N.W. Ontario,* Ont. Bur. Mines, Vol. XXVII, 1918, pt. 1, p. 181.

Seine series and south of a line through Bennett Lake and the creek draining that lake west, and south of the Seine river in the east. These rocks are light green and usually have a brownish hue, due to the presence of weathered ferruginous carbonate. Generally, they are extremely schistose, although some massive varieties were noted. They are composed of fine-grained highly sericitized oligoclase-andesine feldspar, quartz, chlorite, and biotite. Some varieties are porphyritic, the metacrysts consisting of feldspars and quartz eyes.

North of this belt, for about 1½ miles, the lavas are dark-green, dense-to-slightly schistose, and fine-grained to moderately porphyritic. The rocks are composed of moderately-to-highly sericitized andesine feldspar, quartz, chloritized hornblende, and biotite. Some types contain bluish opaline quartz eyes.

The massive lavas gradually change to schistose, silicified lavas containing only minor andesine feldspar, much fine-grained secondary quartz, chlorite, and biotite. Progressing northward, there is a gradual increase in the biotite content and in the schistosity. These rocks are classified as biotite schists and, in some cases, biotite gneisses.

In the field, it appears that the change from massive andesitic lava to biotite schist is due to the effects of increased metamorphism as the orthogneiss is approached. This change can be observed along the north limb of the iron formation. At the west end, near the nose of the syncline, the lavas are moderately schistose and silicified, and only minor amounts of biotite are present. This type persists until the iron formation bends around the nose of the anticline; from here northward the rocks become progressively more silicified and schistose, and the content of biotite gradually increases.

These biotite schists were mapped as Coutchiching by McInnes.[1] Because of the evidence above, these rocks are reclassified as meta-lavas of Keewatin age.

IRON FORMATION

Several bands of magnetite iron formation are intercalated with the lavas. The most prominent band, consisting of two parallel beds, can be traced around the nose of the major syncline, along the north limb, and around the nose of the anticline to the north edge of the area mapped. The iron formation can also be found at several localities along the south limb of the syncline, and again north and south of the narrows on Calm Lake. Where observed, the iron formation consists of thin, lenticular bands of magnetite separated by wider bands of material consisting of quartz, chloritized hornblende, biotite, and magnetite. The maximum width of these formations is about 50 feet.

Post-Keewatin Intrusive Rocks

The second major geological problem concerns the relative ages of the intrusive rocks. Lawson[2] recognizes two ages of intrusives: the Laurentian (post-Keewatin, pre-Huronian), and the Algoman (post-Huronian). As evidence that there are two ages of granite, Lawson states that an unconformity exists between the Bad Vermillion granite (Laurentian) and the Seine series (Upper Huronian) at Shoal Lake, whereas elsewhere granites and gneisses intrude the Seine and are, therefore, dated as post-Huronian (Algoman). Smyth,[3] and

[1]William McInnes, "Report on the Geology of the Area Covered by the Seine River and Lake Shebandowan Map Sheets," *Annual Report*, Geol. Surv. Can., Vol. X, 1899, Report H.

[2]Andrew C. Lawson, *The Archaean Geology of Rainy Lake Re-Studied*, Geol. Surv. Can., Memoir No. 40, 1913, p. 103.

[3]H. L. Smyth, "Structural Geology of Steep Rock Lake, Ontario," *American Journal of Science*, 3rd Series, Vol. 42, 1891, p. 323.

others, interpret the contact between the Steeprock Lake formation and the grey granite gneisses as an erosional unconformity. The sediments are considered to be Huronian, and the gneisses Laurentian.

There is no doubt that a younger granite exists. However, the theory that there was a period of granitic activity between the deposition of the Keewatin lavas and that of the Seine and Steeprock formations depends entirely on the existence of an erosional unconformity between these formations and an older granite. Parsons and the author are not in agreement with Lawson's interpretation of the contact relations between the Seine and the Bad Vermillion granite. They consider this to be an intrusive contact, and therefore, the granite is younger than the Seine. In the vicinity of Steeprock Lake, Bartley[1] reports that the Steeprock conglomerate and the gneiss are both highly sheared along the contact, and that in places the conglomerate appears to have been granitized. If such is the condition the sediments would be older than the gneiss. The contradictory interpretations of these contact relations indicate that the existence of the unconformities is not positive. Therefore, the two ages of granite, and consequently the classification of the Seine and Steeprock Lake series as Huronian, must be questioned.

In this map area, two different groups of intrusives were mapped. The older intrusive is a great zone of orthogneiss, which extends across the northern part of the region. The gneiss is intruded by younger rocks, which range in composition from granite to hornblendite. Correlating these rocks with those described elsewhere along the belt, the orthogneiss might be classified as Laurentian and the granite as Algoman. However, from field evidence, the assumption that a long geological interval separated the two intrusions is not justified. Furthermore, trace-element similarity even suggests that there may be a genetic relationship between the two. Therefore, these rocks are classified as two groups of post-Keewatin intrusives separated by an interval of unknown duration.

ORTHOGNEISSES

The orthogneisses extend across the north half of the map area. In the west these rocks tend to be massive, poorly foliated, and light in colour. North of Calm Lake the rock changes and becomes strongly foliated with alternating dark-grey to black and light bands.

The leucocratic rocks (light-coloured) are medium-to-coarse grained, and contain 90 percent sericitized oligoclase feldspar and quartz, with minor hornblende, biotite, and chlorite. The melanocratic (dark-coloured) varieties are usually medium-grained, highly foliated, and on the average contain 30 percent hornblende and chlorite, sericitized oligoclase-andesine feldspar, and minor quartz, biotite, and epidote. The leucocratic variety is classified as a quartz-feldspar orthogneiss, and the melanocratic as a hornblende orthogneiss.

The intrusive nature of these gneisses can be observed in the vicinity of Beynon Lake where the contact between the biotite schist and the gneiss is well exposed. The schists are highly metamorphosed close to the contact, and many felsitic dikes, the fine-grained equivalent of the gneiss, intrude the schists. At other places near the contact these dikes cut the lavas and schists.

GRANITE-TO-HORNBLENDITE INTRUSIVES

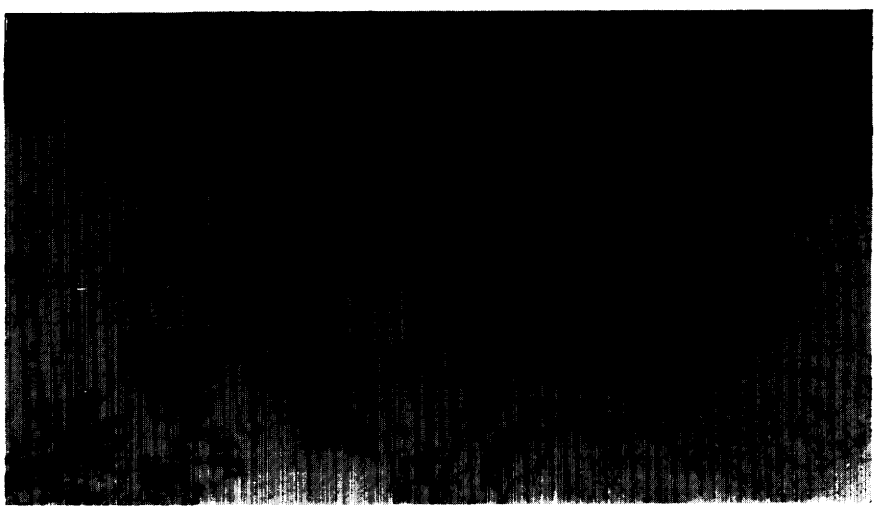
These intrusives outcrop as stock-like masses along a fairly straight line from east to west. The stocks vary considerably in size; the largest, along the

[1] M. W. Bartley, *Iron Deposits of the Steeprock Lake Area*, Ont. Dept. Mines, Vol. XLVIII, 1939, pt. 2, p. 38.

east shore of Calm Lake, is about 3 miles in diameter, but several smaller ones are only a few hundred feet across.

The contact relations between these rocks and the gneiss can be seen on a point in Calm Lake ¾ mile east of Broffel's camp. The granite intrudes the gneiss, indicating that the gneiss is older. (See photo.)

Within some of these stocks the rocks are well differentiated. The best example of this phenomenon is in the Calm Lake intrusive, where the rocks range from red biotite granite, to granodiorite, to porphyritic hornblende diorite, to dense fine-grained hornblendite, with possibly some syenite and gabbro. In the stock northwest of Crilly, the rocks range from a porphyritic hornblende



Contact between hornblende gneiss (1) and younger granite (2).

diorite to a hornblende microdiorite and gabbro. Many of the smaller intrusives are composed of coarse-grained biotite hornblendite.

The rocks of this group appear to be the youngest consolidated rocks in the map area.

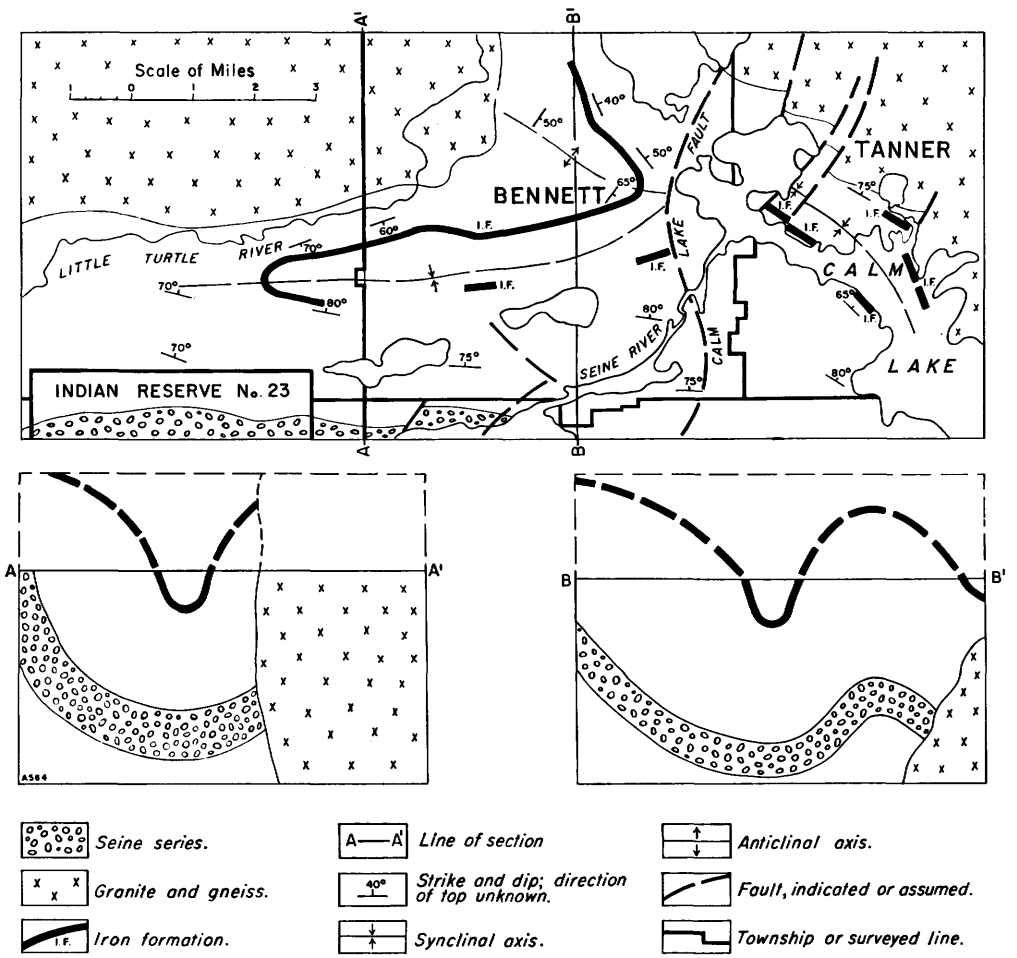
STRUCTURAL GEOLOGY

A detailed interpretation of the structure was hindered by a lack of sufficient reliable criteria for determining the stratigraphic tops of formations, and by transitional metamorphism, which made it difficult to segregate the rock types lithologically. However, the Seine series and magnetite iron formation can be readily identified. They are valuable marker beds and extremely useful in the interpretation of the regional structure. In many places, drag folds confirmed stratigraphic tops.

Folding

The dominant structure in this area is a large, tightly folded syncline, which is in part isoclinal and in part overturned. In the extreme west, the axial-trace strikes east-west, swings northeast up to Calm Lake, and then curves back to the southeast. The whole structure appears to plunge steeply east. (See accompanying sketch.)

In Bennett township, the strikes and dips indicate a steeply plunging isoclinal syncline. Furthermore, the magnetite iron formation marker bed, which can be traced around the nose of the syncline and drag folding, confirms the existence of the syncline. In Tanner township, however, this structure is not easily recognized because all the dips are steeply north. Drag folds suggest that the axial-



Structure of part of the Bennett – Tanner map area; also diagrammatic vertical sections along lines, A – A¹ (bottom left), and B – B¹ (bottom right).

trace passes between the two iron formations, and that the north limb is overturned. The overturning was most probably caused by the greater pressures that were exerted on the lavas in this area as the gneissic mass moved southward.

Near the northwest end of Calm Lake, the synclinal structure splits into a recognizable anticline, which strikes northwest and plunges steeply southeast.

It is believed that a related syncline, as shown on the sketch, must have been developed to complement the present structure. A number of southwesterly dips near the northeast tip of Calm Lake suggest that the axial-trace passes near here. Most of this structure has been obliterated by the intrusion of the gneiss.

Faulting

The principal directions of faulting are approximately N.30°E. and N.45°W. The most important fault in the area has been designated the Calm Lake fault. This fault is sinuous but has a general strike of N.30°E. It is a right-strike separation fault, that is, the east block has moved south in relation to the west block. It is considered important because movement along it faulted the eastern extension of the chlorite-carbonate schist to the south of this map area, where it was found, indicating a strike separation of about 8,000 feet.

Three other faults, parallel, and to the east of, the Calm Lake fault, were identified. All are right-strike separation faults. Further to the east, another fault belonging to this set was recognized. The average displacement along these faults is about 3,000 feet.

The principal fault of the second set strikes N.45°W. from the Seine River to midway between McPherson and Bennett lakes. The presence of a strong shear zone along the south shore of the Calm Lake narrows suggests that some faulting in a northwesterly direction may underlie the narrows.

ECONOMIC GEOLOGY

There have never been any producing mines in the map area. However, at Steeprock Lake, 25 miles east, large quantities of high-grade iron ore are being developed and mined, and elsewhere along this belt of Precambrian rocks numerous occurrences of gold and sulphide mineralization are reported. This widespread mineralization indicates that mineralizing solutions invaded the rocks along the belt, so there is a reasonable possibility of locating deposits of economic value.

The geology of this area suggests that there is a greater possibility of discovering base metal deposits than other metals. Most of the known base metal occurrences are associated with the hornblende diorite intrusives; therefore, it is thought that additional prospecting in and around these rocks is warranted.

Gold

No economic deposits of gold have been reported from the area, but numerous test pits and trenches sunk on quartz veins and shear zones indicate that the rocks were prospected in the past.

Many quartz veins were noted in the course of mapping; all are short and narrow and contain no visible mineralization. Most of these quartz veins occur in the biotite schists near Calm Lake (see photo) and in the chloritic lavas overlying the Seine series. Most of these veins are conformable to the structure and occur generally where the rocks have been crenulated. From this examination it would appear that sizable structures were not present at the time of introduction of the quartz-bearing solutions, and that these solutions were generally poor in metallic minerals, including gold.

Along the south shore of the narrows on Calm Lake there is a persistent silicified shear zone, which can be traced in a northwesterly direction for about 8,000 feet. Several test pits have been sunk on this zone. Pyrite was noted in several places, but no chalcopyrite or free gold was observed.

Iron

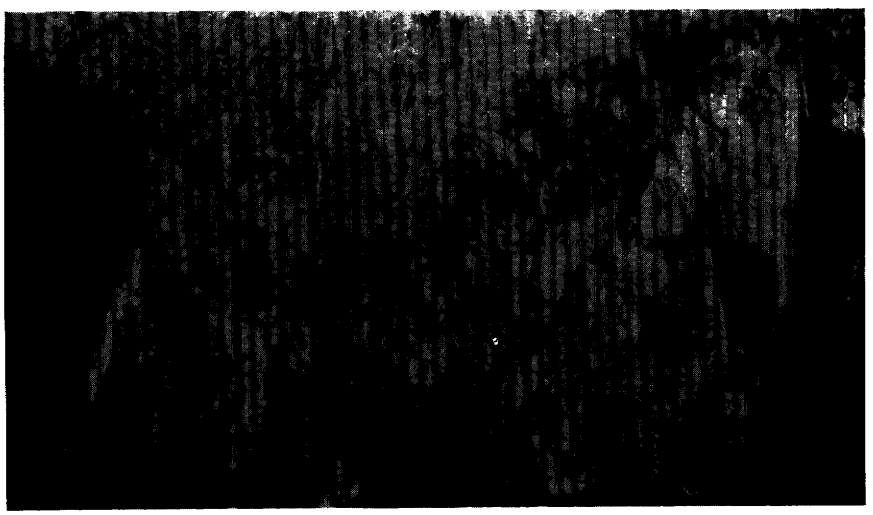
Iron occurs in the area as lean, siliceous, banded magnetite intercalated with the volcanics. The magnetite bands are normally less than 1 inch wide, and are

separated by 2–6 inches of siliceous volcanic material. These iron formations seldom exceed 50 feet in width and are not economic at present because of their highly siliceous character.

No occurrences of the iron-rich carbonate rock, such as is found at Steeprock Lake, were noted.

Base Metals

Recent prospecting for base metals has been moderately successful. Several sulphide occurrences and interesting areas are discussed here. The location Nos. coincide with similar Nos. on the map.



Quartz veinlets in biotite schist, near Calm Lake.

LOCATION NO. 1

This is located northwest of Crilly. Noranda Mines Limited has outlined an interesting zone of sulphides composed principally of pyrite, pyrrhotite, and chalcopyrite. Development work has indicated erratic sulphide mineralization along a strike length of about 4,800 feet. Widths up to 50 feet of massive sulphides have been encountered. A grab sample of diamond-drill core containing massive sulphides was assayed but contained only traces of gold, copper, and nickel.

The sulphides occur in a medium- to fine-grained, foliated hornblende diorite and hornblendite. The mineralization appears to be controlled by a northwesterly-trending shear zone. Thin section examination suggests that the mode of origin was by injection along the shear, accompanied by some replacement. Because sulphides have been found elsewhere in the same rock type, it seems reasonable to assume that there is a genetic relationship between the two. It is thought that the immiscible sulphides were segregated from the basic magma, after which the magma was intruded and sheared contemporaneously, to be followed by the injection of the sulphides.

LOCATION NO. 2

This is located near the southwest corner of a small hook-shaped lake, northwest of Crilly. No sulphides were found here during the present survey, but the presence of copper in the basic rocks has been reported.

LOCATION NO. 3

This is located in the creek bed to the east of the hook-shaped lake mentioned above. No sulphides were noted here, but there is a large amount of limonite in the creek bed. Similar conditions were noted at the Noranda property, where a creek drains across the sulphide zone, suggesting that there may be sulphides under this creek. Rock exposures are lacking in the valley, but there is a possibility that the basic rocks to the south extend this far north.

LOCATION NO. 4

A short narrow zone of shearing in hybrid rocks occurs along the north shore of McPherson Lake just west of the basic intrusive. Small amounts of pyrite were found.

LOCATION NO. 5

A large block of Recent conglomerate cemented by pyrite was found in this vicinity, suggesting that somewhere nearby there should be a sulphide deposit.

Sand and Gravel

Numerous small pockets of clean, well sorted sand and gravel occur throughout the area. The largest deposits lie between Calm Lake and Flanders, and along the Atikokan–Calm Lake road.

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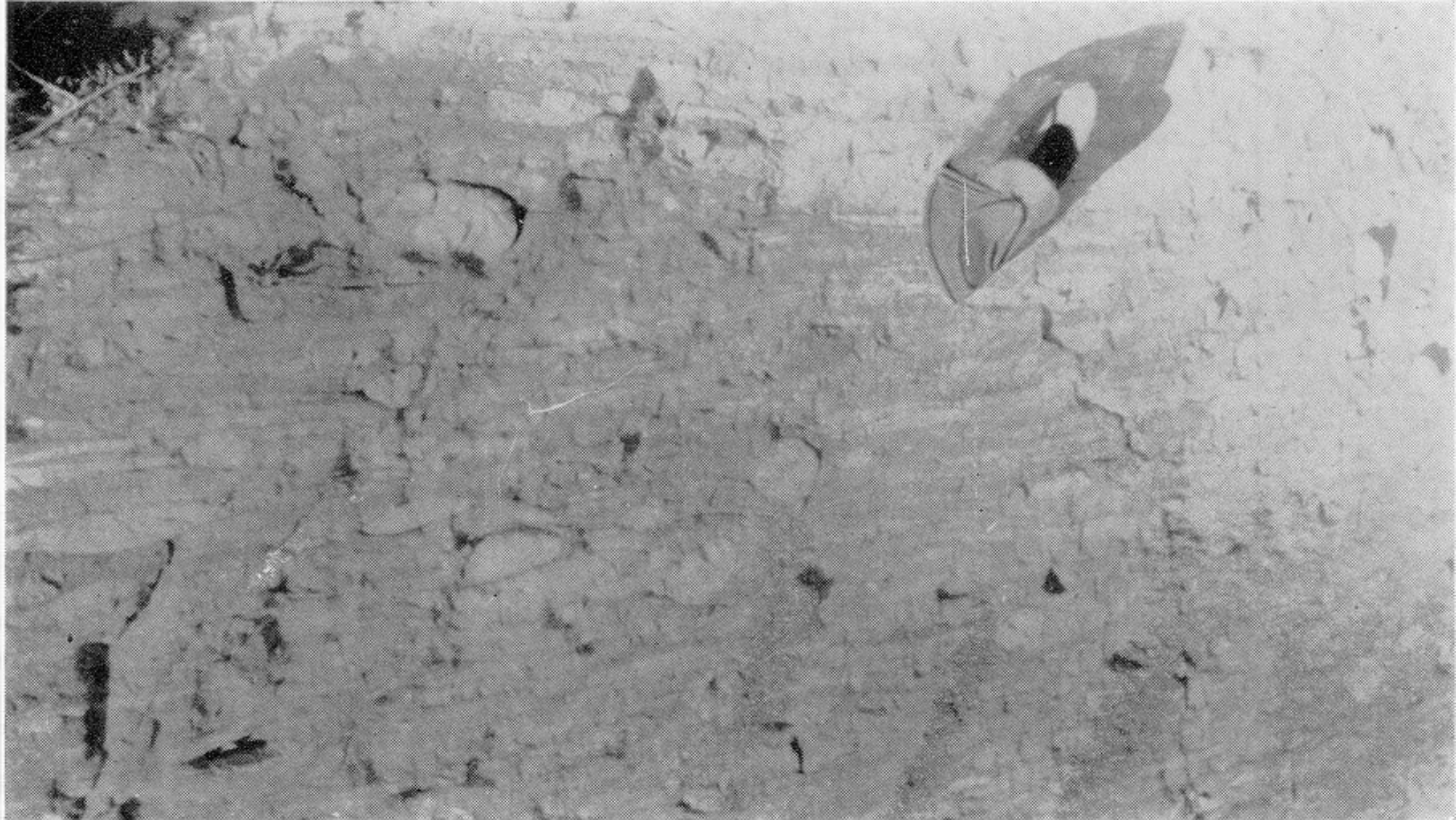
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Geology of the Lumby Lake Area

By

RALPH S. WOOLVERTON

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COLOURED GEOLOGICAL MAP

Map No. 1960g—Lumby Lake Area, Districts of Kenora and Rainy River, Ontario.
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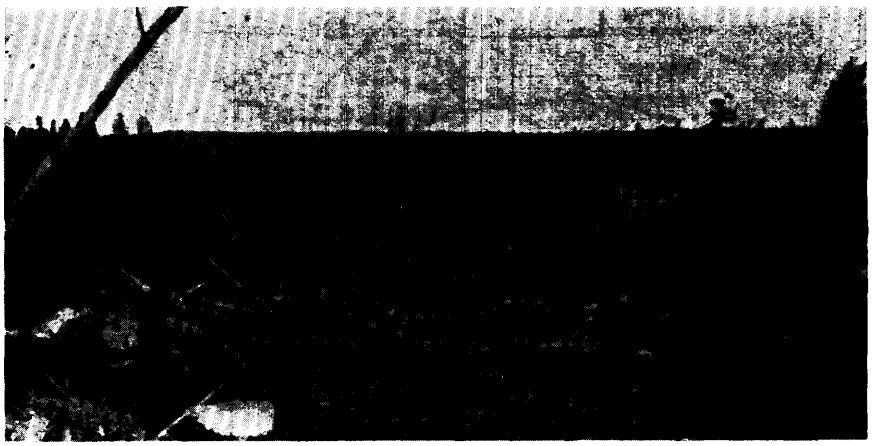
Geology of the Lumby Lake Area

BY

Ralph S. Woolverton

INTRODUCTION

During the 1951 and 1952 field seasons, the author was employed by the Ontario Department of Mines to carry out a geological survey on the greenstone belt in the vicinity of Lumby Lake, in the southeast corner of the District of Kenora. During the 1951 season the area between Redpaint and Bar lakes was surveyed, and in 1952 mapping was extended southwestward to Finlayson Lake and eastward to the boundary of the District of Thunder Bay.



View northward over Gargoyle Lake from the winter road to Pipestem Lake.

Field Work

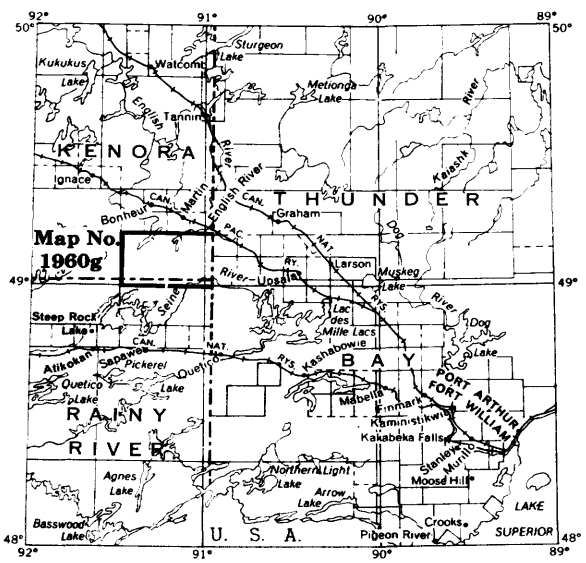
Mapping was done in the field on a scale of ¼ mile to an inch, using as base maps the Forest Resources Inventory maps of the Ontario Department of Lands and Forests. Mapping was carried out by canoe along the shorelines of the lakes, and by traversing overland between known points, usually locations on lakes, recognizeable on air photographs. Traverses were about ¼ mile apart and were laid out to cross the strike of the schistosity, formations, and contacts at high angles. Air photographs on the same scale as the base maps were used to spot tie-in points of traverses but were found to be useless for mapping outcrop because of the heavy obscuring bush. Overland traversing was found to be very difficult because of the dense undergrowth and the slash in recently cut-over areas.

Acknowledgments

During the 1951 season, the author was ably assisted by R. A. Knutson, R. L. Pretty, S. Korchuk, and the late Charles Billington. In 1952, A. J. Laurin, J. A. Outram, and G. E. Bouchier provided able assistance. The kind hospitality and assistance of Noranda Mines Limited, the Great Lakes Paper Company, and J. A. Mathieu Limited, is acknowledged.

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Key map showing the location of the Lumby Lake area. Scale, 1 inch to 50 miles.

Previous Work

As far as is known, the first geologists to vist the area were Robert Bell and A. R. C. Selwyn of the Geological Survey of Canada, who together, in the course of a reconnaissance survey from Thunder Bay to Red River in 1871, crossed the eastern part of the greenstone belt from south to north by way of Brush Creek.

W. R. C. Smith of the Geological Survey of Canada crossed the greenstone belt by the Brush Creek route in 1890, making a micrometer and compass survey. The following year, William Lawson mapped the chain of lakes southwest of English River station, on the Canadian Pacific railway, and Smith made his way, with difficulty, across the greenstone belt from English River via the Scotch lakes and Norway Lake. In 1892, Smith and W. W. Leach continued explorations in the Scotch lakes–Norway Lake area, remapped the topography around Pyramid Lake, crossed to the Seine River via Brush Creek, and worked northwards in a vain attempt to find a route to the Scotch River system. From Steeprock Lake, these early investigations were extended as far north as Redpaint Lake. In 1896, William McInnes of the Geological Survey of Canada crossed the

greenstone belt via the Scotch-Irish-Welsh-Norway lakes–Bar Creek route found by Smith in 1891. The results of the investigations by McInnes and Smith were compiled by McInnes, after Smith's death, and appear on the Seine River Sheet (Map No. 6, of the Geological Survey of Canada, issued in 1897). This map outlines the greenstone belt very much as it is known today.

Although the area received considerable attention from prospectors in the late 1890's, it was not visited again by geologists, as far as is known, until 1937, when L. F. Kindle traversed the area during a reconnaissance survey for the Geological Survey of Canada. The report on this field work was written by T. L. Tanton in 1938.

K. C. Rose of the Industrial Development Department of the Canadian Pacific Railway Company surveyed the area between Norway and Hematite lakes in 1951, and A. E. Rissanen completed the survey as far as Upsala in 1952.

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Location

The area mapped is that part of the greenstone belt and adjacent granitic rocks lying between the north end of Finlayson Lake on the southwest and the boundary of Thunder Bay District on the east. This area lies about midway between the Canadian National Railways' Port Arthur–Winnipeg line, and the Canadian Pacific Railway's main line. Lumby Lake is about 20 miles due south of the town of Bonheur on the C.P.R. The part of the greenstone belt examined lies mainly within the District of Kenora.

Access

The area is accessible by pontoon- or ski-equipped aircraft from bases at Dryden, Ignace, and Fort Frances. Commercial aircraft operate from Dryden and Fort Frances, and the Provincial Air Service of the Ontario Department of Lands and Forests has an aircraft based at Ignace, a divisional point on the C.P.R. about 30 miles northwest of Lumby Lake.

Motor roads from Martin, on the C.P.R. and the Trans-Canada Highway, to Upper Scotch Lake and to within a ¼ mile of Norway Lake have been built by Great Lakes Paper Company. Truck roads lead from Sweden Lake to other camps west of Norway Lake, and many winter roads and haul roads have been built in this area.

From Sapawe on the Port Arthur–Winnipeg line of the C.N.R., J. A. Mathieu Lumber Company has built a motor road, which provides access to the company's camps in the eastern part of the area. Use of these private roads is subject to regulations laid down by the companies. Another truck road, now largely overgrown, leads from English River station on the C.P.R. to an abandoned lumber camp midway between Pyramid and Prism lakes. Many haul roads and winter roads have been built in the Keewatin–Pipestem–van Nostrand lakes area during recent lumbering activity. In the western part of the area, wagon roads and trails cut during early mining and lumbering activity are now mostly overgrown. The old stage road, which led from Bonheur on the C.P.R. to the Sawbill and Hammond Reef gold mines on Marmion Lake and which follows the east shore of Redpaint Lake, is now very difficult to locate. A few new trails were cut during the renewed prospecting activity in 1951-52.

Various canoe routes provide access to the area. From English River on the C.P.R. or the Trans-Canada Highway, entry can be made by way of Scotch River and Lower Scotch Lake. Also from English River an ancient Indian canoe route leads to the eastern part of the area via Hawk and Squirrel lakes to Pyramid Lake, where the greenstone belt can be crossed via Brush Creek. Entry can also be made to the eastern part of the area by descending the Firesteel River from Upsala to the Seine River and then ascending Brush Creek to Oldman Lake. The early explorers, Bell and Selwyn, approached the area by descending the Seine River from Lac de Mille Lacs.

From Steeprock, entry could be made to Redpaint Lake through Marmion Lake and Sawbill Bay. A canoe route is shown on early maps, but some of the portages could not be found. A service road from Steeprock to the diversion cuts at Raft Lake provides motor transport to within a few miles of the southwestern part of the area.

The network of lakes and streams provides excellent canoe routes throughout the area; the portages are generally short and well cut out, and many of the portage trails in the eastern part of the area have been replaced by haul roads during recent lumbering operations.

It is of interest to note here that the motor roads from Sapawe to Keewatin Lake, and from Martin to Norway Lake could be linked by the building of 5–6 miles of road, thus providing a route from the Trans-Canada Highway to the Atikokan highway.

Topography

This area, like so much of the Precambrian part of Ontario, has relatively low relief, with differences in elevation rarely exceeding 300 feet. Locally the country has rather a rugged nature due to a succession of ridges and valleys more or less parallel to the direction of schistosity, and to the presence of pronounced linear valleys across these features.

The highest points of the area preserve parts of a peneplane, rejuvenated by uplift and dissected during parts of one or more preglacial erosion cycles. Pleistocene glaciation modified and rejuvenated the landscape again, and, with the last retreat of the ice sheet, the present river erosion cycle was started. It is still in an extremely youthful stage.

The area includes parts of two main watersheds. Most of the greenstone area is drained southward into the Seine River system. North of the divide the drainage is northward into English River. Because the area lies on the divide, the run-off via the streams of the region is small, and in dry weather the streams are reduced to mere trickles. For this reason water-power resources of the area are negligible. Oldman Lake is used as a log-holding basin by J. A. Mathieu Lumber Company. A dam and sluice have been built at the outlet of the lake; pine logs are dumped on the lake ice in winter and after spring break-up are floated via Brush Creek and the Seine River to the mill at Sapawe.

The main lines of drainage were established by preglacial streams and show considerable subsequent adjustment to the bedrock structure. The present pattern of lakes and streams is in part consequent in the old drainage lines and in part upon the glacial debris spread over the landscape. The present drainage system is a good example of the influence of the structure of bedrock on consequent drainage, with modification by damming by glacial debris.

Flora and Fauna

The forest of the area is mainly coniferous; the most abundant trees are spruce, balsam, jackpine, poplar, cedar, and birch. Good stands of white pine occur in areas of sandy ground moraine. Timbering, i.e. lumbering and tie-cutting, has been carried out in the past near Norway and Redpaint lakes; and pulpwood is now being cut near Riverview, Seahorse, and Norway lakes. White pine is being lumbered in the Oldman-Keewatin-Pipestem lakes area by J. A. Mathieu Lumber Company, and a small tie-cutting plant is operated south of Richardson Lake by the same company.

A dense, vigorous second-growth of alder, balsam, spruce, and jackpine over much of the area seriously hampers overland traversing and prospecting. Considerable slash in recently cut-over areas also hinders overland travel, but other parts of the area are accessible because of many roads and trails cut during lumbering operations.

Moose and deer are very scarce in the area. Black bears are numerous and threaten prospectors' and surveyors' provisions left unprotected. In most of the lakes the only plentiful fish is pike and yellow pickerel, but a few small lake trout were taken from Redpaint Lake, and large lake trout are reported to be common in the clear waters of Norway Lake.

GENERAL GEOLOGY

The greenstone belt in the Lumby Lake area is one of many such belts of similar early Precambrian rocks that occur in the country between Lake Superior and Lake Winnipeg. Though smaller than many of these, averaging only 3–4 miles in width, it is made up of the typical assemblage of early Precambrian (Keewatin-type) basic and intermediate lavas and pyroclastic rocks with some sediments, in most places highly altered, schistose, and steeply folded.

At several places in northwestern Ontario, evidence of two periods of granitic intrusion in the granite complex has been found. On the assumption that these two ages are the same, wherever found, the term Laurentian has come to be used to designate the older age, and the term Algoman to designate the younger. Laurentian granite has been recognized only where early Precambrian sediments overlie it unconformably, as at Steeprock Lake. The Laurentian granite shows a variety of lithologically different phases, as does also the Algoman granite, which is recognized as intruding early Precambrian sediments. Where relationships of

the granite with Temiskaming-type strata cannot be investigated, the granite cannot definitely be assigned to the Laurentian or Algoman. In the Lumby Lake area certain areal correlations are assumed in the granites bordering the greenstone belt, and on this and other debatable evidence Laurentian and Algoman granites are tentatively distinguished. For this reason the terms Laurentian and Algoman are used in this report with considerable reservation, and with the realization that, within the area covered, conclusive evidence for two ages of granite is lacking.

TABLE OF FORMATIONS

CENOZOIC	
RECENT:	Alluvial deposits in lakes and along rivers.
PLEISTOCENE:	Boulder clay; varved clay; glaciofluvial deposits of boulders, gravel, sand, and silt.
	Great Unconformity
PRECAMBRIAN	
ALGOMAN (?):	Hornblende and biotite granite and granite gneiss; syenite; aplite and lamprophyre.
	Metadiorite (may be pre-Algoman, and in part Keewatin).
LAURENTIAN (?):	Altered hornblende and biotite granite and granite gneiss, mainly sodic; porphyritic granite, granite porphyry (quartz porphyry).
	Intrusive Contact
KEEWATIN-TYPE:	Argillite (mostly graphitic, and in part concretionary); fine-grained argillaceous greywacke; conglomerate; crystalline limestone; iron formation; and hornblende, garnet-mica, andalusite-biotite-garnet, graphite and other schists; cordierite-garnet-mica, and other hornfelses derived from the sediments.
	Altered basic and intermediate volcanics; minor rhyolite; tuff, agglomerate, flow breccia; minor interbedded quartzite, and argillite; and hornblende, biotite, chlorite, sericite, and carbonate schists and hybrid rocks derived from these various types of rocks.
	Includes some intrusive metadiorite, and serpentinite (may in part be post-Keewatin).

Keewatin-Type Volcanics

FLOW ROCKS

Most of the volcanic rocks of the Lumby Lake greenstone belt are altered basic and intermediate lavas, mainly andesite and basalt, with minor dacite. These are the oldest rocks of the area. The term greenstone is used to designate the altered equivalents of basic and intermediate lavas. Most of the original minerals of the volcanics have been altered to a mass of chlorite, epidote, and carbonate; with such a high degree of alteration, it is difficult to classify them according to their original mineral composition. Thus the names given are based on the general field appearance, on the presumed original composition as suggested by residual minerals, or by the nature of the alteration products.

Though the Keewatin rocks have been reconstituted mineralogically by regional metamorphism, the original texture and structure have been preserved in many places and are best seen on clean, weathered surfaces. Only in relatively few places are such primary structures as pillows, amygdules, and flow top features preserved in such form as to be valuable for determining the tops and bottoms of flows. Pillow structures are often distorted by shearing, and the pillows may be drawn out to many times their original length, thereby losing the shape and packing characteristics that are the top-determining criteria.

Amygdaloidal structure is common and is especially noticeable in the pillowed parts of flows. Nowhere, however, was it well enough preserved or exposed to be useful for top determination. Ropy structure was observed in several places but was not very useful in delineating flow contacts, and only in one place could the direction of top of the flow be determined by such a contact.

Textures in the greenstones range from aphanitic to coarse-grained. Grain gradation in individual flows was seldom observed and nowhere is exposed well enough to serve as a means of indicating tops and bottoms. Most of the flows are fine-grained equigranular, but a few andesites are porphyritic.

The Keewatin-type lavas in the greenstone belt are basalts, andesites, and minor dacites. In general, it is in the field that classification can best be made, as these rocks in thin section are seen to be altered to a mat of chlorite, epidote, secondary feldspar, carbonate, kaolin, and other secondary minerals, with little or no indication of the primary minerals. In the field, the colour of the weathered surface was used to a large extent to differentiate between basalt and andesite, the former being dark-green to black on the weathered surface, whereas the latter is light-green or grey-green. Fresh surfaces were found to be similar in colour and texture.

Basalt, or its relative greenstone, is less common throughout the southern part of the area than andesite. North of the band of sediments basalt is more common, representing about 75 percent of the flow rocks. This areal distribution was found impossible to map because of intermediate types between the two.

Dacite is found only in the southwestern part of the area, along the northwest shore of Lumby Lake and Spoon Lake. It is a medium-grained porphyritic grey-green rock, weathering to a light-green surface on which feldspar crystals up to ¼-inch weather in relief. It is not so completely altered, possibly because of its more acid composition, as the basalt and andesite of the area. It occurs with, and in places appears to grade into, non-porphyritic andesite. Also, with the diminution of the porphyritic texture and the introduction of a few quartz phenocrysts, it seems to grade into a rhyolite porphyry towards the south. For this reason it is possible that at least some of the acid porphyritic rocks in the Lumby-Jefferson lakes area may be equivalent in age to the Keewatin-type greenstones. That the dacite is extrusive is supported by the presence of dacite fragments in agglomerate at Lumby Lake.

Under the microscope, the typical andesite shows a primary crystalline structure, and is composed of subhedral crystals and microlites of plagioclase in a groundmass of epidote, chlorite, quartz, and opaque minerals. The plagioclase, forming about 30 percent of the rock, is albite, indicating that the lava is spilitic. Furthermore, the presence of spilitic metadiorite and the high-soda southern granites suggest that albitization may be fairly widespread.

In several places a porphyritic andesite is exposed. North of Rea Lake, a formation about 100 feet thick striking N.80°W. can be traced for about 1½ miles. Other occurrences are found on the large peninsula in Bar Lake, on the trail between Rea and Spoon lakes, and ½ mile south of the west end of Lumby Lake.

This rock has been rather aptly termed "golf ball porphyry" by prospectors. It occurs rather frequently in the greenstone areas of northwestern Ontario and has been described by various geologists. Wright[1] has applied the name "leopard rock" to it because of its spotted appearance.

[1]D. G. H. Wright, *The Black River Area*, Ont. Dept. Mines, Vol. XXX, 1921, pt. 6, pp. 27–6ꝑ

This porphyritic lava is composed of a medium-green, fine-grained groundmass, probably originally andesitic in composition in which are set idiomorphic phenocrysts of feldspar up to 1½ inches in diameter, which are generally quite subordinate to the lava matrix and are in places well rounded in outline, suggesting either movement within the flow or corrosion by chemical reaction with the matrix. Locally the rock grades into a greenstone schist, which has lenses of lighter-coloured material, which are obviously sheared phenocrysts.

A thin section cut across a phenocryst was expected to reveal the type of feldspar by microscope study, but though the crystal outline was visible, the interior was found to be composed of a mass of anhedral grains of clinozoisite, which represents the alteration of the original calcic plagioclase.

ACID ROCKS OF DOUBTFUL AGE

Some of the finer-grained acid rocks in the area mapped as a quartz porphyry-diorite complex may be extrusive rhyolites and associated dike rocks of the same age as the Keewatin-type greenstones. The largest area of these fine-grained acid rocks extends from the west end of Lumby Creek eastward to Richardson Lake and ranges in width from about 1 mile at Spoon Lake to 20-foot zones near Richardson Lake. Most of this area is considerably, and in places intensely, sheared, much of the quartz porphyry being altered to a quartz-sericite schist. In the vicinity of Richardson Lake the porphyritic nature is almost entirely absent, and the narrow zones are altered to fine-grained, white-weathering, quartz-epidote rocks with minor garnet. Narrow sill-like bodies of quartz porphyry occur north cf Gargoyle Lake, but evidence of an intrusive or extrusive nature is lacking.

That the larger area of quartz porphyry is extrusive is suggested locally by an apparent gradation from dacite into quartz porphyry. Also the presence of acid tuffs and quartzites seems to indicate that acid rocks such as those under question were erupted or exposed during Keewatin time. On the other hand, the gradation southwards in this area from rhyolite porphyry, through granite porphyry, and porphyritic granite into Laurentian (?) granite suggests that they are all related to a single period of intrusion.

The presence of metadiorite of pre- and post-Laurentian age is a further obscuring feature near the south contact.

The same situation exists on the south side of the Laurentian (?) granite in the Sapawe Lake area 15–20 miles to the south. Hawley[1] considers all the quartz porphyries (felsites and micropegmatites) to be of Laurentian age. Here also the relationships of the intrusions of diorite and gabbro are not clear, but Hawley recognizes a pre- and post-Laurentian set of intrusives.

VOLCANIC FRAGMENTALS

Various types of volcanic fragmentals occur throughout the area, mainly as occasional thin beds separating lava flows. Acidic varieties appear to be most abundant, though the predominance over basic types may be more apparent than real, since metamorphism may have altered the basic tuffs to such an extent that they are no longer recognizeable.

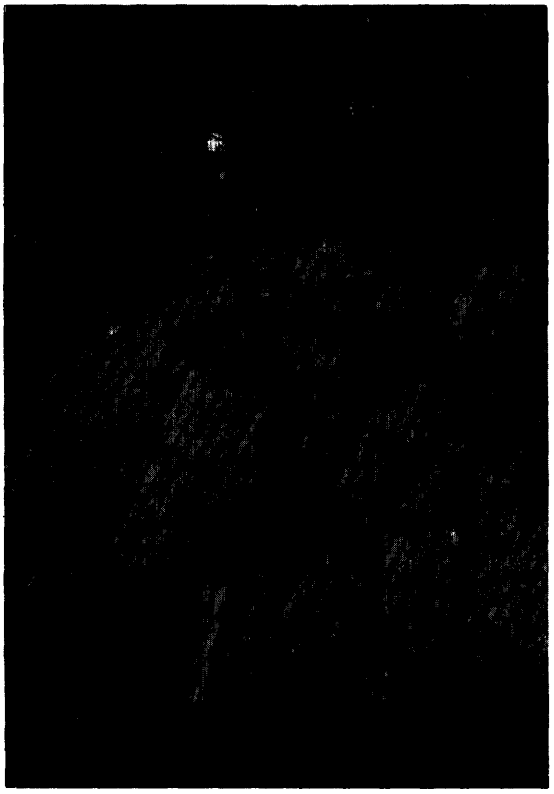
The texture ranges from very fine-grained tuffs to agglomerates with fragments up to 8 inches in diameter. In several places a gradation from agglomerate to tuff was used for top determination.

Except for a band of agglomerate-tuff that extends from Lumby Lake to north of Spoon Lake, a band of acid tuff extending from Rea Lake to Bar Lake,

[1]J. E. Hawley, *Geology of the Sapawe Lake Area*, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6, p. 11.

and a band midway between Upper Scotch Lake and Leach Lake, the volcanic fragmental horizons are of limited length, and though many outcrops were observed, they could not be correlated between adjacent traverses.

Flow breccias were observed in a few places within the greenstone area. On a point in the south bay of Bar Lake, angular fragments of andesite and hornblende schist occur in an andesite matrix. There is no indication of any bedding, the



Agglomerate on north shore of Lumby Lake.

fragments are jumbled together, and the rock is not schisted. A somewhat similar rock is exposed at the south side of a small lake at the side of the road south of Hematite Lake but is considerably schisted.

Volcanic fragmentals appear to be more common in the western part of the area than in the east.

GREENSTONE SCHISTS

Various types of schists have been derived by regional and contact metamorphism of the greenstones, and these grade either into the massive greenstones recognizeable as originally volcanics or into dioritic intrusions. Varying degrees of schistosity are recognizeable in nearly all the oldest rocks of the area and in the higher degrees it has obliterated the primary volcanic structures.

The most common types are chlorite schist, chlorite-carbonate schist, and actinolite schist, which are the result of low-grade regional metamorphism. Near the north contact, and in the tongue extending westward from Redpaint Lake, and east of Upper Scotch Lake, hornblende and hornblende-biotite schists

predominate. In the shear zone near the south contact, and in the sheared and dragfolded zone on the east side of Redpaint Lake, and in minor shear zones in various places, sericite schist and sericite-carbonate schists have been developed.

In the area between Norway and Rea lakes and eastward north of Bar Lake, banded schists derived from Keewatin volcanics are common. The banding appears to be due to the metamorphic effect of the intrusion of Algoman granite on previously schisted greenstone, and has given rise to pseudo-bedding. If any one band, $\frac{1}{8}$–$\frac{1}{4}$ inches wide, is traced along strike it is found to be either discontinuous or to double back forming a parallel band, finally forming a very elongate closed figure.

Early Precambrian Sediments

MINOR SEDIMENTS

Interbedded at various places in the Keewatin volcanics are minor beds of quartzite, argillite, and iron formation. These beds are relatively narrow, although the complete width is seldom exposed, and some are represented by a single small outcrop. All of them stand vertically, or nearly so, and few are traceable between traverses. Some are too small to be shown on the map at the scale used. It is difficult in the field to distinguish between fine-grained sediments and volcanic tuffs, especially between their schistose derivatives.

These narrow bands of sediments occur both north and south of the main band of sediments but are more numerous to the north. They are especially common in the areas west of Norway Lake and north of Cryderman Lake. Even here, correlation of zones between adjacent traverses was not possible. Magnetic attractions of various intensities are associated with some of these narrow bands, and since many such attractions are found in areas of no outcrop, it is concluded that many unmapped zones occur.

MAIN SEDIMENTARY BAND

A band of sediments, 300–3,500 feet wide, extends from east of Brush Creek to the west end of Seahorse Lake. It strikes N.80°W., and its various members dip vertically or nearly vertically. Its position is marked over most of its length by a series of lakes whose basins have been eroded out of the softer components of the belt. In the vicinity of Norway Lake, it is intruded by Algoman (?) granite; at the east end of Hematite Lake, a granite intrusive, the so-called van Nostrand stock, intrudes the sediments and forms a 3-mile gap in the belt. To the southeast, the band of sediment approaches to within 1 mile of the Laurentian (?) granite, but the mutual age relationships are not known.

This main band of sediments is composed of cherty iron formation with local carbonate rock and conglomerate, overlain by fine-grained argillaceous greywacke with important lenses of graphitic and concretionary argillite, and local conglomerate. Regional and contact metamorphism has produced a variety of schists and hornfelses. West of Garnet Bay minor amounts of Keewatin-type volcanics are interbedded with metamorphosed sediments.

The sediments appear to lie along, or near, the trace of the axial plane of a major syncline interpreted from structural determinations in adjacent volcanics; a relationship suggesting that the sediments are at or near the top of the greenstone sequence in the area. No evidence for unconformity was found at the poorly defined contacts.

West of Garnet Bay, large areas of the sedimentary belt are hidden under muskeg and masked by thick vegetation; a few outcrops of fine-grained tremolite schist and cherty iron formation were found, as well as graphite schist and argillite,

near Seahorse Lake. Cherty silica is found near Garnet Bay, also highly metamorphosed argillaceous greywackes and banded carbonate rock. Contact metamorphism in the argillaceous sediments has given rise to a variety of schists and hornfelses, the most common being garnet-mica schist, which forms most of the band between Garnet Bay and Pinecone Lake. Lean banded iron formation occurs between Spool and Pinecone lakes and extends eastward along the north shore of Pinecone Lake as a high cliff. Graphitic argillite occurs as narrow lenses in argillaceous greywacke on the south side of Pinecone and Cryderman lakes. Iron formation extends from Cryderman Lake eastward to the east end of Hematite Lake, and a large lens of argillite overlying it forms the south half of the belt at Hematite Lake. Siderite and massive sulphide are found associated with interformational breccia at, and near, the contact of the iron formation and argillite in this area. Iron formation overlying metamorphosed argillaceous greywackes occurs at the east end of Hematite Lake and east of van Nostrand Lake.

East of Brush Creek, the rocks in the sedimentary belt become more schistose and, in the few places seen, are altered to quartz-sericite schist.

Iron formation

The various phases of the fine-grained cherty silica formations found at various places along the main belt of sediments are described under this heading. Much of it resembles a fine-grained quartzite in the field, but its general cherty character, its association with iron minerals, and a petrographic study of the different types has led to incorporation of the various phases under this main heading. Parts of it resemble most of the smaller zones of fine-grained cherty quartz, being white or buff weathering, generally fine-grained, and showing various degrees of banding. No part of it was found, in the field or in petrographic study, to resemble the quartzite near Hook Lake mentioned in a previous section.

The eight phases of the iron formation are:

Cherty magnetite iron formation
Recrystallized magnetite iron formation
Cherty silica
Banded silica and siderite
Pisolitic siderite-chert
Massive siderite
Massive sulphides
Inter- and intraformational breccia

The iron formation, in its various phases, occurs mostly in the northern part of the main band of sediments but is not continuous over the complete length. It ranges from narrow ½-inch bands in argillite, carbonate rock, and banded schists up to zones ¼ mile in width. Near the granite contacts, considerable recrystallization has taken place. Crystalline limestone occurs within it and is described separately. Some of the phases to be discussed are exposed only in the diamond-drill core from the Mathieu property but show features worthy of special description.

Cherty Magnetite Iron Formation.—Outcrops of fine-grained, cherty, magnetite iron formation were observed at two widely separated localities in the sedimentary belt, i.e. at the southeast shore of Seahorse Lake, and on a small island at the north end of Keewatin Lake. At both places, the rock consists of finely banded chert and magnetite. Narrow bands of magnetite 1/16–¼ inch in width are interlayered with lighter-weathering siliceous bands to ½ inch, in

which minute magnetite crystals are disseminated. The magnetite bands weather to a dark reddish brown, whereas the siliceous bands weather to a medium grey or light orange.

Microscopic study of the siliceous bands in the iron formation at Seahorse Lake shows a fine granular mosaic of quartz grains averaging about 0.05 millimetres in diameter. The grains show no evidence of recrystallization such as sutured boundaries. Some of the quartz grains in the mosaic show wavy extinction. The granular nature of the rock is emphasized by red iron oxide stain that penetrates most of the intergrain contacts.

Anhedral crystals or groups of crystals of magnetite up to 0.02 millimetres in diameter occur disseminated throughout the siliceous bands; they constitute less than 5 percent of the rock. Iron oxide staining and fine acicular crystals of goethite are associated with the magnetite. Minute needles of actinolite, none exceeding 0.02 millimetres in length, occur throughout the section studied, mainly as inclusions in the quartz.

Recrystallized Magnetite Iron Formation.—A lens of magnetite iron formation about 300 feet wide occurs between Spool and Pinecone lakes and extends along the north shore of Pinecone Lake. It is probably a recrystallized equivalent of the type of iron formation similar to that described in the previous section. It consists of alternating bands of light-blue, grey, or red silica and black siliceous magnetite. The bands are commonly about ¼ inch, but in places are 1 inch or more in width. The dark bands are composed of mixed fine-grained magnetite and silica. The siliceous bands resemble a medium-grained vitreous quartzite. The iron content is probably not more than 20 percent.

In thin section, siliceous bands of this rock are seen to be composed of about 95 percent quartz and 5 percent pyroxene, magnetite, uralite, and calcite, with minor oxide staining.

The quartz occurs as irregular, interlocking grains up to 5 millimetres in diameter, and contains many inclusions of pyroxene, and magnetite, and zones of minute gaseous and liquid inclusions, some of which appear to outline the position of pre-existing quartz grains. Patches of quartz of different orientation occur within the large irregular grains. The quartz is highly strained, all grains having wavy extinction; the boundaries between the large grains are much serrated.

The pyroxene is a pale-green, slightly pleochroic augite occurring as corroded anhedral crystals averaging 0.2 millimetres in diameter. Some crystals have central zones of brown to yellow ferro-augite, and most have peripheral zones of alteration to the pale-green fibrous amphibole, uralite, which in most places 'sprouts' into radial arrangements up to 2 millimetres in size of long, curved needles, which invade the quartz grains.

Magnetite is in about the same proportion as pyroxene, being in subhedral crystals and crystalline aggregates up to 0.5 millimetres but averaging about 0.2 millimetres in size. Many small particles occur with pyroxene as inclusions in the quartz.

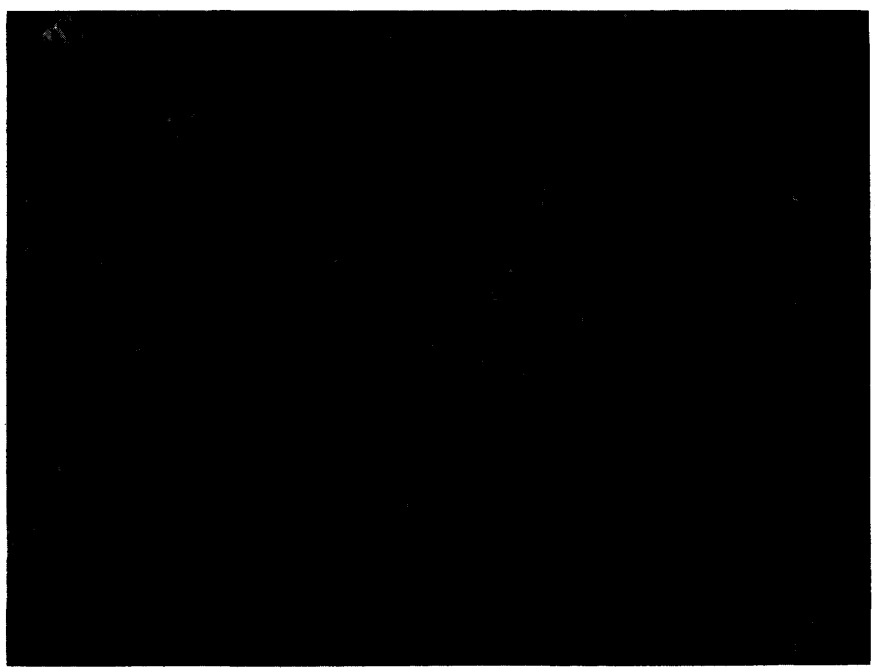
A very minor amount of calcite also occurs as patches of anhedral crystals within quartz.

This zone of iron formation has been subjected to contact metamorphism by the intrusion of Algoman (?) granite to the north and south. It is probable that the granite does not lie very deep below the surface in the area between the intrusives.

The contact metamorphism is marked here by changes in a rock of extreme silica composition, with a small amount of ferric iron, calcium, magnesium, and other elements. The metamorphism has reached the stage where the quartz has

been completely recrystallized, with few recognizable traces of a fine-grained mosaic quartz as seen in the cherty magnetite iron formation, to larger interlocking grains with considerable evidence of strain.

Cherty Silica.—Under this heading are included those fine-grained, white- to buff-weathering, sugary-textured phases of the iron formation. This type of cherty silica (called quartzite in the field) was observed on the north side of Garnet Bay, between Cryderman and Keewatin lakes, and along the shores of Hematite Lake; it has also been intersected by diamond-drilling near Hematite Lake. It is relatively resistant to erosion and forms prominent hills; its association with weakly resistant carbonate rock accounts for the considerable relief in the



Lenticular structure in cherty iron formation on north side of Garnet Bay.

Pinecone-Hematite lakes area. Except where it is locally banded with carbonate rock, banding is not very prominent. Usually it consists of bands of white silica with narrow and irregular bands of pale buff-coloured silica; these bands are up to several inches wide. In places graphitic material occurs as narrow irregular discontinuous bands, which may give rise to shaly partings. A few pyrite cubes and siderite rhombs can be seen on fresh surfaces.

A small cliff on the north shore of Garnet Bay shows a lenticular structure in white cherty silica. The lenses are 1–2 feet long and 4–6 inches thick, and show faint laminal banding. They are exposed only in two dimensions, so their exact shape is not known. They resemble somewhat cherty lenses in the andalusite-biotite-garnet schist on the south side of the entrance to Garnet Bay. It is suggested that these cherty lenses were originally masses of gel silica formed on the bottom of a basin of deposition, perhaps because of slight agitation during precipitation of silica, which caused accretion about nuclei during the rolling around of the gel masses. The lenticular shape is due either to collapse under its own weight, or later deformation, or both.

A thin section of a typical specimen from the east end of Cryderman Lake shows, under the microscope, a fine-grained quartz mosaic with a granoblastic texture, forming about 97 percent of the rock. The quartz grains range from 0.05 to 0.3 millimetres in size.

Siderite occurs as small grains, as fine-grained aggregates, and as isolated rhombs, associated with cryptocrystalline aggregates of goethite and a small amount of granular calcite.

The cherty silica phase at Hematite Lake grades southward by an increase of siderite content into pisolitic siderite and massive siderite. At other places, as at the east end of Cryderman Lake, this siderite member is lacking. With an increase of iron carbonate, the rock weathers more rusty and red, until the weathered product is a sinter-like gossan.



Folded banded silica and siderite iron formation near collar of No. 4 drill hole on Mathieu property; shows colour gradation across some bands, and micro-faulting across the fold structures.

Banded Silica and Siderite.—Banded siliceous iron formation of the type described under this heading is well exposed near the east shore of Keewatin Lake. The best exposure shows well banded chert and cherty siderite highly folded and closely fractured and faulted. The bands vary from 2 inches to less than $\frac{1}{16}$ inch in width, and weather to black, brown, reddish-brown, buff, and white. The lighter, cherty layers show an apparent 'graded bedding' of coarse-to-fine granular chert with a corresponding change of colour from light to dark. This 'graded bedding' is uniform over the outcrop and nearby outcrops, and if bedding of clastic grains was being dealt with would suggest that the strata faced towards the east.

To the south of this outcrop similar banded iron formation has been uncovered by stripping, and heavy limonite gossan overlies bedrock over a considerable area on the hill to the northeast for several hundred feet.

A thin section of a drill-core sample of this type of rock, cut normal to the banding, shows, under the microscope, granoblastic quartz mosaic bands and

carbonate bands. The quartz mosaic bands show a gradation of grain size across the bands. Some of the bands are almost pure quartz and these are generally coarser grained than those bands containing more carbonate. Across an average band the amount of disseminated siderite increases as the average size of quartz grains diminishes. Some of these siliceous bands grade by increase of siderite into the dark siderite bands; other siderite bands have sharp contacts with quartzose bands. The carbonate bands are composed of fine-grained siderite as anhedral aggregates and crystals averaging about 0.01 millimetres; cherty fine-grained quartz forms up to 30 percent. Within these bands occur fine, fairly continuous, parallel zones composed of an exceedingly fine-grained mixture of siderite, graphite, and stilpnomelane. Dark-brown pleochroic needles of stilpnomelane up to 0.5 millimetres in length and a few small (0.1 mm.) anhedral crystals of pyrrhotite occur in the siderite bands.

The axial plane of the folds in the banded iron formation, at the exposure mentioned above, strike about N75°W. and dip about vertical. Many minor faults strike about parallel to the axial planes, strike separations being from a fraction of an inch to several feet.

Pisolitic Siderite-Chert.—The diamond-drill cores from recent drilling on the Mathieu property at Hematite Lake provide much information about the siderite iron formation that cannot be obtained from surface exposures because of heavy gossan and iron-stained bedrock.

A pisolitic phase between massive siderite and sulphide on the south and more or less pure cherty silica on the north was observed in core from drill hole No. 5, of the 1952 program, at 208 feet deep.

A prominent oölitic or pisolitic structure was noted on the core surface and was prominent on a flat saw cut made across the core. According to Pettijohn,[1] such structures, if over 2 millimetres in diameter, should be termed pisolites rather than oölites.

The pisolites are roughly round in shape, averaging about ¼ inch in diameter. They are composed of alternating bands of creamy siderite and fine-grained chert, a single pisolite being composed of four or five alternating bands. Where a saw cut crosses the exact centre, a small pyrite crystal may show as a nucleus.

In thin section, the pisolites show as generally round or oval, ranging up to 0.6 millimetres in diameter, and are composed of at least two rings of fine-grained siderite and cherty quartz arranged around a small pyrite crystal. The interstitial areas between pisolites are composed of a cherty quartz mosaic, recrystallized in places.

Minor needles and sheaves up to 1 millimetre in length of pale-green stilpnomelane, and minor patches of chlorite occur within the siderite bands.

The presence of pisolitic siderite is an important consideration in the study of the origin of the siderite iron formation. There is no agreement in literature on the origin of oölitic or pisolitic structures. Some theories demand direct or indirect intervention of organisms, others require their formation in a gel medium, whereas still other theories claim they are a replacement structure. Aldrich[2] describes siderite oölites in granular chert beds in the Gogebic range of Wisconsin and claims that they were originally siderite, partially or completely replaced by microcrystalline quartz, leaving a residuum of finely divided iron oxide distributed in the same way as the remaining carbonate to prove that the oölites were originally siderite.

[1]F. J. Pettijohn, *Sedimentary Rocks*, Harper and Bros., New York, 1949, p. 75.
[2]H. R. Aldrich, *Geology of the Gogebic Iron Range of Wisconsin*, Wis. Geol. Nat. Hist. Surv., Bull. No. 71, 1929, p. 157.

Massive Siderite.—As has been mentioned, the siderite-chert formations, including the pisolitic siderite-chert, grade in general southward into zones with a greater proportion of siderite near the contact with argillite. Several such zones, up to 40 feet in width, have been intersected by diamond-drilling in the area between Hematite and Keewatin lakes. Closer drilling is necessary before an estimation of the size and grade of these zones can be made. Pyrite crystals and disseminated pyrrhotite form 5–10 percent of the lenses intersected.

Two zones of this type of mineralization were encountered in diamond-drill hole No. 3, of the 1950 drilling program on the Mathieu property, 500 feet east of the west end of Hematite Lake on the north shore. Most of the core had been removed for assay, so that the complete section could not be examined. The mineral composition is indicated in assays provided by Candela Development Company, given below.

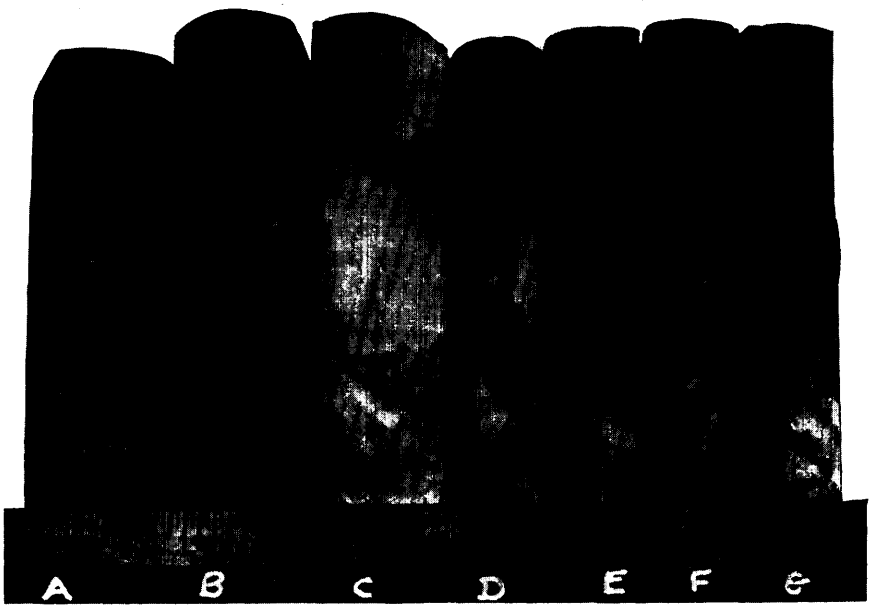
MINERAL COMPOSITION, DIAMOND-DRILL HOLE NO. 3, CANDELA DEVELOPMENT CORPORATION LIMITED

Zone	Total Iron	Iron due to Siderite	Manganese	Iron: Manganese Ratio	Silica	Sulphur
	percent	percent	percent		percent	percent
249–299 ft. of massive siderite with some pyrite and pyrrhotite	23.86	23.09	1.65	13.9	3.75	0.77
	30.03	26.90	1.94	13.9	19.50	3.13
	26.94	25.51	1.80	14.1	26.20	1.43
	29.70	25.96	1.76	14.7	21.90	3.74
	26.46	25.36	1.75	14.5	26.90	1.10
360–375 ft. of massive siderite with some pyrite	32.30	31.04	2.32	13.4	10.65	1.26
	37.33	36.41	2.32	15.7	9.20	0.92
	34.09	33.49	2.51	13.3	2.85	0.60

Allowing for the iron content of the pyrite and pyrrhotite as estimated at a 1:1 ratio with sulphur, iron:manganese ratios were calculated and are included in the accompanying table. The iron:manganese ratio remains fairly constant with widely varying amounts of total iron, sulphur, and silica and indicates that the manganese is associated with the iron carbonate, the carbonate mineral actually being a mangano-siderite with about 7 percent manganese. Variations from the average iron:manganese ratio of 14.2:1 probably arise from errors in the iron:sulphur ratio estimation due to varying proportions of pyrite and pyrrhotite. The close and uniform relationship of the manganese and iron is suggestive of a sedimentary origin for the siderite, as the manganese and iron cycle are closely related.

Massive Sulphides.—A zone of pyrrhotite-pyrite mineralization occurring in the iron formation at the contact with argillite has been traced by diamond-drilling for a distance of about 2 miles in the Hematite-Keewatin lakes area. It is possibly a continuous zone. The widths of this zone (or zones), as indicated by diamond-drilling, range from several to over 100 feet. A pair of holes, inclined at 45°, drilled north and south of a site east of Keewatin Lake by Candela Development Company, intersected respectively 291 feet of disseminated sulphides assaying 23.4 percent sulphur, and 273 feet assaying 20.9 percent sulphur; these holes were possibly drilled along the strike of the formation, which is considerably folded in this area. Several narrow lenses of concretionary graphite schist, similar to that exposed in the pit at Cryderman Lake, have also been intersected in the argillites near the contact.

The sulphide mineralization consists of disseminated to massive pyrrhotite and pyrite, which occurs in various proportions. The most common and typical appearance is of cubes and pyritohedrons of pyrite up to ½ inch in diameter scattered throughout massive pyrrhotite or throughout pyrrhotite disseminated in chert. Pyrrhotite occurs also as minor narrow stringers in chert and graphite schist, and as ½-inch-long lenses within the breccias in the argillite near the contact.



DRILL CORE FROM MATHIEU PROPERTY

A. Greywacke showing graphitic streaks.
B. Intraformational breccia in graphitic argillite.
C. Intraformational breccia in cherty silica-siderite.
D. Interformational breccia at iron formation – argillite contact.
E. Intraformational breccia in banded silica and siderite.
F. Banded silica and siderite.
G. Interformational breccia at iron formation – argillite contact.

In the sulphide zones at Hematite Lake, well-crystallized pyrite contrasts sharply with the massive or finely disseminated pyrrhotite. Two generations of pyrite are suggested within one crystal. The older inner part of the pyrite crystals shows less definite boundaries and has more inclusions and cracks than the pure, massive, outer peripheral rim, which shows extremely sharp straight contacts with surrounding minerals. No other sulphides have been reported. Candela Development Company has assayed the sulphides for cobalt and nickel, but all results have been negative; one assay of 0.005 ounces of gold has been reported; all other assays have returned no gold.

The occurrence of the sulphides concentrated along, and near, the argillite contact over a distance of 2 miles suggests an origin either closely related to the origin of the iron formation or a hydrothermal origin with deposition structurally controlled by the contact. The author believes that the early pyrite is probably syngenetic sedimentary, similar in origin to the pyrite of the concretionary argillite. The later pyrite and pyrrhotite is possibly hydrothermal and may be genetically associated with the van Nostrand stock.

Interformational and Intraformational Breccias.—At many places in the drill core from the sediments at Hematite Lake, the cherty silica, siderite, and sulphide zones and argillite show zones of breccia. Some of the breccias may be due to microfaulting such as that seen in the outcrop of banded silica-siderite described previously. Most of the breccia noted appears to be of interformational and intraformational origin, although some of it may be of tectonic origin. It occurs as definable zones of various widths within the cherty silica, in the siderite and sulphide zones at the iron formation–argillite contact, and within the argillite.

Several surface exposures show brecciation within the cherty silica formation; at the east end of Cryderman Lake narrow curved fragments of white granular chert up to 2 inches in length occur in a buff-weathering, impure, cherty silica with some graphitic material.

In a drill hole near the east shore of Keewatin Lake a 2-foot zone of intraformational breccia, within the banded chert-siderite formation, is composed of fragments of chert, siderite-chert, and banded chert and siderite in a matrix of dark-buff-weathering sideritic chert. The fragments are angular to lenticular, have been considerably moved and rotated from their original positions, and are arranged in shape and size so as to show an indistinct bedding.

In other drill holes to the east, intraformational breccia is found in the siderite-chert zones; here, angular fragments of cherty silica averaging 1–2 inches in diameter are enclosed in a matrix of buff- to creamy-weathering chert with minor disseminated siderite. In some holes, at the contact with the argillites, a zone of interformational breccia occurs; this consists of angular fragments of pure cherty silica or sideritic silica in a dark-grey or black argillaceous matrix. The fragments are irregular and angular in shape, range in size from an $\frac{1}{8}$ inch up to 2 inches, and have sharp contacts with the matrix.

Within the graphitic argillite, zones of intraformational breccia are found; the fragments are not easily recognizable being about the same colour and texture as the matrix. They are about $\frac{1}{2}$–1 inch in size, tend to be fairly closely packed, and are slightly elongate parallel to the bedding.

Discussion of Iron Formation

The general occurrence and nature of the breccias across the various phases of the iron formation and argillite may provide a means of identifying the top of this part of the sedimentary belt.

An intraformational breccia is the product of the breaking up of a bottom sediment by desiccation or by currents into fragments which, with little or no transportation, are redeposited in a matrix of more or less similar composition. Such a breccia indicates no great break in deposition.

In places where chert grades southward into pisolitic or massive siderite or passes directly into argillite, the nature of the breccia and its value for determining the top of the formation is well shown. Where a gradual change from pure chert to siderite-chert occurs, a zone of breccia will be composed of angular fragments of pure white chert in a matrix of slightly sideritic chert, or of sideritic chert fragments in a chert of higher siderite content. These breccias are believed to be true intraformational breccias and suggest that both the silica and siderite are primary sediments, and that minor brecciation of the deposits at the bottom was perhaps contemporaneous with, or closely followed by, deposition of gel silica bearing relatively more siderite. It has been noted that pisolitic and oölitic structures are common associates of intraformational breccias.[1]

[1]F. J. Pettijohn, *op. cit.*, pp. 210, 211.

The interformational breccia, at the contact of the chert and argillite, is composed of fragments of chert in an argillaceous matrix. This could be caused by a post-consolidation (pre- or post-crystallization?) breaking up of the chert beds by desiccation, by bottom currents, or by slumpage, the resulting fragments being cemented by muds and clays, which now form the base of the argillite.

The intraformational breccia in the argillite follows a similar pattern; the finer, more graphitic matrix being later than the lighter-coloured fragments.

In the area where drill core was available for study the tops of the formations are towards the south. The dips range from 85°S. to vertical.

If we conclude from the foregoing observations that siderite has been deposited in greater amounts towards the top of the cherty iron formation, we may then apply this conclusion to the banded silica-siderite phase and assume that the "graded bedding" described previously can be used for top determination as though it were graded bedding in clastic sediments.

If the proportion of iron entering the basin of deposition in the colloidal state was gradually increased during the time represented by the deposit, we will have a decreasing amount of silica in the precipitated gel, and in general, with each successive penecontemporaneous brecciation, an increase in the amount of siderite present in the matrix. The bands in the banded silica-siderite phase would thus represent a local normal occurrence of differential chemical precipitation.

The gradual increase of siderite being deposited along, and in places rhythmically with, silica from north to south may be due to an increase in the amount of iron being transported into the basin because of a change of climate with changing weathering conditions, or to the uncovering of a more basic rock type. A change of water temperature or a gradual decrease in the CO_2 content of the atmosphere, with resultant change of pH of the environment of deposition, could produce the same result. The gradual change was the possible forerunner of the abrupt change from chemical to clastic deposition that occurred after periods of local penecontemporaneous deposition.

The highly folded condition of the banded silica-siderite phase of the iron formation is a striking feature. The origin of complex folding in such a hard and brittle rock has long been a subject of discussion. Moore and Maynard,[1] in discussing complex folding of iron formations, suggest that crystallization of the silica-iron gel did not occur until the weight of overlying rocks pressed the water out, and accompanying heat caused the gel to crystallize; thus, before it was fully crystallized, the soft rock readily flowed and became highly contorted.

A study of the breccias at Hematite Lake indicates that the chert has been broken into sharply angular fragments before the deposition of the argillaceous matrix. Similarly the banded chert-siderite is brecciated and cemented by sideritic chert, indicating that the gel had crystallized, or at least become brittle, shortly after deposition. The highly complex folding in the banded silica siderite bands resembles in its variety the folds produced by slumping of unconsolidated or plastic material on bottom slopes. If we assign such an origin to the complex folding, the later brecciation can be attributed to desiccation, bottom currents, or more probably to further slumpage after crystallization of the silica-iron gel.

[1]E. S. Moore and J. E. Maynard, "Solution, Transportation and Precipitation of Iron and Silica," *Economic Geology*, Vol. 24, 1929, pp. 272-303, 365-402, 506, 527.

James,[1] in a description of the Iron River iron formation, arrives at a like conclusion concerning the origin of somewhat similar interformational breccias and also suggests that:

> The breccia records the beginning of a tectonic disturbance that was to terminate the epoch of chemical sedimentation and usher in an epoch of clastic deposition . . . The breccias would be the normal result of local increases in submarine slopes, with consequent slumping and sliding of the partly consolidated sediments.

The iron formations of the Lumby Lake area are similar to iron formations found elsewhere in the Precambrian Shield. The small lenses interbanded with Keewatin-type lavas and the banded magnetite-silica phase of the main band of sediments resemble the usual form of Keewatin iron formations, consisting of thin alternating layers of cherty quartz and magnetite or hematite. The iron formation of the Hematite Lake area resembles in some respects the ranges of the Michipicoten area, and though exploration is still in its early stages it has suggested the presence of siderite bodies as large as some of those at Michipicoten. It compares also with the siderite bodies of the Iron River range of northern Michigan. Though similar in size and mineralogy, the geological setting and stratigraphy differ. The accompanying table is given for comparison.

COMPARISON OF IRON FORMATIONS

Michipicoten[1] (Keewatin (?))	Hematite Lake (Keewatin (?))	Iron River[2] (Huronian)
Basic lava	Greenstones	
Banded silica (0–675 ft.)	Pyritic argillite and greywacke (0–1,400 ft.)	Greywacke (100–400 ft.)
Pyrite member (0–120 ft.)	Sulphide member (55 ft.)	Breccia (0–200 ft.)
Carbonate (0–240 ft.)	Carbonate (0–41 ft. (?))	Chert and siderite (150–300 ft.)
Acid volcanics	Banded silica (0–1,300 ft.)	Graphitic and pyritic slate (20–50 ft.)
	Greenstones (several 1,000 ft.)	Siltstone (500 ft.)
		Greenstones (several 1,000 ft.)

[1]W. H. Collins and T. T. Quirke, *Michipicoten Iron Ranges*, Geol. Surv. Can., Memoir No. 147, 1926, pt. 1.
[2]H. L. James, "Iron Formation and Associated Rocks in the Iron River District, Michigan," *Bulletin*, Geol Soc. Amer., Vol. 62, 1951, p. 253.

No pisolitic or oölitic siderite has been reported from Michipicoten, and the siderite is generally believed to have been formed by replacement of acid lavas, a type of rock absent from the sequence of Hematite Lake. James[2] considers the siderite of the Iron River range to be sedimentary, but also reports[3] that no oölitic structures in siderite have been found in northern Michigan. Aldrich[4] reports syngenetic pisolites of siderite from the Gogebic range. The Hematite Lake range has, in its sulphide phase, a high proportion of pyrrhotite, and it differs thus from the "range pyrite" of Michipicoten, which has about 10 percent magnetite and pyrrhotite.

[1]H. L. James, "Iron Formation and Associated Rocks in the Iron River District, Michigan," *Bulletin*, Geol. Soc. Amer., Vol. 62, p. 259.
[2]*Ibid.*, p. 263.
[3]H. L. James, "Current U. S. Geological Survey Investigations in the Iron Ranges of Northern Michigan," (Abstract pt. B), *Economic Geology*, Vol. 45, 1950, p. 386.
[4]H. R. Aldrich, *Geology of the Gogebic Iron Range of Wisconsin*, Wis. Geol. Nat. Hist. Surv., Bull. No. 71, 1929.

The Hematite Lake iron formation (despite the name given to the lake) does not, as far as is known, contain any hematite and has not been enriched by leaching of silica; it thus differs from many of the iron ranges of the Lake Superior district in having been protected from oxidation and leaching solutions since its origin. The banded silica-siderite phase is not particularly common; it is reported from the Cayuna range and the Iron River range but does not occur in the Menominee range and is only minor in the Mesabi and Vermilion ranges.

Graphitic schists and slates are commonly associated with iron formations, but few have the remarkable development of pyrite concretions characterizing the graphitic argillites of the main band of sediments in this area.

Crystalline Limestone

Crystalline limestone occurs at various places within the main band of sediments, as a series of lenses at no particular stratigraphic level mainly within the lower chemical sediments. In places it is interlaminated with cherty silica and, although minor association with fine-grained greywacke was noted, nowhere was it observed in association with graphitic argillite. Most occurrences are in zones of dragfolding, and in the Garnet Bay area it occurs in the crests and troughs of large dragfolds.

It is generally banded and may be white, pink, brown, or grey in colour. Texture ranges from fine grained, banded to coarsely crystalline, massive, near granite contacts. Near Seahorse Lake pure crystalline limestone—finely banded, fine-grained blue-grey marble—outcrops in a fault-line valley and on the lakeshore.

In the Garnet Bay area crystalline limestone is associated with cherty silica and banded garnet-mica schists and conglomerate; it is concentrated in the crests and troughs of dragfolds as outlined by the conglomerate bed and is itself intricately dragfolded. At Garnet Bay, on the north shore of Spool Lake, and at the west end of Pinecone Lake, it has been recrystallized by the intrusion of the Algoman (?) granite, and textures vary from medium to coarse grained with, at Garnet Bay, the development of up to 20 percent diopside and minor magnetite.

From Pinecone Lake eastward no massive crystalline limestone was observed. A zone of fine-grained limestone, similar to that at Seahorse Lake, occurs in a dragfolded zone at the east end of Cryderman Lake but is banded with chert and merges southward into cherty iron formation carrying minor siderite. Other outcrops of banded limestone and chert occur at Keewatin Lake and at the east end of Hematite Lake, both occurrences being associated with dragfolding. No limestone was seen in the sediments east of the van Nostrand stock.

The limestones are similar to limestones in the Steeprock series around Steeprock Lake, described by many who have visited that area. Moore[1] describes it as being recognizable in the field by its bluish colour and distinguishes it from the ferruginous carbonate, which weathers brown or red:

> The blue limestone is largely crystallized and highly deformed, and part of it is silicified. Numerous stringers of silica traverse the beds and laminate the formation, and very intricate structural patterns may be observed.

Moore believes the Steeprock limestone was formed in the deeper parts of the basin in which the Steeprock series was deposited, where clearer waters prevailed.

[1]E. S. Moore, *Geology and Ore Deposits of the Atikokan Area*, Ont. Dept. Mines, Vol. XLVIII, 1939, pt. 2, pp. 12, 13.

Limestone has been reported from other Archean-type rocks in northwestern Ontario. A narrow lens of limestone resembling that west of Seahorse Lake, from near Mine Center in the Rainy River area, is described by Lawson.[1] Other occurrences of crystalline limestone in the North Spirit Lake area, and Sandy Lake area respectively, are described by Bateman[2] and Satterly.[3]

The limestone probably originated as a chemical precipitate, being deposited from waters carrying calcium bicarbonate into the basin of deposition. Possibly, local increases of temperature, causing an increase in the pH of the water through removal of CO_2, took place periodically so that calcium carbonate would be precipitated as lenses.

The observation, in many of the limestone outcrops, of complex dragfolding, and the association with large dragfolds at Norway Lake suggest that the origin of the rock may be connected in some way with the dragfolds, such as by the replacement of dragfolded zones. However, the dragfolds at Garnet Bay were caused by forces accompanying the intrusion of the granite, and the limestone shows the metamorphic effect of this intrusion. Also, lamprophyre of Algoman (?) age cut the folded limestones at Garnet Bay; the age relationships thus indicate that the limestone is not a replacement of pre-existing rocks derived from Algoman igneous activity.

The association with dragfolding may be due to squeezing of the easily recrystallized, incompetent limestone between competent layers into these folded zones, corresponding to a thickening in a fold arch whereas competent bands maintain an even thickness. Folding would be concentrated in the limestone because of its incompetency. Differential stresses would therefore be relieved by flowage largely within the limestone.

Conglomerate

Conglomerate occurs at several places along the main belt of sediments as small lenses interbedded in the iron formation and argillaceous greywackes.

The largest bed is found along the southwest side of Norway Lake where it forms an excellent horizon for tracing dragfolds in the metamorphosed sediments. Smaller lenses occur at various stratigraphic levels in the band of sediments.

The smaller beds contain closely spaced, stretched pebbles and boulders of greenstone in a garnetiferous argillaceous matrix and are less than 10 feet thick and are traceable for only a few tens of feet along strike.

The folded bed at Norway Lake contains pebbles, cobbles, and boulders up to 6 inches in size, of andesite, porphyritic greenstone, hornblende schist, quartz, and chert. Fine-grained greenstone predominates in the cobble and pebble size; chert and quartz occur only as rounded pebbles less than 1 inch in diameter; porphyritic greenstone occurs in the few fragments of boulder size observed. A rough gradation of grain size and type was noted over a 60-foot width at one exposure. On the north side, cobbles and boulders, with a few pebbles, occur in a chlorite matrix; southwards the matrix becomes more quartzose, and the fragments become smaller with more quartz and chert appearing; still farther south garnets start to appear in the matrix, and the fragments decrease in size until the conglomerate gives way to a banded garnet-mica schist in which no clastic material can be seen.

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[1]Andrew C. Lawson, *The Archean Geology of Rainy Lake Re-studied*, Geol. Surv. Can., Memoir No. 40, 1913, p. 44.

[2]J. D. Bateman, *Geology of the North Spirit Lake Area*, Ont. Dept. Mines, Vol. XLVII, 1938, pt. 7, pp. 60, 61.

[3]J. Satterly, *Geology of the Sandy Lake Area*, Ont. Dept. Mines, Vol. XLVII, 1938, Pt. 7, p. 22.

Argillaceous Greywacke, and Metamorphic Derivatives

A large part of the band of sediments is composed of fine-grained, light- to dark-grey, metamorphosed, argillaceous greywackes, described in the field mainly as garnet-mica schists or as hornfelses derived from greywackes. Argillaceous greywacke occurs along most of the length of the belt of sediments and forms the southern part of the belt. It ranges in thickness up to 1,000 feet. In the area west of Norway Lake, the distribution is concealed by overburden. From Garnet Bay eastward to Pinecone Lake, at Keewatin Lake, and at the west and east contacts of the van Nostrand stock, garnet-mica schists and hornfelses occur.

The argillaceous greywacke grades along and across the strike into carbonaceous argillite with decrease of grain size, decrease in the amount of cherty quartz, and increase in the amount of disseminated carbon and iron sulphides. Contacts with cherty iron formation, though rarely observed, are fairly sharp. The greywacke is more or less typical Archean greywacke. Nowhere does it show ripple marks, or cross bedding, rare features in Archean sediments. It is generally dark in colour, well indurated and, where the clastic nature is preserved, is composed of angular detrital fragments set in a prominent to dominant clay matrix. Banding derived from the original bedding ranges from $\frac{1}{8}$ inch to 6 inches in width, the average being about $\frac{1}{2}$ inch.

A study of the least metamorphosed type, found at Hematite Lake, shows the greywacke to be composed of subangular to very angular fragments of quartz, plagioclase feldspar, chloritic greenstone, and epidote set in a matrix of sericite, chert, feldspathic material, calcite, and minor graphite.

The most common metamorphosed form taken by the greywacke formation is the banded garnet-mica schist. Other more or less metamorphosed forms are common, ranging from banded hornblende-biotite schist with incipient garnets to schists of greater degree of metamorphism containing 35 percent garnet. At intrusive contacts garnet-cordierite-biotite hornfelses have been formed.

Thin sections of these metamorphic derivatives studied microscopically show little evidence of the clastic origin of the original rock. Cherty cryptocrystalline silica is almost always present between the grains of metamorphic minerals. No fragments of feldspar, and only a few grains of clastic quartz remain.

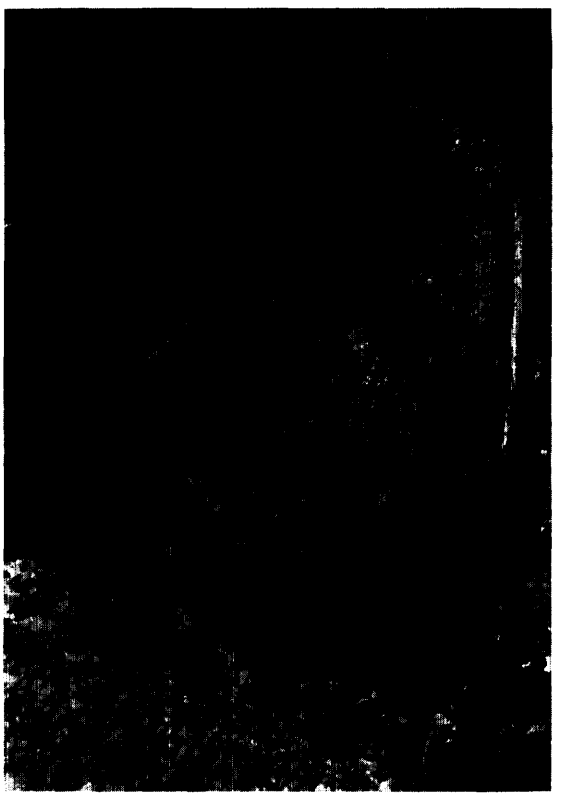
A zone of greywacke of high alumina content is represented by a banded andalusite-biotite-garnet schist exposed at the entrance to Garnet Bay. This rock consists of about 30–35 percent andalusite as subhedral impure crystals, 25 percent biotite, 25 percent cherty quartz, and 10 percent of opaque minerals (magnetite, pyrite, and graphite).

Medium-grained garnet-biotite-cordierite hornfels occurs at the west side of the granite plug at Spool Lake. It shows a characteristic sugary texture and no banding. It is composed of: cordierite, about 20 percent; quartz, 15; biotite, 25; garnet, 30; plagioclase feldspar, 5; and magnetite, 5 percent.

The variety in the types of banded schists developed, mainly garnetiferous, is a reflection of the kind and relative amount of argillaceous material, which, along with a varying amount of silica, was deposited in the sedimentary basin. The original greywacke appears to have been clay or silt with a varying amount of clastic material, or both. The variations in the metamorphic derivatives indicate the variations in the kind and amount of the clay minerals and silt originally in the matrix of the greywacke.

Argillite and Metamorphic Derivatives

Graphitic argillite and its metamorphic derivatives are found in many places as separate lenses within the argillaceous greywackes in the southern part of the main band of sediments. A few isolated lenses are found in the volcanics north and south of the sedimentary band.



Pit in graphitic argillite at Pinecone Lake. Fine earthy material is impure native sulphur, white efflorescence is soluble iron sulphate.

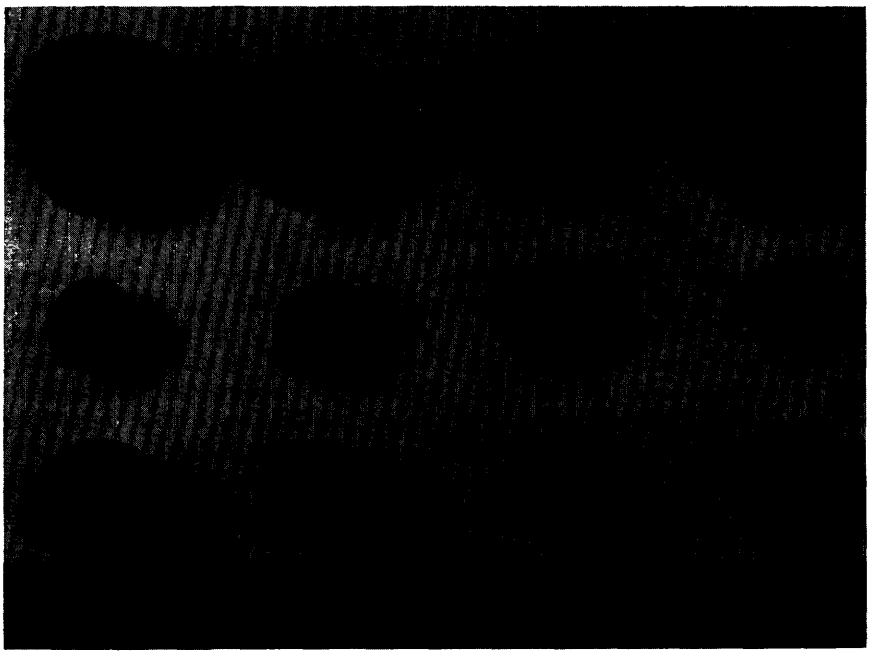
A narrow band of black graphitic argillite extends east and west from Cross Lake. Lenses of spotted graphite schist, and graphitic argillite occur at Spool, Pinecone, and Cryderman lakes; it is doubtful if these occurrences are part of a single zone, although outcrops are scarce in the intervening areas. The largest lens, up to 1,400 feet thick, occurs at Hematite Lake; here it is generally more slaty, with zones of graphite schist, highly polished on slip faces. East of van Nostrand Lake graphitic slates outcrop on the haul road to Oldman Lake.

The argillite group ranges from a dense, hard, bedded type, through slate, to a fissile graphite schist. Mostly it is black or dark grey in colour. Graphite is a common constituent especially of the slaty and schistose facies. Magnetite, pyrite, and pyrrhotite occur in places, with concretions of pyrite common at Cryderman and Hematite lakes.

Under the microscope, the argillite shows disseminated chert throughout, with minor sericite and tremolite. Pale yellow needle-like crystals of tourmaline compose about 5 percent of the rock at Pinecone Lake. Flakes of graphite render

thin sections almost opaque. A specimen of the graphitic argillite from a pit at Pinecone Lake, submitted to the Provincial Assay Office, showed 13.70 percent carbon. The purity of the flake graphite is not known.

Spherulitic concretions of pyrite occur in the more graphitic parts of the argillite lenses. At a test pit on the south shore of Cryderman Lake, spherical concretions averaging ¾ inch in diameter have weathered free and occur loose in great numbers. The concretions do not occur uniformly distributed throughout the rock but are concentrated in bands up to 1 foot thick separated by narrow bands of black argillite. These bands, representing the original bedding, strike east and dip vertically.



Typical pyrite concretions from pit at Cryderman Lake. Broken weathered concretions show internal concentrically laminated structure.

The internal structure of the pyrite concretions can be seen best on the weathered surfaces of broken concretions. Most have a concentrically laminated internal structure with radial structure in some of the laminae. Radial structure is present in the peripheral ring about ⅛ inch wide in most concretions. A few concretions show a similarity of patterns in the concentric rings, suggesting simultaneous periods of growth in response to some external influence during diagenesis.

Pyrite concretions such as those described have been reported in Keewatin rocks from a few localities. Baker[1] reports on occurrence of pyrite concretions in Keewatin-type ash rocks at the Alexo Nickel mine in the Timiskaming district. Tanton[2] describes a black, carbonaceous, slate-like rock in the Harricanaw-Turgeon Basin of Quebec, which contains abundant pyrite concretions.

[1]M. B. Baker, *Alexo Nickel Mine, Timiskaming District*, Ont. Bur. Mines, Vol. XXVI, 1917, p. 272.

[2]T. L. Tanton, *The Harricanaw-Turgeon Basin, Northern Quebec*, Geol. Surv. Can., Memoir No. 109, 1919, pp. 30, 31.

Native sulphur occurs in the test pits at Cryderman and Pinecone lakes, and an efflorescence of white and yellow iron sulphate, one of the minerals of the halotrichite family, occurs in the pit at Pinecone Lake where it is protected from the elements. The sulphur and iron sulphate appear to have been formed in the zone of weathering by decomposition of the sulphides in the presence of carbon.

The graphitic and concretionary argillite so resembles some post-Cambrian black marine shales that it must be concluded that it originated as a black mud, rich in organic material derived from primitive organisms. Pettijohn[1] attributes an organic marine origin to the pyrite- and carbon-bearing greywackes and their associated slates in the Canadian Shield. Graphitic rocks in the Huronian of the Iron River area of Michigan, described by James,[2] have been found to contain carbon of known organic origin.

The lenses of graphitic argillite are considered to represent zones of stagnation or restricted circulation in the sedimentary basin in which organic material decayed, and in which iron brought into the basin was precipitated directly as sulphide concretions or as black sulphides of iron diagenetically changed to pyrite concretions.

Discussion of Sediments

Top determinations in the volcanics north of the main belt of sediments are all towards the south; south of the sediments good exposures of pillow lavas indicate that the tops are towards the north. The general picture is that of a closed, upright syncline with the axial plane at or near the south side of the east-west band of sediments. There is no indication of symmetry in the band of sediments as might be expected if the axial plane of the fold lay within the sediments, and it is concluded that it is a homoclinal series, which lenses out at depth and does not therefore reappear on the south limb of the syncline. No indication of unconformity at the contacts with volcanics was noted, which suggests that the sediments are of the same general age as the Keewatin-type volcanics.

The main band of sediments represents a much longer, more widespread, and more varied type of sedimentation than is represented by the smaller zones. It may be divided into two main epochs; the earlier being mainly of chemical sedimentation, the later being of clays and muds with some coarser clastic material. With cessation of volcanic activity the period of chemical precipitation started with deposition of colloidal silica in a quiet basin with local precipitation of calcium carbonate and deposition of minor clastic material. As the precipitation of chert continued, the amount of iron being brought into the basin increased, and an increasing amount of siderite, or ferric iron hydrosol subsequently reduced to siderite, was deposited. Local brecciation of bottom deposits became more and more frequent, and as the depositional environment changed, more pyrite was deposited along with the chert and siderite. This period ended with local brecciation, and a general change from chemical to clastic sedimentation took place. Fine-grained greywackes were laid down as clay and silt, with lenses of black concretionary graphitic argillite representing zones of restricted circulation where organic material was preserved from oxidation, and where iron sulphide was deposited as pyrite concretions or as amorphous sulphide diagenetically concentrated into concretions. Colloidal material continued to be precipitated

[1]F. J. Pettijohn, "Archean Sedimentation," *Bulletin*, Geol. Soc. Amer., Vol. 54, 1943, pp. 925–72.

[2]H. L. James, "Iron Formation and Associated Rocks in the Iron River District, Michigan," *Bulletin*, Geol. Soc. Amer., Vol. 62, 1951, p. 259.

along with the clastic material, and indeed much of the clayey material itself may have been colloidal. Coarse clastic material was deposited locally with the fine-grained material, forming conglomerates with argillaceous and quartzose matrices.

Keewatin-Type Intrusives

METADIORITE

A large part of the igneous rocks of the greenstone belt is composed of sills, dikes, and irregular bodies of fine- to medium-grained metadiorite, many of which are undoubtedly associated with the igneous activity giving rise to the extrusive rocks; and from which they are difficult to distinguish. Within the greenstone area, the basic intrusives have massive and schistose phases. They occur as narrow lenses, seldom over 200 feet in width, parallel to the regional schistosity. Separate mapping within the greenstone area was not possible.

The rock is dark grey to green on fresh surfaces and weathers to a rough medium-green surface. Textures vary from medium to coarse grained, with fine-grained border phases; traces of diabasic texture were noted. The original feldspar is completely altered to a mass of epidote, chlorite, calcite, and albite. The original pyroxene is completely altered to secondary actinolite and chlorite. Sphene is a common constituent locally and is associated with skeletal crystals of ilmenite.

The Keewatin-type metadiorite and post-Laurentian metadiorite are similar in appearance and petrography.

SERPENTINITE

Bands of serpentine rock, representing serpentinized dikes and sills of peridotite, were observed in the Oldman and Gargoyle lakes area. They appear to be 100–200 feet wide, striking parallel to the general trend of the area. The age relationship with the Laurentian granite is not known, though the intrusive at Oldman Lake is near or at the contact.

The rock is light grey to brown weathering, dark green to black on fresh surfaces. In thin section it appears as a mesh of serpentine derived from the alteration of an original dunite. Serpentine occurs as kernels pseudomorphous after olivine. The typical cracks of the crystals are filled with minute cross fibres of serpentine with magnetite, and the interstitial material between the pseudomorphs consists of fibrous serpentine, minor chlorite, epidote, and magnetite.

Laurentian(?) Intrusives

SOUTHERN GRANITE

The granitic rocks on the south side of the Lumby Lake greenstone belt have been assigned a Laurentian age by various geologists in the adjacent areas. The term Laurentian was used at the time of the earliest investigations to refer to the complete assemblage of granite and gneisses throughout the region. Lawson[1] used the term to refer to the granite underlying the Steeprock series and proposed the term Algoman for younger rocks in the same area. Since that time these terms have attained a widespread and unfortunate usage that implies correlation in time in areas far removed from the type areas. Hawley[2] and Moore[3] and others in the Rainy River–Steeprock–Sapawe Lake area have sup-

[1]Andrew C. Lawson, *The Archean Geology of Rainy Lake Re-studied*, Geol. Surv. Can., Memoir No. 40, 1913, p. 51.

[2]J. E. Hawley, *Geology of the Sapawe Lake Area*, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6.

[3]E. S. Moore, *Geology and Ore Deposits of the Atikokan Area*, Ont. Dept. Mines, Vol. XLVIII, 1939, pt. 2.

ported this concept of two ages of granite and have continued to use the names proposed by Lawson. The assemblage of granite and gneiss extending eastward from the Steeprock–Finlayson Lake area and forming a mass of batholithic proportions has been considered by them to be of Laurentian age (in the sense of being older than the Steeprock series).

Although it was possible for the author to investigate only a narrow zone of these rocks along the south side of the map area, distinct differences were observed between these granites and the fresher granite on the west and north sides of the area. Because of these differences and certain geological relationships, it was concluded that the southern granite is earlier than the granite on the north and west sides of the greenstone belt. A small zone of possibly older granite occurs at Pyramid and Little Chill lakes.

Along the western part of the south contact, from Richardson Lake to beyond Jet Lake, is a zone averaging 1 mile in width of so-called quartz porphyry, which is considered to be a contact phase of the southern granite. In many places in and near this contact zone, small bodies of altered diorite and gabbro are associated with the Laurentian(?) rocks. Some of these are clearly intrusive into the granite or its contact phase, showing chilled borders, cutting across the gneissosity of the granite, and containing inclusions of granite. They are so numerous in the contact phase of the Laurentian(?) rocks that the whole was mapped as a quartz porphyry–diorite complex. Many inclusions of greenstone occur within the contact zone and in the granite and are difficult to separate from the later fine- and medium-grained metadiorite. Two possible ages of basic rocks are indicated at several places, one cut by, and one cutting, the granite; the older may be a recrystallized volcanic rock. The diorite bodies are absent in the Oldman Lake area and increase in number westward from Richardson Lake, and in the area bounded by Jet, Top, Longhike lakes and Sawbill Bay underlie about 50 percent of the area.

Much of the Laurentian(?) rock has been subjected to intense shearing and alteration, the resulting fissile sericite schists in places being difficult to distinguish from schists derived from greenstones, as in the shear zones southwest of Redpaint Lake and between Lumby and Hutt lakes.

The Laurentian(?) granite is grey to pink in colour, light weathering, and medium grained; a high chlorite content gives a light-green colour locally. Thin sections show considerable textural and mineralogical variety. The feldspar is sodic oligoclase or albite; potassic feldspars were seen only in specimens from Oldman Lake. The plagioclase is generally considerably saussuratized and may itself be a secondary feldspar–being derived by soda metasomatism from a more basic plagioclase. The ferromagnesium minerals of the granite, biotite, and hornblende, have been largely altered to aggregates of epidote, chlorite, quartz, and calcite. Quartz composes up to 45 percent of the granite and is concentrated into granular masses about 3 millimetres in size and is also disseminated throughout the rock as very small anhedral crystals less than 0.1 millimetres in size. Evidence of mylonitization of the Laurentian granite is shown in its fractured and strained quartz, fractured and bent laths of plagioclase, and bent biotite and chlorite fibres.

THE CONTACT ZONE

The term quartz porphyry is applied to a light-weathering, dark- to medium-coloured acid rock characterized by the presence of numerous blue opalescent quartz eyes, which occurs as a contact zone between the Laurentian (?) granite ann the greenstone It inntrudes the Keewatin-type volcanics locally near the

south contact as narrow lenticular dikes and sills; these are so numerous in the area south of Lumby Creek that the complex of greenstone, quartz porphyry, and diorite was impossible to map on the scale used. It is well illustrated on the map of the L. C. Anderson property. (In map case.)

A rough gradation across the contact zone from south to north was noted; from altered granite, through porphyritic granite, granite porphyry, to intrusive(?) rhyolite porphyry at the contact with the greenstones. Some of the



Angular inclusions of greenstone in Laurentian(?) granite at Oldman Lake. Greenstone retains ellipsoidal structures.

rock so mapped is not a "quartz porphyry", but the presence of blue opalescent quartz is typical of the contact phase. The area is one of considerable mylonitization, and the mapping of the acid rocks of the contact area is made difficult by the crushing and shearing that has affected them.

The characteristic blue opalescence of the quartz is seen in thin section to be due to countless minute cracks and strains, and to innumerable liquid and gaseous inclusions, in some of which Brownian movement of minute gas bubbles in liquid can be detected.

It is possible that some of the rhyolite porphyry near the contact with the greenstone represents original Keewatin-type rhyolite flows, but the general sequence across the contact zone and the lack of primary flow structures suggest that it is part of the single period of granite intrusion.

Hawley[1] has observed a somewhat similar sequence on the south side of this Laurentian(?) batholith in the Sapawe Lake area. Here, the quartz porphyry (felsite and micropegmatite) passes northward into the grey granite with increase of feldspar and ferromagnesium minerals. In the vicinity of the contact, porphyritic granite contains small blue eyes of quartz. The apparent gradation of the

[1]J. E. Hawley, *Geology of the Sapawe Lake Area*, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6, p. 13.

contact of the porphyries northward into the grey granite may, according to Hawley, be taken as evidence that they are more or less contemporaneous and are both the result of one period of igneous intrusion.

Moore has mapped the area near the contact of the Laurentian granite and greenstone in the Steeprock Lake area as a mass of hybrid rocks containing a mixture of granite and Keewatin greenstone, which grades eastward into a body of granite with few remnants of greenstone. The map accompanying the report by Bartley[1] on the Steeprock area shows many diorite intrusives cutting the Laurentian(?) granite.

Algoman(?) Intrusives

METADIORITE

Within the contact phase, in the greenstone area, and to a lesser extent within the Laurentian(?) granite occur a great number of exposures of medium- to fine-grained metadiorite of medium to dark-green colour. As mentioned above, many of the diorite masses within the greenstone area are related to the Keewatin volcanic activity. Those in the contact phase of the southern granite are undoubtedly in part Keewatin in age, being extensively intruded by the porphyries. However, within the contact phase and within the Laurentian granite, a post-granite age is indicated for some of the diorite; it is tentatively assigned to the Algoman. Possibly it represents a late stage of Laurentian igneous activity or an early stage of Algoman activity, or even an intermediate stage as indicated by volcanic material in the Steeprock series. That it is older than Algoman is suggested by the degree of alteration affecting it.

Since the earliest investigations in the region, the problem of two ages of diorite in relation to the Laurentian(?) granite has been discussed. McInnes[2] says that generally the diorite is older than the Laurentian rocks throughout the Seine River area, but that locally the diorite is the intruding rock.

Most of the intrusives of metadiorite occur as lenticular bodies, approximately parallel to the regional trend. A small stock of metadiorite at the east end of Twobay Lake has a dike-like apophysis that cuts quartz porphyry.

Thin sections of the metadiorite show its considerable alteration. The rock is composed of about 60 percent actinolite, locally fibrous; about 20 percent altered plagioclase feldspar of the composition of albite ($Ab_{91}An_9$); 10 percent secondary quartz; the remainder of the rock being the alteration products epidote, chlorite, calcite, and sphene.

The presence of albite was noted in the petrographic study of many of the greenstones, metadiorites, and the Laurentian(?) granite. Its presence is interpreted as the result of a widespread albitizing reaction associated with one of the periods of intrusion.

GRANITE AND GRANITE GNEISS

Large masses of generally fresh-appearing granite and granite gneiss of possible Algoman age have intruded the greenstones and early granite on the west and north sides of the greenstone belt, and smaller intrusives occur within the greenstones. The granite west of Redpaint Lake resembles, and is probably continuous with, the large area of granite in the northwestern part of Moore's map[3] of the Atikokan area, which was assigned an Algoman age by him on the basis of Lawson's definition of the term.

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[1]Map No. 48b (to accompany Ont. Dept. Mines, Vol. XLVIII, pt. 2, 1939).

[2]William McInnes, "Report on the Geology of the Area covered by the Seine River and Lake Shebandowan Map Sheets," Geol. Surv. Can., *Annual Report*, 1897, Report H., p. 28.

[3]Map No. 48a (to accompany Ont. Dept. Mines, Vol. XLVIII, pt. 2, 1939).

The Algoman(?) granite is the youngest Precambrian rock of the area. Though diabase dikes of Keweenawan age has been reported from the map area, none were found during the mapping of the area.

In general the Algoman(?) granite is fresh, medium to coarse grained, light pink to red on fresh surfaces, and weathers to a pink or cream colour. It has many lithologic phases and may vary in composition and appearance over short distances. Pegmatitic varieties occur locally. Generally it is found to be potash-bearing, contrasting thus with the soda-rich southern granite of earlier age. Hornblende and biotite varieties predominate, but muscovite granite is locally important.

Jointing is well developed in this younger granite, and the relationship of the jointing with the direction of glaciation has been a dominant factor in the location of glacially plucked lake basins, especially the Irish-Scotch lakes chain where the lake basins are related to the nearby granite-greenstone contact.

Emplacement of the granite intrusive appears to have been effected by brecciation and stoping of intruded rocks or by *lit par lit* injection into schists giving a narrow contact zone of injection gneiss; in other places emplacement has been accomplished by forceful pushing aside of the surrounding schists.

Thin sections of typical Algoman(?) granite show a number of mineralogical variations. The common minerals composing the granite are: quartz averaging 25 percent; plagioclase feldspar, 10–35 percent; microcline and orthoclase, 20–25 percent; augite, hornblende, and biotite are commonly present and form up to 15 percent of the rock. Accessory minerals noted include sphene, apatite, zircon, ilmenite, and fluorite.

APLITE

Fine- to medium-grained aplite and granite dikes and sills up to 25 feet in width, apophyses from the main intrusive mass of Algoman(?) granite, cut the greenstones and sediments near Norway Lake, Pinecone Lake, and east of Irish Lake. A few dikes of aplite cut a syenitic contact phase at Viking Lake.

The aplite dikes at Norway and Pinecone lakes are fine to medium grained, pink to white in colour, have a characteristic sugary texture and are usually finer grained than the parent granite. Larger dikes east of Irish Lake resemble Algoman(?) granite and do not have the sugary texture of aplite.

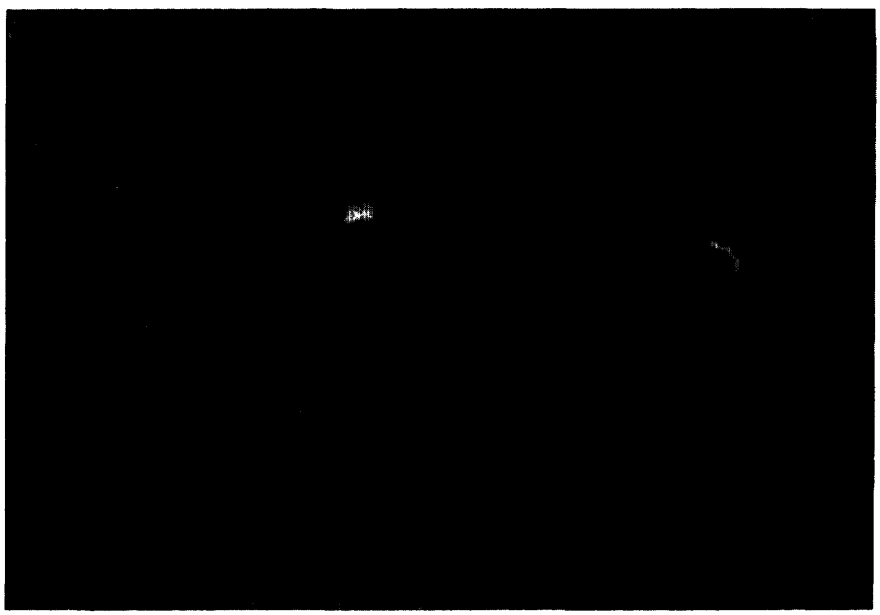
LAMPROPHYRE

Narrow lamprophyre dikes, probably related to the main period of Algoman(?) intrusion, cut schist and andesite at Redpaint Lake, limestone at Garnet Bay, iron formation at Hematite Lake, and argillaceous greywacke at van Nostrand Lake. These dike rocks are considerably altered and the original mineral constituents largely destroyed, though some show original biotite both as phenocrysts and in the groundmass. The mineralogical content suggests that the rock was originally a kersantite or minette. A single outcrop of a lamprophyre dike containing phenocrysts of hornblende was found at Garnet Bay.

OTHER ALGOMAN(?) INTRUSIVES

At various places within the north part of the greenstone belt, small plugs and stocks of granite, syenite, and associated hybrid rocks, whose fresh appearance and general occurrence suggest a correlation with the Algoman intrusives, have intruded the earlier rocks. A common feature of these intrusives is the presence of a contact phase of more basic rock. In some the range of petrographic character is extreme, the earlier crystallized or contaminated border facies having the composition of gabbro, hornblendite, or syenite. The contact phase of a

small plug of syenite at Bar Lake is a hybrid rock with the composition of an olivine gabbro; probably deeper erosion would show a granite core to the syenite. The Spool Lake plug is a hornblende granite with a narrow border of hornblende augite syenite. A hybrid border phase occurs at the contact of the massive granite of Norway Lake and the van Nostrand stock. Small areas of fresh intrusive basic and intermediate rock such as at the small lake north of Cross Lake are believed to be hybrid contact rocks of unexposed granite intrusives. Such border phases are lacking at other places where the mode of emplacement may have been different, perhaps owing to the differences in the physical-chemical characteristics of the intruding magma.



Outcrop surface of porphyritic microcline granite of central part of van Nostrand stock; on haul road north of van Nostrand Lake.

van Nostrand Stock

The small stock of Algoman(?) granite between Hematite and van Nostrand lakes is referred to as the van Nostrand stock. It is composed of a main central zone of porphyritic microcline granite remarkably uniform in colour and mineral composition, with no banding or lineation of any kind. Near the contacts, the granite grades, by decrease in amount of potash feldspar, into a border zone of grey-to-white, non-porphyritic pyroxene syenite about 200 feet wide.

The central part of the stock, underlying about 4 square miles, is a porphyritic granite composed of pink microcline in phenocrysts averaging about ½ inch long, with quartz, biotite, and hornblende in the groundmass. Accessory minerals, seen in thin section, are sphene, apatite, and magnetite.

The intrusive contacts with the schists and sediments are fairly regular with relatively few apophyses extending out from the stock. Metamorphic effect of the intrusion on the intruded rocks has been slight; the greenstone schists have been changed to hornblende schists for a few tens of feet from the contact; metamorphic effects are more noticeable in the argillaceous greywackes, which have been altered to garnet-mica schist. Where the contact can be observed it is very

sharp, with no evidence of assimilation of the country rock. Part of the contact with the volcanics on the southwest side of the stock is an intrusive breccia, about 300 feet wide, consisting of large fragments of hornblende schist in a matrix of the border phase.

On the north side of the stock a few narrow dikes extend out from the stock; one type is similar to the non-porphyritic syenite border phase, whereas another type resembles the porphyritic granite of the centre part of the stock. This latter type was observed to cut the border phase exposed at Pipestem Lake. These relationships suggest that the non-porphyritic border zone is an early crystallized phase composed of the early crystallizing minerals of a granite magma. Before the final crystallization of the central part of the intrusive, the solid border phase cracked, and the fluid crystal mush forced its way into the fissures leading through the border phase into the greenstones and consolidated as narrow porphyritic dikes.

The granite stock is probably a cupola on the Algoman(?) granite batholith exposed over a large area north of the greenstone belt. The regional east-west trend of schistosity has been diverted near the contacts with the stock to be almost parallel to the contact. Dips in the schists are steep and away from the contact. It is believed that a cylindrical mass of intrusive magma forcibly pushed its way upwards through the schist cover, with most of the expansion northward because of the buttress of old granite to the south.

Pleistocene

The area has been extensively glaciated. Bedrock is very unevenly covered by a sheet of glacial material consisting of variously sized boulders in sandy clay. From Redpaint Lake east to longitude 90°15'W. bedrock is extensively exposed; on some traverses over 75 percent of the walking was on bare outcrop. Eastward from longitude 91°15'W., the relative amount of overburden increases, until only scattered knobs of outcrop are found. East of Brush Creek most of the area is covered by muskeg.

In the western part of the area two hills, composed of sand and gravel of glacial outwash origin, were mapped. Other outwash deposits of sand and gravel are exposed on lumber roads north and east of Norway Lake. Outwash deposits of stratified gravel occur at the old lumber camp south of Pyramid Lake, and also near the lumber camp at the west end of van Nostrand Lake. Similar gravels have been obtained for road building along the road southward towards Sapawe. Dune or beach sand is exposed on the winter road near Hawk Lake in the extreme northeast corner of the map area.

Varved clay, overlain by gravel and Recent stream sand occurs at the east end of the logging sluice at the outlet of Oldman Lake; at places further up Brush Creek the banks are composed of clay, but no varves were seen. The clays were probably deposited in the same glacial lake as the varved clays recently exposed by the lowering of Steeprock Lake; this glacial lake was given the name Lake Johnston by Antevs.[1]

Glacial striations on bedrock exposures are very common throughout the area and offer abundant proof that the last direction of ice flow was towards the southwest between S.1°W. and S.60°W. Most measurements lie between S.15°W. and S.30°W. On a stripped area at Lumby Lake a set of striations striking S.60°W. was observed superimposed on an older set striking S.15°W.

[1]Ernst Antevs, "Glacial Clays in Steeprock Lake, Ontario, Canada," *Bulletin*, Geol. Soc. Amer., Vol. 62, 1951, pp. 1223–62.

Recent

Recent deposits in the area are confined, with one exception, to unconsolidated sand and silt in rivers, creeks, and lakes. Recent sands of river origin, reworked glacial material, overlie varved clay at Brush Creek, and a delta of fine sand and silt is being built in Oldman Lake at the outlet of Brush Creek. Fine white quartz sand occurs along most of the Seine River in the map area, and natural levees, 8 feet high, occur along its banks south of Oldman Lake.

Minor tillite, several feet thick, has been formed by the cementation of glacial debris by limonite gossan over the sulphide bodies at Hematite Lake and is so thoroughly consolidated as to core easily in diamond-drilling. Plant roots, twigs, and small logs have been replaced by limonite and retain the outline of their internal structure.



Boulder clay exposed on roadside south of Hematite Lake.

STRUCTURAL GEOLOGY

Primary Structures in Volcanics and Sediments

Useful structural data were found in a few places within the volcanics. The shape and packing of pillow structure was used most extensively, but only in about fifty outcrops was this found sufficiently undeformed to indicate the direction of the flow top. Because of the relatively few top determinations, and because of some contradictory determinations, it is acknowledged that the fold pattern is probably considerably more complex than the somewhat generalized picture outlined below.

Although bedding, and banding derived from bedding, are generally well exposed in the sediments and assist in the general structural interpretation, primary features valuable for determining the facing of the sediments are relatively rare being confined to graded bedding and the sedimentary breccias; no ripple mark, or cross-bedding was found.

Areal Structure

The general structural picture is that of a folded Keewatin-type greenstone sequence downfolded between, and intruded by, granite masses of two ages, cut by faults and fractures, and extensively sheared. The fold system has been deeply eroded.

AREAL TRENDS

Two main trends have been outlined in the greenstone area mapped. The main part of the greenstone area trends about N.80°–85°W., the strike and dip of the regional schistosity being parallel to marker horizons, which can be traced for some distance. A smaller area of greenstone extends from the main part of the belt into the area between Upper Scotch and Leach lakes; the trend in this belt is N.25°–30°E. and is approximately parallel to the contacts with the granite.

Linears due to faults, fractures, and joint intersections in the granite areas trend about N.30°E. Near the contacts with the greenstones, gneissosity is approximately parallel to the schistosity within the greenstone area.

SCHISTOSITY

The general strike and dip of the schistosity in the greenstones in the area is about parallel to the few formations traceable for any distance. The dip is very steep or vertical, varying locally in angle and direction. North of the main band of sediments most measurements indicate a steep dip southward, whereas south of this zone most measurements indicate a steep northward dip. Near intrusive contacts, schistosity may be locally crumpled or may be developed parallel to the contact. Schistosity has been crumpled to produce dragfolds within the stronger shear zones, and superimposition of S-surfaces of severely dragfolded zones has produced splintery schists with a lineation parallel to the dragfold axes. Locally, as at the junction of the Scotch Lake trend and the main greenstone belt, two sets of schistosity appear to have been imposed on the rocks, producing a measurable lineation.

Folding

MAIN FOLD PATTERN

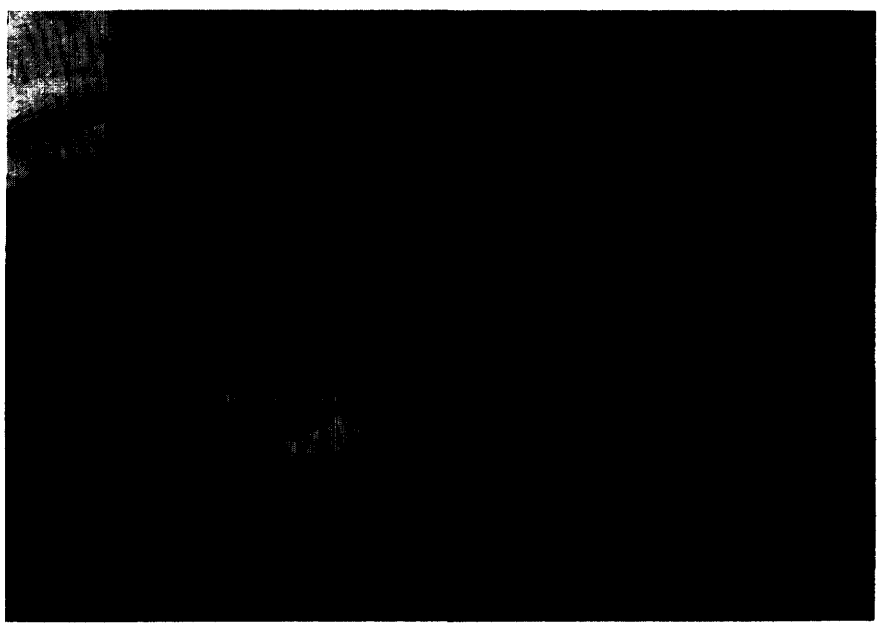
The greenstone area may be divided into two main fold structures. The more important of these is the main east-west structure extending from Redpaint Lake to the east side of the map area. Structural data in the volcanics on each side of the main belt of sediments and within the sediments indicate a major syncline with the trace of the axial plane at or near the south side of the belt of sediments. There is no indication of symmetry in the sequence of formations on the limbs of the fold, and the absence of the sediments on the south limb is explained by postulating a basin of deposition of limited areal extent. A few top determinations in volcanics west of Lumby Lake indicate an anticline overturned towards the south and striking parallel to the main east-west syncline. The direction and amount of plunge, if any, is not known. A curved, northeastward-trending syncline is indicated by the attitude of schistosity between Irish and Leach lakes.

The intrusion of the Laurentian(?) batholith followed the original compression and folding of the Keewatin-type greenstone into isoclinal folds, which were only locally affected by the disturbances preceding and accompanying the Algoman(?) igneous activity. It is possible that the forces of the Algoman(?) revolution duplicated, to some degree, the earlier forces, intensifying or modifying the earlier imposed structures.

The north-east trending band of hornblende schist between Upper Scotch and Leach lakes appears to be a fold structure imposed by compression by orogenic forces preceding the intrusion of Algoman(?) granite, and then truncated by the Algoman(?) intrusive. Superimposition of sets of schistosity has locally complicated the structure where it joins the main belt.

DRAGFOLDING

Local variations in the dip of schistosity noted throughout the area may be due to dragfolding associated with major folding in the area. The tongue of iron formation that diverges from the main band of sediments at Cryderman Lake and extends westward towards a smaller tongue extending eastward from Pine-



Dragfolds in limestone-chert beds at Garnet Bay, showing lineation parallel to the axial lines. Siliceous bands project above limestone bands on this water-washed outcrop.

cone Lake may be a doubly plunging local dragfold on the north limb of the main syncline; the axial plane is convex upwards, so that erosion has cut through the higher part of it.

Many of the dragfolds within the schists can be related to differential movement on local or major shear zones, or to intrusion of igneous bodies. Those dragfolds in shear zones range in size from minute crenulations, a fraction of an inch across, in shears involving interlaminal slip planes, 1 inch or so apart, to folds many yards across in a zone of dragfolding ¼ mile wide.

Dragfolds, due to forces derived from igneous intrusives or by later movement along the contact, are best developed in the sediments along and near the contact with the Algoman(?) granite in the Norway Lake area. A conglomerate marker horizon has been folded into steeply plunging dragfolds up to 700 feet wide. Many small dragfolds were observed in the hornblende schist near the Algoman(?) granite northwest of Seahorse and Timlin lakes.

Faulting and Fracturing

The rocks of the area have been broken by a number of faults, shear zones, and joints. Some of these occupy linear valleys and can be readily distinguished on air photographs of the area. The pattern of faults and joints is to a considerable extent reflected in the drainage pattern.

SHEAR ZONES

Lumby-Spoon Lakes Shear Zone

A sheared zone, 100–2,000 feet wide, extends eastward from the west end of Lumby Creek, along a line of lakes to Hutt Lake, and disappears in the vicinity of the Pogo Lake portage. It dips northward at 70°–80°, with a few local dips as low as 45°. It occurs mainly within the area mapped as a quartz porphyry–diorite complex; most of the rock within the shear zone is a quartz-sericite schist, for, except near the contacts with sericite schists, the diorite is not much affected by the shearing. Differential movement is indicated at Spoon Lake by a small vertical lamprophyre dike being offset at a shearing at a contact of quartz-sericite schist and diorite. The movement gave rise to a right-hand strike separation of 3 feet.

Slickensides on shear planes in the sheared zones at Spoon Lake pitch 30°–35°E., microcorrugations in sericite schists nearby pitch nearly vertically, and vertical dragfolds in sericite schist south of Jefferson Lake indicate a relative movement of the north side eastward, which agrees with the strike separation observed on the dislocated vertical lamprophyre dike. The slip vector of the total movements occurring on the slips of this shear zone could not be determined.

The rocks in and near this shear zone are mineralized with sulphides at Lumby Lake and Spoon Lake. Thorough prospecting appears to be warranted throughout the area affected by the movements.

Minor Shear Zones

Minor shear zones parallel to the regional trend, and other evidence of differential movement parallel to the schistosity occur throughout the area. The more important of these are shown on the map. The minor shear zones are recognized by a high degree of foliation, with slickensides, polish, or microcorrugations on the planes of schistosity; by the presence of dragfolds; and topographically by gullies and elongated lakes. Where the pitch of the lineation can be measured on the planes of schistosity, it is generally very steep to vertical. As these shears are strike shears, no horizons are available for determining the amount and direction of the movement. Dragfolds developed by the shearing are useful locally in this respect and provide the means for determining the last direction of movement; no uniformity of results over the area was observed.

Redpaint Lake Shear Zone

One of the main structural features of the area is the zone of rupture that enters the map area southwest of Jet Lake and extends northeast to beyond Riverview Lake. It is part of a regional structure that extends from the Steeprock Lake area to the north end of Cloven Lake, a distance of about 35 miles; over most of this distance it occupies a pronounced valley occupied by elongated lakes. Within the map area, faulting has occurred on this zone of rupture. South of Redpaint Lake it forms a sheared zone in quartz porphyry, diorite, and greenstone, up to 1,500 feet wide, which narrows southward. At Redpaint Lake it is associated with a zone of intense crumpling of the chlorite schist, and northeastward it passes through Riverview Lake as a fault-line valley.

Various formations have been brought into contact along the fault zone. In the extreme southwest the Keewatin-type greenstone is brought up against the sheared quartz porphyry–diorite zone; from Jet Lake to Redpaint Lake, Algoman(?) granite is in fault contact with this contact zone and forms a prominent scarp; at Redpaint Lake greenstone may be in fault contact with Algoman(?) granite under the lake.

Movement on the main regional fault has produced a right-hand strike separation in the Jet Lake area of at least ½ mile, and north of Redpaint Lake of about 300 feet. The amount of relative movement is not known, but dragfolds in the shear zone south of Redpaint Lake indicate a relative movement of the northwest side upward of 10°–20° and towards the northeast. The schists in the shear zone dip vertically or very steeply; both east and west dips were measured. It is possible that the greenstone area in the southwestern part of the map area was the faulted continuation of the Lumby Lake greenstone belt, but evidence for differential movement on the regional fault suggests an opposite direction of movement. It is possible that it joins up with a greenstone area south of the map area, but this could not be checked in the time available.

Associated with the shear zone on the east side of Redpaint Lake is a zone of intense crumpling and fracture cleavage in the greenstone. From this crumpled zone, and possibly extending through it to coalesce with the regional structure, a fault occupying a fault-line valley passes northeastward and dies out in the greenstones northeast of Seahorse Lake. The amount and direction of movement on this fault is not known; the occurrence of limestone on the west side of the fault suggests that the sedimentary belt, extended to the southwest from this, has either been faulted upward on the west side and eroded away, or downfaulted on the west side so that only minor parts appear.

The zone of crumpling and fracture cleavage in the greenstones on the east shore of Redpaint Lake is a prominent feature closely related to the regional structure. Dragfolding is well developed at many places along the shear zone, and some of the folds in the crumpled zone may be associated with movement on the shear zone. The crumpled rocks are dark- to medium-green chlorite-carbonate schist and splintery sericite-carbonate schist derived from Keewatin-type volcanics. The folds actually observed in the schists range from ¼ inch to several feet from crest to crest. In general they decrease in amplitude and become more open eastward, gradually dying out about ½ mile east of Redpaint Lake. The attitude of schistosity varies greatly throughout this area, indicating folds several hundred feet across. The folds are generally chevron type, but U-shapes are common; most are fairly open.

The axial planes of the folds strike between N.25°–44°E.; dips range from 80°E. to vertical, to 87°W.; the axial lines plunge 80°–90° towards the northeast. Lineation due to intersection of S-planes is common and, where well developed, has produced a soft, splintery sericite schist. At the Alcock showing, mineralized quartz-carbonate veins up to 5 feet in width occur in the crests of folds up to 15 feet across in sericite schist. Brecciation and slickensides occur in the rocks adjacent to a fault-line valley at this showing.

Locally, along the east shore of Redpaint Lake and on nearby islands, fracture cleavage is well developed. A prominent set, fairly uniform in attitude for a distance of 2,000 feet along the shore, strikes N.20°E. and dips 16°W.; the average spacing of the fractures is about 4 inches. This closely spaced jointing is, in part at least, a shear phenomenon since certain fractures pass into a series of *en échelon* tension cracks aligned at 30° from the main fracture. Much more closely spaced fracture cleavage occurs on small islands off the east shore of Redpaint

Lake; a thin section shows the fractures to be a shear phenomenon, being small reverse faults, which die out over a few inches into minute corrugations of schistosity. No definite conclusions regarding differential movements in the shear zone could be reached from a study of the attitudes of the fracture cleavage.

Evidence in the Redpaint Lake area suggests that, in this vicinity, the general east-west formational trend, prior to the regional rupturing, changed to a southwest-northeast trend and was possibly continuous with the Finlayson Lake belt extending into the Steeprock area. This is further suggested by the southwestward trend of the Laurentian(?) intrusives unaffected by the main shearing, and by the occurrence of patches of sheared pillowed volcanics within the shear zone at the south end of Redpaint Lake.

The zone of crumpling now marks the zone of a rather abrupt change of schistosity. It is probable that at one time, perhaps before the Algoman(?) disturbance, the foliation curved uniformly around the early granite mass. With the intrusion of the Algoman(?) granite, or by later forces from the northwest and associated in time with the main regional break, the foreshortening by crumpling of greenstones took place.

An important factor in the development of the shear zone and associated crumpled zone is the presence of the early granite mass, which acted as a buttress, around and against which the schists have been buckled. With an increase of pressure from the west, impinging upon the greenstone and early granite equally and in a direction normal to the direction of major folding, the greenstone crumpled as the buttress held fast: an indication of this is the increasing amount and width of crumpling northward from the quartz porphyry–diorite complex. It is possible that the shortening of the greenstone section continued until the angular relationship of the buttress and edge of the greenstone was parallel to a shearing component of the force from the west strong enough to overcome the weaker resistance in that direction. Differential movement from such shearing would be of the west side towards the northeast.

The force producing the Redpaint Lake structure may be the same as that proposed by various geologists in the Steeprock area to account for the buckling of the Steeprock series and underlying Keewatin-type greenstones against the Laurentian granite on the east to form a series of folds with their axial planes trending northward. Hawley[1] suggests an east-west couple with the north block moving eastward and states that the age of the deformation is Algoman. Bartley[2] indicates a later compressive force in the north-south direction, which produced cross-faulting and slight overturning to the south, and which he believes to be associated with the Algoman igneous activity.

CROSS-FAULTS AND FRACTURES

Cross-faults and fractures trending N.30°–50°E. are common features of the western part of the area and are expressed topographically by valleys and gullies cutting across the east-west ridges. Although the strike separation could not be accurately determined for any of the faults, evidence for faulting lies in the dragfolding, slickensides, and brecciation that occurs in the rock adjacent to the fault-line valleys. Some of the linear valleys that mark faults or fractures curve eastward and disappear as they pass northward from the Laurentian(?) granite into the greenstone area.

[1] J. E. Hawley, *Geology of the Sapawe Lake Area*, Ont. Dept. Mines, Vol. XXXVIII, 1929, pt. 6, pp. 20, 21.

[2] M. W. Bartley, *Iron Deposits of the Steeprock Area*, Ont. Dept. Mines, Vol. XLVIII, 1939, pt. 2, p. 40.

The post-Algoman(?) fault that enters the greenstone area at Lumby Lake can be traced by its topographic expression across the greenstone belt and into the granite at Norway Lake. It appears to displace the vertical agglomerate-tuff bed on the north side of Lumby Lake, giving rise to a strike separation of 300 feet, and the contact at Norway Lake by the same amount. These strike separations are deduced by extrapolation of indicated trend and may be in error.

An interesting observation concerning this fault is the gradual bending eastward in the southern part of the greenstones, and the bending back northward in the northern part. This may be due to post-faulting differential movement on the slip planes of the Keewatin-type schists; or it may be due to the contrast in physical characteristics between granite and schists, causing the fracture to assume different directions in different rock types. Examples have been noted where fractures curve to align with regional trends as they pass into a less competent rock.

Several cross-fractures, probably with some movement, occur in the Spoon Lake area. Two of these, adjacent to the points of land in Spoon Lake, appear to be associated with the main east-west shear zone and appear only on the north side of the shear zone. A third fracture cuts the shear zone between Spoon and Herontrack lakes, curves northeastward and disappears in the greenstones. These cross-faults or fractures at Spoon Lake are important in the localization of mineralization at Spoon Lake; galena, sphalerite, chalcopyrite, and gold are reported from the points on the north shore.

The Bar Creek fault follows the contact of the quartz porphyry–diorite complex and Laurentian(?) granite for almost ½ mile, but it is not known if this distance represents a strike separation along a fault.

Several other northeast-trending valleys occur in the area, and some are occupied by faults. These valleys become fewer eastward perhaps because of the greater amount of overburden masking bedrock.

Faults associated with the greenstone–Algoman(?) granite contact occur north of Pinecone Lake and north of Gargoyle Lake; both are marked by gullies. No indication of the direction of movement was noted on the former; dragging adjacent to the latter suggests that the south side moved downwards vertically in relation to the north side.

No definite conclusion can be reached regarding the nature and origin of these cross-faults. The northeast-southwest-trending faults may be unduly emphasized, since the valleys that mark their courses are approximately parallel to the direction of flow of the ice sheet over the area and thus might be accentuated by glacial scour.

Brecciation

Fault breccias and intrusion breccias occur at several places throughout the area. Other less readily identifiable breccias are found locally. An important zone of brecciation occurs along the north shore of Pinecone Lake and between Pinecone and Spool lakes. It is best exposed on the north side of the east end of Pinecone Lake where it forms a cliff 50–75 feet high and is composed of irregular, angular fragments of basalt up to 3 inches in diameter set in a calcite matrix with minor chert. At the base of the cliff a few fragments of garnetiferous schist occur in the breccia, suggesting that along this part of the brecciated zone, the breccia is at the contact of the volcanics and sediments. The brecciation in the volcanics dies out northward over 100–200 feet. Between Pinecone and Spool lakes, and at Spool Lake, the breccia is composed of angular fragments of sedi-

ments and hybrid rocks in a calcite matrix. These breccias are part of one zone of brecciation, which may be the result of post-Algoman(?) movement concentrated in and near the band of sediments. The calcite of the matrix may have been derived by solution from the limestone occurring in the vicinity.

Breccia, intersected in the iron formation and graphitic argillite by diamon - drilling at Hematite Lake, has been described under intraformational and interformational breccias. Some of the microfaulting in the banded silica-sericite is so intense as to produce a breccia.

Minor zones of brecciation, too weak or too small to be mapped, are common throughout the area. Those occurring in the area between Magnesium, Irish, and Gargoyle lakes are no more than closely spaced intersecting joints in greenstone, opened by slight movement and filled with carbonates.

ECONOMIC GEOLOGY

The area has not yet been thoroughly prospected, but minor finds have been made occasionally since the discovery of gold near Longhike Lake in the 1890's. Early prospecting was an extension of investigations farther south, where the Sawbill and Hammond Reef mines were operating about the turn of the century. One of the early geologists in the area, McInnes,[1] noted the presence of pyrite and chalcopyrite in float about the shores of two small lakes near the height-of-land south of Norway Lake.

With the failure of the early gold properties, no further interest was shown in the area until the discovery of gold at Lumby Lake in 1937 renewed prospecting, and finds of copper and zinc were reported. Development work was unsuccessful, and the claims lapsed.

The Alcock gold property at Redpaint Lake was staked in 1946 in the vicinity of old locations near the Bonheur trail. In 1948 and 1950 the Lumby Lake showings were restaked, and the report that Noranda Mines Limited and Newkirk Company Limited had optioned the claims caused considerable speculative staking in 1950–51. Many of the claims staked at that time have lapsed.

Investigations, since 1950, of the iron formation on the Mathieu property at Hematite Lake have revealed the presence of iron sulphides and siderite, and, in 1952, Candela Development Company explored these zones as a source of iron and sulphur.

Metallic Minerals

GOLD

Gold has been reported from many places in the area, but only a few of these were visited. Gold occurs in quartz veins and in quartz-carbonate veins cutting both massive and sheared Laurentian(?) granite and Keewatin-type greenstones. It is also found associated with base metal sulphides disseminated in sheared quartz porphyry and greenstone.

Gold was first discovered in the area near Longhike Lake, and the development at the Golden Winner mine was carried on for about a year and a half in 1899 and 1900. Production amounted to 15 tons for a total value of $70 at the price for gold in 1900. The exact location of the old mine is not known, it is described by Bow[2] as being

> situated on a small lake 4 miles northeast of Sawbill lake and a mile and a half east of the Bonheur-Sawbill road . . . The workings are about one-quarter mile northeast of the lake on which the camps are situated. The buildings consist of stamp mill, hoist house and blacksmith shop at the mine, and office, storehouse and boarding camps on the lake.

[1] William McInnes, *Summary Report*, Geol. Surv. Can., Vol. IX, 1896, Report A, p. 35.
[2] J. H. Bow, *Mines of Northwest Ontario*, Ont. Bur. Mines, Vol. X, 1901, p. 109.

The geology is described by Bow as follows:

The deposit as exposed down the shaft is a large body of chloritic schist interbanded with quartz lenses and stringers all more or less highly impregnated with iron pyrites and dipping about 45 degrees south.

The underground development and installation of a stamp mill is a further example of the lack of judgment evident in the early mining development throughout the Kenora–Rainy River district. The work dates back to an era when the discovery of native gold was considered sufficient justification for sinking a shaft, and followed a pattern all too frequent in the early days. The reasons for the failure of the district as a gold producer are outlined by Bruce.[1]

A shaft is also reported to have been sunk to a depth of 30 feet on location E. S. 20, about 1 mile south of the east end of Spoon Lake, by the management of the Golden Winner mine in 1899. The old workings were not seen by the author, but from the described locality it appears to be in the area underlain by Laurentian(?) granite.

In 1937, Albert Wren, with a Geological Survey of Canada survey party, picked up a piece of float at the west end of Lumby Creek, which on assay gave a gold content of many ounces per ton. The report of the high assay resulted in considerable prospecting in the immediate area, considerable trenching and stripping, and a small amount of diamond-drilling by the Wilson-Wren interests and Red Cedar Gold Mines Limited. Copper and zinc deposits, with some gold values, were found during this prospecting.

Gold occurs in the Lumby Lake shear zone and is concentrated in siliceous zones and associated with copper, lead, zinc, and silver. The gold content is very low however; a siliceous zone with disseminated sulphides is said to have assayed 0.034 ounces per ton over 20 feet; with Ag, 0.57 ounces per ton; Cu, 0.25 percent; Zn, 0.22 percent. A grab sample taken by the author from a test pit in sheared porphyry at Spoon Lake assayed 0.05 ounces of gold per ton; with Ag, trace; Cu, 0.29 percent; Zn, 6.74 percent; Pb, 1.75 percent.

On the Alcock property, gold occurs in and near rusty quartz-ankerite veins occupying the crests of folds in sericite-carbonate schists and is associated with pyrite and chalcopyrite. Assays up to 1.99 ounces per ton are reported from grab samples of the vein material. Smaller quartz-ankerite veins occurring in minor flexures in schists at Gargoyle Lake carry only traces of gold.

Visible gold is said to occur at several places in the vicinity of Pyramid Lake. A test pit ¼ mile south of Brushport Lake reveals considerable pyrite and minor sphalerite in a dike of altered quartz porphyry. A grab sample, taken by the author, and assayed by the Provincial Assay Office, showed 0.09 ounces of gold per ton and a trace of silver.

COPPER

Copper deposits were found in the Lumby Creek area during prospecting for gold in 1938-1939, the original discovery being made at the junction of the creek from Morris Lake and Lumby Creek west. Further exploration in 1951 revealed deposits at several places in a mineralized shear zone along Lumby Creek. Chalcopyrite occurs as fillings in the selvages of pillow structure in andesite and disseminated in siliceous zones within sheared quartz porphyry. Minor diamond-drilling in 1938 by Wilson-Wren interests and Red Cedar Gold Mines Limited and a larger drilling program in 1951 by Noranda Mines Limited in this zone, failed to give encouraging results.

[1]E. L. Bruce, *Gold Deposits of Kenora and Rainy River Districts*, Ont. Dept. Mines, Vol. XXXIV, 1925, pt. 6, pp. 1, 2.

Minor chalcopyrite mineralization has been noted at several other showings in the area, notably at Spoon Lake, Rea Lake, Redpaint Lake, and at Blowout Lake.

LEAD

Galena crystals up to ½ inch occur in a narrow quartz vein cutting chlorite schist on the north side of Lumby Lake. Galena, associated with sphalerite, occurs in sheared, altered quartz porphyry on the north-central point of Spoon Lake on the Little Long Lac option, where considerable trenching and stripping has been done.

ZINC

Sphalerite occurs disseminated in the siliceous zone in sheared quartz porphyry at the west end of Lumby Creek on the Anderson property; one channel sample was reported to assay 0.5 percent over 5 feet. A grab sample taken by the author from a test pit at Spoon Lake and assayed by the Provincial Assay Office gave 6.74 percent zinc; gold, 0.05 ounces per ton; silver, trace; copper, 0.29 percent; lead, 1.75 percent.

IRON

There appears to be a good possibility of discovering economic deposits of iron in the area. No bodies of hematite are known, but persistent reports of hematite float in the Norway Lake area, plus the occurrence at Norway Lake of carbonate rock resembling the Steeprock limestones, have given rise to minor prospecting in this vicinity. Small lenses of magnetite iron formation have been found in the volcanics north of the band of sediments, and within the main sedimentary band at Seahorse Lake and Pinecone Lake. The iron content of these rocks is too low for economic extraction.

Magnetic attractions, some of them quite strong, occur at a number of localities mainly in or near the sediments, and may indicate magnetite or pyrrhotite bodies and thus warrant investigation. The most important of these magnetic attractions are shown on the map.

Lenses of siderite, partly very siliceous and partly fairly massive, have been intersected by diamond-drilling in the Hematite Lake area, where Candela Development Company explored bodies of sulphide in the iron formation. These siderite lenses contain up to 37 percent iron and range up to 40 feet in thickness. These have been intersected in drill holes spaced over a length of 4,000 feet between Hematite and Keewatin lakes.The occurrence of siderite in pisolitic form and its association with intraformational breccias and banded silica suggests a syngenetic sedimentary origin.

Industrial Minerals

GARNETS

Dark-red garnets of the almandine-pyrope variety occur in varying amounts in the argillaceous sediments, especially near the intrusive granite contacts at Garnet Bay, Pinecone Lake, and Hematite Lake. The crystals are generally well formed trapezohedrons and range up to ¼ inch in diameter. The garnet content averages less than 10 percent of the rock, but in certain zones west of Garnet Bay, the garnet content is estimated at 35 percent.

ANDALUSITE

A thin section of a specimen of metamorphosed sediments exposed at the south end of Norway Lake shows about 30 percent andalusite, as small, impure, disseminated metacrysts. This rock should be investigated as a source of ceramic material.

GRAPHITE

Lenses of graphitic argillite and graphite schist are common in the southern part of the main band of sediments, from Cross Lake to east of van Nostrand Lake. Graphite occurs in these rocks as fine flakes disseminated throughout and forms highly polished films on slip surfaces. A grab sample taken by the author from the pit at Pinecone Lake and assayed by the Provincial Assay Office, contains 13.70 percent carbon (C). The purity of the flake graphite is not known. The graphite content of the argillite appears to be highest where the rock contains many pyrite concretions of syngenetic or diagenetic origin, a fact that suggests an organic origin for the carbon.

SULPHUR

As noted in the section on iron, exploratory drilling on the Mathieu property has revealed bodies of massive and disseminated pyrite and pyrrhotite in the iron formation that might be significant as a source of sulphur. Pits at Pinecone and Cryderman lakes expose small lenses of massive sulphide in concretionary graphite schist. A small amount of native sulphur, derived from weathering of the sulphides, was found in both these pits. Traces of nickel and copper were reported by the Provincial Assay Office in a sample of massive pyrrhotite from Cryderman Lake.

Discussion, and Recommendations for Prospectors

Most of the gold and base metal deposits of the southern part of the area show an obvious areal relationship with the Laurentian(?) soda-granite. Even a casual inspection of the claim maps shows a concentration of old mining locations in the area underlain by the Laurentian(?) batholith extending southward to the Sapawe Lake area. Most of the locations were staked on narrow, gold-bearing quartz veins in small shear zones in granite, but none was large enough to be mined at a profit.

Conditions in the contact area of the Laurentian(?) and Keewatin-type rocks appear to have been favourable for the deposition of gold and base metals. The so-called Lumby Lake shear zone and its associated cross-faults may have provided the main channelways for the mineralizing solutions. Deposition has occurred in and near these channelways, in favourable zones such as the pillowed parts of flows, subordinate shears, and parts of the main shear close to cross-faults and fractures. This shear zone and its associated structures warrant thorough prospecting over the known length from Lumby Lake to the area south of Jefferson Lake.

Though the areal relationship of these deposits with Laurentian(?) rocks is obvious, the time of deposition of the ore minerals is not definite. The association with cross-fractures at Spoon Lake has been noted, but the relative age of these fractures cannot be definitely established. On some of them, and on the Lumby Lake shear zone, possible post-Algoman(?) and post-mineralization movement has occurred. The gold-quartz veins, containing little or no carbonate, occurring in the greenstones and early granite, appear to associate with Laurentian(?) rocks, whereas gold-bearing quartz-ankerite veins within the greenstones are associated with, or are later than, the intrusion of the Algoman(?) granite.

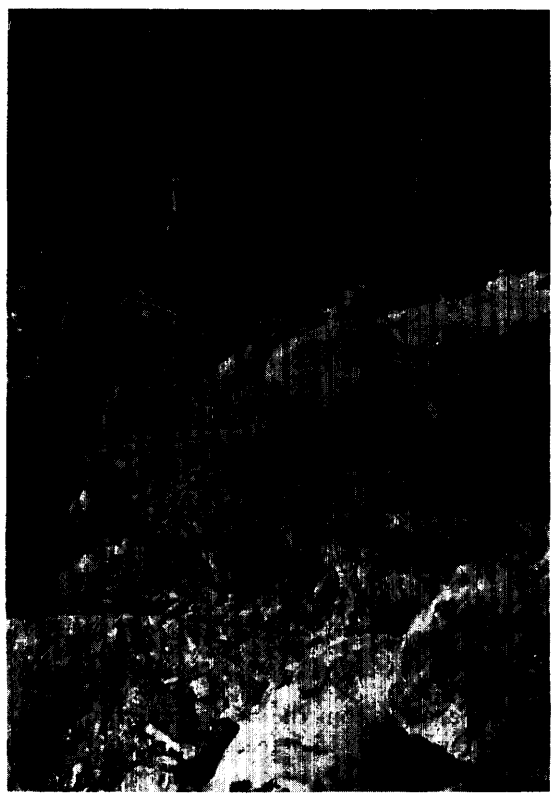
Iron deposits are confined to the iron formations interbedded in the volcanics and in the sedimentary belt. None of the magnetite iron formation in the main belt or in the smaller zones is thought to be of commercial importance at present prices for iron. Siderite and at least some of the pyrite at Hematite Lake is of

syngenetic sedimentary origin; the pyrrhotite and later pyrite may possibly be of hydrothermal replacement origin, the mineralizing solutions emanating from the magma of the van Nostrand stock, or of an unexposed Algoman(?) intrusive.

DESCRIPTION OF PROPERTIES

1. L. C. Anderson

Original staking in the area of the Anderson property was done in 1938, and the property was held until 1940 by Red Cedar Gold Mines Limited, and by the Wilson-Wren interests. A group of 50 claims was restaked by L. C. Anderson of Port Arthur in 1948 and 1950. Newkirk and Company Limited optioned the property and amalgamated their holdings with 38 adjacent claims held by Noranda Mines Limited, who were in charge of the exploration on the 88 claims. Work was started in February, 1951; an electromagnetic survey was done before breakup, and diamond-drilling, mapping, and trenching continued until July, 1951, when Noranda withdrew from the property, and the 50 claims reverted to Newkirk and Company. Nine holes totalling 2,417 feet were drilled in this program.



Mineralized shear zone in schisted andesite at main trench on Anderson property.

The property extends from Twobay Lake to the east side of Herontrack Lake and is underlain by Keewatin volcanics, chlorite and chlorite-sericite schists, and by intrusive quartz porphyry. All these rocks have been affected

by shearing. The contact with the Laurentian(?) granite lies about ½ mile south of the property. The schistosity of the rocks throughout the property strikes about N.85°–90°W., and dips 65°–75°N.

A strong east-west shear zone extends through the eastern part of the property. Most of the mineralization on the property is found in or near this shear zone. A cross-fault cuts across this shear zone at Lumby Lake, and a fault zone was intersected by drilling under Morris Lake.

Sulphide mineralization occurs in many places on this property, but the strongest concentration is in, and near, the shear zone west of Lumby Creek where gold, copper, silver, lead, and zinc have been found. Mineralization has been found in the quartz-sericite schist derived by shearing from quartz porphyry, and in sheared and unsheared volcanics.

Gold, silver, zinc, and copper occur in a silicified zone in sheared quartz porphyry at the west end of Lumby Creek. A series of trenches in this area show pyrite, chalcopyrite, and sphalerite disseminated over widths up to 20 feet. A compilation of assays supplied by Noranda Mines Limited, over a 20-foot width in the westernmost trench is as follows: Au, 0.034 ounces per ton; Ag, 0.57 ounces per ton; Cu, 0.25 percent; Zn, 0.22 percent.

On the east side of the creek, float containing chalcopyrite and sphalerite has been found. Diamond-drilling in this area revealed several mineralized siliceous zones, indicating a possible eastward extension of the zone west of the creek. Assay values were generally low, and good mineralization was confined to narrow widths.

The copper occurrence in the trench at the east side of the creek flowing north from Morris Lake into Lumby Creek is thought to be the original copper discovery of the area. Sulphide mineralization occurs in two zones of pillowed andesite in this trench; chalcopyrite and pyrite have been deposited in the selvages between the pillow structures and clearly outline their shape. The southern zone is 14 feet wide and assays (south to north) as follows:

Length Feet	Copper Percent
4.0	0.19
5.0	1.30
5.0	0.81

The north zone, separated from the south zone by 20 feet of low-grade material, is exposed for a width of 16.5 feet and a length of 25 feet and assays (south to north) as follows:

Length Feet	Copper Percent
5.0	1.18
5.0	1.37
6.5	0.68

The gold and silver content is reported to be very low. The assays above were supplied by Noranda Mines Limited.

Sulphide mineralization is exposed in trenches in quartz-sericite schist (sheared quartz porphyry) along Lumby Creek, between the trench mentioned above and the west end of Lumby Lake. Minor chalcopyrite and pyrite occur in a trench adjacent to the collar of Noranda's No. 1 drill hole. A channel sample over 6 feet, assayed by Noranda Mines Limited, gave: Cu, 0.66 percent; Au, trace; Ag, trace; and a contiguous 6-foot channel sample gave; Cu, 0.39 percent; Au, trace; Ag, trace.

2. Noranda Mines Limited

Noranda Mines Limited holds a group of 38 unpatented claims extending westward from the L. C. Anderson property to Redpaint Lake and south of the Alcock property. Considerable prospecting had been done earlier in this area, probably about 1895–1900 and again in 1937–38. These claims were staked in 1950, and exploratory work was done in the spring and summer of 1951.

The claims are underlain by an assemblage of rock types mapped as a quartz porphyry-diorite complex, which is a contact phase of the Laurentian(?) granite. The assumed contact of this complex with the Keewatin greenstones crosses the northern part of the property. A wide zone of shearing and folding, trending N.30°E., occurs along the west side of the property near Redpaint Lake.

Two shear zones containing gold-bearing quartz veins were drilled by Noranda in 1951. The Blowout showing occurs in a spruce grove between Claw and Blowout lakes on claims K.14520 and K.14517. The company reported that no significant gold assays were obtained in any of the six short drill holes put down on the showing.

A showing on claim K.14521 on the east shore of Redpaint Lake, ¼ mile north of the narrows, consists of a quartz vein 3 feet wide exposed for a length of 25 feet in a narrow shear zone in diorite. Four short holes were drilled in August, 1951, but gold assays were nil. One 6-foot channel sample across the shear zone gave an assay of 4.8 ounces of gold per ton, but other channels gave only nil to traces of gold. (Assays by Noranda Mines Limited.)

3. C. A. Alcock

This group of 13 unpatented mining claims is situated on the east side of the north end of Redpaint Lake. Several old mining locations are shown on the claim maps in the vicinity; early prospecting was done about 1895–1900. The present claims were staked by C. A. Alcock in 1946. The claims are underlain by greenstones and sericite-chlorite schists and lie near the west margin of the greenstone belt, astride a wide zone of strong NE.–SW. shearing and crumpling that extends along the east shore of Redpaint Lake.

Many rusty quartz-carbonate veins occur on this property, and all those examined appear to be associated with the folding, in most places occupying the crests and troughs of different sized folds in the highly contorted schists.

The main showing lies about 600 feet south of the north bay of Redpaint Lake, on claim K.11821, and consists of six test pits and strippings extending for 125 feet along the southeast side of a gully trending N.35°E. The valley marks the trace of a strong regional fault. Quartz-ankerite veins up to 5 feet in width occur in the crests of folds, in splintery sericite-carbonate schists associated with this fault. Mineralization consists of pyrite and chalcopyrite; no visible gold has been noted. Mr. Alcock reports that grab samples from this showing assayed 0.07–1.99 ounces of gold per ton, and that a channel sample, taken across 4.5 feet, assayed 1.38 ounces of gold. A grab sample, taken by the author and submitted to the Provincial Assay Office, yielded 0.35 ounces of gold per ton and 0.48 percent copper. Gold is reported to occur in the wallrock schists as well as in the veins.

A grab sample from a vein 500 feet southwest of this showing is reported by Mr. Alcock to have assayed 0.08 ounces of gold per ton. About 300 feet northeast of the main showing, near No. 1 post of claim K.11821, a rusty quartz-carbonate vein of unknown width is exposed in a small outcrop on the valley side. These veins are probably extensions of the main showing.

The following additional veins were observed on the property: on claim K.11825, a 5-foot quartz-carbonate vein with considerable pyrite in both vein material and altered wallrock occurs at the beaver dam in the pond near the east side of Redpaint Lake. Mr. Alcock reports an assay of 0.03 ounces of gold from a grab sample from this vein. On claim K.11825, a 3-foot vein occurs in small folds on the north shore of the small bay on the east side of Redpaint Lake. On claim K.14471, a test pit south of the point at the north end of Redpaint Lake shows minor pyrite and chalcopyrite in wallrock adjacent to a 3-foot quartz-carbonate vein. On claim K.11822, a 10-foot trench exposes a 1-foot quartz-carbonate vein in crenulations with pyrite and minor chalcopyrite mineralization in the vein and in carbonatized wallrock. A grab sample, taken by the author and submitted to the Provincial Assay Office, yielded 0.16 ounces of gold per ton.

4. Little Long Lac Gold Mines Limited (Option)

Little Long Lac Gold Mines Limited holds by option a group of 32 unpatented claims, staked in 1950, adjoining the east end of the L. C. Anderson property. The claims were prospected in 1951, and considerable stripping and trenching was done in the Spoon Lake area.

The claims are underlain by Keewatin volcanics, and by a complex of intrusive quartz porphyry and diorite. Laurentian(?) granite occurs about 1 mile south of the property. A shear zone extends the length of the property along Spoon Lake, and mineralization is concentrated in and near this shear zone, apparently localized near cross-faults and fractures.

On the west point on the north shore of Spoon Lake, a number of trenches exposed crystals of pyrite up to ⅛ inch, disseminated in sheared quartz porphyry. Gold has been reported, but assays are very low.

On the centre point of Spoon Lake, copper, lead, zinc, gold, and silver occur in altered sheared quartz porphyry. Mineralization may be associated with unsheared diorite masses and appears to be localized by small crenulations in the schistosity produced by cross movements. A test pit in the northeast corner of claim K.14599 exposes chalcopyrite, galena, sphalerite, and pyrite as small masses and disseminations in a silicified zone 8 feet wide. A grab sample, taken by the author from this pit and assayed by the Provincial Assay Office, yielded Au., 0.05 ounces per ton; Cu., 0.29 percent; Zn., 6.74 percent; Pb., 1.75 percent; Ag., trace.

5. J. A. Mathieu

The Mathieu property includes the block of unpatented mining claims K.12409, K.12412-20, K.12424, K.12426-27, K.15779-89, and K.16637-39, optioned by Candela Development Company from J. A. Mathieu, and two blocks K.16609-17 and K.16627–35, staked by Candela.

According to Bartley,[1] the presence of limonite gossan at Hematite Lake was first reported in 1914, but no concerted effort to investigate the underlying bedrock was made until 1948-49, when diamond-drilling was done from the ice of Hematite Lake. In 1950, four holes totalling 2,001 feet were drilled for Mathieu interests in search of iron ore, the work being directed by M. W. Bartley of Port Arthur. In 1952, Candela Development Company, a subsidiary of Freeport Sulphur Company of New York, optioned the property. During the summer of 1952, 13 holes totalling 3,192 feet were drilled.

[1] M. W. Bartley, *Report on the J. A. Mathieu Property*, private report, 1950.

The main belt of sediments crosses the property from east to west, varying in width from 400 feet to over 2,500 feet. The strike of the sediments ranges from N.80°W. to N.85°W., with some flexures and dragfolding; dips are very steep to vertical, with local variations. The sediments may be subdivided into two divisions, the northern part being mainly siliceous iron formation up to 1,200 feet wide, and the southern part argillaceous greywacke and graphitic argillite. The largest lens of graphitic argillite occurs at Hematite Lake. A stock of Algoman(?) granite intrudes the greenstones and sediments of the east end of Hematite Lake. Iron sulphide and siderite occur largely within the iron formation at and near its contact with the argillite, but locally concretionary pyrite zones in the argillite are important. Mineralization consists of massive to disseminated pyrite and pyrrhotite, underlain by lenses of siderite. The siderite is in part pisolitic, and is, along with at least some of the pyrite in the iron formation, probably of sedimentary origin. The pyrrhotite occurs as finely crystalline aggregates, suggestive of replacement of chert, and is later than some of the pyrite. The pyrrhotite, and a later, well-crystallized pyrite may be of hydrothermal origin and associated with the van Nostrand granite stock.

Three zones of mineralization had been outlined by drilling up to 1952. The A zone, on the south side of Hematite Lake, is about 2,100 feet long. Sulphides were intersected by four drill holes, but core lengths were less than 50 feet, and estimated sulphide content was about 40 percent; no siderite was reported from this zone.

The B zone is a possibly continuous band of sulphides in the iron formation; the average width is about 55 feet. Sulphur content of material sampled and assayed by Candela Development Company averaged 15–36 percent sulphur, an approximate average for the zone being 20 percent. The zone is folded north at the west end, so that a pair of holes, drilled north and south from one set-up east of Keewatin Lake, totalled 574 feet of iron sulphides averaging 22.2 percent elemental sulphur.

North of the sulphide zone, and in places interbedded with sulphides, lenses of siderite occur; the iron carbonate contains varying amounts of silica and small amounts of iron sulphides and iron silicates, grading with increasing silica northward into cherty silica zones of low iron content. The siderite zones intersected range up to 40 feet in true width and vary considerably in iron and silica content. Four bands of siderite were intersected in drill hole No. 3 of the 1950 drilling. The widest zone was intersected between 249–299 feet and represents a true width of 41 feet. Assays provided by M. W. Bartley are as follows: Iron, 27.60 percent; manganese, 1.80 percent; silica, 19.63 percent; sulphur, 2.03 percent.

It is possible that the siderite lenses form a zone extending the entire 4,000 feet of the B zone and may prove to be of an economic grade and width in a form readily amenable to modern methods of beneficiation.

The C zone, west of Keewatin Lake, had, until 1952, only limited exploration. Mineralization consists of pyrite concretions in argillite, and disseminated pyrrhotite in the chert on the north. The zone is about 400 feet long, with 15.6 percent sulphur over a core length of 115 feet being reported. No notable siderite mineralization was intersected.

In brief, the sulphide zones, especially B zone, would appear to be a promising source of sulphur and iron. The siderite associated with the sulphides may be developed into an economic source of iron.

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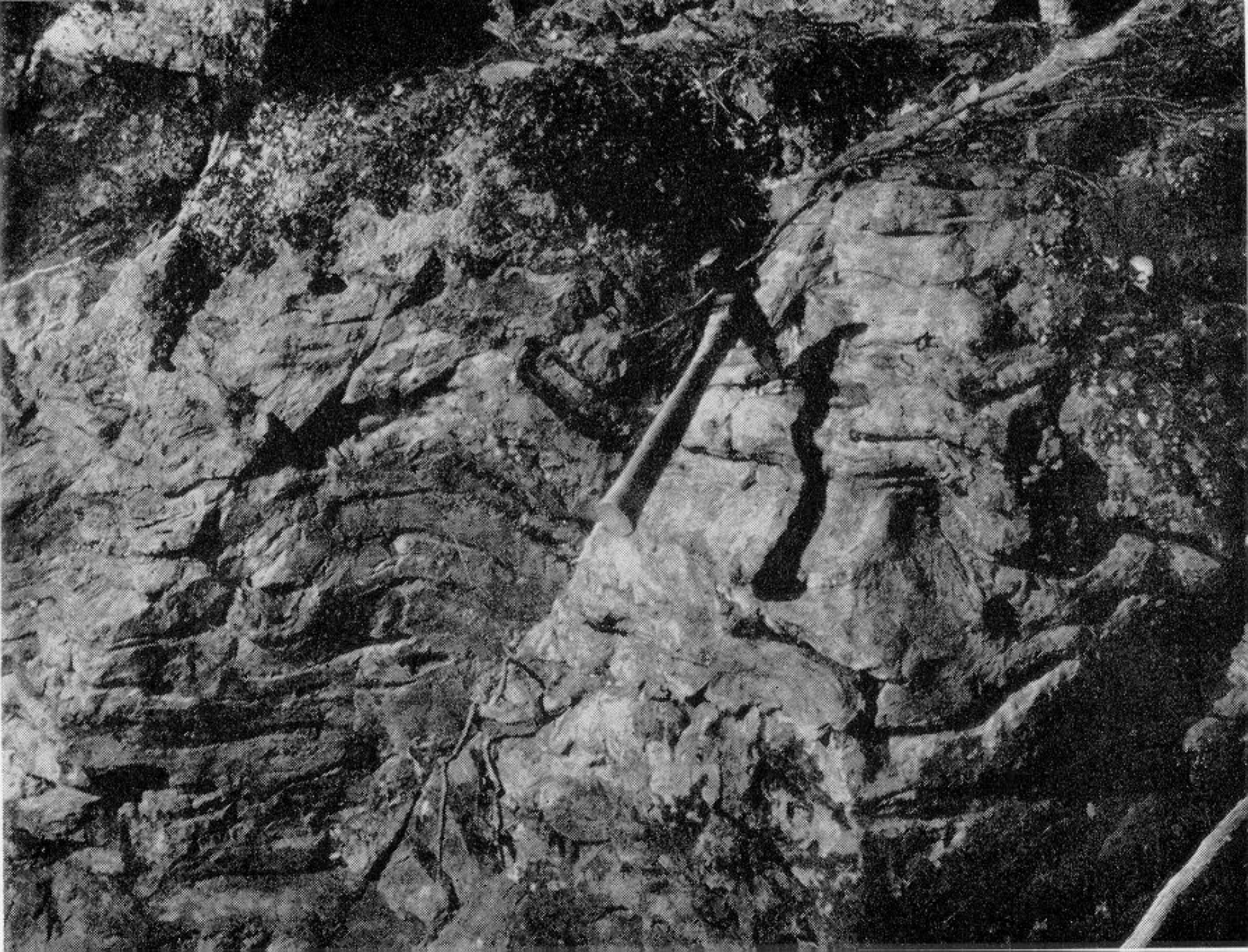
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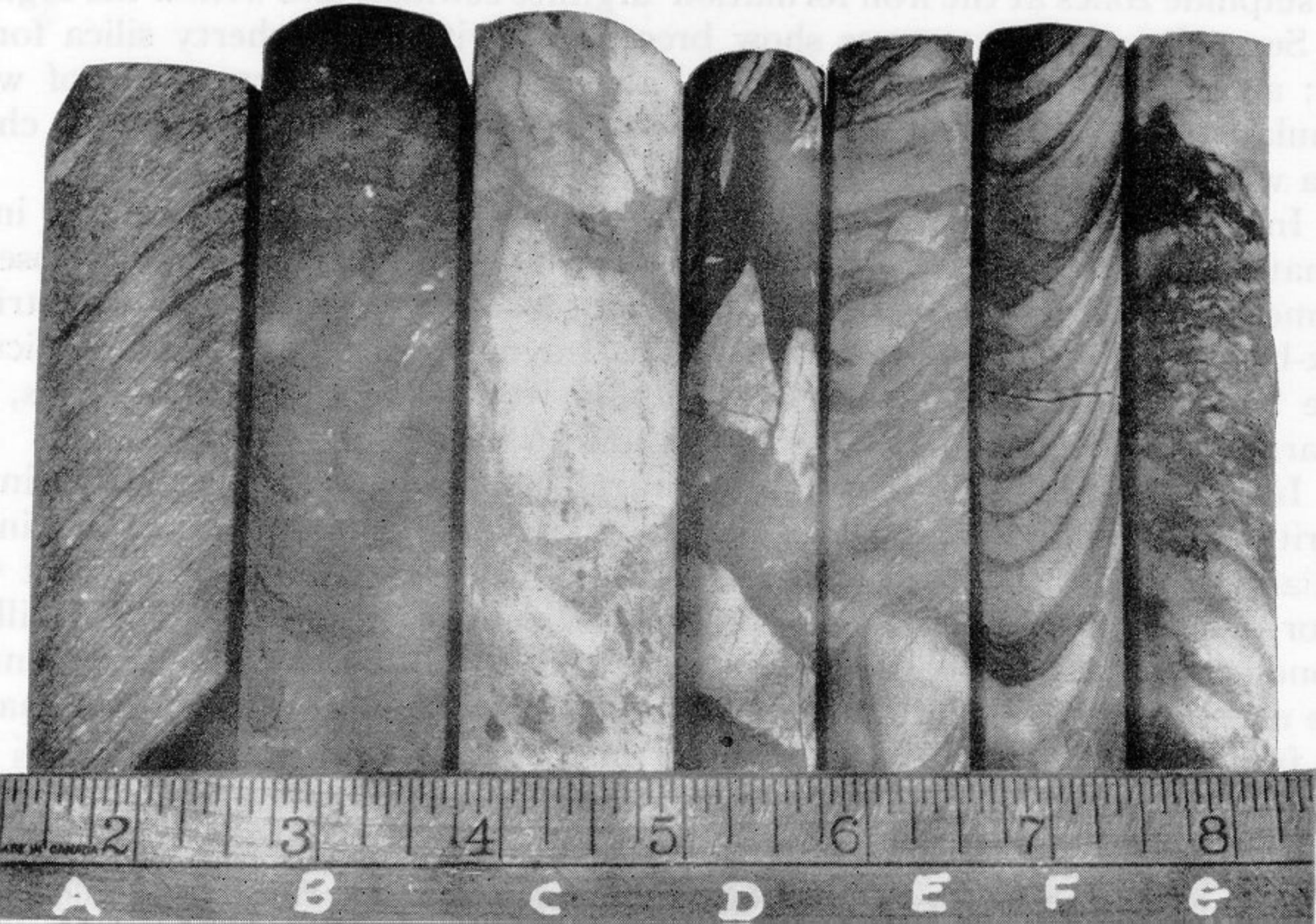
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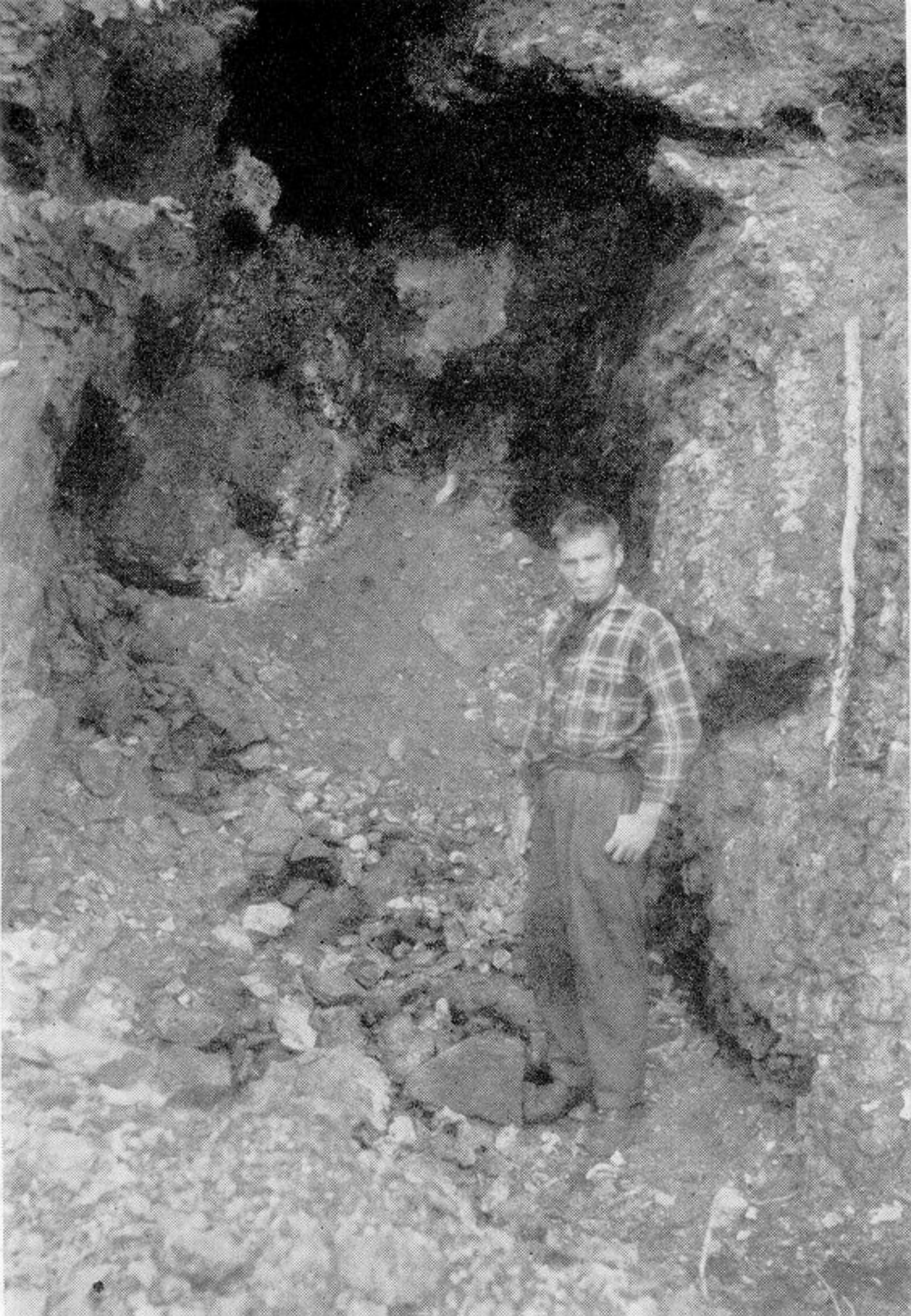
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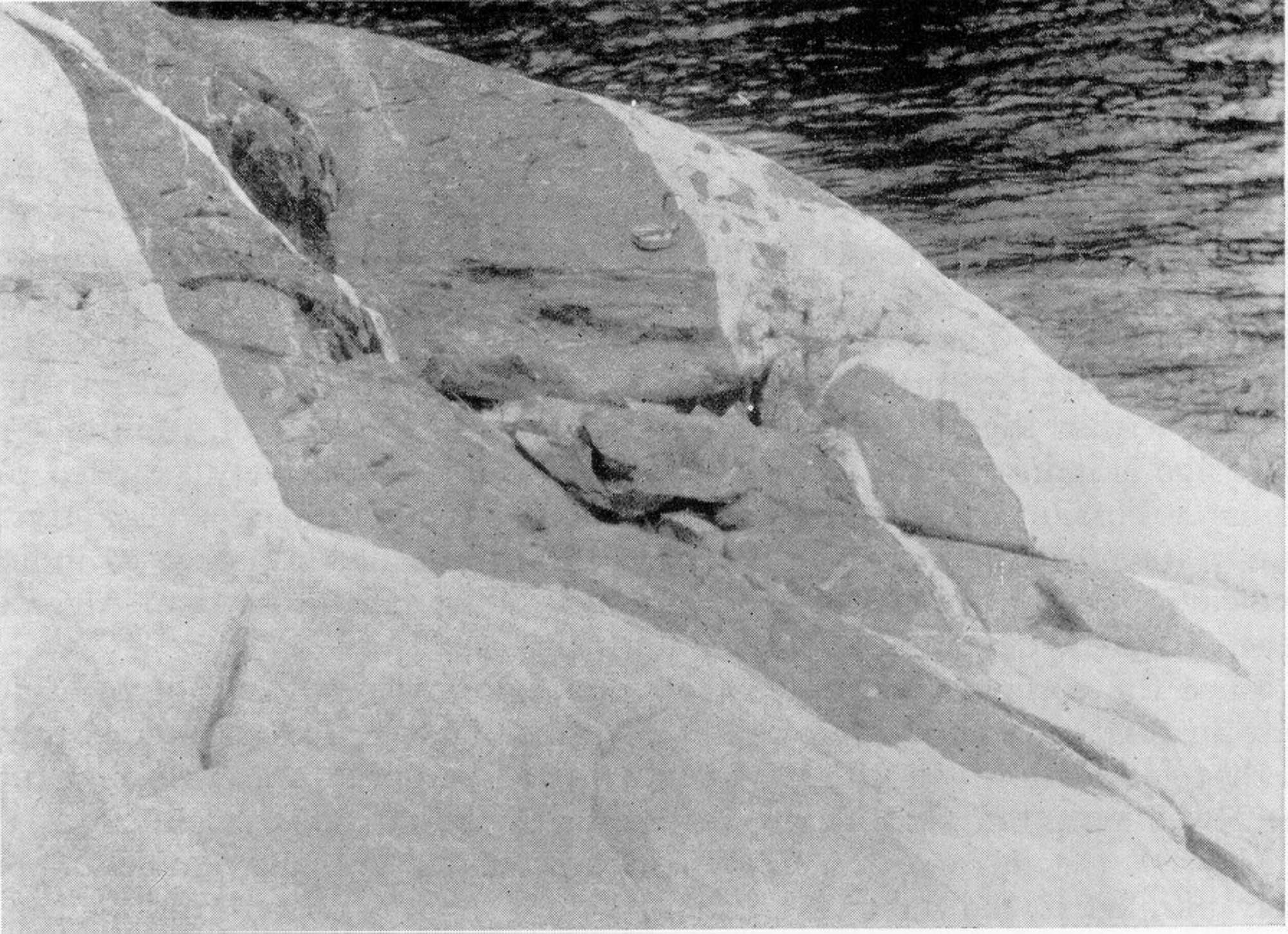


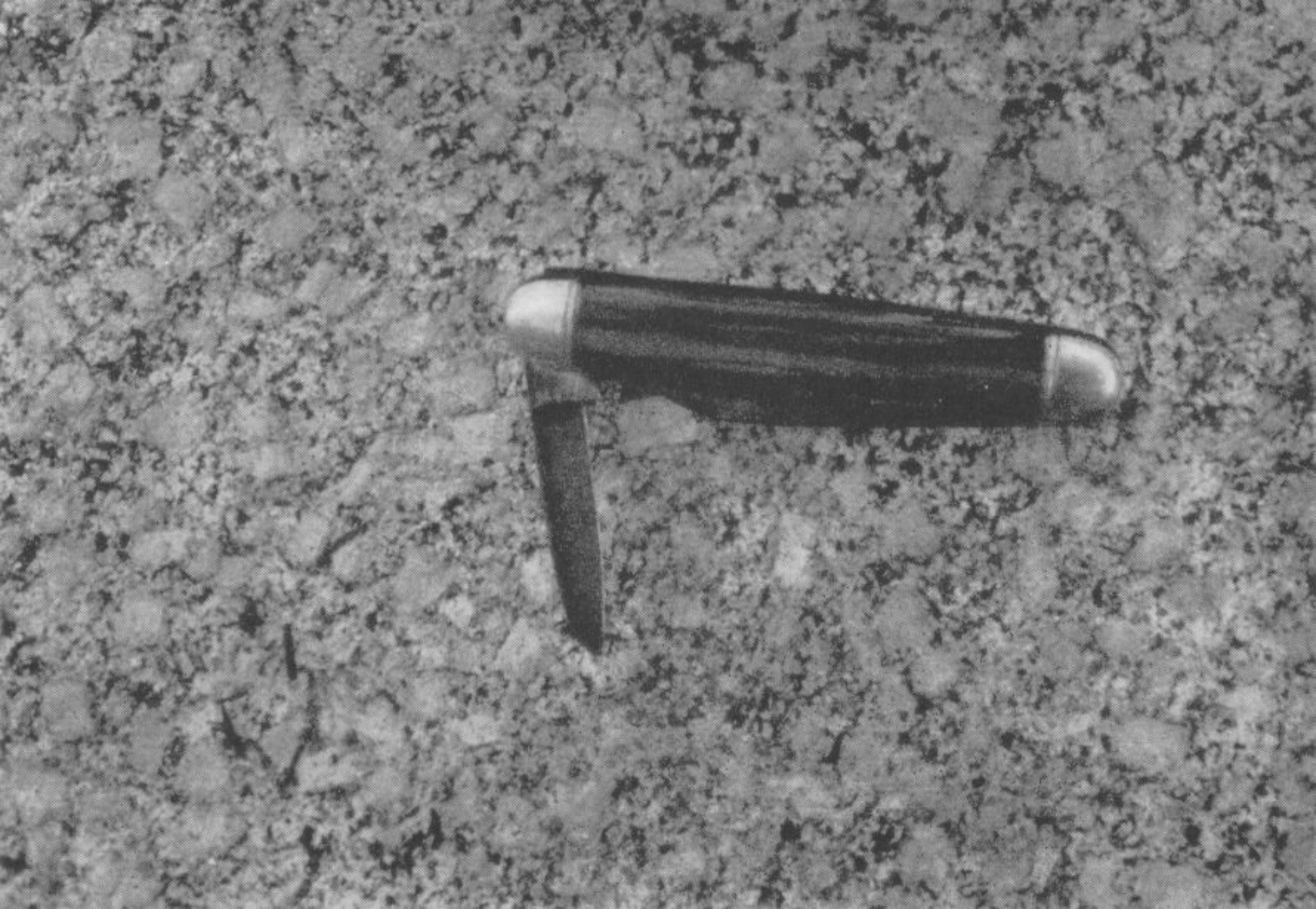



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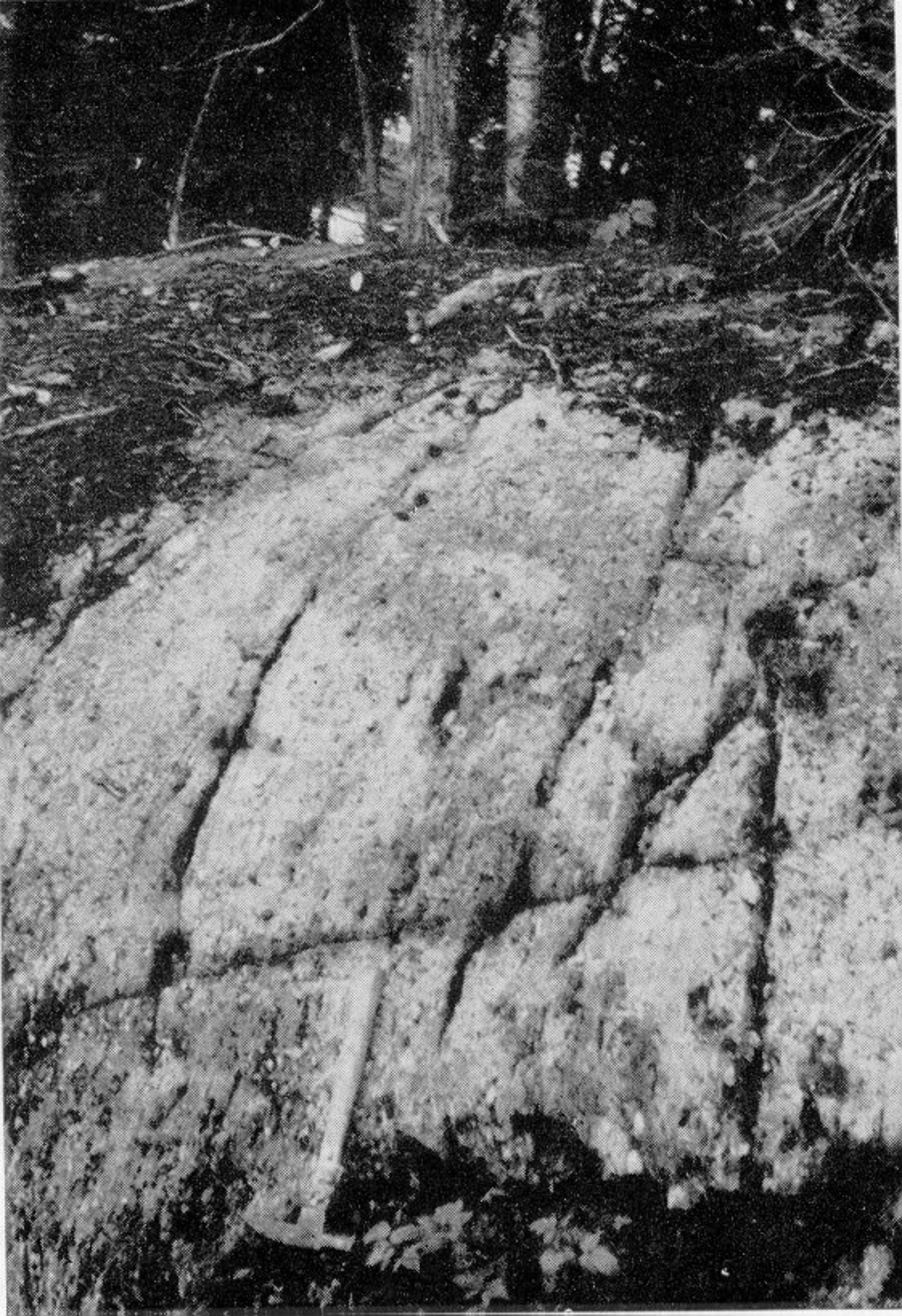

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ONTARIO
DEPARTMENT OF MINES

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M. E. HURST, *Provincial Geologist*

Geology of the Dyment Area

By

J. SATTERLY

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COLOURED GEOLOGICAL MAP

Map No. 1960h—Dyment Area, District of Kenora, Ontario. Scale, 1 inch to ½ mile. . *map case*

Geology of the Dyment Area

BY

J. Satterly[1]

ABSTRACT

This report deals with the general, structural, and economic geology of Melgund, Revell, and Hyndman townships, District of Kenora. Previous reconnaissance geology was carried out in 1906. Precambrian rocks exposed are volcanics cut by diorite-to-granite intrusives, and late diabase dikes. The volcanic rocks exhibit two periods of metamorphism; an earlier period of low-grade metamorphism is shown by mineral assemblages of the greenschist facies, and upon this is superimposed thermal metamorphism by the diorite-granodiorite-granite masses, producing rocks belonging to the hornblende hornfels facies. Many narrow lenticular quartz veins with erratic native gold content have been prospected. Minor copper showings are found in the marginal diorite of the Revell granodiorite mass. The appendix describes molybdenite showings in Echo township in a granodiorite–granite pegmatite–aplite–quartz complex. The molybdenite is found in all four rock types but is most abundant in aplite, as disseminated flakes or in fracture fillings.

INTRODUCTION

The townships of Melgund, Revell, and Hyndman, here called the Dyment area, are in the District of Kenora. There are only two small settlements in the area, Dyment on the Canadian Pacific railway, and Borups Corners on the Trans-Canada highway, 3 miles south of Dyment. Tache station is a siding on the Canadian Pacific railway in Revell township. Melgund township once contained about thirty farms, but by 1958 about half of these had been abandoned.

The area is part of what in the early days of gold mining in northwestern Ontario was known as the New Klondike gold region. This region extended north and south from the stations of Brulé[2] and Tache on the Canadian Pacific railway. Dyment station was built in 1898,[3] and a hotel (since destroyed) erected by D. A. Larson, was opposite what is now the local store and postoffice. (See photo on p. 10.)

No gold production has been recorded in the three townships mapped, but gold has been produced from two properties, the Sakoose and Tabor Lake properties, just south of Melgund township. The Sakoose mine (HW 416), formerly the Munro and Watson mine or the Golden Whale, is about 8 miles south of Dyment station and was at one time connected by a spur line to that station on the Canadian Pacific railway. Between 1899 and 1902 it mined and shipped 7,735 tons of ore to the Keewatin Reduction Works at Keewatin.[4] The property was acquired in 1944 by Van Houten Gold Mines Limited. Gold production

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[1]Geologist, Ontario Department of Mines.

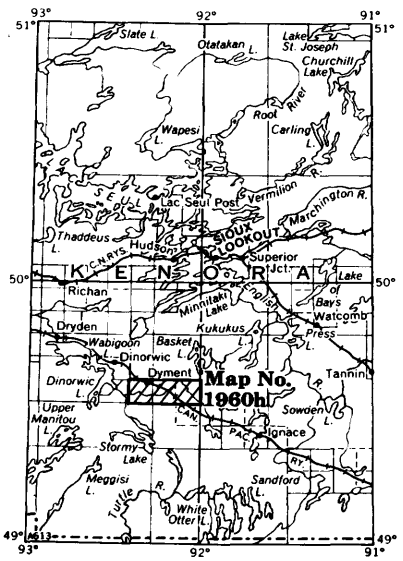
[2]Now abandoned, formerly on the C.P.R. line in Avery township.

[3]James A. Bow, "Mines of Northwestern Ontario," *Report of the Bureau of Mines*, Vol. VIII, pt. 1, 1899, p. 72.

[4]W. E. H. Carter, "The Mines of Ontario," *Report of the Bureau of Mines*, Vol. XI, 1902, p. 255.

amounted to $968 in 1945,[1] and to $8,083 in 1947.[2] In 1958 the property was restaked by G. L. Pidgeon of Wabigoon and optioned to Brewis and White Limited of Toronto. The Tabor mine (SV 258) was held in 1898 by J. Tabor and J. Stephenson of Wabigoon. In 1935, Clark Gold Mines Limited produced gold to the value of $1,248 from this property.[3] In 1942 the property was acquired by Tabor Lake Gold Mines Limited and in 1957 was leased to Pantan Mines Limited. This company carried out a program of diamond-drilling of six holes in early 1958, dewatered the shaft for sampling in July, and in late 1958 erected a new headframe and did development work on the 400-foot level.

Geological mapping of Melgund, Revell, and Hyndman townships was completed in the 1958 field season by the author and three assistants. Melgund



Key map showing the location of the Dyment area. Scale, 50 miles to 1 inch.

township adjoins the Dryden-Wabigoon area.[4] Base maps for the geology were compiled from the map sheets of the Forest Resources Inventory series, Ontario Department of Lands and Forests, and surveys of townships, of the Trans-Canada highway, the Hydro-Electric Power Commission of Ontario, and the Trans-Canada pipeline, adjusted to fit the planimetric detail on the scale of 1 inch to ¼ mile. Rock exposures were transferred from the air photographs to the base map and were adjusted in the course of field work. All buildings are shown even if abandoned or collapsed, since the latter may serve as useful landmarks. Preliminary uncoloured geological maps of the three townships on the same scale were released for distribution in December, 1958.

[1] *Statistical Review of the Mineral Industry of Ontario for 1945*, Ont. Dept. Mines, Vol. LV, 1946, pt. 1, *facing* p. 10.

[2] *Statistical Review of the Mineral Industry of Ontario for 1947*, Ont. Dept. Mines, Vol. LVII, 1948, pt. 1, *facing* p. 10.

[3] *Statistical Review of the Mineral Industry of Ontario for 1935*. Ont. Dept. Mines, Vol. XLV, 1936, pt. 1, p. 11.

[4] J. Satterly, *Geology of the Dryden-Wabigoon Area*, Ont. Dept. Mines, Vol. L, 1941, pt. 2. (Map No. 50e.)

Acknowledgments

The field party is greatly indebted to officials of the Ontario Department of Lands and Forests for friendly and helpful assistance in carrying out the geological survey of the area, especially to John Anderson, Chief Forest Ranger, Dryden; Paul Borup, Deputy Chief Ranger, Dyment; and Fred R. Nicoll, Chief Forest Ranger, Ignace. The author especially appreciates the work of the pilot, H. A. Hoare, Ontario Department of Lands and Forests, Ignace, for flying personnel and supplies to and from Garneau Lake under difficult operating conditions.



Headframe, Sakoose property, south of Melgund township. September 1, 1958.

G. L. Pidgeon of Wabigoon supplied the author with information on the old mining locations and regional geology, which greatly helped in planning the field work.

In 1958, the author was ably assisted in the field by S. B. Lumbers, D. W. Gibson, and C. H. H. McNairn.

Useful information on surveys of highway No. 17 was kindly supplied by K. Seller of the Ontario Department of Highways.

Means of Access

The area is crossed by the main line of the Canadian Pacific Railway, the Trans-Canada Highway (No. 17), and the Trans-Canada pipeline. Dyment is 28 miles east of Dryden, a town halfway between Fort William and Winnipeg. Borups Corners on the Trans-Canada highway in Melgund township is 32 miles east of Dryden and 37 miles west of Ignace. In 1958, the Trans-Canada highway was undergoing straightening and reconstruction in Revell township and towards Ignace.

Melgund township is fairly accessible, being crossed by the Trans-Canada highway, the road from Dyment to the Sakoose mine and branch road to Tabor Lake, a number of concession and lot-line roads, as well as old timber roads, and access roads made to the pipeline during its construction in 1957.

Revell township is crossed by the Trans-Canada highway, Canadian Pacific railway, and Trans-Canada pipeline. A private road of Dryden Paper Company, from the Trans-Canada Highway to, and beyond, the northeast corner of the township, gives access to northeastern Revell and northwestern Hyndman



Headframe, Tabor Lake Gold Mines Limited, south of Melgund township. September 1, 1958. This headframe was replaced by a new headframe in late 1958.

townships. This road crosses the Canadian Pacific railway at Tache station. The southeastern part of Melgund and the southwestern part of Revell townships are the least accessible areas in the two townships, since the Mennin and Wabigoon rivers can only be crossed in a few places at low water levels. The large swamp in northern Revell township extending from lot 2 to lot 12, concession VI, and lot 3 to lot 7, concession V, was not traversed systematically, but all the important rock islets were examined. G. L. Pidgeon reports that in some summers this swamp is impassible.

Much of Hyndman township must be reached by traversing east or west from the Wabigoon River. Garneau Lake, a shallow weedy expansion of the river, may be reached by aircraft or by a canoe route starting from the Trans-Canada highway at Pinafore Lake west of Raleigh. The Wabigoon River above Garneau Lake in this township is very weedy, shallow, and contains many sand bars. The southwest corner of Hyndman township is accessible from the Trans-Canada Highway and Canadian Pacific railway.

Previous Geological Work

In 1897, Parks[1] examined the north boundary of Melgund township in the course of traversing Base and Meridian lines in the region. The first geological map covering the three townships was that of McInnes[2] published in 1906. No geological mapping has been carried out in the area in the interval between 1906 and the present survey.

Descriptions of the gold occurrences immediately to the south of Melgund township, namely the Sakoose (HW 416) and Tabor Lake (SV 258) properties, will be found in a number of reports of the Ontario Department of Mines.[3]



Campsite, Garneau Lake, Hyndman township.

Topography

The topography and drainage of the region is partly controlled by the distribution and variety of the Pleistocene deposits that mantle large areas of the Precambrian rocks.

In Melgund township, and part of adjoining Revell township, these deposits are clays laid down in glacial lake Agassiz. They result in a gently rolling landscape, with few outcrops and slow-flowing meandering streams only rarely inter-

[1]W. A. Parks, "Geology of Base and Meridian Lines in Rainy River District," *Report of the Bureau of Mines*, Ont. Bur. Mines, Vol. VII, 1898, pt. 2, pp. 161-83, and Map No. 7a.

[2]Map No. 663, *Districts of Rainy River and Thunder Bay (Ignace Sheet)*, Scale, 4 miles to 1 inch, Geol. Surv. Can., 1906, (William McInnes).

[3]For Sakoose mine, see: Ont. Bur. Mines; Vol. VII, 1898, pp. 77, 78, 123, 124; Vol. VIII, 1899, pp. 42, 72, 73; Vol. IX, 1900, pp. 63, 64; Vol. X, 1901, pp. 100-102; Vol. XI, 1902, p. 255. Ont. Dept. Mines; Vol. XXXIV, 1925, pt. 6, pp. 38, 39 (and sketch map); Vol. XLII, 1933, pt. 4, pp. 39, 40 (and Fig. 11).

For Tabor mine see: Ont. Bur. Mines, Vol. VIII, 1899, pp. 42, 75, 276. Listed under Clark Gold Mines, Ltd.: Ont. Dept. Mines; Vol. XLV, 1936, pt. 1, pp. 11, 92; Vol. XLVI, 1937, pt. 1, p. 114; Vol. XLVII, 1938, pt. 1, p. 102; Vol. XLVIII, 1939, pt. 1, p. 93.

rupted by rapids or falls where rock reaches the present surface level. However, in the northern and southern parts of Melgund township many rock exposures project through the clay and rise to a maximum height of 100 feet above the general level. The elevation of Dyment station is 1,350 feet.

The northern part of Revell township is covered by a very large spruce-tamarack swamp or muskeg containing a few rock islands. It is bordered on the



Wabigoon River above Garneau Lake near the east boundary of Hyndman township.

southwest and east by sand plains in which there is little rock exposure. South of the swamp and sand area, rock exposures are common, becoming quite abundant in the area underlain by the Revell granodiorite mass. The elevation of Tache station in central Revell township is 1,367 feet.

Hyndman township is split diagonally from northwest to southeast by the Wabigoon River, the area to the southwest being an archipelago of rock islands separated from one another by swamps, whereas that to the northeast is covered by sand, gravel, and boulder deposits of glacial origin, resulting in a knob-and-kettle topography in which rock exposures are few or absent. The maximum relief is 100 feet.

The drainage of the area is almost entirely by the Wabigoon River and its tributaries. The Wabigoon River zig-zags across the three townships and is joined in Revell township by the Revell River, in Melgund township by the Mennin River from the south, and by Melgund Creek, draining Melgund Lake in Avery township, from the north. The northeastern part of Hyndman township is not in the Wabigoon drainage basin but is drained by the Basket River north to the English River.

Natural Resources and Development

The Canadian Pacific Railway operated the first train from Fort William to Winnipeg in 1883.[1] The station at Dyment was built in 1898. Melgund township was surveyed in 1898, and Revell township in 1903-4. Melgund was opened for settlement in 1911, and 21 locations were taken up.[2] By 1958 about half of the farms had been abandoned.



Store, Dyment. View north across C.P.R. main line to fire tower, Melgund township.

Forests[3]

The principal tree species in the area are jackpine, black and white spruce, balsam fir, poplar, and white birch. Most of Melgund township has been cut over, and many parts of it have been burned at different times. There is much slash and thick second-growth. Revell township has also been burned at frequent intervals. The sand areas have stands of jackpine of different ages. The granite area has been burned, and the rock exposures are covered with sparse to thick second-growth jackpine and spruce. Hyndman township is within the timber limits of Dryden Paper Company Limited. In the rock area southwest of the Wabigoon River mixed woods are found containing remnant stands of mature forest, with much deadfall and a thick understory of mountain maple, alder, and cherry. The sand-gravel-boulder area northeast of the Wabigoon River consists of stands of jackpine of different age groups, owing to frequent forest fires. Some large jackpine have been cut in the southern part of Hyndman township.

[1] *Fifth Report of the Bureau of Mines*, Ont. Bur. Mines, Vol. V, 1895, Section III, p. 171.
[2] Report of the Commissioner of Crown Lands, 1911, pp. vi, 40.
[3] See also: *Kenora District*, Rept. No. 15, 1953, Forest Resources Inventory, Div. of Timber Management, Ont. Dept. Lands and Forests.

GENERAL GEOLOGY

The consolidated rocks of the area are Precambrian in age. The oldest group of rocks consists almost entirely of volcanic flows, mainly basalt and lesser amounts of rhyolite, and their derived metamorphic equivalents. These rocks are equivalent in age to the Wabigoon volcanic group of the adjoining Dryden-Wabigoon area, believed to be Keewatin in age.

The volcanic rocks are intruded by the Revell granodiorite mass in Revell and Melgund townships, and by a granitic complex in the northeast half of Hyndman township. These masses range from diorite to granite in composition and are tentatively assigned to the Algoman.

A diabase dike that cuts both the volcanic and granitic rocks is the youngest Precambrian rock. It is a continuation of a dike that was mapped in the Dryden-Wabigoon area and is considered to be Keweenawan in age on the basis of lithology and age relationships.

The Precambrian rocks are, in places, covered by extensive deposits of Pleistocene age and numerous swamps or muskeg of Recent age. The Pleistocene deposits consist of glacial till, glaciofluvial sand, gravel, and boulders, and glacial-lake clays, silts, and sands, the last laid down in glacial lake Agassiz. Some of the sand deposits have been re-worked by wind in late Pleistocene or Recent time. The Recent deposits consist of stream deposits, and peat and vegetal deposits such as the Revell swamp.

The following table of formations summarizes the geological succession:

TABLE OF FORMATIONS

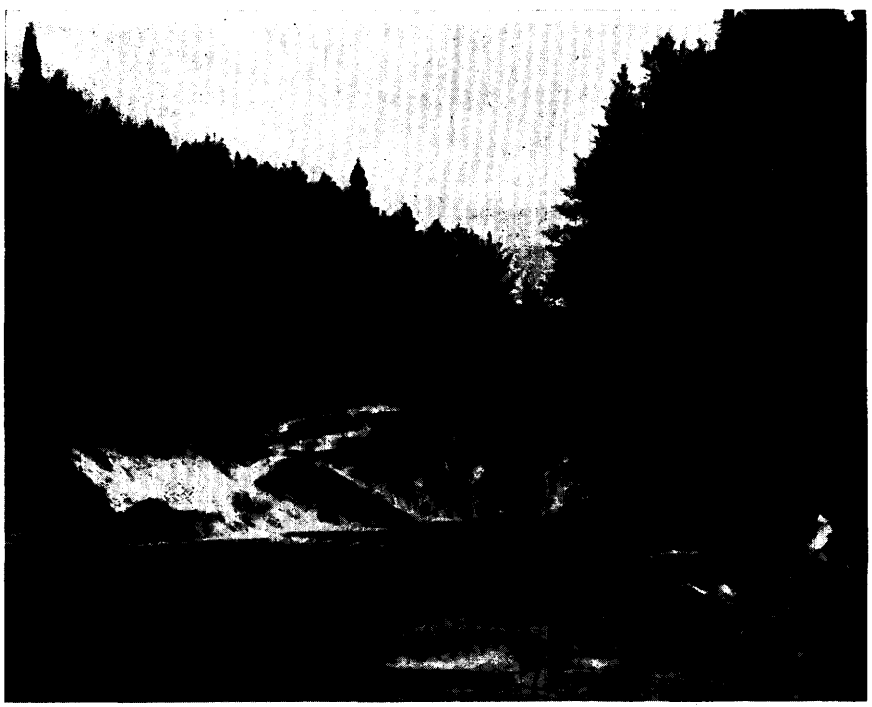
CENOZOIC	
RECENT:	Peat, river deposits, dune deposits.
PLEISTOCENE:	Boulder clay (glacial), silt, sand, gravel, boulders (glaciofluvial); varved clay (glacial lake); sand (dunes).
	Great Unconformity
PRECAMBRIAN	
KEWEENAWAN:	Quartz diabase (dikes).
	Intrusive Contact
ALGOMAN:	Felsite. Quartz-feldspar porphyry, feldspar porphyry. Granite pegmatite. Leucogranite, biotite granite. Biotite granodiorite, biotite-hornblende granodiorite, hornblende-biotite quartz diorite. Hornblende diorite.
	Intrusive Contact
KEEWATIN:	Basic Volcanic Rocks: Basalt, pillowed basalt, gabbroic lava, porphyritic basalt, basalt breccia or tuff, amphibolite, hornblende schist. Acid Volcanic Rocks: Rhyolite, porphyritic rhyolite, rhyolite breccia or tuff.

Keewatin

BASIC VOLCANIC ROCKS

Basalt

The volcanic rocks are believed to be all basaltic in composition, no flows of intermediate composition being recognized. These rocks range from light- to dark-green to almost black in colour, and are also found in various shades of grey to grey-green. The green colours are due to the presence of such mafic minerals as amphibole and chlorite, and the grey colours to zoisite or clinozoisite. The basalts (more properly metabasalts) are fine- to medium-grained rocks and may



Rapids over amphibolite near granodiorite-basalt contact, Wabigoon River. Lot 2, concession II, Melgund township.

be amygdaloidal, occasionally porphyritic, and frequently pillowed. They are often sheared, and in places intensely carbonatized. The development of amphibolites within the contact aureole of the granitic masses is described under the heading Metamorphism. (p. 17.)

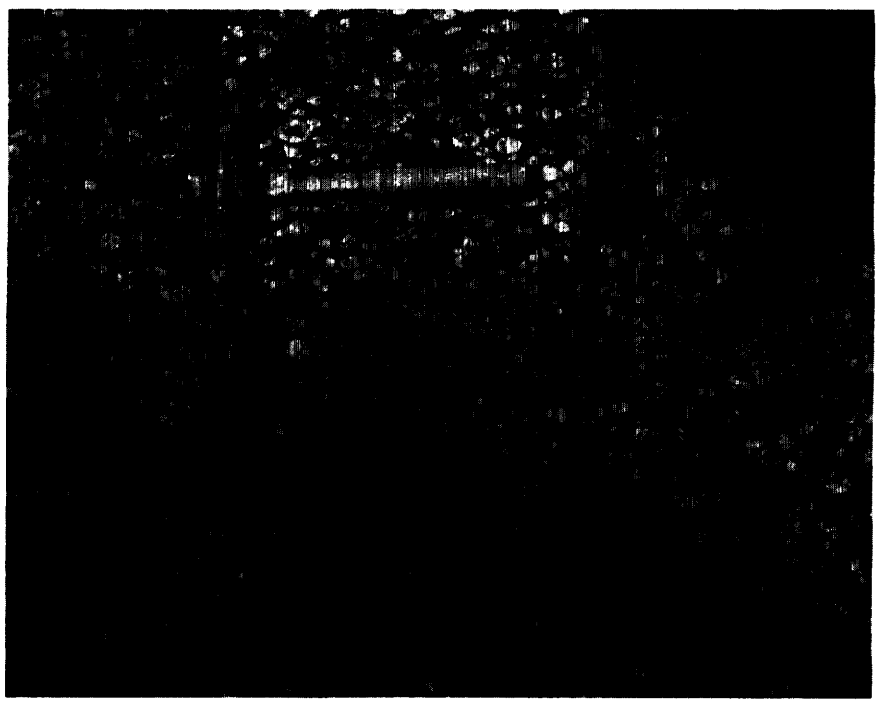
Owing to vegetal and drift cover, good continuous exposures of the basalt flows were not observed, the actual flow contacts being covered. The frequent repetition of pillowed basalt, fine-grained basalt, and medium- to coarse-grained gabbroic lava in rock exposures indicates that the flows are 50–100 feet thick.

The pillows in the flows are not well preserved in these townships, and very few top determinations were made as compared to those in the adjoining Dryden Wabigoon area. Top determinations were only obtained from pillowed basalt in the greenschist facies zone. Even here many of the pillow selvages are dis-

torted by drag-folding, and fishtail structures are not uncommon.[1] Pearl-grey zoisitized pillowed basalt was noted at abandoned farm buildings on the line between lots 10 and 11, concession VI, Melgund township.

In the amygdaloidal basalts, the amygdaloids consist of calcite, calcite and quartz, or chlorite. The calcite has usually weathered out, leaving a pock-marked surface in exposures. In the carbonatized lavas, the carbonate is an iron-bearing variety, as indicated in surface exposures by a rusty zone from $\frac{1}{8}$ to as much as $\frac{1}{2}$ inch thick.

The massive, fine- to medium- to occasionally coarse-grained parts of the basalt flows are diabasic gabbro or gabbro. Following modern usage, these rocks should be called metagabbro. They have been altered and consist now of an



Porphyritic basalt on an "island" in Revell swamp just northeast of Adair Lake.

aggregate of plagioclase, replaced in part by clinozoisite; a fibrous aggregate of actinolite and chlorite representing the original pyroxene; and much clinozoisite in granular aggregates interstitial to the plagioclase and actinolite. Other minerals are abundant accessory leucoxene, often titanomagnetite, and quartz present in very minor amount. Relict ophitic texture was observed in one of four thin sections examined.[2]

Porphyritic Basalt

Isolated occurrences of porphyritic basalt were found in most of the lots in concession VI, Melgund township; in lot 1, concession V, and lot 5, concession VI, Revell township; and east of Adair Lake, north of Revell township (see photo).

[1] *Cf.* J. Satterly, *Geology of the Dryden-Wabigoon Area*, Ont. Dept. Mines, Vol. L, 1941, pt. 2, p. 11.

[2] *Cf.* H. W. Pfeffer, "Origin and Metamorphism of Keewatin-Type Metadiabases ('Diorites') of the O'Sullivan Lake Area, Ontario," *Proceedings*, Geol. Assoc. Can., Vol. 7, 1955, Pt. 1, pp. 83–101.

Some of these occurrences are not very accessible. A typical exposure, but not the best, may be seen on an abandoned farm in lot 5, concession VI, Melgund township. About 200 feet west of the farm buildings a low rock ridge exposes a porphyritic basalt with scattered feldspar phenocrysts ¼–1 inch across. They are very pale-pink in colour and have been completely altered to a fine-grained, porcelainic aggregate of clinozoisite.[1]

Two other excellent exposures may be noted. At Burnet Lake, in lot 12, concession VI, Melgund township, the rock contains pinkish-white-weathering, green feldspar phenocrysts from less than ¼-inch to 1½-inch across in a pale-green-weathering, dark-green, fine-grained groundmass. The feldspar crystals are

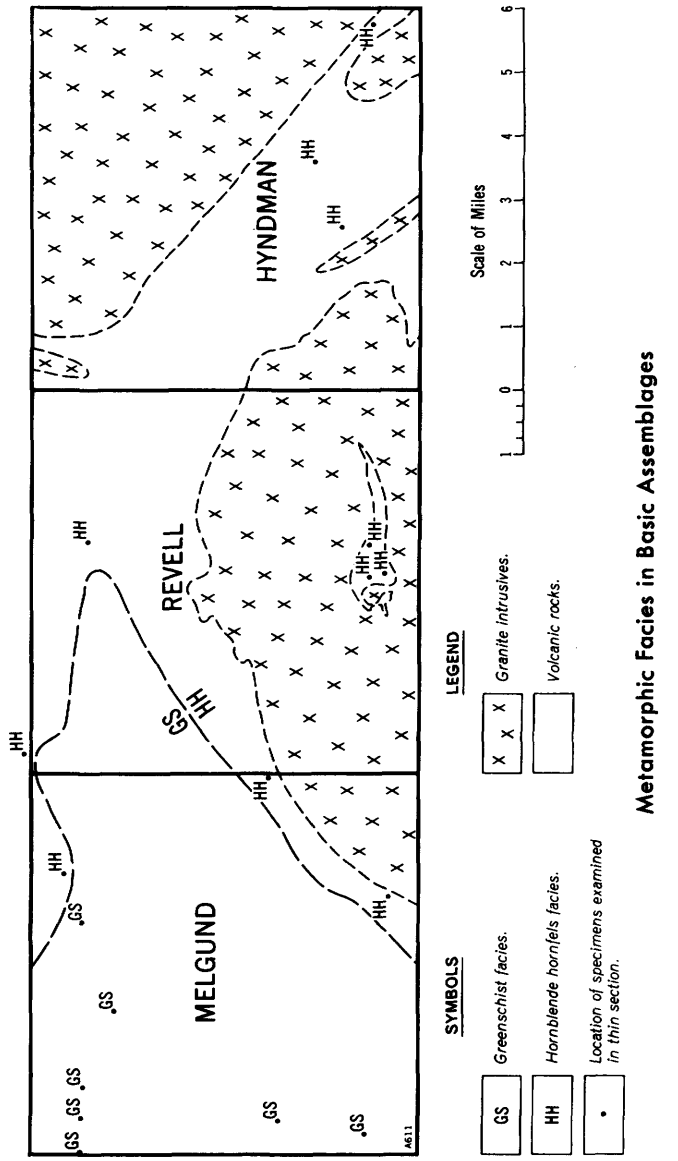


Rapids on Mennin River over amphibolite (pillowed basalt) near granodiorite contact. Lot 4, concession 1, Melgund township.

crowded together to form about 50 percent of the whole. The other exposure is on the southeast corner of a rock islet, 850 feet east of Adair Lake, and 330 feet north of the north boundary of Revell township. The porphyritic basalt (see photo) forms a 10-foot band in sharp contact on the southwest with 3 feet of sheared fine-grained amphibolite (metabasalt), followed by 3 feet of medium-grained amphibolite (metagabbro), and grades northeast into fine-grained amphibolite (metabasalt).

The distribution of occurrences indicates that the porphyritic basalt occurs at a number of horizons in the volcanic rocks, but, owing to vegetal or drift cover, it was not possible to trace the zones for any distance. In none of the occurrences examined was any evidence of intrusive relationship found. All the field evidence indicates that the porphyritic basalts are parts of the basalt flows.

[1]Identified by D. A. Moddle, Provincial Assay Office, Ont. Dept. Mines, 1958.



Metamorphic Facies in Basic Assemblages

Basalt Breccia and Tuff

Occurrences of basalt breccia and tuff were found at only a few places in the area as compared to an abundance of agglomerates in the Dryden-Wabigoon area. Small exposures of breccia were noted in lot 12, concession II, and lot 11, concession IV, Melgund township. No flow breccias were found in the basalt flows. Narrow interbeds of thinly-banded rocks, possibly tuffs, were found in lot 10, concession III, and lot 2, concession IV, Revell township.

Metamorphism

Field evidence and microscopic study of the basic volcanic rocks in 18 thin sections indicates two periods of metamorphism: an earlier period of low-grade regional metamorphism, as shown by mineral assemblages of the greenschist facies; upon which is superimposed thermal metamorphism by the granite-granodiorite-diorite masses, producing rocks belonging to the hornblende hornfels facies.[1] (See sketch map.) The boundary between the greenschist and hornblende hornfels facies zones is also marked in the field by the disappearance of intense carbonatization in rocks of the greenschist facies.

Rocks examined from the greenschist facies zone were originally basalt, pillowed flows, gabbro (coarse flows), and porphyritic basalt. The mineral assemblages in these rocks are characterized by the alteration of the original mafic minerals to a fibrous amphibole–actinolite and a pale-green chlorite; of the plagioclase to abundant aggregates of clinozoisite grains and flakes of white mica; of the accessory opaques (titanomagnetite(?)) to leucoxene; and by the frequent presence of abundant iron-bearing carbonate. The feldspar phenocrysts in the porphyritic basalt are entirely replaced by an aggregate of white-to-pink clinozoisite, which has the appearance of unglazed porcelain in the hand specimen.

Rocks of the hornblende hornfels facies appear in the basic volcanic rocks and associated coarse flows at about 1 mile from the contact of the granitic masses. The volcanics belt in Hyndman township is barely over 2 miles wide, so no members of the greenschist facies can be expected. The rocks of the hornblende hornfels facies are plagioclase amphibolite or plagioclase-hornblende schist. The mineral assemblage is dominantly plagioclase, amphibole, and minor quartz. The amphibole is a hornblende with yellow-green to blue-green pleochroism. The plagioclase is altered to clinozoisite and white mica aggregates. Quartz is present, although as a minor constituent, presumably because free silica was produced as a result of recrystallization of the amphibole. The accessory minerals are now magnetite and titanite. The difference in grain size between pillow lavas and coarse flows is still apparent in the derived amphibolites; the pillow lavas are represented by aphanitic to fine-grained amphibolite. All stages may be seen, from a rock with easily recognizable pillows, to one in which the pillow selvages are so attenuated that the resulting banded rock might be mistaken for a rock of sedimentary origin. The coarse flows are recrystallized to medium- to almost coarse-grained amphibolites. Alternating exposures of these two grain sizes of amphibolites were mapped throughout the belt of volcanic rocks in Hyndman and northeastern Revell townships.

[1]See F. J. Turner, "Mineral Assemblages of Individual Metamorphic Facies," Chapter VII, *Metamorphic Reactions and Metamorphic Facies*, Geol. Soc. Amer., Memoir 73, 1958, pp. 199–239.

The metamorphic history of the basic volcanic rocks in this area may be summarized as follows:

TABLE I—METAMORPHIC HISTORY OF THE BASIC VOLCANIC ROCKS

	Event	Rock Type	Mineral Assemblage
1.	Volcanic activity.	Basalt.	
2.	Low-grade regional metamorphism. Greenschist facies.	Metabasalt.	Plagioclase, actinolite, chlorite.
3.	Thermal (contact) metamorphism. Hornblende hornfels facies.	Plagioclase amphibolite.	Plagioclase, hornblende, quartz.
4.	Retrogressive metamorphism.	"Plagioclase" amphibolite.	Plagioclase to clinozoisite and white mica.

ACID VOLCANIC ROCKS

Rhyolite, Porphyritic Rhyolite, Rhyolite Breccia and Tuff

Rhyolite, rhyolite breccias and tuffs, and their metamorphic equivalents are found as narrow interflows or beds in the basalt flows at a number of widely scattered localities in the three townships. No typical volcanic textures such as amygdaloidal or vesicular were found, and only careful examination of some of the exposures revealed the presence of lenticular fragments as closely packed fragments on etched weathered surfaces, since the fragments could not be distinguished from the groundmass on fresh surfaces. Both fine-grained and porphyritic rhyolite were mapped. By shearing, metamorphism, and metasomatism many of these rocks have become schistose and are now carbonate-sericite-quartz schists. Varieties with well-developed banding may have been acid tuffs or siliceous sediments.

It is not certain that all the carbonatized porphyritic types belong here, some may be of intrusive origin and of a later age, possibly Algoman.

The most extensive exposures are in Melgund township, outside the metamorphic aureole of the Revell granodiorite mass. In lots 10–12, concession IV, adjacent to highway No. 17, a fractured, fine-grained, waxy-yellow rock is exposed that interfingers with basalt flows in lot 10, north of the highway, and is marginally interbedded with them in lot 11. In these exposures no volcanic or fragmental structures were found. In thin section the rock largely consists of round grains of feldspar and quartz, wrapped in films of sericite flakes. It is either a metarhyolite or rhyolite crystal tuff.

In lot 10, concession I, Melgund township, adjacent to the Tabor road, a light-weathering, porphyritic rhyolite breccia contains lenticular fragments, mostly ¼–2 inches long. The largest fragment found was 3 by 9 inches in size. These fragments are indistinguishable from the matrix on fresh surfaces. This band is interbedded with fine-grained amygdaloidal basalt and medium-grained massive basalt. Similar fragmental rocks were recognized in the exposure cut by a Keweenawan diabase dike in lot 9, concession II, Melgund township. The rock here ranges from massive to sheared to schistose. In places, fragments, ⅛ inch or less, and occasionally up to 1 inch, can be recognized. The rock was originally a porphyritic rhyolite or rhyolite breccia.

Narrow, discontinuous bands of acid rocks were mapped in the basalt flows (now amphibolite) adjacent to the Revell granodiorite mass in northeastern Revell and Hyndman townships. These rocks are schistose to gneissic. They are sericite-biotite-quartz-feldspar schists, sometimes carbonatized as well. Some show relict quartz eyes and are thought to have been porphyritic rhyolite originally, others may be siliceous sediments. One occurrence in Hyndman township contains a red garnet. The rock is a garnet-muscovite-biotite-quartz-plagioclase gneiss. This rock may be a metasediment. However, it may be noted that garnets were found in what were thought to be metarhyolites in the Dryden-Wabigoon area.[1]



Exposure of granodiorite on highway No. 17 in lots 3 and 4, concession I, Revell township.

Algoman

The Algoman granitic rocks range from diorite to granite in composition. The granitic and volcanic rocks are cut by dikes of granite pegmatite, porphyry, and lamprophyre. Felsite may be the youngest member of the group but has only been found as dikes cutting the basic volcanic rocks.

The granitoid rocks are diorite, quartz diorite, granodiorite, or granite. They form several masses or complexes within the three townships mapped. These masses may be conveniently named as follows:

1. *Revell Batholith.*—In Melgund, Revell, and Hyndman townships and extending into the area south of these townships. It consists largely of granodiorite with lenticular border zones of diorite and quartz diorite.

[1] J. Satterly, *op. cit.*, p. 12.

2. *Hyndman Quartz Diorite Complex.*—Part of a much larger granitic complex, underlying the northeast half of Hyndman township. This complex consists of grey quartz diorite, granodiorite, and pink granite, with minor occurrences of granite pegmatite.

3. *Oval Lake–Countess Lake Diorite-Granodiorite Complex.*—In southeastern Hyndman township.

4. *South Hyndman Granodiorite.*—Tongue extending northwest from the south boundary of Hyndman township between the Canadian Pacific railway track and Garneau Lake.

DIORITE

The diorites are medium-grained, dark-green rocks composed predominantly of plagioclase and hornblende (see modal analyses in Table II). The plagioclase ranges from basic andesine (An_{40}) to acid labradorite (An_{54}). Much of it is fresh or only partly altered, but in some specimens it is almost completely altered to an aggregate of clinozoisite and a white mica. The hornblende is usually completely recrystallized, being strongly pleochroic from yellow-green to blue-green. In two specimens (Nos. 60 and 89) relict schiller or salite structures were observed in thin sections and may indicate that the original mafic mineral was a pyroxene, and therefore that the rocks were originally gabbros. Quartz, sometimes opalescent, is present, usually in minor amounts. Biotite occurs in amounts about equal to that of quartz. The common accessory minerals are apatite, epidote, magnetite, and more rarely, pyrite or pyrrhotite.

TABLE II—MODAL ANALYSES OF DIORITES

(n.d. = not determined)

Specimen No.	Locality	Quartz	Plagioclase	Hornblende	Biotite	Accessories
		percent	percent	percent	percent	percent
36	Revell tp., con. IV, lot 6 (HW 525)	3.9	46.7 (An_{40})	44.5	1.3	3.6
28	Revell tp., con. IV, lot 6 (C.P.R.)	0.7	43.1 (An_{44})	48.7	3.2	n.d.
89	Revell tp., con. IV, lot 3	7.8	55.0 (An_{54})	32.1	4.0	1.1
87	Revell tp., con. III, lot 1	5.7	47.9 (An_{46})	40.3	5.1	1.0
135	Hyndman tp., south of C.P.R.	.....	58.2 (An_{54})	38.7	2.9	0.2
44	Hyndman tp., south of C.P.R.	0.5	19.4 (An_{46})	79.4	0.4	0.3
148	Hyndman tp., north of C.P.R.	2.1	36.7 (An_{49})	58.4	0.6	2.2
147	Hyndman tp., northwest of Countess Lake	0.2	56.3 (An_{42})	38.5	1.0	4.0
60	Hyndman tp., north of Oval Lake	.....	57.8 (An_{48})	40.1	0.4	1.7

The distribution of the diorites indicates that they are marginal to the Revell granodiorite mass and form the base (?) of the Oval Lake–Countess Lake diorite-granodiorite complex.

In Revell township diorites (specimens Nos. 36, 28, 89, and 87 in Table II) form a band about 500 feet to nearly 1,500 feet wide along the north contact of the Revell granodiorite mass from lot 2 to lot 8, concession IV. A little disseminated pyrrhotite and chalcopyrite were found on a small outcrop south of the C.P.R. track in lot 7, concession IV (HW 505).

In southwestern Hyndman township diorites (Nos. 135, 44 and 148 in Table II) form a lenticular zone up to 2,000 feet wide as a border to the Revell granodiorite mass. Between the diorite and granodiorite is a zone of quartz diorite from 700–3,000 feet wide. A showing of disseminated pyrite, pyrrhotite, and chalcopyrite in a hornblende-rich diorite (No. 44 in Table II) has been prospected on claim P.75.

The Oval Lake–Countess Lake diorite-granodiorite mass is poorly exposed. The northern (basal (?)) part is a diorite (Nos. 147 and 60 in Table II). A single exposure of pyroxenite containing magnetite was mapped just north of Oval Lake. The contact between diorite and granodiorite on the map is approximate.

The transitional contacts between the diorites and basic volcanic rocks observed in some places, and the variable content of hornblende and plagioclase found in the specimens examined suggest to the author that the diorites are hybrid rocks derived by the assimilation of the basic volcanic rocks by an acid magma.

QUARTZ DIORITE

Quartz diorite, an important member of the Hyndman granitic complex, forms a lenticular body on the east side of the Revell batholith, and isolated occurrences along the north border of the Revell batholith.

The quartz diorites were studied in ten thin sections (see Table III). They are composed essentially of andesine, quartz, hornblende, and biotite. Accessory minerals in order of abundance are epidote, apatite, sphene, magnetite, and occasionally pyrite. The plagioclase in two of the ten thin sections is as basic as labradorite. The feldspar is usually fresh, but a number of grains are clouded with fibrous aggregates of white mica (sometimes plumose) and coarse aggregates of clinozoisite crystals.

TABLE III—MODAL ANALYSES OF QUARTZ DIORITES

Specimen No.	Locality	Quartz	Plagioclase	Hornblende	Biotite	Accessories
		percent	percent	percent	percent	percent
76	Revell tp., con. III, lot 9	14.4	53.0	17.4	13.6	1.6
29	Revell tp., con. IV, lot 6 (C.P.R.)	19.7	48.4	15.1	16.5	0.3
91	Revell tp., con. IV, lot 4	23.2	43.5	16.0	14.0	3.2
68	Hyndman tp. (Pidgeon claim)	27.3	48.5	4.2	14.4	5.6
49	Hyndman tp. (Pidgeon claim)	20.2	54.3	10.3	14.5	0.7
159	Hyndman tp., south of C.P.R.	21.0	55.6	11.4	11.4	0.6
53	Hyndman tp., Basket River	16.8	56.3	14.3	10.1	2.5
51	Hyndman tp., Hyndman Lake	26.2	55.2	1.3	9.8	7.5
65	Hyndman tp., north-east of Garneau Lake	30.0	49.0	3.8	12.2	5.2
57	Hyndman tp., Oval Lake	25.5	51.1	7.4	14.2	1.8

In the Hyndman complex the quartz diorite (Table III, specimens Nos. 53, 51, 65, 57) is usually a grey to blue-grey, massive to foliated, fine- to coarse-grained rock. Biotite is more abundant than hornblende, except in No. 53. In the Revell batholith border zones the quartz diorite (Table III, specimens Nos. 68, 49, 159, 76, 29, 91) is a massive, grey to greenish-grey, fine- to medium-grained rock with biotite and hornblende present in about equal amounts, except in No. 68.

TABLE IV—MODAL ANALYSES OF GRANODIORITES

(n.d. = not determined)

Specimen No.	Locality	Quartz	Plagioclase	Microcline	Hornblende	Biotite	Accessories
		percent	percent	percent	percent	percent	percent
122	Revell tp., con. II, lot 8 (hwy. No. 17)	27.7	49.7	12.0	.....	8.2	2.4
6	Revell tp., con. III, lot 12	32.8	51.9	8.7	.....	5.6	1.0
58	Hyndman tp., Oval Lake	27.5	39.1	12.2	11.1	10.1	n.d.
54	Hyndman tp., Basket River	22.9	53.6	12.9	.....	9.1	1.5

GRANODIORITE

The Revell granodiorite forms a roughly circular batholith about 12 miles across. According to McInnes' map[1] it extends about 8 miles south of the south boundary of Revell township and forms the north end of a long body of granite gneiss that extends many miles to the southeast.

In the Dyment area the granodiorite mass is remarkably uniform in composition. The rock is quite massive, and foliation was only observed near the margins of the batholith. The granodiorite is a pink-and-white to grey, medium- to almost coarse-grained rock composed essentially of oligoclase, microcline, quartz, and biotite (see Table IV, specimens Nos. 6, 122). Muscovite may be present, associated with biotite. Parts of the oligoclase are replaced by clusters of white mica and clinozoisite. The biotite forms large flakes or clusters of flakes usually accompanied by the accessory minerals epidote, apatite, sphene, and rarely zircon. A few flakes of molybdenite were seen in the granodiorite on the Dryden Paper Company's road in lot 6, concession III, Revell township.

Granodiorite was also found at the Basket River in northeastern Hyndman township (Table IV, specimen No. 54). At an old beaver dam, a fine-grained, "pepper-and-salt," grey biotite granodiorite contains inclusions of biotite-hornblende-quartz diorite, and is cut by pink leucogranite and dikes of pink granite pegmatite.

A biotite-hornblende granodiorite of medium-grain was found near Oval Lake in southeastern Hyndman township (see Table IV, specimen No. 58).

GRANITE

Fine- to medium-grained pink leucogranite or biotite granite are not uncommon throughout the Hyndman granitic complex. In the Basket River area, in northeastern Hyndman township, intrusive contacts indicate that the order of sequence in the granitic rocks is (1) quartz diorite, (2) granodiorite, (3) pink granite, and (4) pink leucogranite pegmatite (dikes).

Since no detailed study of the pink granite has been made, the more general terms pink leucogranite and pink biotite granite have been used in the legend, although thin-section study of two specimens from the Basket River area shows they are quartz leucomonzonite.

One other occurrence should be noted. There is a small tongue of slightly foliated pink leucogranite in the northwestern corner of Hyndman township.

GRANITE PEGMATITE

Stringers and dikes of granite pegmatite were only found in the Basket River area of the Hyndman granitic complex in northeastern Hyndman township. These dikes are mainly leucogranite pegmatite. A few 1-inch booklets of muscovite were seen in an 18-inch dikelet at an old beaver dam on the Basket River. No sulphides were noted in these dikes.

QUARTZ-FELDSPAR PORPHYRY, FELDSPAR PORPHYRY

Quartz-feldspar porphyry dikes are fairly abundant in the basalt lavas, parallel to the contact of the Revell granodiorite mass in southeastern Melgund township, and less so in western Revell township. A few other occurrences were found. The dikes range in width from a few feet to a maximum of 200 feet. Intersecting fractures result in badly frost-broken exposures, in which it is difficult to determine the strike of the dikes.

[1]Map No. 663, *Districts of Rainy River and Thunder Bay (Ignace Sheet)*, Scale, 4 miles to 1 inch, Geol. Surv. Can., 1906, (William McInnes).

The rocks are typically white-weathering, grey porphyries with prominent white feldspar crystals and glassy quartz eyes in a fine-grained groundmass. Thin-section study shows that the feldspar is albite. The only mafic mineral is biotite, present in flaky aggregates, partly chloritized. Accessory minerals are titanomagnetite, apatite, and epidote.

Carbonatized varieties are difficult to distinguish from carbonatized porphyritic rhyolite unless they show cross-cutting relationships to the volcanic rocks. Such a dike is exposed in lot 10, concession VI, Melgund township; it is a feldspar porphyry, with pale-green albite phenocrysts to $\frac{1}{8}$ inch across, in a buff-coloured carbonatized groundmass.

FELSITE

Very fine-grained, buff-coloured dikes were mapped on the Canadian Pacific railway track west of Tache, in lot 6, concession IV, Revell township. These dikes cut the volcanic rocks. They are placed in the Algoman group on the basis of lithological similarity to felsite dikes in the adjoining Dryden-Wabigoon area.

A carbonatized felsite dike, striking N.32°W., was found cutting the volcanic rocks in lot 9, concession VI, Melgund township.

BASIC DIKES

At a few places in the area, fine- to medium-grained, green, grey, or black basic dikes cut the volcanics or granodiorite. These dikes are usually narrow, being less than 10 feet wide. Thin-section examination of three specimens shows that the rocks have been recrystallized. They may not all be of the same age; some may be Pre-Algoman and represent feeders of flows. Two studied are biotite-hornblende lamprophyre (spessartite); one of these cuts granodiorite, and the other, a pillowed basalt. A basic dike cutting amphibolite (metagabbroic lava), on the Canadian Pacific railway track west of Tache, is now a plagioclase amphibolite (metabasalt).

Keweenawan

A diabase dike, 100 feet wide, striking N.60°–80°W., has been traced at intervals across Melgund township into the southwest corner of Revell township. This dike is probably a continuation of a dike that was traced across the Dryden-Wabigoon area.[1] In Melgund township it cuts basalt, rhyolite breccia, quartz-feldspar porphyry, and granodiorite. It is the youngest Precambrian rock in the area; because of its strike, lithology, and age relationships it is believed to be Keweenawan in age.

In the field, it is a typical rusty-weathering diabase with a basaltic chill phase at the borders, grading internally to diabase to almost coarse-grained gabbro in the centre of the dike. In places, the dike is a multiple intrusion.

The dike rock was examined in two thin sections, one from central Melgund, and the other from southwestern Revell township. They are almost identical. The rock is a typical quartz diabase with ophitic texture. The minerals present are labradorite, augite, biotite, and quartz in micrographic intergrowth. The plagioclase is clouded with clinozoisite aggregates and replaced by biotite along minute fractures. Much of the augite is fresh, but some is replaced by a fresh hornblende. Biotite forms aggregates between the other minerals and is partly altered to chlorite. Accessory minerals are apatite in minute prisms, and abundant skeletal, octahedral-to-cubic crystals of ilmenite-magnetite with or without sphene.

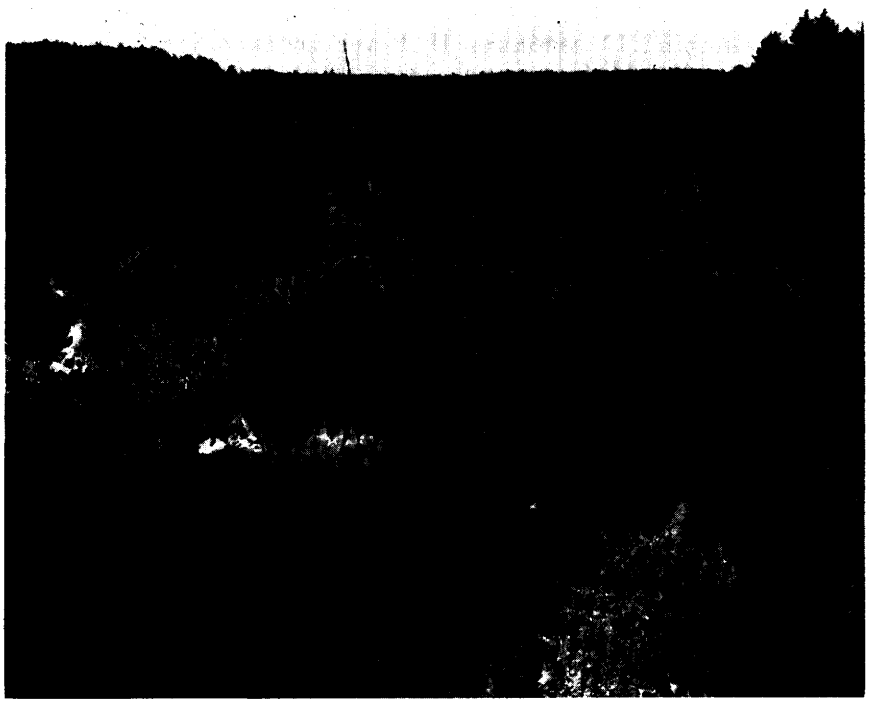
One other small diabase dike was mapped in lots 4 and 5, concession I, Revell township, where it cuts granodiorite.

[1] Map No. 50e, Ont. Dept. Mines.

Pleistocene

The Pleistocene deposits are boulder clay, glaciofluvial sand, gravel, and boulders, and glacial lake clays and sands.

Glacial striae observations in the three townships indicate that the direction of glacial movement was S.46°W., the extremes being S.20°W. and S.68°W. This is based on the average of thirty-four observations; twenty-four in Melgund, four in Revell, and six in Hyndman township. The greater tree and vegetal cover in Revell and Hyndman townships, and the larger percentage of exposure of granitic rocks, accounts for the fewer readings in these townships. In the Dryden-Wabigoon area the average direction of glacial movement is S.37°W., based on 107 observations.



Revel River and valley in sand outwash plain. View west from highway No. 17. Lot 8, concession II, Revell township.

MORAINE

A terminal moraine of sand, gravel, and boulders covers the northeast half of Hyndman township. The southwest boundary corresponds approximately with the Wabigoon River. Maximum relief is not more than 100 feet. It exhibits typical knob-and-kettle topography. Random scattered granite boulders from 1–10 feet are common and occasionally reach diameters of 25–30 feet. This belt of glacial and glaciofluvial deposits is probably an extension of the Hartman moraine and continues southeast towards Ignace.

OUTWASH PLAIN

Parallel to, and southwest of, the above moraine, an outwash plain of sand, with minor amounts of sand, gravel, and boulders, is well exposed in much of Revell township and in northeastern Melgund township. This sand plain slopes very gently to the southwest. On parts of it dunes have been developed, some of

which have rock cores and are now stabilized by forest and vegetal growth. A few road-cuts or open pits, made during the reconstruction of highway No. 17 in 1958, reveal that the sand deposits have flat-to-inclined bedding and often show steeply dipping beds and cross-bedding. These sands were found overlying clay in two places: (1) at the Wabigoon River in lot 10, concession II, Revell township; and (2) at Melgund Creek in lot 6, concession V, Melgund township. These occurrences are believed to have been formed by the reworking of the outwash plain deposits by the waters of glacial lake Agassiz near shore.

VARVED CLAY

Clays cover the south and west halves of Melgund township. New road-cuts or cuts below grade on highway No. 17 show that these clays are varved. They were laid down in glacial Lake Agassiz.

During the reconstruction of highway No. 17, a cut near the bridge over the Wabigoon River, in lot 10, concession II, Revell township, exposed these clays. The clays are gently folded, and some incompetent zones, one foot or more in thickness, are intricately folded. The general dip is gently to the southwest. The sections available in the cut did not allow accurate measurement, and the figures that follow are approximate:

	Feet
Sand	3
Clay, unvarved; grades at top into sand	1.5
Clay, varved; 70 varves counted in 4 feet	5
Clay, varved; red-coloured "winter" layers, which are as much 2.5 inches thick	1.5 to 2
Clay, varved; varves 0.5–0.75 inches thick	5
Bottom of Section	

To the east of the cut there appears to be a maximum of about 5 feet of fine, gently-dipping sand overlying the above section.

These red varved clays are also exposed in the Dryden-Wabigoon area[1] and are reported to occur farther west.[2]

A shore cliff of glacial Lake Agassiz in the sands of the outwash plain can be traced across lots 1–4, concession V, Revell township, just southeast of Dyment. The cliff has an estimated height of 30 feet, and the top is about the same elevation as Dyment station, which is 1,350 feet. The Lake Agassiz shoreline elevation is therefore estimated to be at 1,320 feet. This may correspond to the Campbell shoreline.[3]

Recent

Peat deposits probably underlie all the numerous swamps and muskegs in the area. The largest swamp and muskeg covers much of the northern part of Revell township. Muskegs, showing a pronounced ribbon structure (see photo) along their drainage channels, are found in lots 1–3, concession III, Revell township. These string bogs are described by A. E. Porsild as "an[4] entrophic bog fed by ground water rich in mineral salts and of a pH. value of 8.0 or better, and bearing a flora much richer and more varied than the cup-domed, rain-fed, acid, oligotrophic sphagnum bogs of the 'hochmoor' type."

Stream erosion during the Recent period is most marked in the outwash sand plain, the present streams flowing in deeply entrenched valleys, whereas on the glacial Lake Agassiz clay plain the streams are characterized by abundant meanders.

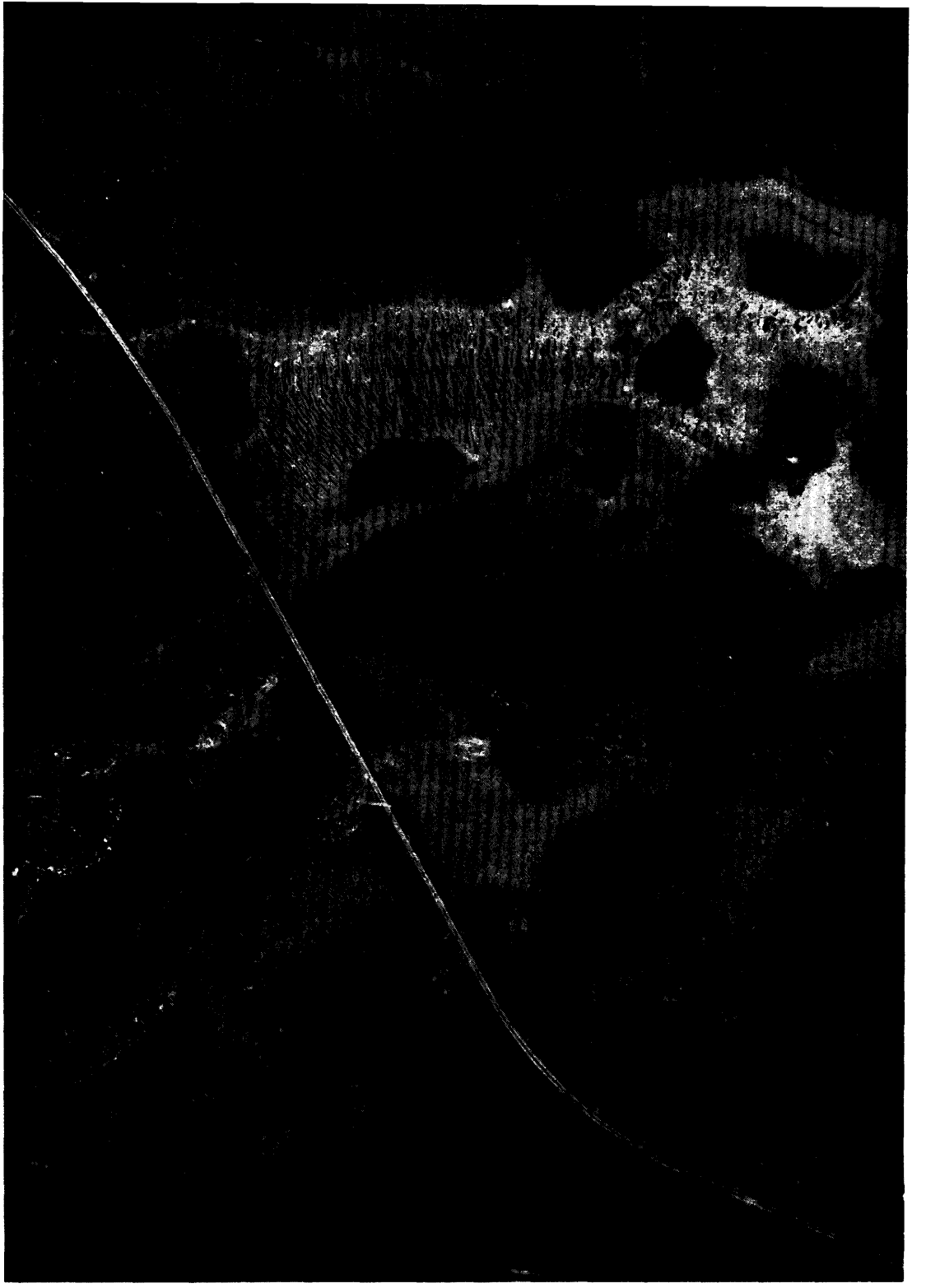
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[1] J. Satterly, *Geology of the Dryden-Wabigoon Area*, Ont. Dept. Mines, Vol. L, 1941, pt. 2, p. 45 and photo.

[2] W. A. Johnston, *Glacial Lake Agassiz with Special Reference to the Mode of Deformation of the Beaches*, Geol. Surv. Can., Bull. No. 7, 1946, p. 10.

[3] W. A. Johnston, *op. cit.*, Figure 1, *facing* p. 2.

[4] A. E. Porsild, Chief Botanist, National Museum of Canada, personal communication.



Vertical Air Photograph showing String Bog in Lots 1–3, Concession III, Revell Township

(Courtesy Ont. Dept. Lands and Forests)

STRUCTURAL GEOLOGY

All top determinations, strikes, and dips of foliation are shown on Map No. 1960h. Relatively few top determinations were obtained in the basalts owing to the deformation of the pillows. Those obtained are confined to concessions V and VI of Melgund and Revell townships, and all face north. At Tabor Lake, 2,000 feet south of the southwest corner of Melgund township, the author obtained one top determination to the south in pillowed basalt. In the southern part of lot 10, concession I, Melgund township, the apparent sequence of amygdaloidal basalt through fine- to coarse-grained flows indicates tops north. In the southeast corner of Satterly township (see Map No. 50e)[1] there is one top determination to the northwest. Therefore, if an anticlinal axis is indicated it lies at, or close to, the south boundary of Melgund township.

The basic volcanic rocks within the contact aureole of the Revell batholith or Hyndman granitic complex have been recrystallized to amphibolite or hornblende gneiss. Relict pillow structures are often seen in these rocks, but the pillows are elongated and the selvages distorted. No top determinations could be made.

As may be seen in the accompanying map, No. 1960h, the foliation parallels the borders of the batholiths. In the belt of metavolcanic rocks between the Hyndman complex and the Revell batholith the foliation dips at the basalt-granite contact, 30°SW., in southeastern Hyndman, to vertical in northwestern Hyndman township, and, crossing the belt in the central part of Hyndman township, the dips steepen to vertical at the Revell batholith contact.

Around that part of the Revell batholith mapped in the three townships, the foliation in the volcanic rocks dips vertically to 65 degrees away from the contact.

A few faults were found in which the displacement could be measured in inches. No large-scale faulting was recognized.

Minor drag-folding, in a band of rhyolite breccia in lot 1, concession I, Melgund township, indicates that the rocks on the north side of the band moved east.

ECONOMIC GEOLOGY

Gold

Mining locations for gold were surveyed as early as 1888. No gold production has been obtained in the area mapped, but some is recorded from the Sakoose and Tabor Lake properties immediately to the south of Melgund township.

A large number of quartz veins have been explored in the three townships, nearly thirty occurrences being examined by members of the field party. In many of these showings the quartz veins were apparently so insignificant that a small pit completely removed the vein material. The quartz is usually barren of sulphide mineralization, and gold assays range in most occurrences from nothing to a trace. Gold, if present, is in the native form and apparently very erratic in distribution, so that grab samples taken for assay may give results that are quite misleading.

The quartz vein material in the pits, shafts, or on the dumps at the old mining locations, consists of chlorite-quartz, quartz-carbonate, or rarely quartz-carbonate-tourmaline. Inclusions of the wall rock are often abundant, and sulphide mineralization, if present, is often confined to these inclusions. In some veins, black films are found parallel to the vein walls, indicating that the veins have been re-opened a number of times. Wall-rock alteration in the basic volcanic rocks is carbonatization, and in the rhyolites is sericitization and carbonatization. A green mica was noted with the quartz at one occurrence in Melgund township.

Descriptions of the showings at the old mining locations and elsewhere are summarized in Table V.

TABLE V—GOLD OCCURRENCES

Location	Development	Geology
Melgund tp., con. I, lot 5 (S.V. 211).	Pit.	Amphibolite (metavolcanics) cut by dikes of feldspar porphyry, felsite, pink and grey granites. In the pit, rusty-weathering volcanics across a width of 5 ft., injected with lenses of blue-grey to sugary-white quartz, also rust-stained. No sulphides observed, perhaps owing to oxidation. Shearing N.30°E., dip 70°NW.
Melgund tp., con. I, lot 4 (north half).	Pit.	A 6-ft.-wide, rusty-weathering shear zone in hornfelsed basalt, containing disseminated pyrrhotite and minor chalcopyrite.
Melgund tp., con. I, lot 8 (A.D. 80).	Pit, 2 × 4 ft.	Sheared carbonatized basalt cut by 1- to 2-ft. white quartz vein traced for 20 ft. Rusty vugs (weathered carbonate (?)). No sulphides observed.
Melgund tp., con. I, lot 9 (A.D. 75).	Pit, 8 × 7 × 5 ft. deep.	Sheared basalt and rhyolite. A quartz-carbonate vein up to 3 ft. wide exposed on west wall of pit. No sulphides observed.
Melgund tp., con. I, lot 9 (A.D. 68).	Shaft, 4 × 8 × 20 ft. deep; pits and trenches near shaft.	Sheared and carbonatized basalt and rhyolite, striking N.60°E., dip vertical. On dump, quartz-carbonate vein material in contact with a green mica-carbonate rock. No sulphides observed. No quartz was seen in place in the shaft or surrounding workings.
Melgund tp., con. I, lot 10 (A.D. 89).	Pits, 8 × 3 × 4 ft. deep; 3 × 2 × 1 ft. deep.	Sheared carbonatized basalt and interbanded sericitized rhyolite, striking N.60°E., dip vertical. No visible quartz in pit, but quartz-carbonate vein material with inclusions of sericitized wall rock on dump. No sulphides observed. In smaller pit, 3 ft. from larger, quartz lenses seen on east wall. No mineralization observed.
Melgund tp., con. I, lot 10 (A.D. 87).	Pit.	Carbonatized, sheared, amygdaloidal basalt, striking N.70°E., dip 85°N., with quartz-carbonate material at pit. No sulphides observed.
Melgund tp., con. II, lot 5 (S.V. 210).	Pit.	Carbonatized basalt cut by quartz-feldspar porphyry dike (frost-broken outcrop). Rusty-weathering quartz-carbonate vein material containing wall rock inclusions. Pyrite in disseminated cubes or grains.
Melgund tp., con. II, lot 5 (south half).	Pit.	Basalt with coarse pyrite, adjacent to Keweenawan diabase dike.
Melgund tp., con. II, lot 7 (A.D. 82).	None.	Carbonatized basalt, pillowed lava, and rhyolite, striking N.60°E., dip vertical. Quartz-carbonate vein, 2 ft. wide, exposed for 3 ft. in one place. Strike and dip not available.
Melgund tp., con. III, lot 2 (south half).	Pit, 6 × 10 ft.	Massive basalt cut by 3-ft. glassy white quartz vein, striking N.68°E., dip 70°N. No sulphides observed.

TABLE V—GOLD OCCURRENCES—*Continued*

Location	Development	Geology
Melgund tp., con. III, lot 4 (S.V. 254 (K.11779) into S.V. 263) G. L. Pidgeon.	Pits and trenches; 15 along a line N.55°E. for a distance of 1,320 ft. Diamond-drilling (14 holes, packsack).	Sheared carbonatized basalt, striking N.55°E., dip vertical. Pyritized zone 3–5 ft. wide, containing quartz-carbonate ± tourmaline vein material in ptygmatically folded lenses or stringers in widths from less than 1 to 12 in. Erratic sulphide mineralization; pyrite, rarely chalcopyrite, and very rarely galena. Pyrite in cubes. Many of the pits filled with broken rock; quartz can be seen on dumps but not in place. Visible gold seen in one pit.
Melgund tp., con. III, lot 7 (A.D. 84).	Pit, 6 × 8 ft.	Sheared carbonatized basalt, striking N.55°E., dip vertical. Conformable blue-grey quartz vein up to 1 ft. wide, narrowing to 1½ ins, 3 ft. down (water level). Minor subsidiary quartz stringers on west side of main vein. No visible mineralization.
Melgund tp., con. IV, lot 2 (E. 163).	Shaft, 5 × 5 ft., reported to be 20 ft. deep (G. L. Pidgeon); filled with water to within 4 ft. of surface. (June, 1958.)	Sheared carbonatized basalt, striking N.65°E., dip vertical. Quartz-carbonate stringers and veins parallel to shearing, in widths to 8 ins. Quartz contains films of chlorite, but no sulphide mineralization seen except one speck of chalcopyrite.
Melgund tp., con. IV, lot 6. (E. 161).	Pit, 5 × 6 ft.; 5 ft. to water level.	Sheared, sericitized rhyolite, striking N.70°E., dip vertical. No quartz visible on walls of pit. Quartz-carbonate ± tourmaline vein material on the dump. No sulphide mineralization observed. A quartz-carbonate vein up to 18 ins. wide was found 1,100 ft. SW. of the pit. No sulphides were found.
Melgund tp., con. VI, lot 4 (north part).	Pit, 9 × 9 ft.; 15 ft. to water level. (Depth 20 ft., W. Boadway).	Carbonatized basalt, striking N.70°W., dip vertical. On dump, material with disseminated pyrite, chalcopyrite, and pyrrhotite, and chlorite-quartz vein material without visible sulphides.
Revell tp., con. II, lot 1	Pit, 5 × 8 ft., filled with water.	Granodiorite. On dump, glassy white quartz, minor rusting or hematite staining. No sulphide mineralization observed in the quartz, a few cubes of pyrite noted in granodiorite adjacent to quartz.
Revell tp., con. IV, lot 2 (H.W. 673).	Shaft, timbered, 4 × 6 ft.; surrounded by a dump 40 × 40 × 5 ft. high.	Sheared grey rhyolite with quartz eyes, striking N.70°W., dip vertical. On the dump, sugary white quartz vein material. Included bands of sericite-quartz schist (sericitized rhyolite) contain scattered disseminated pyrite. No pyrite mineralization was observed in the quartz.
Revell tp., con. IV, lot 6 (H.W. 611).	Pits (2), 30 ft. apart.	Fine-grained, rusty-weathering, 15-ft. granite dike striking N. 85°E., cuts basalt. Minor quartz observed in place in pits. On dump, rusty-weathering white quartz, in part vuggy, with marcasite.
Revell tp., con. IV, lot 6 (H.W. 525).	Shafts (2), 5 × 8 ft., one 40 ft. below the other. Each surrounded by a dump. Upper shaft, 20 ft. deep to water level.	Shafts near the contact between diorite (Algoman) and amphibolite (metavolcanic). The lower shaft dump consists of sheared amphibolite, sugary cr glassy white quartz, minor carbonate. No sulphides observed. At the upper shaft, the dump rocks include diorite and porphyritic basalt, as well as a minor amount of quartz-carbonate vein material. A little pyrite was seen in the quartz and the wall-rock diorite.

Revell tp., con. IV, lot 8 (H.W. 609).	Pit, overgrown, filled with water, 8 × 12 ft.	Amphibolite (metavolcanic). On dump, glassy white granulated quartz with films of country rock, or biotitized lava inclusions. No sulphides observed.
Revell tp., con. IV, lot 11 (northeast corner of S.V. 338).	Pits (2), 5 × 10 × 7 ft. deep; and 6 × 8 × 9 ft. deep.	Sheared basalt, striking N.62°E., dip 70°N. Pit, 60 ft. east of northeast corner of S.V. 338 does not show any quartz in place in the pit. Quartz on the dump is rusty white quartz; some chlorite, no sulphides. Main pit, 100 ft. east of northeast corner of SV. 338, in sheared basalt, exposing on west wall a rusty white quartz vein thinning 9–3 ins. at the bottom of the pit. On east wall pinches 4–0 ins. and widens to 3 ins. at bottom. Vein strikes E-W, and dips 85°N. to vertical. The quartz vein could not be traced beyond the pit owing to lack of exposure.
Revell tp., con. V, lot 5 (H.W. 642).	Pits (3).	Amphibolite (metavolcanic). Three pits in a carbonatized sheared zone, N.80°W., over a length of 100 ft. Lenticular quartz stringer on dump. Pink to rusty-stained glassy quartz, with ¼-in. blebs of marcasite, partly in vugs.
Revell tp., con. VI, lot 10.	Pit.	Pillow lava. No quartz observed in place in the pit. On the dump, fragments of rusty-stained glassy white quartz, practically no sulphides, pyrite noted in one sample.
Revell tp., con. VI, lot 12 (S.C. 1).	Pit.	Pillow lava and volcanic breccia, striking N.80°W. In pit, and for a length of 7 feet, a 6–18-in. glassy grey-white quartz vein exposed. Striking N.35°W., dip vertical. No sulphides observed.
Hyndman tp., V. 33 (C.P.R. track).	Shaft, 4 × 6 ft.; 60 ft. deep. (G. L. Pidgeon.) Two dumps.	Amphibolite (metavolcanics). On dumps, granular glassy white quartz, with many included films or bands of biotite-sericite-quartz schist with abundant coarse pyrite. Minor disseminated pyrite and pyrrhotite in quartz associated with films of country rock.
Hyndman tp., H.W. 534. (G. L. Pidgeon.)	Stripping, pits.	Hornblende-biotite quartz diorite. Main showing: A shear zone, 10 feet wide, stripped for 800 ft. in a direction N.30°W. Dip vertical. In the shear zone, *lit par lit* sugary white quartz veins from a few inches to 10 ft. wide. Mineralization is largely confined to biotite schist (meta-quartz diorite) bands between the quartz veins and consists of disseminated pyrite. Second Showing: A shear zone with *lit par lit* quartz parallel to the above and exposed over a length of 400 feet. A pit 200 ft. east of the main showing also exposes quartz, and may be an extension of the second showing.
Hyndman tp., 2,300 ft. east of H.W. 534.	Strippings, pits, trenches: 10 workings over N-S length of 275 ft. Overgrown and caved-in, in part.	Rhyolite schist bands in amphibolite (metavolcanic). These lenticular bands are from 4 in. to 20 ft. wide, and strike N.18°–45°W., dip vertical. Rhyolite schist bands are probably lenticular and discontinuous. Some are mineralized with disseminated pyrite and are rusty weathering.
Hyndman tp., P. 75 (south of mileage 24, C.P.R.)	Pit, 4 × 6 × 4 ft. deep (overgrown).	Hornblende diorite. Quartz vein material on dump. Pyrite noted in quartz and in inclusions of country rock in quartz.

Copper

Copper mineralization is found in the diorite bodies marginal to the Revell granodiorite. Copper-nickel showings in southwestern Hyndman township have been examined by the Canadian Pacific Railway Company and are described below. A small copper showing was found by the field party on an exposure of diorite in location HW 505, 1,000 feet south of the C.P.R. track, 1¼ miles west of Tache.

In Revell township the main diorite mass extends for nearly 3 miles along the north contact of the Revell granodiorite from lot 2 to lot 8, concession IV. Isolated occurrences of diorite were found in lots 1, 2, and 9, concession III. In Hyndman township the diorite forms a crescent-shaped mass extending about 1 mile west and 1 mile north of the C.P.R. track. The small size of these diorite bodies is not encouraging for additional prospecting for copper.

CANADIAN PACIFIC RAILWAY COMPANY

Tache Property

In 1956 the Canadian Pacific Railway held a group of 18 claims in the southwestern party of Hyndman township. Development work was carried out on two copper-nickel showings about 2,000 feet south and 500 feet west of mileage 24 on the Canadian Pacific railway. The work comprised a geophysical survey, trenching, and 3 diamond-drill holes totalling 460 feet, and was carried out by Consolidated Mining and Smelting Company of Canada Limited in 1956[1] on claim K.24367,[2] part of old location P.75. Five bulk samples were taken from the trenches and were analysed with the following results: copper, 0.21–0.37 percent; nickel, 0.27–0.33 percent.[3]

The trenches expose a dark, massive, almost coarse-grained hornblende diorite containing erratically disseminated pyrrhotite and chalcopyrite. Slightly more sulphide is present in sheared chloritized hornblende-rich phases of the diorite.

In the report on the magnetometer survey attached to M. W. Bartley's report, T. W. Page states: "It would appear that there is insufficient mineralization in the unexposed sections along strike to create an anomalous condition. In other words it would appear that mineralization as exposed is as strong as any that is covered by overburden."

Gravel

The distribution of glaciofluvial deposits of sand, gravel, and boulders has been noted in the section of this report dealing with the Pleistocene. (See p. 21.)

Very large quantities of sand from the outwash plain in Revell township were used for fill during the reconstruction in 1958 of the Trans-Canada Highway (No. 17) in Revell township. Gravel for surfacing this road was hauled from a deposit in lot 1, concession VI, Revell township, adjacent to the Dryden Paper Company's road.

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[1] Jas. E. Thomson and Others, *Copper, Nickel, Lead, and Zinc Deposits in Ontario*, Ont. Dept. Mines, Metal Resources Circ. No. 2, 1957, p. 22.

[2] Reported as in K.24362, but this appears to be an error.

[3] M. W. Bartley, *Report on Mining Claims K.24358 to K.24375*, Canadian Pacific Railway Company, Jan. 26, 1956.

APPENDIX

PIDGEON MOLYBDENUM MINES LIMITED

Echo Township, District of Kenora

Pidgeon Molybdenum Mines Limited hold 12 claims in Echo township, District of Kenora. The molybdenite showings are mainly on claim Pa.14051, in the northwest quarter of the south half of lot 8, concession V.

Molybdenite was originally discovered by H. S. Armstrong's assistants, J. K. Webb and H. E. Neal, between Lateral Lake and Moly Lake, and east of Lateral Lake.[1] These showings were staked by G. L. Pidgeon, and in 1954 the property was optioned to Detta Minerals Limited, renamed Candore Explorations Limited in 1956. It was acquired in 1957 by the present company, which was controlled by Rio Tinto Mining Company of Canada Limited. Rio Tinto dropped their option in 1958.

The property may be reached by gravel roads from the Dinorwic–Sioux Lookout highway (No. 72) by leaving it at 0.45 miles north of mile-post 23 (19.9 miles north of Dinorwic) and travelling west, north, and west, 6.3 miles to the property. Camp buildings are 6.1 miles from the highway.

Development on the property consists of stripping, trenching, diamond-drilling, and an adit. In 1954, Detta Minerals Limited drilled 2 holes, totalling 350 feet, and drove an adit 73 feet in length from which 255 tons of rock was taken for bulk-sampling.[2] The adit was completed in 1955 with an over-all length of 114 feet. In 1957-58, Rio Canadian Exploration Limited drilled 21 holes, totalling 7,257 feet, on claims Pa.14051, Pa.14081, Pa.14071, and Pa.15232.

On the geological map of Echo township[3] two exposures of granodiorite are shown on the claim marked Pidgeon. These two exposures contain the main and southwest molybdenite showings. They are situated at, or near, the east contact of Armstrong's Lateral Lake granodiorite stock. Harding's map of the Gullwing Lake–Sunstrum Area[4] shows this stock to be the east end of his Tot Lake–Gullwing Lake granite mass that extends west across Webb township to Gullwing Lake. This mass has been intruded into an anticlinal fold in the metasediments.

There are three showings on the property. The Main Showing is near No. 1 post of claim Pa.14051. Work has been carried out on a low northeast-striking ridge rising 20 feet above swamp level, and consists of stripping and pits scattered over a length of 300 feet and a width of 75 feet. An adit, 114 feet long, has been driven at S.60°E. into the side of the ridge from its northwest side at a few feet above swamp level. The adit walls have been slashed on both sides at a point 55 feet from the portal. Exploration has also been carried out at the Cliff or North Showing, 600 feet northeast of the adit, on claim Pa.14081, and at the Southwest Showing, 1,100 feet southwest of the adit portal, on claims Pa.14081 and Pa.14194.

At the Main Showing, the ridge consists of a complex of grey granodiorite, cut by pink muscovite granite pegmatite, pink aplite, and glassy white (occasionally pink) quartz. Aplite is the most abundant rock type, forming about 50 percent of the whole ridge. The aplite stringers and dikelets, from less than 1 inch to 3 feet in width, strike northeast and dip 45°SE. The pegmatitic quartz and quartz stringers also strike northeast, as well as other directions. They

[1] H. S. Armstrong, *Geology of Echo Township*, Ont. Dept. Mines, Vol. LIX, 1950, pt. 5, p. 37.
[2] *Mining Operations in 1954*, Ont. Dept. Mines, Vol. LXIV, 1955, pt. 2, p. 106.
[3] Map No. 1950–1, *Township of Echo*, District of Kenora, Ontario, Scale, 1 inch to 1,000 feet, Ont. Dept. Mines, 1950. (To accompany; H. S. Armstrong, *op. cit.*)
[4] Map No. 1950–2, *Gullwing Lake–Sunstrum Area*, District of Kenora, Ontario. Scale, 1 inch to 1 mile, Ont. Dept. Mines, 1950. (To accompany; W. D. Harding, *Geology of the Gullwing Lake–Sunstrum Area*, Ont. Dept. Mines, Vol. LIX, 1950, pt. 4.)

appear to have a vertical dip. The quartz veins are mostly less than 1 foot wide, the widest seen on surface being 5 feet. The veins consist of quartz with scattered feldspar crystals, or quartz with feldspar at the margins.

Molybdenite mineralization is present as scattered to abundant flakes in the aplite, as fracture-filling seams in the aplite, and as scattered flakes in the muscovite granite pegmatite and quartz. Muscovite, and to a lesser extent pyrite, is associated with the molybdenite mineralization. Pyrite occurs in cubes, from ¼ inch to as much as 1 inch across, in aplite, or in coarse aggregates often intimately associated with molybdenite and muscovite. Bismuthinite[1] is a rare accessory in muscovite granite pegmatite, occuring as minute prismatic crystals 1/16 inch across and up to 1 inch in length. Magnetite is present in minute, round grains and occasionally larger masses up to 1 inch across in aplite stringers. Tourmaline was noted in one place as an aggregate of minute black needles and radiating clusters filling a fracture.

Owing to the erratic distribution of the molybdenite mineralization, no visual estimate of the amount present can be made.

At the Cliff or North Showing, an aplite-granodiorite complex has an exposed width of 50 feet. A north-south, 75-foot trench, about 40 feet above swamp level, exposes aplite, granite pegmatite, and quartz. The pegmatitic quartz veins are 3–5 feet wide. Molybdenite is erratically distributed in patches and seams up to ¼ inch thick, or disseminated in compound flakes, mostly ¼-inch or less across, to a maximum of ½-inch in diameter. Cubes of pyrite, up to ½-inch edge, occur in aplite. A pit, about 600 feet north of the Cliff Showing, exposes some molybdenite in aplite.

The South Showing is in a clearing, 100 by 500 feet in size, trending N.60°E. Stripping and pits expose a complex of granodiorite, granite pegmatite, aplite, and quartz across widths to a maximum of 100 feet. The aplite forms *lit-par-lit* stringers and dikelets that strike N.50°E. and dip 45°SE. Random pits expose molybdenite mineralization as seams and flakes associated with pyrite and muscovite. Pyrite cubes are occasionally as much as 1½ inches across. Minor accessory minerals are magnetite and biotite.

The age relationships of the host rocks are, beginning with the oldest: (1) granodiorite; (2) granite pegmatite; (3) aplite; and (4) pegmatitic quartz.

The bulk sampling of the adit indicated two sections of molybdenite mineralization.[2] The first, 0–23.1 feet, assayed 0.24 percent MoS_2 over 23.1 feet; and the second, 42.0–67.3 feet, assayed 0.57 percent MoS_2 over 25.3 feet.

[1]Identified by D. A. Moddle, Provincial Assay Office, Ont. Dept. Mines, 1958.
[2]K. J. Benner, private report to Detta Minerals Limited, Feb. 25, 1956.

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ONTARIO
DEPARTMENT OF MINES

HON. JAMES A. MALONEY, *Minister* H. C. RICKABY, *Deputy Minister*
M. E. HURST, *Provincial Geologist*

Gunflint Iron Range in the Vicinity of Port Arthur

By

W. W. MOORHOUSE

Gunflint Iron Formation of the Whitefish Lake Area

By

A. M. GOODWIN

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MAPS OF THE GUNFLINT IRON RANGE

MAP NO.

1960i —Whitefish Lake Area ..... *in map case*
1960j —Silver Mountain Area ..... "
1960k —Kakabeka Falls Area ..... "
1960l —Hymers-Stanley Area ..... "
1960m —McIntyre Area ..... "
1960n —Neebing Area ..... "
1960o —Port Arthur Area ..... "
1960p —Loon Lake Area ..... "

ABSTRACT

The gently-dipping Animikie rocks of the Port Arthur region unconformably overlie the greenstones, tuffs, greywackes, and granites of the Archean. The Gunflint iron formation, the lower part of the Animikie, is separated into three subdivisions on the accompanying maps. The Lower Gunflint, beginning locally with gravelly conglomerate, consists of lenticular beds of ferruginous carbonate, chert, jasper, algal cherts, hematite, and magnetite taconites, and west of the Kaministikwia River, silicate taconite. The Lower Gunflint is overlain by the argillite-tuff unit, of black and grey argillite, tuff, carbonate, and chert. The Upper Gunflint, in the vicinity of Loon Lake, is thin-bedded chert and ferruginous carbonate. Similar but thicker beds outcrop along the Current River. West of Port Arthur the Upper Gunflint is largely chert, jasper, and silicate taconite.

The Gunflint is overlain by the Rove formation consisting of argillite, greywacke, and thin carbonate layers. Calcareous concretions are locally abundant. Overlying the Animikie with unconformity but with small angular discordance, is the Keweenawan Sibley formation, consisting of conglomerate, sandstone, limestone, and silty red carbonate rocks. All these rocks are intruded by sheets of diabase, which are responsible for the cuestas, buttes, and mesas that characterize the landscape around Port Arthur and Fort William.

Brief summaries are given of the mineralogy, texture, metamorphism, sedimentary facies and chemical composition of the Gunflint. The prospects for the development of an iron mining industry in the area mapped are not promising at the present time.

Gunflint Iron Range in the Vicinity of Port Arthur, District of Thunder Bay

BY

W. W. Moorhouse[1]

INTRODUCTION

The survey of the Gunflint iron range, described in this report and in the accompanying report by A. M. Goodwin, had as its object a re-examination of the stratigraphy, structure, and relationships of the Gunflint iron formation, and an appraisal of the Gunflint as a possible source of direct-shipping or concentratable iron ore. The author was engaged in this work during the field seasons of 1950 and 1951. The survey covered outcrops of the iron formation from Whitefish Lake to Loon Lake, a total distance of 65 miles. The results of this work and that of Dr. Goodwin (see following report) are shown in the eight maps in the case at the back.

No new indications were found of commercial concentrations of direct-shipping ore, or of deposits of concentrating ore likely to be profitable under present conditions. Some interesting stratigraphic and structural relationships have developed from the mapping program and are summarized in the report.

From time to time surface prospecting and drilling have been carried out by individuals and companies to locate mineable iron ores, but have so far met with little success.

Methods of Mapping

Since the main objective of the mapping program was the location, lithology, and structure of outcrops of the Gunflint iron formation, most of the mapping was confined to areas in which these occur, and to determining the limits of the iron range as at present exposed. In the part of the area northeast of Port Arthur, the Gunflint was mapped by means of systematic traverses spaced at 10-chain intervals; traverse lines were located on Forest Resources Inventory vertical photographs, at a scale of approximately 1 inch to ¼ mile, of the Ontario Department of Lands and Forests. In the section between Navilus and Conmee Point, Animikie outcrops are mostly restricted to the coast line of Thunder Bay, and detailed work was limited to these outcrops, with a few reconnaissance traverses to the north to confirm the absence of any significant outcrops of the Animikie.

West of Port Arthur and Fort William, outcrop is so scarce that it was felt to be unprofitable to systematically traverse the area in which the Gunflint occurs. Here all the major creek and river valleys were traversed in search of outcrop, and all roads were traversed to locate exposed rock in the interstream areas. As a result of this procedure, together with a systematic stereoscopic examination of

[1]Professor, Department of Geological Sciences, University of Toronto.

air photographs, it is thought that the most important outcrops have been examined and mapped. It is certain that all rock exposures have not yet been located; however, owing to the difficulty of identifying the stratigraphic position of isolated outcrops, little important information has been lost through this.

The assignment of a particular outcrop to its proper stratigraphic position in the Gunflint is difficult, not only because of the interrupted and sometimes sparse distribution of rock, but also because of marked facies changes and numerous faults, most of which are of unknown displacement. For this reason the

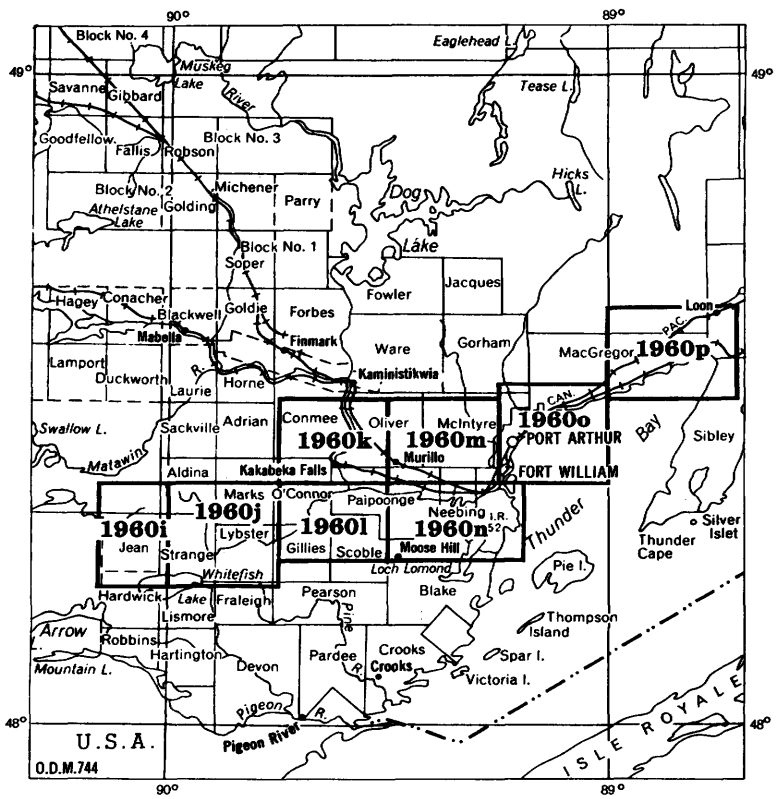


Figure 1—Key map showing the locations of the map areas described in this and the following report. Scale, 1 inch to 20 miles.

position of the contact separating the Lower and Upper Gunflint on the accompanying maps is only provisional and may well be modified if further information is obtained from drilling or excavation.

Acknowledgments

The author is indebted to M. W. Bartley, consulting geologist, and to W. L. C. Greer, resident geologist of the Ontario Department of Mines at Port Arthur at the time the mapping was done, for many favours and much useful information. Jules Cross assisted by giving the benefit of his experience and knowledge of the area. Thanks are also due to E. G. Pye, now resident geologist at Port Arthur, for his co-operation on several occasions.

In both 1950 and 1951, A. M. Goodwin was senior assistant on the field party and was responsible for much of the mapping. His careful work and willing

co-operation at all times are sincerely appreciated. The work of mapping was facilitated by the willing and efficient efforts and interest of G. A. Sears and M. J. Salm in 1950, and J. D. Godfrey and E. A. Matchett in 1951.

Means of Access

All parts of the area are readily accessible from highway No. 17, the Dawson Road, the Oliver Road, all of which are paved, or from township roads, some of which are now paved. Few parts of the area mapped are more than one hour's walk from roads accessible with car or truck.

Population

The Port Arthur–Fort William area is one of the most populous areas of northern Ontario. In 1951 there were more than 66,000 inhabitants. Like most of the larger centres in northern Ontario, the population is very mixed; Scottish, Scandinavian, and Finnish elements probably constitute the largest ethnic groups.

Natural Resources

Between Loon Lake and Whitefish Lake, extensive areas are cleared for cultivation or pasture. Most of the agricultural produce of the area is consumed locally. Forest, which crowds the urban and agricultural land against the shore of Thunder Bay, is almost entirely second growth; some pulp is cut in the area and processed in the local pulp mill.

Although many attempts have been made to produce silver from veins in the area, significant production came only from Silver Islet, just off Thunder Cape. There is no metal production in the area at the present time.

Sand and gravel are abundant and are produced for construction and road-building. Diabase is quarried at Silver Harbour for riprap used in the construction of breakwaters in the harbour. Owing to their position at the head of navigation on the Great Lakes, the twin cities are of great importance to the transfer of wheat from the west, and iron ore from Steeprock Lake to lake carriers.

Previous Work

A review of the history of stratigraphic terms used in the Thunder Bay area has been given by Tanton. (See below.) A summary of early geological work in the area, and a complete bibliography are also given in his report. Therefore, a detailed discussion of previous work, and a full bibliography are not given here.

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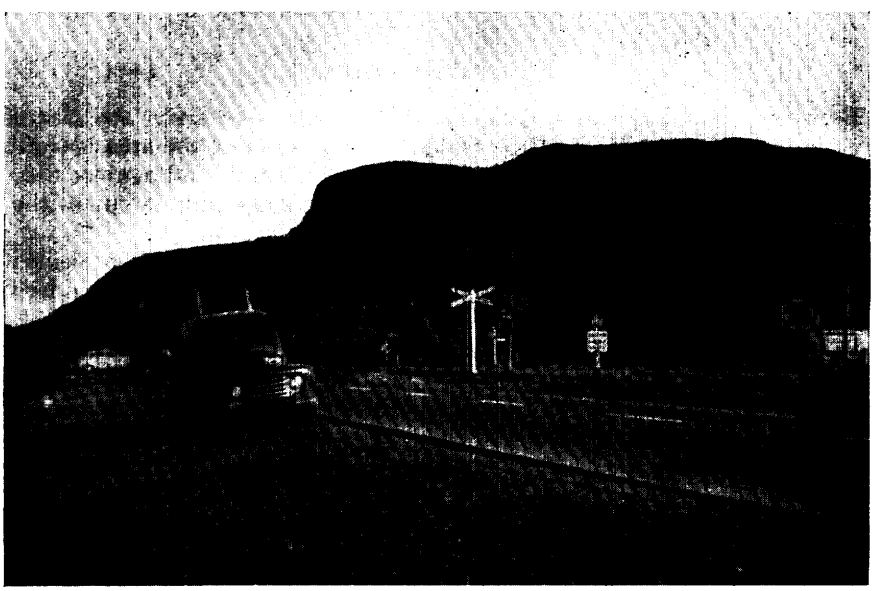
W. N. Smith, "Loon Lake Iron-bearing District," *Annual Report*, Ont. Bur. Mines, Vol. XIV, 1905, pt. 1, pp. 254–60.

T. L. Tanton, *Fort William and Port Arthur, and Thunder Cape Map-Areas, Thunder Bay District, Ontario*, Geol. Surv. Can. Memoir No. 167, 1931.

C. R. Van Hise and C. K. Leith, *The Geology of the Lake Superior District*, U.S. Geol. Surv., Monograph No. 52, 1911, pp. 45, 46, 81–83, 94, 95, 100, 101, 110–15, 205–10, 366–70.

Since Tanton's report of 1931, a few publications dealing with rocks of the area, or with correlation problems, have become available, among which are the following:

R. G. Blackadar, "Differentiation and Assimilation in the Logan Sills, Lake Superior District, Ontario," *American Journal of Science*, Vol. 254, 1956, pp. 623–45.
B. A. Bradshaw, *Petrological Comparison of Lake Superior Iron Formations*, unpublished Ph.D. Thesis, University of Toronto, 1956.
A. M. Goodwin, *Stratigraphy of the Gunflint Iron-bearing Formation*, Ph.D. Thesis, University of Wisconsin, 1953.
A. M. Goodwin, "Facies Relations in the Gunflint Iron Formation," *Economic Geology*, Vol. 51, No. 6, 1956, pp. 565–95.
C. K. Leith, Richard J. Lund, and Andrew Leith, *Pre-Cambrian Rocks of the Lake Superior Region*, U.S. Geol. Surv., Professional Paper No. 184, 1935.
W. W. Moorhouse, "The Proterozoic of the Port Arthur and Lake Nipigon Regions, Ontario," *The Proterozoic in Canada*, (edited by J. E. Gill), Roy. Soc. Can., Special Publication No. 2, 1957, pp. 67–76.
M. E. Wilson, "The Canadian Shield," in *Geologie der Erde, Geology of North America—I*, Verlag von Gebrüder Borntraeger in Berlin W. 35, see especially pp. 238–44.



Mount McKay, a butte capped by diabase; the terrace is floored by a thin diabase sheet.

Topography

The countryside between Loon Lake and Whitefish Lake is dominated by cuestas, mesas, and buttes resulting from the weathering and erosion of the flat-lying to gently dipping Animikie sediments and the diabase sheets that intrude them. The highest of these are the mesas capped by diabase, such as Thunder Cape (1,768 feet above sea level or 1,166 feet above lake level), Pie Island, and the range of hills of which Mount McKay (1,581 feet above sea level) is the most northerly (see photo). To the north of Mount McKay and similar mesas and cuestas to the west, a broad flat plain, largely covered by drift, extends northward to the contact with the granites and schists of the Archean. These rise at a low angle from below the unconformity that separates them from Animikie to form the rugged upland of generally low elevation (900-1,400 feet above sea level) typical of most of northern Ontario.

The relatively flat plain lying to the west of Port Arthur and Fort William is occupied by the valley, flood plain, and delta of the Kaministikwia River, and those of the Neebing and McIntyre rivers. Between the river valleys, it is covered by a thin layer of glacial drift, mostly boulder clay, swamp deposits, and varved clays. Varved clays are exposed locally, as on the Current River above the Lyon Boulevard bridge and around the northeast end of Thunder Bay.

Like the lower reaches of the Kaministikwia River, the Whitefish River below Nolalu is entirely in drift. Between Nolalu and Leeper, this drift, largely stratified sand and gravel, attains thicknesses of about 100 feet.

Thunder Bay is essentially a drowned lowland, bounded on the north by the unconformity between the Animikie and the Archean, on the east by the Sibley escarpment, and on the west by the deltas of the Kaministikwia, Neebing, and other rivers.

GENERAL GEOLOGY

The consolidated rocks of the area are Precambrian in age. Oldest are the old, folded, metamorphosed greenstones and sediments, indicated on the maps as Keewatin type, cut by granites and related batholithic rocks. These are typical Archean rocks. Overlying them are relatively flat-lying Proterozoic rocks, which have been grouped together as the Kaministikwan group by Tanton.[1] In this group are included the Animikie series, the Sibley sediments, the Osler sediments and volcanics, and the diabase sills and dikes that cut these rocks. The Sibley and Osler sediments and diabase intrusives are grouped with the Keweenawan by most authors. The term Kaministikwan is not used in this report.

TABLE OF FORMATIONS

PRECAMBRIAN

KEWEENAWAN:

Intrusives: Diabase sills, sheets, and dikes.

Intrusive Contact

Sediments: Sibley formation.

Unconformity

ANIMIKIE:

Rove formation.

Gunflint iron formation.

Unconformity

ALGOMAN TYPE: Granite, granodiorite, syenite, pegmatite, porphyry, aplite, lamprophyre.

Intrusive Contact

KEEWATIN TYPE: Greenstone, pillow lava, rhyolite, andesite, amphibolite, minor sediments.

Keewatin Type

The most extensive area of Keewatin-type rocks examined in the survey lies southwest of Loon Lake, between highway No. 17 and the Canadian Pacific railway, extending westward along the highway as far as Silver Harbour. Pillow lavas are found among these outcrops, as well as metadiabases, which in most

[1]T. L. Tanton, *Fort William and Port Arthur, and Thunder Cape Map-Areas, Thunder Bay District, Ontario*, Geol. Surv. Can., Memoir No. 167, 1931, pp. 17, 23, 24.

cases are presumed to represent the coarse parts of flows. Minor acid and intermediate volcanics were also encountered, but these are largely tuffaceous in nature. A fairly widespread rock type is a curiously massive, fine-grained biotite andesite or trap. North and west of Blende Lake there are many outcrops of this rock, which are lamprophyric in aspect. Dioritic or diabasic bodies of much coarser grain are associated with it.

Recrystallized gneissic and amphibolitic greenstones are found as inclusions in granite, and at contacts with granites.

A few outcrops of greywacke were encountered north of McKenzie Station, and southwest of Bittern Lake. Greywacke was also observed underlying Animikie conglomerate on the Pass Lake road, just east of the north end of Blende Lake, and in the same area it has been reported from diamond-drilling operations. The greywackes are not as abundant as might be thought from the descriptions of the geology given by Van Hise and Leith,[1] and Smith.[2] There were insufficient outcrops to establish the existence of a distinct sedimentary series in the area mapped.

Algoman Type

Along much of its contact with the older Precambrian, the Animikie overlies granites that are similar to those called Algoman in northern Ontario. Generally these are massive, light-coloured granites, granodiorites, and similar rocks. No detailed petrographic study has been made of them, but some outcrops, such as those northwest of Bittern Lake, and at the dam at Kakabeka Falls, are gneissic in character.

Small intrusives, apparently shonkinitic or syenitic in composition, are exposed north of Navilus, but were not encountered elsewhere.

Dikes of pegmatite, aplite, felsite, porphyry, and lamprophyre are found cutting greenstones or granites, but are not sufficiently numerous or prominent to warrant detailed description here.

All the rocks mentioned cut the Keewatin-type lavas and sediments, and are overlain unconformably by the Animikie.

Pre-Animikie Unconformity

The unconformity between the Animikie and the underlying Archean is an exceptionally even surface. Minor irregularities may occur, suggesting slight differences in elevation of the original surface, but these are of much less magnitude than the variations in elevation visible in the present glaciated surface on the Archean. So in general, it seems that the Animikie was deposited on a perfect peneplane.

Also of interest in the relationship between the Animikie and the older rocks is the lack of weathering and alteration of granites immediately below the unconformity. In many areas, the unconformity is marked by a thin skin of conglomerate, the Kakabeka conglomerate of Tanton. Almost unaltered granite is separated from this conglomerate by about ½–1 inches of green chloritic material, containing feldspar and quartz fragments. In many places where the contact may be seen, even this meagre evidence of weathering and decay is absent, and conglomerate or taconite lies directly on granite as fresh as glaciated outcrops of the same rock.

[1] C. R. Van Hise and C. K. Leith, *The Geology of the Lake Superior District*, U.S. Geol. Surv., Monograph No. 52, 1911, p. 205.

[2] W. N. Smith, "Loon Lake Iron-bearing District," *Annual Report*, Ont. Bur. Mines, Vol. XIV, 1905, pt. 1, pp. 254–60.

The lack of weathering at this surface seems inconsistent with the idea that it was the site of prolonged and deep chemical weathering. It must be pointed out, however, that the Animikie and Keweenawan sediments indicate progressive marine overlap in their distribution. This would probably destroy any layer of soil or clay overlying the bedrock as the sea advanced over the peneplane.

Animikie Series

In this report two formations are included in the Animikie series, the Gunflint iron formation and the Rove formation. Tanton includes a third, the Kakabeka formation, a conglomerate at the base of the series; but this conglomerate is so thin, so erratic in its occurrence, and so closely associated with other units of the Gunflint, that it has been considered better to include it as a basal member of the Gunflint. Therefore it does not appear as an independent unit in the table of formations.

The Gunflint iron formation is an extremely complex formation. The complexity has two main causes: the great variety of rock types in the Gunflint, due to the varied combinations of possible mineralogy, texture, and structure; and the rapid vertical and horizontal changes in the rock type. Horizontal changes in lithology are so rapid, that the section on one side of a quarry may be different from that on the other. In consequence, only one member, an argillite-tuff complex, with some carbonate, can be traced throughout the area mapped. This divides the iron formation into a lower unit, of extremely varied lithology, but usually chert, and an upper unit, which in some areas, for example Loon Lake, is predominantly banded chert and carbonate, but elsewhere, as west of Fort William, is predominantly granular taconite. West of Kakabeka Falls, the lower Gunflint increases rapidly in thickness, according to the correlation used in this report, and becomes predominantly a silicate chert taconite.

West of Nolalu, Goodwin has divided the Gunflint into lower and upper units at an algal horizon, which persists throughout the western part of the Gunflint range. The argillite-tuff beds lie above this unit. At, and east of, Kakabeka Falls, the algal bed cannot be traced. Therefore the argillite-tuff band has been used for the separation of the Upper and Lower Gunflint.

West of Kakabeka Falls, another argillite band has been recognized by Goodwin[1] and Gill[2] near the base of the Gunflint. This has been correlated with the Intermediate Slate of the Gunflint Range in Minnesota, and the Lower Slaty of the Biwabik iron formation on the Mesabi range. At Nolalu this unit is very thin, and apparently it is absent farther east. It should be emphasized that the correlation proposed here is not necessarily the only one possible. In the early stages of mapping it was thought that the argillite-tuff section east from Kakabeka Falls corresponded with the Intermediate Slate. Therefore the correlation finally decided on and used in this report is subject to correction on the basis of additional information.

LOWER GUNFLINT

The Kakabeka conglomerate at the base of the Gunflint may be seen at a number of localities: as isolated patches in an outlier of Animikie rocks about ½ mile north of Crystal Beach; east of the Hodder Avenue bridge over the northeast branch of the Current River; in Oliver township, 3 miles north of Murillo;

[1] A. M. Goodwin, *Stratigraphy of the Gunflint Iron-bearing Formation.* Ph.D. Thesis, University of Wisconsin, 1953, pp. 7, 8.

[2] J. E. Gill, "Gunflint Iron-Bearing Formation, Ontario," *Summary Report*, Geol. Surv. Can., 1924, Part C, p. 44C.

on islands in the Kaministikwia River, just below the dam above Kakabeka Falls (see accompanying photo); in north-central Marks township; and in the bed of the Whitefish River west of Hillside. According to Tanton, the conglomerate and associated quartzite are up to 4 feet thick; they usually amount to only a few inches. The pebbles of the conglomerate are mostly not over an inch or two in diameter. Most are vein quartz, but a few pebbles of jasper and Archean iron formation are generally visible. Locally, pebbles of granite or greenstone may occur. In some places the matrix is siliceous, elsewhere it is chloritic.

The Lower Gunflint is an extremely varied formation. The rock types represented include algal cherts and jaspers, thin beds of hematite and magnetite taconite, layers of chert, jasper, ferruginous carbonate, and taconites of chert, jasper, and iron silicates.

The finest exposures of the algal facies are to be seen in and near the Whitefish River at Hillside. Most of the concretionary structures are cauliflower-shaped heads 1–2 feet in diameter. One reef-like structure in the river is about 20 feet long and 10 feet wide. The core of this reef consists of partially bleached jasper, with thimble-like or tube-shaped structures. Around the core are 2-inch-thick layers of chert, jasper, and carbonate. In the same locality there are small cabbage-like and biscuit-shaped concretions up to 6 inches in diameter.

Well-preserved growths up to a foot thick were found on islands north of the bridge at Kakabeka Falls; little seems to remain in place here. A small outcrop of jasper with concentric structures is exposed along the sideroad to Silver Harbour and along the railway cut just north of Green Point. A layer of laminated algal structures is also exposed on highway No. 17 just east of the road to Loon Lake.

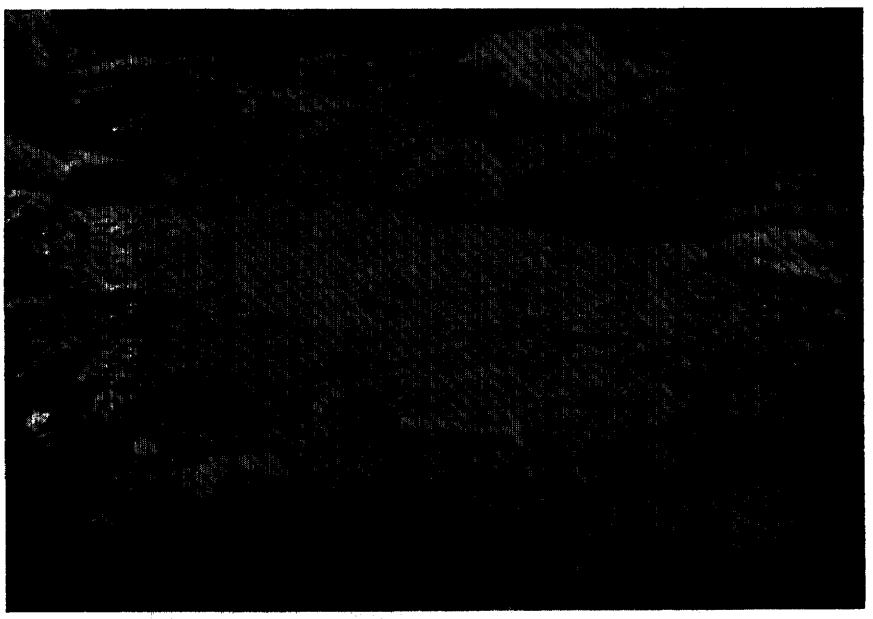
Most of the algal remains consist of chert or jasper. The presence of cherty oölites associated with them indicate that silicification has taken place, and it is considered probable that the growths were originally calcareous and have since been silicified.

Some representative sections from the Gunflint are illustrated in Figure 2. In the northeastern part of the area, Loon Lake, the outcrops are composed chiefly of chert, granular chert, and fairly thick-bedded carbonate, with some thin layers of hematite. Along the Current River (see accompanying photo), beds that have been assigned to the Lower Gunflint are predominantly carbonate and chert. At the top of the section, under the Lyon Boulevard bridge, is exposed 4–5 feet of grey, crystalline limestone, overlain by 2 feet of chert, with some ferruginous carbonate. At the railway underpass at the east boundary of Port Arthur, and along the Pass Lake road, near highway No. 17, thick, massive beds of carbonate make up a large part of the section.

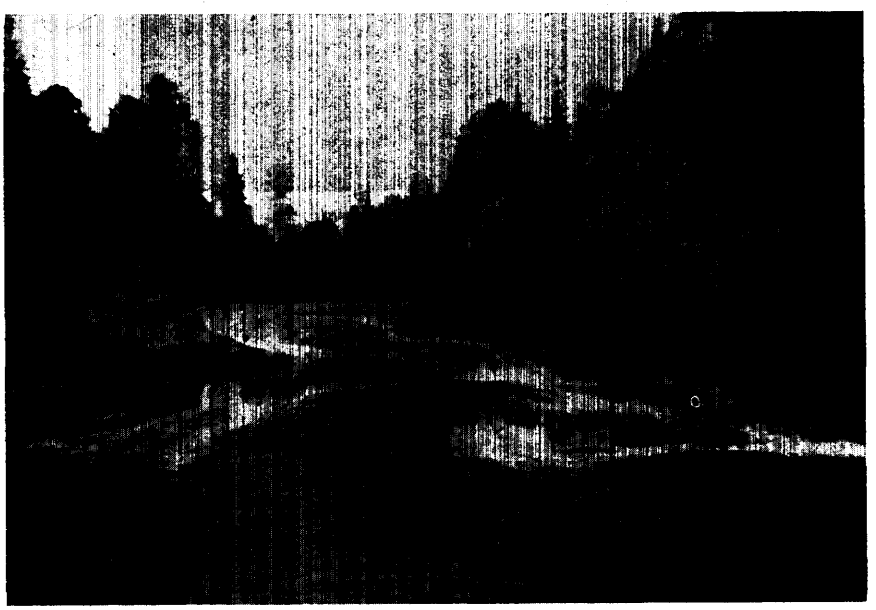
West of Port Arthur, this part of the Gunflint is poorly exposed, but occasional outcrops and locally derived boulders in the drift indicate that it consists predominantly of ferruginous carbonate and chert. A few small outcrops appear on the east bank of the Kaministikwia River, between the dam and the highway bridge. These also consist largely of carbonate and interbedded chert and carbonate, with some beds of carbonate and chert taconite.

On Pitch Creek, a marked change in thickness and lithology of the Lower Gunflint is apparent. A few feet of argillite near the base is followed by 100–200 feet of silicate taconite with wavy bedding, often interbedded with thin layers of shaly silicate. This succession is overlain by an algal layer and beds of jasper and chert taconite, as reported farther west by Goodwin.

No continuous section of the Lower Gunflint has been measured in the area described in this report. The thickest measured section east of Kakabeka Falls is

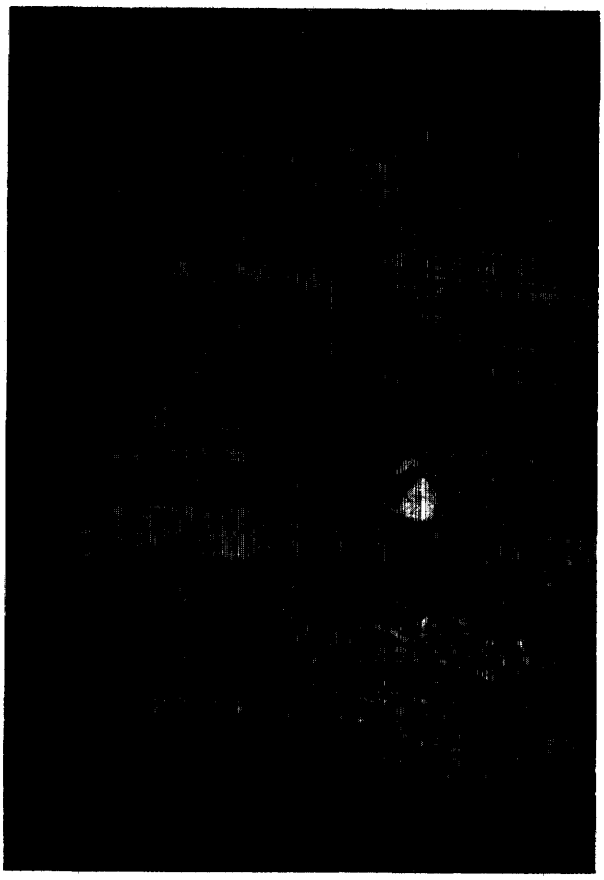


Kakabeka conglomerate, Kakabeka Falls.



Iron-formation outcrops, Current River.

on the Current River. Here about 25 feet is exposed, but the distance to the basement below this section is not known. Results of diamond-drilling by M. A. Hanna Company in McTavish township, made available through the courtesy of this company, are reported to have shown thicknesses of 27–41 feet. At the Shuniah mine, just west of the Current River, a thickness of about 45 feet is indicated.[1]



Regularly bedded chert-carbonate, Highway No. 17, west of the Pass Lake Road.

ARGILLITE-TUFF UNIT

The argillite-tuff unit is very persistent, but in general is poorly exposed. The best outcrops are found in the cuesta faces of the diabase-capped ridges, and in the gorges of the Current River (see Figure 3) and the Kaministikwia River at Kakabeka Falls.

In general the unit is characteristically a black, fissile, thin-bedded argillite, with which are interbedded thin layers of carbonate, thin beds of fine-grained tuff, and a few 2-foot beds of coarse tuff, which are seen only at Kakabeka Falls. These tuffs have a coarse-grained carbonate matrix. Possibly related to them are limestone beds up to 10 feet thick, exposed in Mariday Park, Port Arthur. They

[1]W. M. Courtis, "The Animikie Rocks and Their Vein Phenomena as shown at Duncan Mine, Lake Superior," Amer. Inst. Min. Eng., *Transactions*, Vol. XV, 1886-87, pp. 671-76.

contain considerable chert and traces of volcanic shards and fragments. A similar coarsely crystalline limestone is exposed at the corner of Summit and John streets, Port Arthur, and just below the argillite on the Current River (photo, p. 9).

Farther northeast, about ¼ mile west of Blende Lake, very fine-grained tuffs, some displaying small-scale cross-bedding, are associated with argillite and

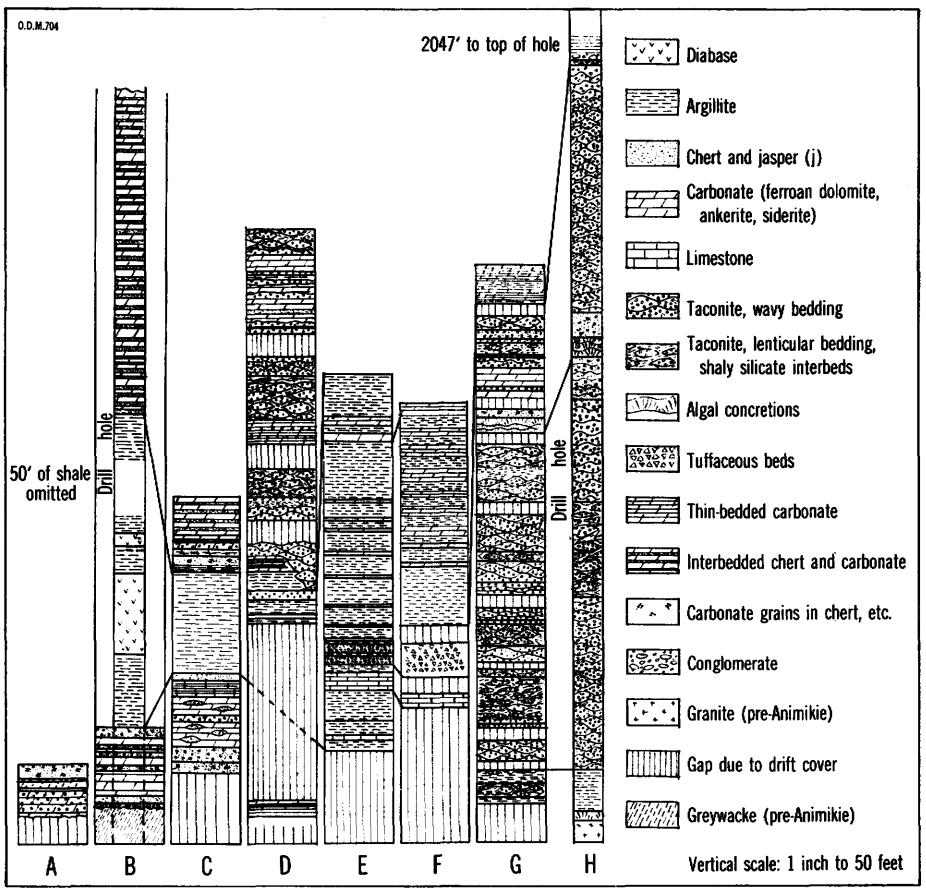


Figure 2—Columnar Sections from Selected Areas and Drill Holes

A—Roadcut south of Loon Lake, highway No. 17.
B—Outcrop east of Pass Lake Road, and log from nearby drill hole.
C—Lyon Boulevard bridge, Current River.
D—McIntyre River.
E—Kakabeka Falls section.
F—Kaministikwia River, south of Kakabeka Falls.
G—Pitch Creek section.
H—Part of drill hole at Mink Mountain (log from A. M. Goodwin).

beds of ferruginous carbonate. Less well characterized tuffs appear as thin layers with normal argillites in beds underlying the diabase east of Silver Harbour.

Along the Current River, the argillites are fairly uniform, thinly laminated, and dark-grey in colour (Figure 3) with little variation, except at the upper transition to carbonate and chert of the Upper Gunflint.

The thickness of the tuff-argillite unit is extremely variable. In the eastern part of the area no exposures of more than 20 feet are to be seen. Drilling records[1]

[1]M. A. Hanna Company.

suggest considerable variation in thickness, 28–105 feet in McTavish township. On the Current River, about a mile upstream from the Lyon Boulevard bridge, 30 feet of argillite is exposed, with chert and siderite both above and below. The most complete and thickest section of argillite exposed is at Kakabeka Falls. Here at least 100 feet of black argillite, with numerous interbeds of ferruginous carbonate, chert, and a tuffaceous zone, comprising several beds of tuff as described above, form the face of the falls. The cap rock of the falls is a massive bed of ferruginous carbonate about 2 feet thick. Downstream from the falls, a rapid change in facies appears to take place, for the upper half of the section becomes rich in carbonate, in the form of thin interbeds with the argillite (see Figure 2).

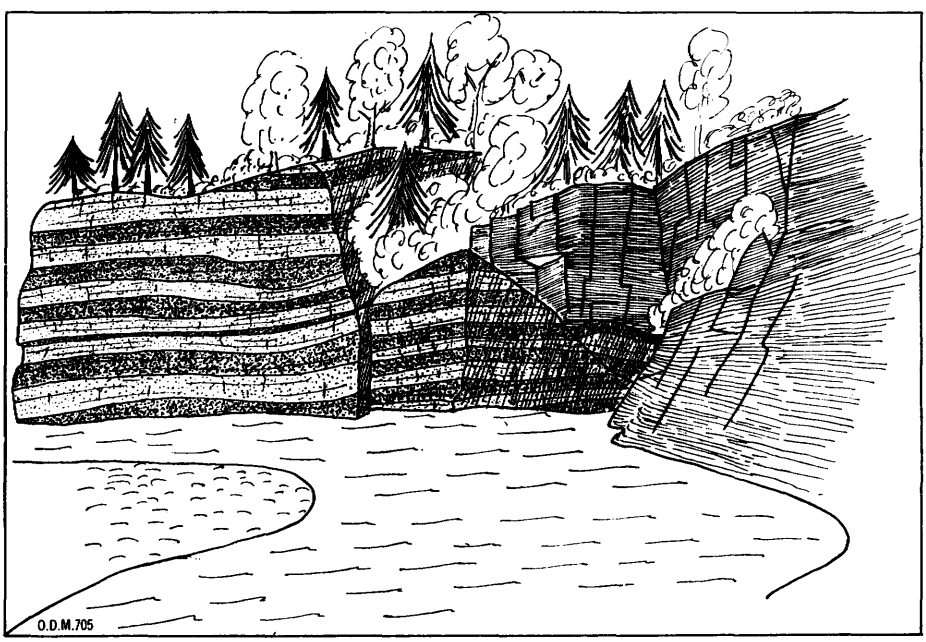


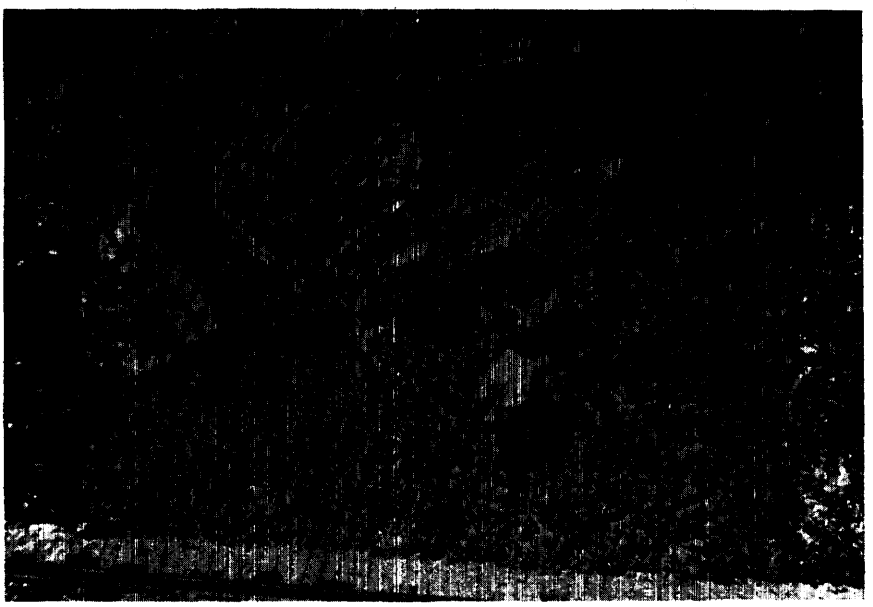
Figure 3—Sketch illustrating argillite and carbonate-chert iron formation in fault contact, Current River.

UPPER GUNFLINT

The Upper Gunflint is a very complex unit, with apparently extensive variations in facies. In the Loon Lake area, however, it is relatively simple, consisting of alternate beds of ferruginous carbonate and chert. The individual carbonate beds average about 1 inch in width and range from ⅛ to 5 inches. The chert beds average ¾ inch in width and range from ⅛ to 2½ inches. Beds of both chert and carbonate show subsidiary fine-scale laminations, and chert beds contain some admixture of carbonate, and vice versa. The principal exposures are found in the vicinity of Chert Lake, and on the Canadian National railway west of the Blende River bridge.

The next major exposure of the Upper Gunflint is along the Current River (see Figure 2, section C). Here again the predominant components are chert and carbonate, but the facies is evidently different from that of the thin-bedded, fissile chert and carbonate to the northeast. Cross-bedded, brecciated beds, and conglomeratic zones occur at several levels. A little greenalite occurs here and there, and stylolitic surfaces form the boundaries of a number of beds.

West of Port Arthur, the Upper Gunflint is well exposed in McIntyre River, Neebing River, and elsewhere, but no continuous section can be constructed owing to the interrupted nature of the outcrop and the presence of faults of unknown displacement. A composite section (Figure 2, section D), based on outcrops on McIntyre River, suggests that about the lower 30 feet is predominantly of thinly bedded chert and carbonate, with interbeds of taconite. Above this is 11 feet of lenticular taconite beds, with interbedded shaly layers. Above this is at least 30 feet of massive, flaggy, lenticular beds of taconite, with occasional shaly silicate interbeds. The irregular bedding shown by many of these outcrops is illustrated in Figures 5 and 6. The lenticular beds range from 1–2 inches to 1 foot in thickness, and from one to several feet in length. When examined in plan, it is found that the lenticular beds have an elongated form, in



Folded thin-bedded chert-carbonate, railway cut, west of the Blende River bridge, C.N.R.

which the east-to-northeast trending dimension is several times the dimension at right angles. In effect these taconite beds are windrows or drifts of granules, and their elongation noted above probably corresponds with the trend of the shore line along which they accumulated. Cross-sections of these structures give the appearance of crude and irregular ripple marks. The term wavy bedding may be applied to this feature.

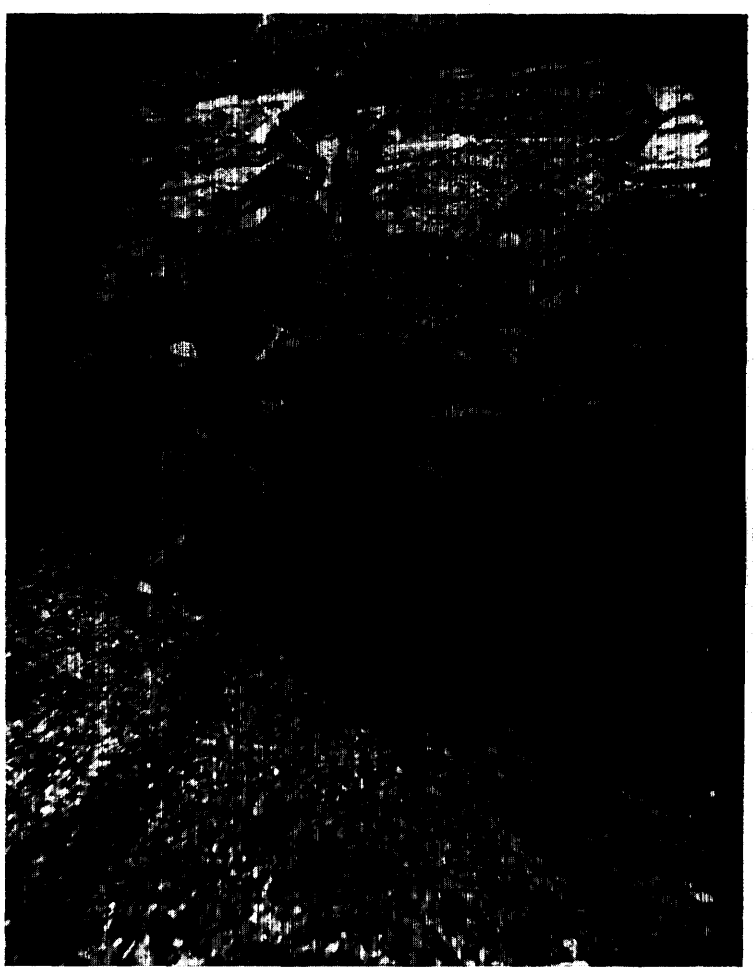
In the western part of the area, the Upper Gunflint is very thick, being 253 feet thick at Mink Mountain.[1] To the northeast, due in part to the truncation of the Gunflint by the Keweenawan sediments, and probably to an actual thinning of the section in this direction, the Upper Gunflint appears to be much thinner. The maximum thickness measured by the author is 130 feet. Smith[2] reports a thickness of 200–250 feet, and Van Hise and Leith[3] give 250–300 feet, but available drill information and detailed mapping do not substantiate these figures.

[1]A. M. Goodwin, *op cit.*, p. 7, Table I.
[2]W. N. Smith, "Loon Lake Iron-bearing District," *Annual Report*, Ont. Bur. Mines, Vol. XIV, 1905, pt. 1, p. 258.
[3]C. R. Van Hise and C. K. Leith, *The Geology of the Lake Superior District*, U.S. Geol. Surv., Monograph No. 52, 1911, p. 206.

ROVE FORMATION

The Rove Formation consists predominantly of dark-coloured fissile argillites. Some calcareous beds occur, and in the vicinity of Pass Lake, varicoloured green and red shales appear.

An outstanding feature of the Rove is the presence of calcareous concretions up to 8 feet or more in diameter (see accompanying photo and Figure 4). A few are exposed in a roadcut on the Pass Lake road. Very many concretions are to be



Concretion in quarry of Rove argillite, Pass Lake Road.

seen in cliffs of argillite along the Slate River. They were first referred to by Logan.[1] The concretions occur at definite horizons in these argillites, and the concretions of each appear to have a characteristic form. The concretions partly replace and preserve the bedding of the enclosing argillites, and partly displace and distort them. Generally the carbonate is fine-grained and dark in colour, but some carbonate is in coarse, flamboyant, dark crystals, and some layers, in a few concretions, are pure white crystalline carbonate. Pyritic cores are often

[1]Sir William E. Logan, "Report on the Geology of Canada," *Report of Progress to 1863*, Geol. Surv. Can., 1863, p. 69.

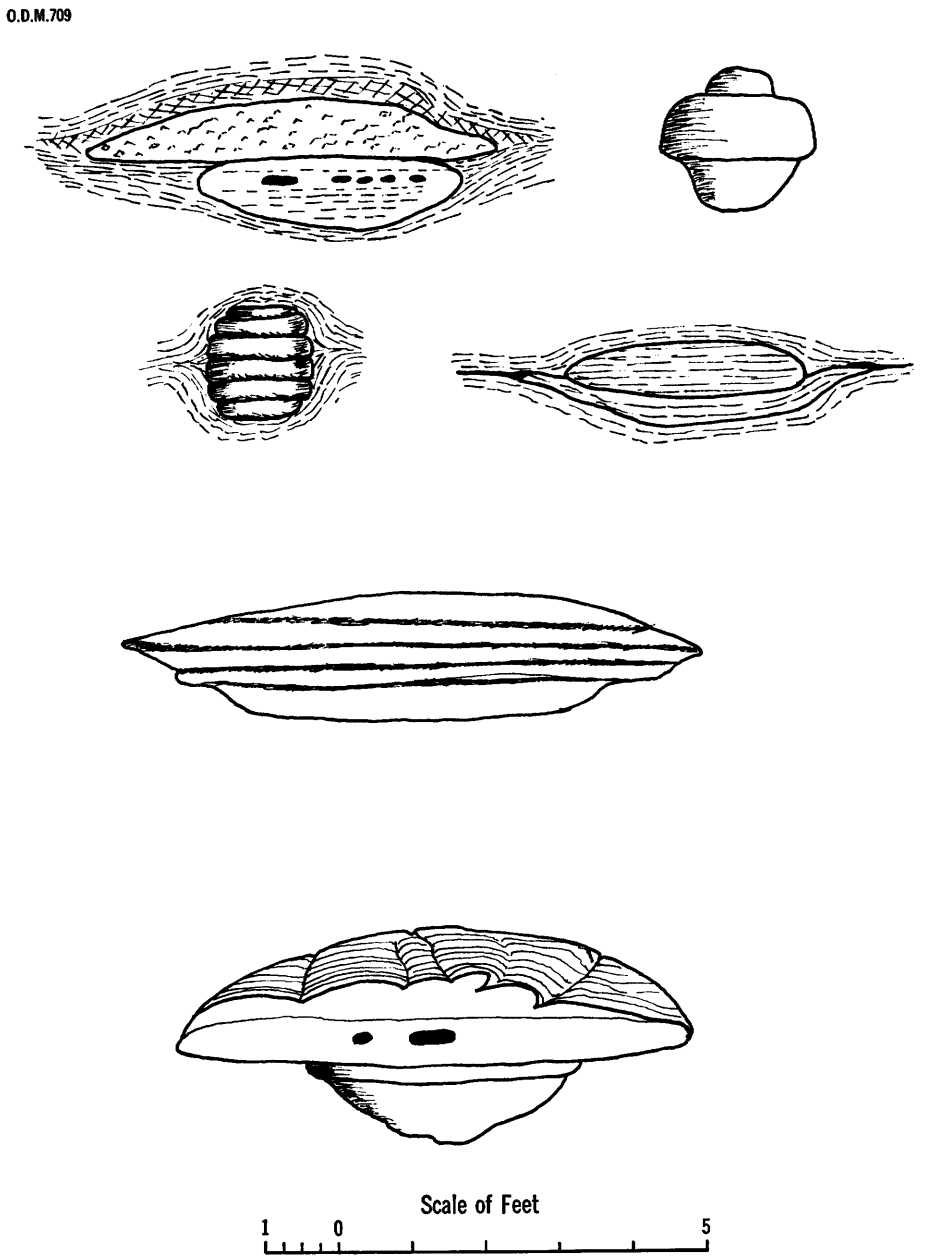


Figure 4—Sketch of various types of concretions, Rove argillite on Slate River.

present. Cone-in-cone structures may occur at the borders of the concretions, as described by Tanton[1] and Logan.[2]

The thickness of the Rove formation is reported to approach 3,000 feet in Minnesota.[3] Southwest of Fort William, Tanton estimates a thickness of 2,000 feet or more; in the vicinity of Pass Lake he finds only 130 feet.[4] To the north, the Rove thins owing to the unconformity that separates it from the overlying Sibley sediments. West of Loon Lake, the Sibley overlaps the Rove and the underlying Gunflint to lie on the Archean.

The Rove appears to be conformable with the underlying Gunflint formation. The marked reduction in thickness of the Gunflint to the northeast is thought to be a result of the thinning of the formation in this direction rather than due to an erosion surface below the Rove. No other evidence of unconformity was recognized.

Unconformity between the Rove and the Sibley

A pronounced and general angular unconformity does not appear between the Rove and the overlying Sibley formation. Locally, however, an angular discordance is apparent.[5] (See Figure 7.) Moreover, the greatly reduced thickness

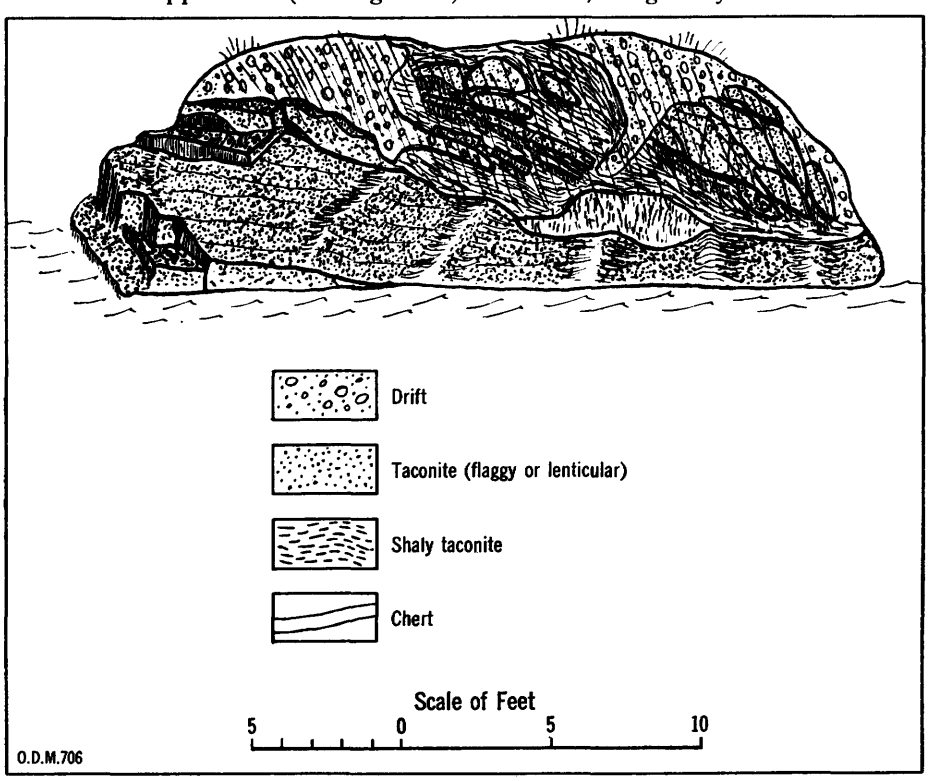


Figure 5 — Irregular, lenticular bedding in taconites, McIntyre River, showing elongated "windrows" of granules appearing in the outcrop.

[1]T. L. Tanton, *Fort William and Port Arthur, and Thunder Cape Map-Areas, Thunder Bay District, Ontario*, Geol. Surv. Can., Memoir No. 167, 1931, p. 42.
[2]Sir William E. Logan, *op. cit.*, p. 68.
[3]F. F. Grout and G. M. Schwartz, Bulletin No. 24, Minnesota Geol. Surv., 1933, p. 16.
[4]T. L. Tanton, *op. cit.*, pp. 36, 37.
[5]L. P. Silver, "The Animikie Iron Range," *Annual Report*, Ont. Bur. Mines, Vol. XV, 1906, pt. 1, p. 169.

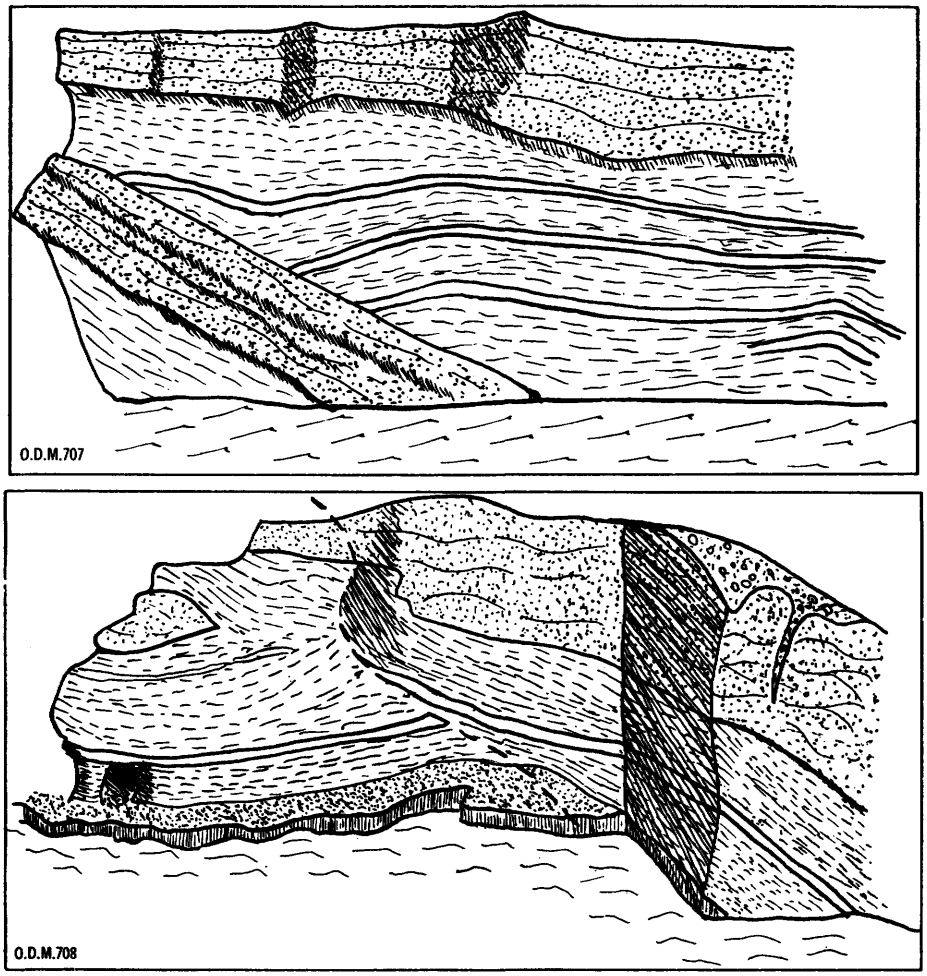


Figure 6—Irregular, lenticular bedding in taconites, McIntyre River. (See Figure 5 for legend.)

of the Rove in the northeastern part of the area, and the progressive cutting out of the Rove and the Gunflint as the Sibley overlaps onto the Archean, suggest a prolonged period of erosion, with deposition of the Sibley on the resulting erosion surface. Since throughout Animikie and Keweenawan time, the Port Arthur area was a relatively stable one, the lack of an angular unconformity of regional extent is not in itself proof that there is no great interval between the Animikie and the Keweenawan.

Keweenawan

SEDIMENTS

Sibley Formation

Since the primary purpose of this report is to describe the Gunflint iron formation, the Sibley formation has been studied only along the cliffs forming the eastern boundary of the Animikie, between Pass and Loon lakes.

In this area, the basal unit of the Sibley is a conglomerate, which appears to be rather erratic and variable in its thickness; it reaches a maximum thickness of 36 feet, but pinches out in places. It contains interbeds of sandstone, some of

which are red and ferruginous, and for part of its outcrop, encloses a band of creamy coloured limestone up to 6 feet thick.

The conglomerate is well exposed in a rock-cut on the Canadian Pacific railway, west of Loon Lake. (See accompanying photo.) The lower, western, exposures contain a predominance of iron formation boulders, while the upper, eastern, part contains a predominance of granite boulders. In the western part, a 5-foot-square area of the conglomerate was found to contain 12 boulders of granite, 43 of iron formation, 6 of vein quartz, and 1 each of pegmatite, chert syenite, greenstone, and quartzite. In the eastern part, a similar area contained 145 boulders of granite, 4 of iron formation, 3 of vein quartz, 7 of pegmatite, 2 of chert, 17 of greenstone, 2 of quartzite, and 1 of jasper. The matrix is predominantly carbonate, particularly in the eastern part of the cut. The largest boulders measured had major and minor dimensions of 18 inches and 10 inches

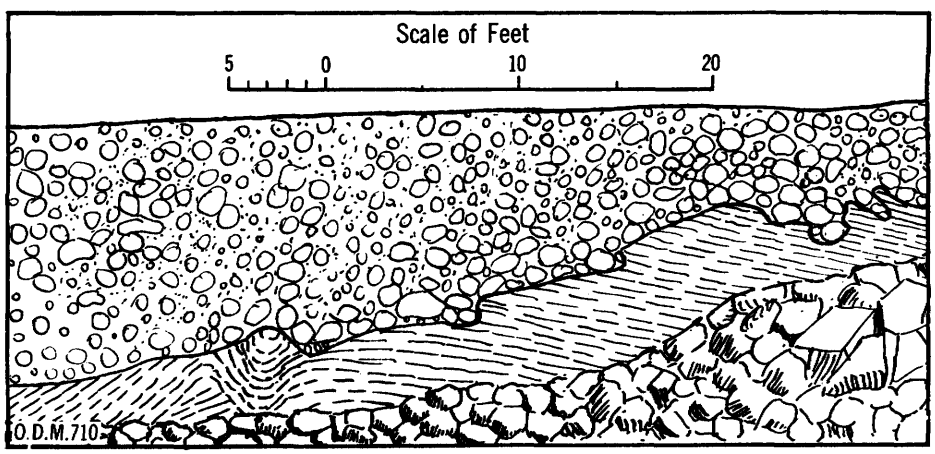


Figure 7—Sketch showing unconformity between Rove argillite and Sibley conglomerate.

when iron formation, 15 inches and 9 inches when granite. Boulders and pebbles of other rock types are much smaller. In all, 20 feet of conglomerate is exposed in this cut, of which the topmost 5 feet is mostly limestone.

In some places along the cliff, north of Pass Lake, the conglomerate is represented by coarse, thin-bedded, red and white sandstones, sometimes with scattered pebbles.

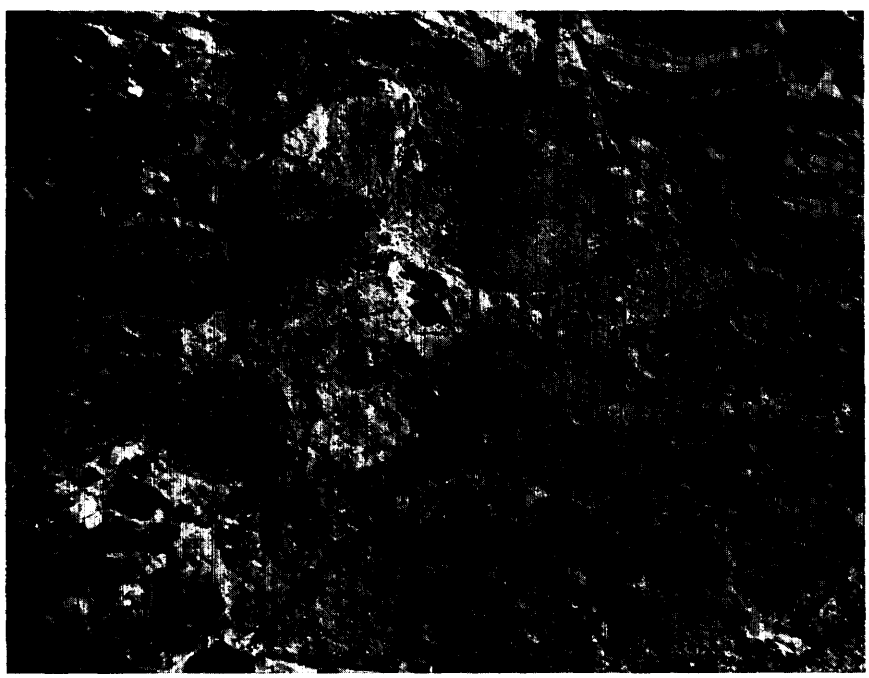
The conglomerate is overlain by a section of rather loosely consolidated white to yellowish sandstone. Some sections show fairly thick beds, 3 feet or so, at the bottom of the layer, becoming thinner bedded towards the top. Even the thicker beds show traces of thin lamination within them. Some outcrops show vague ripple marks and cross-bedding, but in general the bedding is the most prominent feature of this unit. A thickness of as much as 51½ feet has been measured in the cliffs north of Pass Lake. Thin quartz stringers, filling joints, are a noticeable feature of the outcrop of this sandstone, because owing to their superior resistance to weathering, they stand out above the surface of the sandstone that they cut.

This sandstone, which is Unit B of Tanton's subdivision of the Sibley, is overlain by a second sandstone, reported to be 40 feet thick by Tanton and called by him Unit C. In the area examined in the present survey, the two sandstones are similar if not identical, and no attempt was made to separate them on the map.

Unit D of Tanton, overlying the preceding formations, is composed of limestone and chert. It was encountered only west of Silvern Lake, where it was

about 10 feet thick. Tanton reports a maximum thickness of 3 feet on Thunder Cape and the Sibley Peninsula.

Between Iron Lake and Silvern Lake, and south and east of Pass Lake, the succeeding Unit E is represented by brick-red, massive carbonate rocks and deep-red shaly material. In thin section the carbonate rocks are found to be of unusual character, for clastic sand grains of quartz and feldspar are enclosed in a fine-grained, iron-stained carbonate. The only structure visible in the outcrop, apart from the bedding indicated by shaly layers, is the presence of pale-greenish to yellowish spots in the otherwise red rocks. Many of these blotches enclose a black spot or grain about the size of a pinhead. It is thought that this black spot



Sibley conglomerate, carbonate matrix.

is organic matter, and that the ferric iron typical of this formation has in its vicinity been reduced to the ferrous condition, resulting in the change in colour. The more shaly phases of the unit appear to be very rich in iron. Large hills of the massive red carbonate rocks and shaly material are visible south of highway No. 17, between Loon Lake and Nipigon.

The top unit of the Sibley, Unit F, and the overlying Osler series of sediments and volcanics were not encountered in the area mapped and have not been examined. They are briefly described in Tanton's report.[1]

INTRUSIVES

Logan Sills and Diabase Dikes

The Logan sills of diabase are the most important structural units in the topography of the Thunder Bay region, forming as they do the cap rocks of the typical cuestas, buttes, and mesas that surround the Bay. (Photos, pp. 4 and 20.)

[1]T. L. Tanton, *op cit.*, pp. 55, 57–62.

In contrast to the sills in the Lake Nipigon region, which may reach thicknesses of 1,000 feet, the Logan sills are relatively thin. The greatest thickness recorded by Tanton is 200 feet, this being the thickness of the sill remnant capping Mount McKay and the adjacent eminences. Most of the sills whose thicknesses were measured in the area mapped, were considerably less than 100 feet. It is rarely possible to determine the full thickness, since the capping of most has been removed by erosion, and the bases of many are concealed by talus. Many sills are of course considerably thinner; for instance, a sill lower down on Mount McKay, which forms the floor of the lookout on the north face of the hill, is only 15 feet thick. It is impossible to state confidently the number of sills represented in the area, because of repetition by faulting.



Diabase outcrops, Oliver Lake, west of Fort William.

The term sill is actually inappropriate for these intrusions, since many of them cut across the Animikie at a low angle. Those along the coast northeast of Port Arthur are in many places in contact with pre-Animikie granite at the lake shore, but a short distance inland they have cut through the Lower Gunflint to insinuate themselves into the argillites overlying it. In fact, northeast of Port Arthur, the diabases occur very generally in the argillite-tuff unit. Since they cut across the formation in this way, these intrusions should be called sheets rather than sills.

The petrology of the diabase sheets has been described by R. G. Blackadar.[1] Except near their contacts, the diabases are olivine diabases, invariably with a small amount of quartz, which is mostly intergrown with alkali feldspar as micropegmatite. The diabase is considerably altered at its contacts with argillite, becoming enriched in biotite and hornblende.

Several variations in texture are found in the diabase. The most striking variations are visible on broad, gently sloping upper surfaces of the sheet north

[1]R. G. Blackadar, "Differentiation and Assimilation in the Logan Sills, Lake Superior District, Ontario," *American Journal of Science*, Vol. 254, 1956, pp. 623–45.

of Navilus, just northeast of Port Arthur. The diabase is very light coloured and contains numerous crystals of feldspar together with grains of bluish milky quartz readily visible to the eye. In the vicinity of these grains, the diabase may have a lamprophyric aspect. This anorthositic phase of the diabase is apparently due to incorporation of granite material, in which the potash feldspar has become dissolved in the diabase, while the larger plagioclase and quartz grains have survived. The plagioclase is, however, fretted by the diabase and veined by fine-grained pyroxene. Many of the quartz xenocrysts are enclosed in rims of pyroxene. Lamprophyric phases of the diabase are also developed around a large inclusion of granite, 400 feet long, in diabase on Mary Island just west of Silver Harbour.

At several places along the shore northeast of Port Arthur, granite outcropping is coated with dense trap (chilled diabase), which contains fragments of granite up to a few inches in diameter.

In addition to the xenocrysts of feldspar and quartz mentioned above, there are local porphyritic phases in the diabase sheets. The best developed is found in an abandoned trap-rock quarry northwest of Navilus. Here are found greenish phenocrysts, some of which are several inches in diameter; epidotic blotches also occur in the upper part of the quarry face.

On Conmee Point and on the small island to the east, the upper contact of the diabase with shale has been marked by the development of a distinctive hybrid rock. Very white weathering, the rock is a siliceous, sodic granite, containing numerous black inclusions of argillite. Argillite overlying the granite is contorted and injected by the granite. Thin sections of the argillite inclusions show that it has been almost completely replaced by albite laths, the form and colour of the inclusions being due to fine-grained carbonaceous matter that still outlines the original bedding.

Diabase dikes are not common in the area mapped. Most of those observed are in the sandstone cliffs east of the Pass Lake road. Their relationship to the diabase sheets is not known, but there is no reason to think that they are different in age.

STRUCTURAL GEOLOGY

The dominant structural feature of the area is the gentle southerly dip of the Animikie and Sibley strata, and the associated diabase sheets. The dip varies considerably, about 0–12 degrees, and local reversals may be observed on the accompanying maps.

Localized folding is present, particularly in the banded chert-carbonate of the Upper Gunflint south of Blende Lake. These structures are very well exposed along the Canadian National railway west of the Blende River bridge. (See Figure 8, and photo on p. 13.) These thinly bedded formations have been thrown into small folds, which range in width from 100 to 300 feet or more. Some of the folds are recumbent. In several of the more highly deformed folds, the carbonate in the core of the fold has flowed, fragmenting the enclosed chert, so that a very distinctive chert-carbonate breccia has formed. The cause of these structures is not clear. In this occurrence, the folds overlie the diabase sill. Similar structures in other parts of the Gunflint range do not have this relationship. It seems possible that here the deformation may have resulted from the heat and movement of the underlying diabase. Gill and Goodwin have attributed it to slump of unconsolidated sediments due to volcanic disturbances. Their localized character proves that the folds can hardly have resulted from normal orogenic forces.

Faults

Faulting is widespread in the area. The faults recognized are, with one exception, steeply dipping faults of the normal type. They are marked by breccia and slickensides, and are commonly filled with vein material, consisting largely of quartz, amethyst, fluorite, barite, and carbonate, often well crystallized. Lean mineralization of galena and sphalerite is found in almost all of these veins, and silver has been mined from several of them. The most productive mine was on Silver Islet, which lies outside the map area. The faults are all younger than the consolidated rocks of the area, since they cut all rocks including the diabase sheets. Diabase dikes may occupy some of these faults, which must therefore be Precambrian in age. Most of the faults strike east-west to northeasterly. A number of faults have also been recognized with north-south to northwest strikes. Owing to the extensive drift cover, it is probable that faults are much more

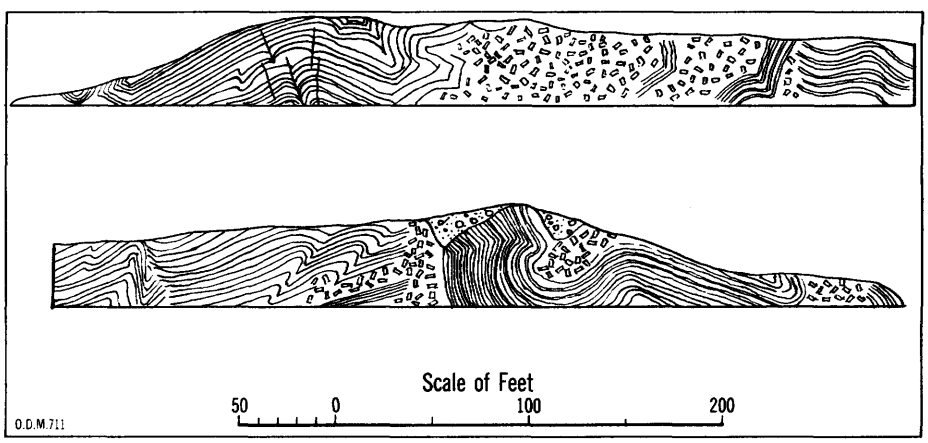


Figure 8—Sketch of folding in thin-bedded chert and carbonate; rock cut on Canadian National railway, west of Blende River bridge. Cores of folds made up of breccia or chert in carbonate. Top section, north side of cut, looking north; bottom section, south side of cut, looking south.

abundant than appears from the maps. Lawson[1] and others have suggested that the succession of north-facing cuestas and cliffs, typical of the Thunder Bay area and northern Minnesota, result from faulting. Since in the area mapped, some of these cuestas are evidently the result of erosion alone acting on gently dipping sediments and intrusive sheets of variable resistance, only those faults have been indicated that are marked by breccia zones, veins, and slickensides.

In general, the fault pattern in the area appears to be the result of vertical movements of small crustal blocks. This type of fracturing is probably attributable to the failure of the competent pre-Animikie crystalline complex resulting from the downwarping of the Lake Superior basin.

A major factor in the structure of the Animikie area in Ontario is the nature of the Lake Superior basin in this region. Martin[2] has shown that the northwest shore of the lake in Minnesota and its continuation across the mouths of Thunder Bay and Black Bay, and the off-shore islands opposite Nipigon, is a relatively steep scarp with a relief of 1,000–1,200 feet. He regards this as a fault-line scarp,

[1]Lawson, *Bulletin*, Geol. and Nat. Hist. Surv., Minnesota, No. 8, 1893, p. 33.
Lawson, *Twentieth Annual Report*, Geol. and Nat. Hist. Surv., Minnesota, 1891, p. 192.
[2]C. R. Van Hise and C. K. Leith, *The Geology of the Lake Superior District*, U.S. Geol. Surv., Monograph No. 52, 1911, pp. 112–15.

that is, an ancient fault scarp resurrected by glacial erosion. This scarp is parallel to the main direction of faulting in the Port Arthur area. Apparently there have been relatively late movements along some of these faults; Gill[1] reports a fault displacement of a glaciated surface west of the present map area.

Measurement of displacements along the faults is usually difficult because of the lack of distinct marker horizons. Most of the faults appear to be minor; the largest movement observed was 40 feet, on a fault exposed in the face of the Sibley cliffs east of the Pass Lake road. Courtis'[2] cross-section of the Shuniah mine indicates a displacement on the fault, in which the vein is located, of nearly 120 feet. Gill[3] mentions a displacement of 300 feet on a fault in the North Lake area west of Whitefish Lake. Van Hise and Leith[4] report a displacement of 300 feet on the fault south of Loon Lake. It is probable that few faults in the area mapped have such large movements.

Only one unimportant flat-dipping fault has been recognized in the area; this cuts argillite on the west branch of the Current River near the north boundary of the map area.

GUNFLINT IRON FORMATION

The stratigraphy of the Gunflint formation has been outlined above. It is now proposed to discuss the mineralogy, textures, and sedimentary structures, chemistry, and economic geology of the Gunflint.

Mineralogy

A variety of minerals occur in the different phases of the Gunflint; variations in the proportions of these minerals, and in their textures, result in many mutually gradational rock types, the lithology of which can only be described in general terms. A considerable amount of mineralogical work has been done by B. A. Bradshaw[5] on specimens of the Gunflint collected by the author. Much of what is reported in this section comes from this source.

The minerals of the Gunflint may be classified briefly into silica minerals, oxides, carbonates, and silicates.

SILICA MINERALS

Quartz

Quartz occurs sparingly in the Gunflint as clastic sand grains. Of far greater importance is its occurrence as recrystallized chert. In many of the taconites, all gradations appear from extremely fine-grained chert to well-crystallized quartz. Most of the quartz occurs within the cores of granules, as mosaic aggregates, but in some taconites it develops extensively in the matrix of the granules. Quartz and amethyst are the most abundant constituents of the veins that occupy the late faults in the iron formation.

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[1] J. E. Gill, "Gunflint Iron-Bearing Formation, Ontario," *Summary Report*, Geol. Surv. Can., 1924, Part C, p. 51C.

[2] W. M. Courtis, "The Animikie Rocks and Their Vein Phenomena as shown at Duncan Mine, Lake Superior," Amer. Inst. Min. Eng., *Transactions*, Vol. XV, 1886–87, pp. 671-77.

[3] J. E. Gill, *op. cit.* p. 40C.

[4] C. R. Van Hise and C. K. Leith, *op. cit.* p. 208.

[5] B. A. Bradshaw, *Petrological Comparison of Lake Superior Iron Formations*, unpublished Ph.D. Thesis, University of Toronto, 1956.

Chert

Chert is the most characteristic silica mineral in the iron formation, and one of its most abundant constituents. It occurs: in distinct beds and lenses; as granules in taconites and carbonate beds; as patches, nodules, veins, and replacements in carbonate; as concretions or nodules and beds in argillites; and as algal structures. The grain size is extremely variable. In some taconites, the grain size is so minute that individual granules of chert stand out under crossed nicols because of their very low birefringence; in others, the chert shows all gradations in grain to quartz.

Jasper is chert that owes its colour to fine-grained disseminations of hematite. It is erratic in its distribution, but is often associated with algal beds. A deep-green chert or jasper is less common than the red variety but may be found locally west of Port Arthur.

Chalcedony

Chalcedony is closely related to chert and is found in some taconites as a matrix of the granules, and locally in vugs, veins, and colloform crusts. It is distinguished by its fibrous, flamboyant appearance under crossed nicols and its low index of refraction as compared with chert and quartz. It does not occur in large amounts in the Gunflint.

OXIDES

Magnetite

Magnetite is present in many specimens of taconite, mostly as tiny grains, often euhedral in form. In a few taconites, granules of magnetite, free from other minerals, occur, but generally the magnetite forms clusters in, or rims around, the granules. Magnetite is quite abundant in beds of iron formation immediately beneath diabase sheets, in some specimens being accompanied only by a little chert. Except in this relatively restricted situation, magnetite never attains the abundance that characterizes its occurrence in the Lower Cherty of the Mesabi Range. Some granules of magnetite are thought to be original constituents of the sediment, since they are found in association with granules of carbonate, chert, and hematite.

Hematite

Hematite is the most abundant oxide in the Gunflint. Many chert granules and silicate granules contain fringes, clusters, and grains of hematite. These may be in the form of fine dust, or in distinct blades, which often project beyond the borders of the granules. Some granules consist exclusively of hematite, and thin beds in the Lower Gunflint, for instance on the Current River at Hodder Avenue, on a small creek near Birch Beach, and on highway No. 17 south of Loon Lake, are made up exclusively of granules of hematite or of hematite and magnetite.

Some massive hematite is exposed in heavily mineralized zones in old workings north of Bittern Lake. Brilliant crimson carbonate, exposed just south of highway No. 17 near Loon Lake, owes its colour to very finely divided hematite. Similar hematite, widely dispersed in small amounts, is responsible for the colour of jasper.

Goethite and Limonite

Yellowish to reddish limonite crusts and coatings are common on weathered surfaces of the iron formation and occupy fractures. Carbonate-rich iron formation is particularly subject to this weathering effect.

Goethite crystals are also found locally as crusts on weathered iron formation and are frequently encountered as small grains and patches in thin sections of surface taconite specimens.

CARBONATES

The carbonates show a considerable variety in composition. Calcite is relatively uncommon, except in limestone beds within, and immediately below, the argillite-tuff unit of the Gunflint, and in the Rove argillite. Mention has been made of abundant calcite concretions in the Rove formation on the Slate River and elsewhere. Dolomite, ferroan dolomite, ankerite, and siderite are all found in the iron formation. These minerals are not readily distinguished in thin section, but index determinations by Bradshaw suggest that ferroan dolomite is the most abundant carbonate, and available analyses of carbonate iron formation support this conclusion. The carbonates occur in a variety of forms and relationships: (1) interbedded with chert in thin, finely laminated beds of fine-grained carbonate and cherty carbonate; (2) interbedded with argillaceous beds at Kakabeka Falls and in the Current River; (3) massive beds of fine- to medium-grained carbonate; (4) fragments in, and matrix of, intraformational breccias and conglomerates; (5) matrix of many taconites; (6) replacing chert granules; (7) as granules like chert, silicates, and oxides; in a few taconites they are the principal granules; (8) stringers of carbonate cutting many of the iron formation members.

SILICATES

Identification of the silicates in the iron formation is difficult because of the varied colour and habit of each species and the lack of diagnostic optical properties in the fine-grained granules. In many thin sections, the silicates are so fine-grained or so darkened by oxidation that they cannot be identified optically with certainty. Such occurrences can only be described as iron silicates, and any more precise terminology is quite unjustified without the application of more exact methods of identification.

Greenalite

Greenalite is regarded as one of the most typical constituents of the Animikie iron formations. It is a poorly characterized iron silicate, which occurs typically in the form of granules and is described by Gruner and others as optically isotropic. In all the thin sections of iron formation examined by the author, no definitely isotropic material could be found. All greenish minerals occurring as granules, patches, flakes, or layers, showed at least feeble interference colours. The presence of greenalite has been confirmed by Bradshaw with X-ray powder photographs. Without these it is impossible to obtain a reliable identification.

Many chert granules in the taconites are stained green or brown, either on the rims or throughout the granule. These stains have been attributed by most authors to submicroscopic greenalite, but there seems little justification for this assumption.

Stilpnomelane

The biotite-like mineral stilpnomelane was shown by Gruner to occur in the Mesabi range. It occurs fairly abundantly in the Gunflint taconites, but is somewhat erratic in its distribution. It varies from clear pleochroic flakes and rosettes to dense, brown aggregates in which the optical properties are difficult to observe.

Minnesotaite

This pale-green, iron-rich talc is also found in the taconites, as fibrous bundles and fine-grained aggregates. It is less abundant in the Gunflint than in similar taconites from the Mesabi range.

Chamosite

The mineral chamosite is reported from the Gunflint by Bradshaw from X-ray identification. It appears as bright blue-green granules and flakes in some of the carbonate-rich members of the Gunflint. Its abundance in the Gunflint is not yet known.

Chlorite

Chlorite flakes were observed in several specimens as alterations of stilpnomelane. Possibly many of the patches and granules of green, weakly birefringent material, which have been referred to as greenalite, are actually chlorite. Much more work is required before a reliable estimate of the abundance of chlorite in the iron formation can be made.

OTHER MINERALS

Pyrite is present locally in the iron formation, usually as small crystals and aggregates. In the argillites at the foot of Kakabeka Falls, it occurs in concretions up to one inch or more in diameter, and as rims on chert nodules.

Occasional grains of chalcopyrite may be seen in the taconites along Pitch Creek.

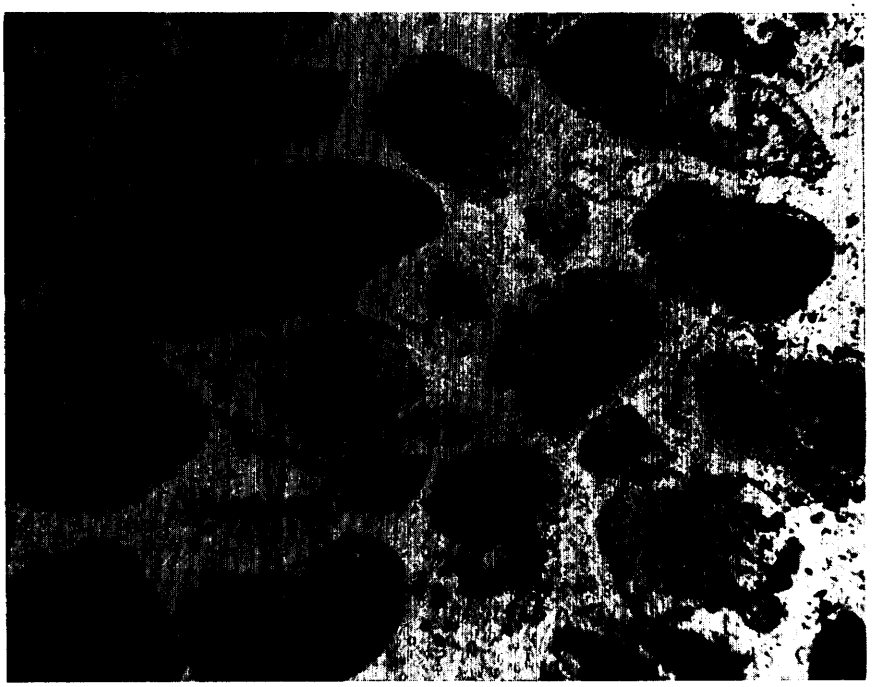
Tiny grains of what appears to be apatite are occasionally seen in the taconites.

Organic matter is present in many phases of the iron formation, but more particularly in well-bedded carbonate rocks and in the argillites. Brownish streaks and lenses in the carbonate are probably carbonaceous matter. Anthraxolite or a similar brittle hydrocarbon is associated with the algal concretions at Hillside, on the Whitefish River. Stylolitic surfaces, found in many outcrops at the contacts of cherty and carbonate-rich beds, are coated with carbonaceous material.

Texture and Sedimentary Structures

TACONITES

The taconites are characterized by their granule texture. The granules are fairly uniform in size, generally 0.5–1 millimetres in diameter. They are mostly oval or slightly flattened in shape and are sometimes described as oölites, but they lack the concentric pattern of the latter. They are composed of oxides, carbonate, chert, silicates, or various combinations of these minerals. (See accompanying photos.) Many of the chert granules are enclosed in a multiple border of greenish or brownish chert. Others have borders, cores, or patches of hematite or magnetite. The silicates also may make up entire granules or may occur as wisps and patches within chert or chert-oxide granules. Silicate, chert, and chert-silicate granules of the taconites on the McIntyre River, Neebing River, and Pitch Creek generally differ somewhat in their shape, being angular rather than rounded. (See photo, p. 29). In most sections of taconites, occasional composite granules or fragments are found enclosing several granules of normal size. Chert granules showing this feature sometimes enclose the smaller ones within single or multiple coloured rims such as are shown by those of normal size.



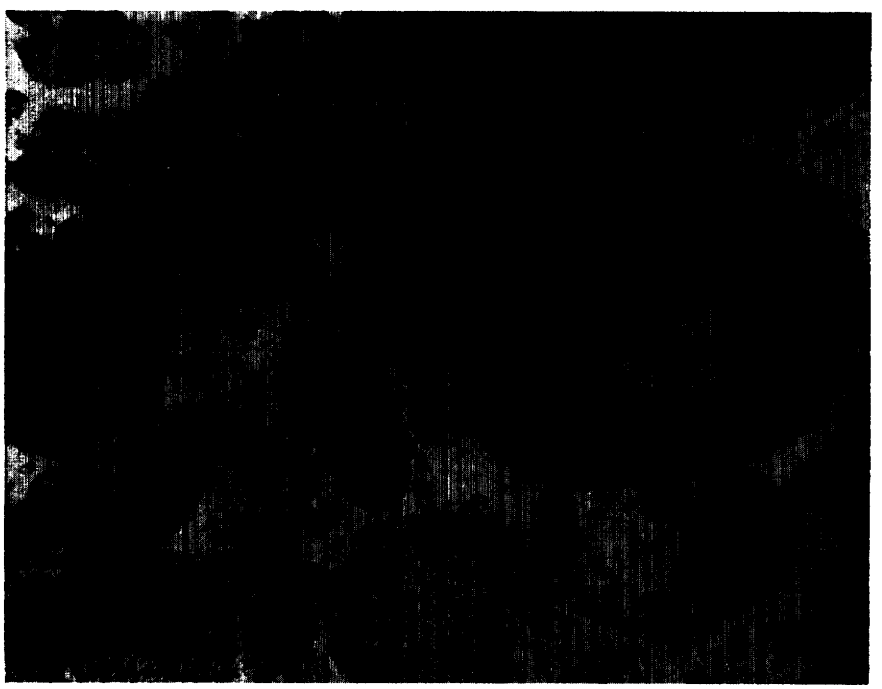
Taconite with granules of iron oxide (opaque) and chert (indicated by iron oxide dust). Plane light.



Taconite showing hematite granules and chert granules with blades of hematite. Plane light.



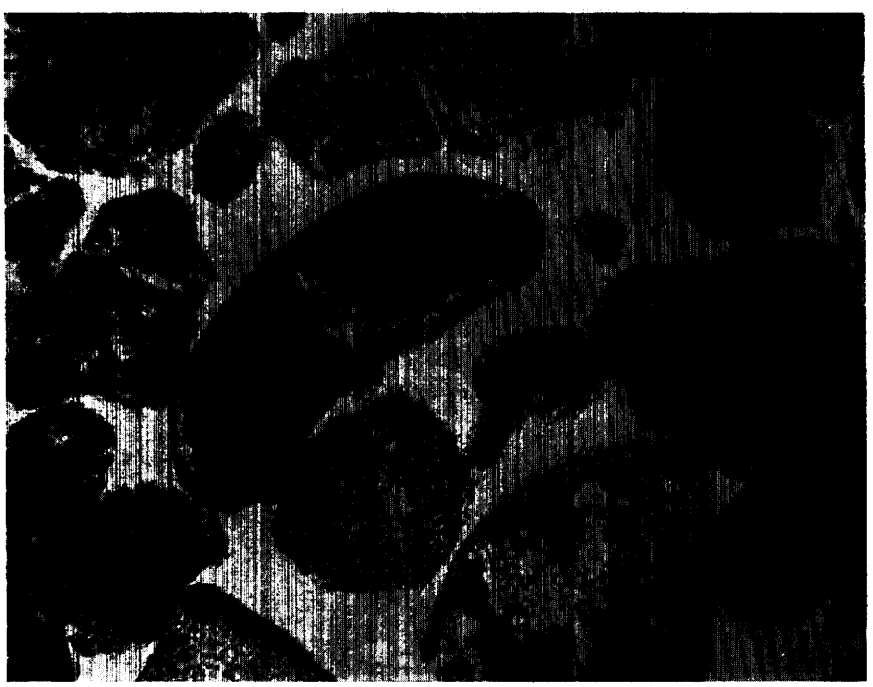
Hematite granules, showing flattened character, enclosed in chert. Plane light.



Oölite of chert and hematite with granules of chert and hematite. Plane light.



Granules of carbonate (dark) veined with chert, and granules of chert, replacing carbonate, and retaining traces of veins, which cut carbonate, before replacement by chert. Plane light.



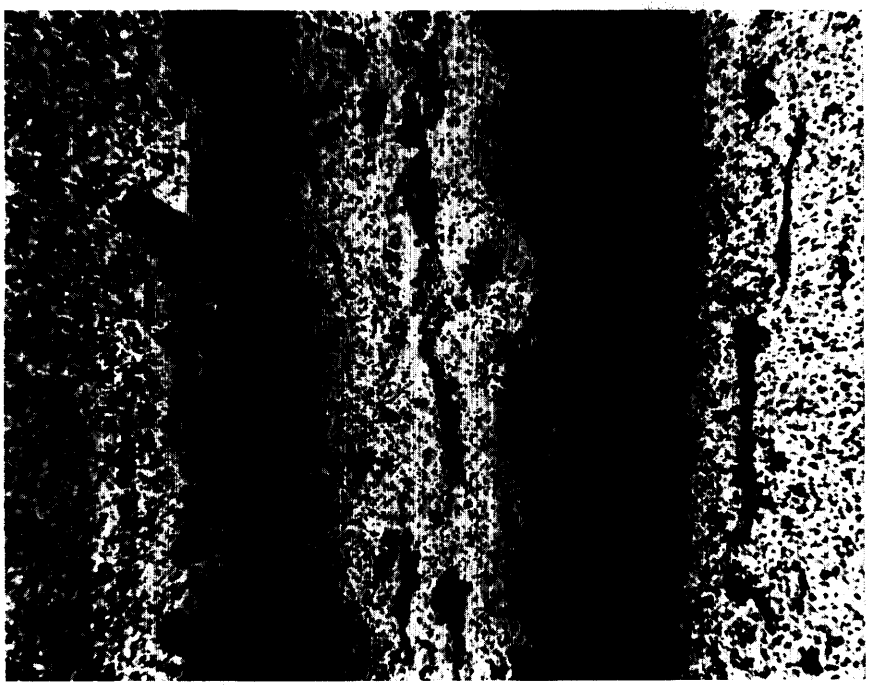
Taconite showing granules of iron silicate, silicate and chert, and chert, in a matrix of recrystallized chert. Plane light.



Taconite with angular, shard-like fragments. Plane light.



Shaly iron silicate with spherulitic carbonate grains from layer between taconite lenses. Plane light.



Thin bedded chert-carbonate; opaque bands are oxidized carbonate. Spots in chert are cores of spherulitic structures. Plane light.



Intraformational conglomerate, Upper Gunflint, Current River. Rounded dusty grains are carbonate. Clear grains and patches are quartz (some clastic). Dark to opaque grain may be volcanic. Matrix largely carbonate. Plane light.

No general paragenetic relationship can be given for the minerals in the granules. Chert is frequently found to replace carbonate (see photo p. 29), but carbonate crystals are often found encroaching on chert granules. Hematite occurs in chert granules in relationships that suggest that it has recrystallized, often forming quite large plates, but it is questionable if this indicates a replacement of the chert by the iron mineral. It probably involves only redistribution. Similar relationships are shown by magnetite.

Thin shaly layers between lenses of taconite and wavy-bedded taconites are composed of silicates and fine-grained carbonate, or spherulites of carbonate. (See photo p. 30.)

THIN-BEDDED CARBONATE AND CHERT

Successions of alternate thin beds of chert and carbonate are typical of the Upper Gunflint south of Loon Lake and of other areas such as the Current River and Kakabeka Falls. Locally they are also components of the Lower Gunflint, for instance, east of Hodder Avenue and in McIntyre township. Both carbonate and chert beds are very fine-grained, although in some samples, coarse euhedral crystals of carbonate fringe and replace the chert layers. Chert layers usually contain some carbonate, and carbonate layers contain some chert. In thin section, both chert and carbonate beds contain tiny spherical bodies, which contain a brownish core, possibly an organic stain. These bodies have a characteristic radiating appearance. (See photo, p. 31.)

Typically, the only structure of this facies is its thin lamination and regular bedding. In a few exposures, the carbonate has flowed and recrystallized, brecciating and enclosing angular fragments of chert. Rarely, as for instance south of Kakabeka Falls, chert occurs in lenticular pinching and swelling beds, around which the carbonate shows evidence of differential compaction, suggesting that the chert is a primary deposit.

MASSIVE CARBONATE BEDS

Carbonate beds a few inches to about one foot thick are found in many Lower Gunflint sections. Some are fairly massive fine-grained carbonate; others are coarser and composed of euhedral grains, with a matrix of chert, organic matter, oxides, etc. The tops of some carbonate beds are marked by stylolitic seams separating them from the overlying chert layers.

FRAGMENTAL BEDS

Fragmental beds occur in many Gunflint outcrops. (See photo, p. 31.) The fragments include carbonate, chert, argillaceous material, granules, and possibly volcanic rocks. Cross-bedding is visible in some clastic beds. They clearly indicate an environment of active, even violent, current or wave action. These are readily distinguished from the breccias described above, which are due to flow of the carbonate, since they contain fragments of carbonate, argillite, etc., as well as chert.

CHERT AND JASPER BEDS

Although most beds of chert and jasper, apart from the chert layers in the thin-bedded chert-carbonate facies, are lenticular taconites, there are a few persistent beds of uniform thickness, up to 1–1½ feet, such as on the Neebing River north of Arthur Street.

Metamorphism of the Gunflint Iron Formation

In general, the iron formation has been subjected to relatively mild metamorphism, as indicated by the fine grain of chert, carbonate, and iron silicates and by the preservation of chalcedony, hydrocarbon residues such as anthraxolite, and the many delicate structures described and illustrated in this report. Some typical silicates, such as minnesotaite and stilpnomelane, are regarded by most investigators as metamorphic, although some believe them to be primary or diagenetic constituents of the original sediment.

Where the iron formations are cut by diabase sheets, there has been variable recrystallization, and some new minerals have formed. At some contacts of the iron formation, metamorphism has involved little more than recrystallization of carbonate, chlorite, etc., with loss of original textures. A specimen from beneath the diabase on Green Point contains diopside, phlogopite, and tremolite, in addition to carbonate, chlorite, and apatite. A sample of iron formation underlying diabase near the east boundary of Marks township is made up of fibrous amphibole, epidote, chlorite, stilpnomelane, quartz, and magnetite. In general, the iron formation underlying the diabase appears to be enriched in magnetite, particularly west of Kakabeka Falls.

Argillites underlying diabase have been recrystallized, with the formation of biotite. In carbonate layers in the argillite, diopside, amphibole, and in places small grains of garnet have been formed. Quartz and carbonate form streaks and stringers in the metamorphosed phases. Mention has already been made of albitized argillites locally produced at the upper contact of the diabase.

Sedimentary Facies in the Gunflint

Reference has been made to variations in lithology of the Gunflint iron formation, indicating varying conditions of deposition, that is, facies variations. (Figure 9.) In a few places, gradations from one facies to another can be observed in the outcrop. Most such changes, however, can only be inferred from variations in what are presumed to be beds of similar age in separate outcrop areas. A fuller treatment of the facies of the Gunflint than is possible here is given by Goodwin.[1]

BASAL CONGLOMERATE FACIES

This facies developed during the initial advance of the sea over the peneplaned and weathered surface of pre-Animikie formations. Weathered material was removed, and resistant quartz and iron-formation pebbles accumulated, mixed with quartz sand or chlorites and clays, which sifted down between them.

ALGAL REEF FACIES

Although widespread in occurrence, this facies is not quantitatively important. It occurs at the base of the Gunflint, or near it, and also at the base of the Upper Gunflint,[2] in the western part of the range. Presumably these structures accumulated where the water was relatively free from sediment, well-oxygenated, and active.

TACONITE FACIES

The silicate-chert taconites are the most typical of this facies. The predominance of ferrous silicate suggests reducing conditions. Wavy, lenticular bedding, composite granules, and similar features suggest active currents and

[1] A. M. Goodwin, "Facies Relations in the Gunflint Iron Formation," *Economic Geology*' Vol. 51, No. 6, 1956, pp. 565–95.

[2] A. M. Goodwin, *Stratigraphy of the Gunflint Iron-bearing Formation*, Ph.D. Thesis, University of Wisconsin, 1953, p. 7.

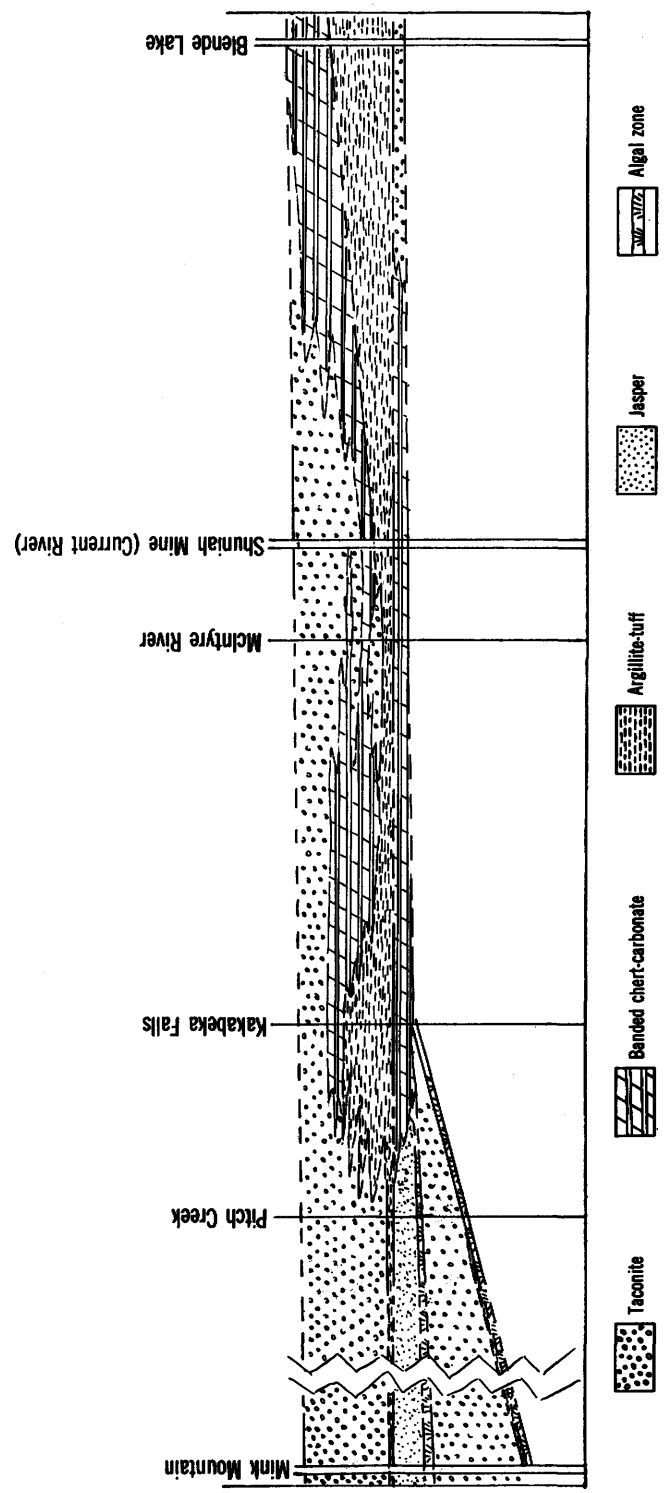


Figure 9—Cross-section showing the distribution of the principal facies, from Mink Mountain to Blende Lake.

wave action. The reducing conditions must therefore have resulted from an abundance of organic matter, although little trace of it is evident in outcrops of this rock. Deposition is presumed to have been in the form of colloidal gels of iron silicate and chert, either by inorganic or organic processes; these gels shrank, cracked, and were broken up and transported in varying degrees by current or wave action. Carbonate may have been precipitated with this material, under similar conditions. Magnetite probably formed under less strongly reducing conditions, and hematite under strongly oxidizing conditions. Current action probably resulted in some admixture of granules from varying local environments, so that minerals such as hematite and iron silicate may occur in the same taconite lens.



Volcanic fragments in a carbonate matrix; basalt fragments and opaque vesicular fragments. Plane light.

CARBONATE FACIES

Siderite, ferroan dolomite, and other carbonates are widely disseminated throughout the Gunflint, and locally make up considerable thicknesses of the formation. They are usually interbedded with cherts. Locally, as in the Current River, they have undergone reworking to form breccias and conglomerates.

The principal carbonate sections represent tracts of the basin of deposition that were, at least for a time, free from clastic sediments and ferruginous and siliceous colloids. Organic matter is present in only some of the carbonate beds.

CHERT-CARBONATE FACIES

This facies is best developed south of Loon Lake. The uniform thin bedding and small-scale lamination are indicative of the quiet conditions to be expected in deep, sheltered waters. The rhythmic alternation of chert and iron carbonate apparently results from recurrent variations in the rate of deposition of one or both constituents, rather than alternating deposition, since there is usually some

chert in the carbonate bands and some carbonate in the chert bands. Clastic material is typically absent, but at Kakabeka Falls, transitions from this facies to argillaceous rocks are evident.

ARGILLITE-TUFF FACIES

The argillite-tuff facies represents a spread of argillaceous material throughout the entire Gunflint Range. In the east, tuffaceous, calcareous, and argillaceous layers are all represented. Except for a few tuff layers at Kakabeka Falls (see photo, page 35) and some limestone beds, bedding is thin and slaty. Organic matter is locally abundant, for instance in the section at Kakabeka Falls. The incursion of argillite throughout the Gunflint, coinciding with tuffaceous contributions, probably represents rejuvenation of stream erosion connected with volcanism and is a precursor of the much more extensive and thicker Rove formation. To the west of Kakabeka Falls, the unit decreases rapidly in thickness, being largely replaced by slaty carbonates and taconites.

Chemical Composition

Complete chemical analyses are not available for the Gunflint iron formation or for individual phases of the iron formation. Iron assays are given in the next section of this report. Many spectrographic analyses have been carried out by Bradshaw[1] on carbonates, cherts, taconites, and argillites of the Gunflint. The elements determined included B, Cr, Co, Ni, V, and Rb. Only in the argillaceous rocks were these elements present in quantities sufficient to be measurable. Some of these results are listed in the accompanying table.

AVERAGE TRACE-ELEMENT CONTENT DETERMINATIONS

Element	Mean	Standard Deviation
	parts per million	parts per million
Animikie argillites:		
Cr	147	135
Co	12	14
Ni	15	13
V	205	146
B	39	42
Rb	147	203
Animikie cherty iron formation:		
V	63	63

Most other elements studied in the iron formations, except in the argillites, occur too erratically to be averaged.

Assays of Gunflint Iron Formation

Several assays of diamond-drill cores obtained from drilling done by M. A. Hanna Company, south of Loon Lake in 1923, were kindly made available by the company. Five-foot sections of the Lower Gunflint ranged from 3.56 to 17.95 percent Fe, and from 36.4 to 53.1 percent SiO_2. The thin-bedded chert-carbonate rocks ranged from 5.32 to 16.68 percent Fe, and from 31.90 to 49.6 percent SiO_2; CaO ranged from 11.52 to 21.60 percent, and MgO from 3.29 to 3.92 percent.

[1] B. A. Bradshaw, *Petrological Comparison of Lake Superior Iron Formations*, unpublished Ph.D. Thesis, University of Toronto, 1956.

Chip samples were taken by the author at a number of localities, to obtain some idea of the over-all grade of different parts of the Gunflint. In a railway cut in the Upper Gunflint, west of the Blende River bridge, 15 feet of chert and ferruginous carbonate, measured normal to the bedding, yielded 21.47 percent Fe, 0.37 percent S, 0.96 percent P_2O_5, and only a trace of Ti. A sample, 11.5 feet long, above the preceding sample, averaged 20.43 percent Fe, 0.29 percent S, 0.89 percent P_2O_5, and a trace of Ti. Similar material from Deception Lake is reported by Bartley to have given 16.56 percent Fe and 39.25 percent SiO_2. A chip sample, taken by the author, from an outcrop of the Lower Gunflint on the north side of highway No. 17, 30 chains northeast of the Loon Lake road, gave, over a vertical distance of 16 feet, 15.75 percent Fe, 0.37 percent P_2O_5, and a trace of Ti. From a zone of carbonate underlying diabase, on the east side of the small lake south of Chert Lake, the author took two chip samples; one, over 4 feet 2 inches, gave 3.94 percent Fe, and the other, 8 feet below, over 3 feet, gave 4.97 percent Fe.

Chip samples were taken by A. M. Goodwin of the metamorphosed iron formation underlying the diabase caps of the three hills north of Pitch Creek and near the east border of Marks township. Assays were as follows:

	Fe percent
South hill	31.62
Centre hill	30.18
North hill	28.73

These samples were taken over a few feet of iron formation immediately underlying the diabase.

Apart from those supplied by M. A. Hanna Company, the assays quoted were made by the Provincial Assay Office, Ontario Department of Mines.

Concentration of Iron in the Gunflint Iron Formation

No extensive zones of direct-shipping iron ore, comparable with those of the Mesabi range in Minnesota, have been discovered in the area mapped. Some zones of apparently enriched iron formation do occur, but all appear to be small in extent. Considerable work was done over half a century ago. Smith[1] has reported on the results of this work as follows:

> The concentration appears to have been determined by two main types of structural conditions:
>
> (1) In the one case, the lower iron-bearing horizon is found lying on the south slopes of the graywacke-granite hills, with a comparatively uniform flat dip to the south. During the deformation which the series has undergone, sufficient movement occurred, both across and along the beds, to fracture and open them up, and thus produce conditions favorable for groundwater circulation.
>
> The areas illustrating this type of structure include that portion of the Animikie area lying north and south of the Canadian Pacific railway, and west from Bittern Lake about two miles, and the area south of Loon Lake and west of Deception Lake. In the latter area the iron formation is exposed practically at the surface, there being but from one to ten feet of overlying drift. In the former, the lower horizon is generally capped by 10 to 35 feet of diabase. As the thickness of the lower horizon in this district is not great (50 to 60 feet), the question of commercial bodies of ore depends largely on the horizontal element. In both areas exploratory work has been done by test-pitting and diamond drilling. The result of the work thus far done shows that over the greater part of these areas the lower iron horizon has been extensively altered to iron oxide, but that associated with the layers showing the greatest concentration a considerable amount of lean silicious material is present, either as lenses in the hematite or as layers interbedded with it. Thus the average sample of any considerable vertical section is low grade.
>
> . . . . . .

[1]W. N. Smith, "Loon Lake Iron-Bearing District," *Annual Report*, Ont. Bur. Mines, Vol. XIV, 1905, pt. 1, pp. 259, 260.

Analyses of samples taken every three inches from four exposures representing vertical distances of six to eight feet each are given below. These are from the natural exposures which showed the greatest observed concentration, and include both the hematite and associated silicious material.

Fe	P	S	SiO_2
percent	percent	percent	percent
45.81	0.020	0.024	31.91
45.22	0.017	0.028	33.13
30.76	0.160	0.058	35.06
30.21	0.256	0.036	37.11

(2) The second structural condition which determined concentration is that of severe local deformation. This is mainly shown at or near the fault planes, where the movements have produced closely folded and brecciated rock masses. Here the conditions were again favorable for the circulation and work of ground water.

This phase of deformation is best illustrated in the Animikie area lying along the fault plane north of Deception lake and extending eastward tc Silver lake, the area east of Deception lake, and that portion of the Animikie area located south and east of Bittern lake. On the above properties at various places both the upper and lower horizons of the iron formation are exposed. In these areas diamond drill holes have been put down, but the main work has been by test-pitting and driving short drifts into the iron formation on the hill sides. As in the previous case, the iron formation is found to be largely altered to iron oxide, but here also the layers showing the maximum concentration are frequently interbanded with lean material, or in the more brecciated phases contain masses of chert irregularly through the ore.

Silver[1] has also reported assays, by A. G. Burrows, from the areas described by Smith, but he does not report the nature of the samples, whether grab, character, chip, or channel samples:

	Fe	S	P
	percent	percent	percent
Tunnel E of Deception Lake	31.03	0.09	0.167
Stripping east of Deception Lake	31.91	0.06	0.321
Wiley's Pit No. 2 [near Beck siding ?]	35.11	0.067	0.016
Cliff of Flaherty's [east of Deception Lake]	27.64	0.088	0.195
Flaherty's tunnel [east of Deception Lake]	40.45	0.021	0.021

A brief discussion of the geology of the area and a few assays are also given in the report of the Iron Ore Committee, 1923, on pages 181–82. The following quotation is taken from this report:

. . . The properties on which exploratory work has been carried on are known as the *Flaherty-Knobel* [extending from Deception lake to the east end of Silver or Sheen lake], *Marks-Wiley* [one block northeast of Beck siding, the other extending from Loon station to southwest of Deception lake], and *McConnell* properties [on both sides of the Canadian Pacific railway, extending from the west end of Loon lake to 3 miles west of the lake; a part of this property is now held by S. Rosenblatt, Fort William]. In these areas numerous diamond-drill holes have been put down and a considerable amount of trenching and test-pitting has been done in search for iron ore. . . .

. . . The following analyses are representative of the grade of ore occurring here:

	No. 1	No. 2	No. 3	No. 4
	percent	percent	percent	percent
Iron	26.51	31.24	40.20	19.68
Silica	34.78	30.86	44.76	61.04
Sulphur	0.06	0.06	0.04	0.13
Phosphorus	0.04	0.08	0.06	0.06

A diamond-drill hole penetrating the ore-bearing strata in reaching a depth of 45 feet, cut two bands of ore with thicknesses of 6½ feet and 1¾ feet, respectively, three bands of lean ore with thicknesses varying from 3 to 5 feet, and three bands of ferruginous chert with thicknesses varying from 6 inches tc 3 feet. . . .

[1]L. P. Silver, "The Animikie Iron Range," *Annual Report*, Ont. Bur. Mines, Vol. XV, 1906, pt. 1, p. 168.

Dominion Bessemer Ore Company Property—About 4 miles to the southwest of the above described area lies mining section location No. 5, in the Township of McGregor, which was operated in 1909 by the Dominion Bessemer Ore Company and from which two cargoes of ore were shipped before the close of navigation. An ore-loading dock was built, also a tramway from the dock to the ore body about one mile inland. Operations ceased at the end of the year and were not resumed.

The ore on this property occurs in two varieties: as hard, greyish, fine-grained hematite; and as friable, brown oxides of iron. The ore-beds are associated with quartzose and sideritic rocks, with a prevailing dip to the southeast of about 50°; they attain in places a thickness of 6 feet, but a thickness of more than 3 feet is not common. Frequently the ore beds thin rapidly. In the better ore beds high-grade ore occurs in segregations with the result that where a whole bed is mined the average iron content of the ore, after cobbing in the quarry, is likely to be below present furnace requirements.

Average analysis of stock-pile samples taken while mining operations were in progress, are reported as follows:

	No. 1 Grade	No. 2 Grade
	percent	percent
Iron	44.30	37.60
Silica	22.60	23.00
Sulphur	0.015	0.275
Phosphorus	0.015	0.024
Manganese	1.50	4.00

The improbability of finding large tonnage and the reported inferior grade of shipments made from mining operations, have deterred further exploitation.

A number of drill holes were put down by M. A. Hanna Company on the McConnell property in 1923. No sections of ore grade were encountered. The range of assays obtained is reported in the previous section.

Two short adits underlying diabase just north of the Canadian Pacific railways, west of Bittern Lake, on the McConnell property, were examined briefly and sampled by the author. The mineralization consists of carbonate, fine-grained hematite, which is often slickensided, and chert. The bedding is irregular. A chip sample, taken by the author normal to the bedding over a length of 5.5 feet, on the southwest wall of the main or north adit, averaged 34.29 percent Fe. A 16-inch sample, taken about 2 feet from the top of the adit, averaged 19.66 percent Fe. A chip sample, for 5 feet above the adit opening, in the rock face, averaged 54.09 percent Fe. A 4-foot 4-inch sample, from the south side of the entrance of the adit near the railway, gave 43.63 percent Fe. All these analyses were made by the Provincial Assay Office. Selected samples, taken from the north adit by G. M. Hutt of the Canadian Pacific Railway, gave 65.26 percent Fe and 6.60 percent SiO_2, and from the south adit, beside the railway tracks, gave 58.96 percent Fe and 15.40 percent SiO_2. These assays were provided by M. W. Bartley.

Economic Potential of the Gunflint Iron Formation

The primary purpose of the present survey was to search for evidence of natural enrichment of iron formation. Apart from the fairly restricted zones west of Bittern Lake as described in the previous section, and an occasional narrow band near Iron Lake, no evidence of enrichment was observed. "Iron ores" are reported by Van Hise and Leith[1] as small, irregular bodies along faults north of Deception Lake and extending eastward to Silver Lake, and south and east of Bittern Lake. Due probably to filling in and weathering of old workings, these zones are no longer recognizable. Considerable attention was given to the

[1]C. R. Van Hise and C. K. Leith, *The Geology of the Lake Superior District*, U.S. Geol. Surv., Monograph No. 52, 1911, p. 207.

faults encountered during mapping, but nothing was seen to indicate enrichment of the iron formation near them.

It would of course be premature to say that no enriched zones occur in the iron formation. Large areas, for instance in McIntyre township, and near, and west of, Kakabeka Falls, are covered by drift and have not been tested by drilling. No trace of enriched ore is to be seen either in visible outcrop or in boulders in the drift.

The possibility of locating concentrating ore must also be considered since this type of iron ore is becoming more important as a source of furnace feed. Most concentrating plants at present are based on the magnetic separation of magnetite from iron formation in which it is the principal iron mineral. No sections of the iron formation northeast of Port Arthur that contain enough magnetite are known. West of Kakabeka Falls, iron formation, immediately underlying the diabase sheets, is sufficiently rich in magnetite to be considered. Investigations so far made on this material show that very fine grinding is necessary to free the magnetite sufficiently to obtain a large enough concentrate of satisfactory grade. This, with the fact that most of this magnetite-enriched iron formation must be recovered from beneath a thick diabase sill, make this source of iron ore unattractive at present. Since most of this type of material is found west of the area described here, the reader is referred to Goodwin's report for further details on grade and concentration tests. Assays, from the three hills located north of Pitch Creek in Marks township, have already been given. This is the only considerable occurrence of magnetite-rich iron formation found by the author northeast of Whitefish Lake.

The banded chert-carbonate of the Upper Gunflint, in the vicinity of Chert Lake and Blende Lake, is of relatively low grade and unsuited for iron ore as it stands. Measurements of a section in a railway cut on the Canadian National railway indicate about 40 percent chert bands and 60 percent carbonate. Presumably the chert and carbonate layers could be readily separated by gravity methods, which might produce a carbonate concentrate with enough iron to be amenable to sintering, but no investigation has been made of the feasibility of such treatment. The presence of considerable chert mixed with the carbonate layers, and the variable iron content of the carbonate, make this material less attractive for such purposes than it would be otherwise.

In general, prospects for the development of iron mining in the Gunflint do not appear good at present. Nothing so far discovered promises economic grade and tonnage.

Gunflint Iron Formation of the Whitefish Lake Area, District of Thunder Bay

BY

A. M. Goodwin[1]

INTRODUCTION

This report[2] deals with the Gunflint iron-bearing formation occurring in Jean, Hardwick, Strange, Lismore, and the south half of Lybster townships, District of Thunder Bay. More specifically, the map area extends from Silver Mountain, which is 32 miles southwest of Port Arthur, westward for 14 miles to Mink



Typical cuesta topography formed by gently-dipping diabase sills, looking eastward across Whitefish Lake.

Mountain, and is about 4 miles wide. Attention is directed to the stratigraphy and iron ore potentialities of the Gunflint formation.

The results of this work and that of Dr. Moorhouse (see preceding report) are shown in the eight maps in the case at the back.

The area has been the scene of a sporadic search for iron and silver ores for the past 65 years. Silver ore of considerable value was removed from Silver Mountain and vicinity prior to 1903, but there has been no recent exploitation. In many localities, the iron-bearing rocks have been examined by surface work and drilling, but no commercial deposits have been discovered.

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[1] Postgraduate Student, University of Wisconsin, 1952.

[2] *See also* A. M. Goodwin, "Facies Relations in the Gunflint Iron Formation," *Economic Geology*, Vol. 51, 1956, pp. 565–95.

The present survey was conducted during the 1952 field season by a two-man party using pace-and-compass methods assisted by air photographs. Information was plotted on air compilation maps on a scale of 4 inches to 1 mile.

Acknowledgments

It is a pleasure to acknowledge the co-operation of M.W. Bartley, Port Arthur, who was in charge of commercial exploration work in the map area at the time of the survey. Dr. Bartley was very co-operative in providing drilling, assay, and concentration test records.

Lawrence Hobbs of University of Western Ontario ably assisted during the season.

Means of Access

The map area is readily accessible from Port Arthur by means of the Silver Mountain road. Numerous wagon roads and trails lead northward from this road into the principal areas of rock exposures.

Previous Work

The first systematic geological investigation of the map area appears to have been that of E. D. Ingall[1] in 1887, who briefly described the iron-bearing rocks exposed in the vicinity of Silver Mountain and Whitefish Lake.

In 1926, J. E. Gill[2] presented the results of his studies of the stratigraphy of the Gunflint formation in the area extending from Gunflint Lake, on the International Boundary, northeastward to Silver Mountain. His report provides a detailed and accurate section of the iron-bearing formation there.

T. L. Tanton,[3] in 1923, described iron prospects at Mink Mountain. In 1931, he published the results of investigations in the Thunder Bay district, in which the present map area is briefly described.[4]

In addition to these geological records, there are records available of considerable exploratory work on the iron-bearing rocks by interested individuals and mining concerns.

Considerable surface work was conducted in the vicinity of Mink Mountain prior to 1926 by local residents, of whom J. McGugan appears to have been the most prominent.

In 1943, Gunflint Iron Mines Company Limited sectioned the iron-bearing formation in the area adjoining Mink Mountain with eight vertical diamond-drill holes. In 1952, L. K. Johnson Explorations, of Duluth, Minn., conducted extensive exploration of the formation in the area between North Lake, 16 miles southwest of Mink Mountain, and the town of Nolalu, 4 miles northeast of Silver Mountain.

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[1]Elfric Drew Ingall, "Mines and Mining on Lake Superior, Part I," *Annual Report*, Geol. and Nat. Hist. Surv. Can., New Series, Vol. III, 1888, Report H.

[2]J. E. Gill, "Gunflint Iron-Bearing Formation, Ontario," *Summary Report*, Geol. Surv. Can., 1924, Part C, pp. 28–88.

[3]T. L. Tanton, "Iron Formation at Gravel Lake, Thunder Bay District, Ontario," *Summary Report*, Geol. Surv. Can., 1923, Part C, pp.1–75.

[4]T. L. Tanton, *Fort William and Port Arthur, and Thunder Cap Map-Areas, Thunder Bay District, Ontario*, Geol. Surv. Can., Memoir No. 167, 1931.

Topography

The maximum relief in the area is about 450 feet and is due to the presence of diabase sill rock that has resisted erosion and now stands above the surrounding flat-lying terrain in the form of large round mesas such as Mink, Sun, Marny, and Silver mountains, or as east-west trending cuestas such as Divide Ridge.

The southern and western parts of the area drain southward by tributaries of the Pigeon River, which enters Lake Superior at Pigeon Point. Elsewhere, drainage is eastward by the Whitefish River, which joins the Kaministikwia River, and thence flows through Fort William to Lake Superior.

Exposures of iron-bearing rock are scarce in the low-lying country adjoining streams and lakes because of drift cover. Beneath the diabase capping of hills and ridges, however, the rocks are well exposed.

GENERAL GEOLOGY

All the consolidated rocks of the area are considered to be Precambrian in age. Glacial till of Pleistocene age, and unconsolidated debris, form an extensive mantle over low-lying parts of the area.

The oldest rocks in the area are granite and granite gneiss with inclusions of chlorite and mica schist, upon which rest, in angular unconformity, gently dipping sedimentary and volcanic rocks, within which numerous diabase sills have been emplaced.

TABLE OF FORMATIONS

CENOZOIC	
PLEISTOCENE AND RECENT:	Till, gravel, sand, and clay.
	Unconformity
PRECAMBRIAN	
KEWEENAWAN:	Diabase and related rocks.
	Intrusive Contact
ANIMIKIE:	Rove formation. Gunflint iron formation.
	Unconformity
ALGOMAN TYPE:	Granite, granite gneiss, with inclusions of chlorite and mica schist.

Precambrian

ALGOMAN TYPE

Algoman-type granitic rocks exposed along the north margin of the sedimentary rocks consist predominantly of normal, pink granite and granite gneiss. The texture ranges, without recognized distribution, from conspicuously gneissic to coarsely pegmatitic.

Numerous inclusions of chloritic and micaceous schist, and gneiss of various shapes and sizes, occur within the granite.

ANIMIKIE

Sedimentary and volcanic rocks of the Animikie rest upon Algoman-type granitic rocks with major angular unconformity. These formations are intruded by diabase of Keweenawan age.

The Animikie consists of two formations: the lower being the Gunflint iron formation, and the upper, the Rove argillite formation. The sedimentary, and locally volcanic, rocks making up the formation dip gently south at an average angle of 5 degrees.

Gunflint Iron Formation

The Gunflint iron formation consists mainly of sedimentary rocks that are unusually rich in iron. The average thickness of the formation is 475 feet. The distribution, lithology, and economic aspects are considered in detail later in this report.



The north-facing escarpment of Divide Ridge.

Rove Formation

The Rove formation consists typically of thin-bedded, black to dark-grey argillite. There are very few exposures within the map area. Argillite, with an approximate thickness of 200 feet, underlies the capping sill on Silver Mountain, and there are exposures up to 30 feet thick beneath the capping rocks on Mink, Sun, and Marny mountains. South of the map area, however, there are great thicknesses of argillite that probably amount to several thousand feet.

KEWEENAWAN

Rocks of the Keweenawan within the map area consist of diabase intrusives.

Remnants of diabase sills, typically about 100 feet thick, form the capping rock on the larger hills and ridges within the map area. The largest exposure is on Divide Ridge, which lies immediately north of Whitefish Lake; it is 6 miles long and 2 miles wide. The diabase sills dip gently southward, conforming more or less to the attitude of the enclosing sedimentary rocks.

All the principal exposures of flat-lying diabase rock in the map area are considered to be remnants of an original single sill, now segmented by faulting and erosion.

A single diabase dike was observed within the map area, transecting the basement complex north of Whitefish Lake; its age, relative to the Animikie rocks,

could not be determined here. Elsewhere in the Thunder Bay district, however, diabase dikes that transect Animikie rocks are common, and it is presumed that the dike mentioned is of the same age.

Cenozoic

PLEISTOCENE AND RECENT

Unconsolidated sand and gravels are widespread and in places very thick. Most of the material is unsorted and appears to represent glacial debris; along the river banks, however, there has been considerable reworking and sorting.

The thickness of the debris ranges from a thin discontinuous mantle of boulders on top of the diabase-capped hills to sand and boulder deposits up to 250 feet thick, such as occur on the southeast side of Mink Mountain.

STRUCTURAL GEOLOGY

The Animikie sedimentary rocks are essentially flat-lying and rest upon a granite terrain of low relief. The principal disturbance has been due to normal gravity faults, which are common throughout the area.

Folds

Except for local variation in attitude, the beds of the Gunflint iron formation dip gently south at an average angle of 5 degrees. A typical variation occurs in the beds adjoining fault planes, where it is common to find local, but intense, folding.

Gill has drawn attention to local folding and brecciation in the uppermost beds of the Gunflint formation on Mink Mountain,[1] and has emphasized the extreme brecciation of the chert beds. Folding and deformation of this type are attributed to violent volcanic disturbances that occurred towards the end of the deposition of the iron-bearing rocks.

Faults

There appear to be two principal systems of normal gravity faults within the map area. One system strikes approximately N.70°E; the other, generally northward. The age relationship between them was not determined, as individual faults cannot be traced with certainty for more than a few miles.

One example of an east-trending fault is located between Silver Bluff and Divide Ridge, in which the north side appears to have moved down about 100 feet relative to the south side. Another example is the fault southeast of Mink Mountain, where the south side has moved down about 250 feet.

The north-trending system is illustrated by the two faults, one on either side of the North River, that together have formed a downfaulted block, or graben. Movement has been about 200 feet.

A fault is indicated between Silver Bluff and Silver Mountain. The diabase capping rocks at both localities are at the same elevation, but whereas the capping rock at Silver Bluff is underlain by iron-bearing rocks of the Gunflint formation, there is 200 feet of Rove argillite beneath the capping rock of Silver Mountain. Thus, there has apparently been a vertical displacement of at least 200 feet, the east side having moved down relative to the west.

There are probably many other faults in the area but with such limited vertical movement that they are not readily discernible.

[1] J. E. Gill, *op. cit.*, pp. 39, 40.

GUNFLINT IRON FORMATION

The Gunflint iron formation is a sequence of sedimentary, and locally, volcanic rocks, with a total thickness of about 475 feet. The formation is characterized by an unusually high iron content, as well as by a variety of textures, the granular texture of the taconite rock being most distinctive. The textural and mineral terms common to this formation have been well described by Gill[1] and readers interested are referred to his report for details.

The general stratigraphic relationships of the formation have been determined by field observations and drilling records. Tables I and II present pertinent drilling records; the location of the holes is shown in the accompanying sketch map.

TABLE I—DRILLING RECORDS
(L. K. Johnson Explorations, 1952)

Member	Thicknesses Encountered in Drill Holes							
	No. 1 (feet)	No. 2 (feet)	No. 3 (feet)	No. 4 (feet)	No. 5 (feet)	No. 6 (feet)	No. 7 (feet)	No. 8 (feet)
Upper Limestone..	5.0							
Upper Taconite....	175.0	63.0		34.3	132.5			
Upper Shale.....	8.2	8.3		5.5	16.5			
Upper Jasper.....	64.5	35.7	40.0	63.9	58.0			
Upper Algal chert.	22.3	6.0	19.4	15.3	8.5		18.0	
Lower Taconite...	196.7	208.5	187.1	204.8	194.0	108.7	231.0	153.0
Lower Shale.....	11.3	5.5	16.5	11.5	9.0			3.5
Lower Algal chert.	2.4		15.3	3.6	13.0	3.0	3.7	13.6
Basal Conglomerate		2.0						
Total.....	485.4	329.0	278.3	338.9	431.5	111.7	252.7	170.1

No. 1—SW. corner of Mink Mountain; T.B.44177—720 ft. N.87°30'W. from No. 2 post.
2—S. of Burnt Bridge on Whitefish River; T.B.44120—1,060 ft. N.18°W. from No. 4 post of T.B.44117.
3—S. shore of Sandstone Lake; T.B. 43828—700 ft. W. from No. 1 post and 200 feet S. of North Line.
4—NE. corner of Unit 4, Divide Ridge; T.B.44384—150 ft. NW. from No. 2 post.
5—S. shore of Iron Range Lake; T.B.43718—300 ft. W. and 150 ft. S. of No. 1 post.
6—Between Iron Range and Sandstone lakes; T.B.43762—400 ft. S. and 200 ft. W. of No. 1 post.
7—W. of North River; T.B.44444—700 ft. W. and 50 ft. S. of No. 1 post.
8—NW. of Nolalu; T.B.44487—25 ft. N. and 100 ft. W. of No. 2 post.

Stratigraphy

The Gunflint formation is divided into lower and upper cycles. Each cycle contains a sequence of members, most of which are common to both. The uppermost member, a limestone bed, is unique to the formation and marks the top of the iron-bearing rocks. (Table III).

[1] *op. cit.* pp. 41–43.

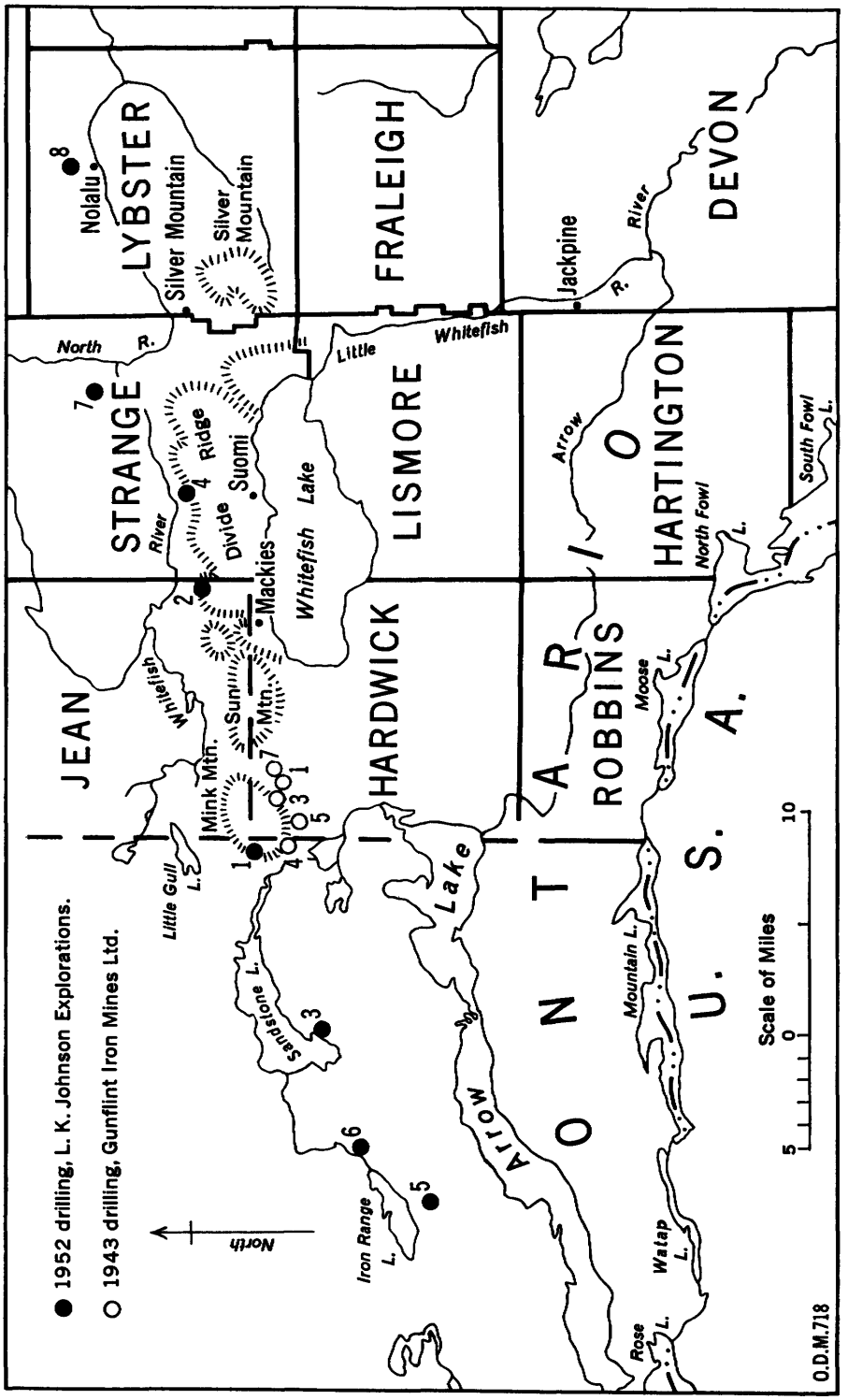


Figure 10—Sketch map showing location of diamond-drill holes.

TABLE II—INTERPRETATION OF SELECTED DRILLING RECORDS
(All drill holes are located south of Mink Mountain)
(*Gunflint Iron Mines Limited, 1943*)

Member	Thicknesses Encountered in Drill Holes				
	No. 1 (feet)	No. 3 (feet)	No. 4 (feet)	No. 5 (feet)	No. 7 (feet)
Overburden	234	226	146	212	179
Upper Taconite	18	7		52	113
Upper Shale	5	2.5			5
Upper Jasper	51	54.5	44.5		53
Upper Algal chert					
Lower Taconite	206	38			60
Lower Shale	32		182.5		
Lower Algal chert					
Basal Conglomerate					
Total	546	328	373	264	410

No. 1—27 chains S. and 19 chains W. of NE. corner of lot W-281.
3—18 chains S. and 22 chains W. of NE. corner of lot W-281.
4—27 chains S. and 18 chains W. of NE. corner of lot 56-X.
5—18 chains S. and 20 chains W. of NE. corner of lot W-280.
7—20 chains S. and 28 chains W. of NE. corner of lot W-280.

TABLE III—GENERALIZED SECTION—GUNFLINT IRON FORMATION

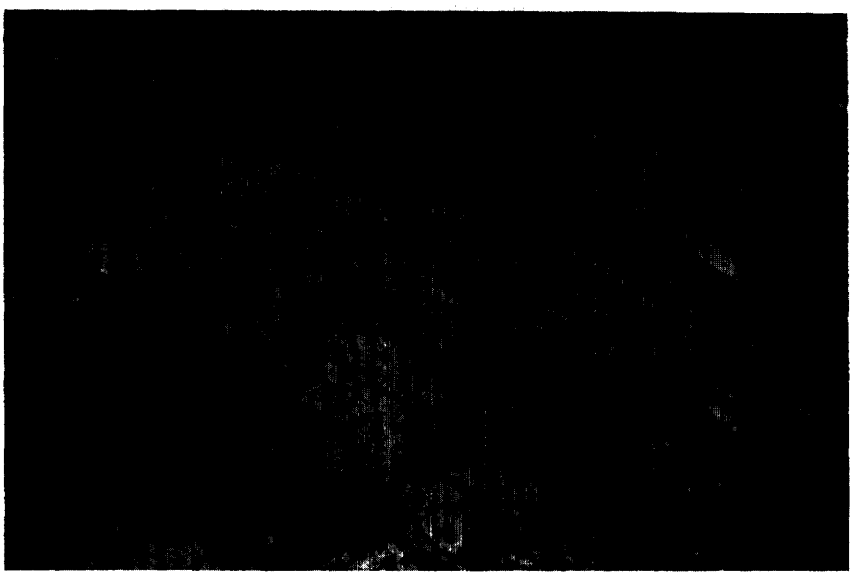
Cycle	Member	Thickness (feet)	Equivalent—Gill's Section
Upper Gunflint[1]	Upper Limestone	5– 20	
	Upper Taconite	150–180	Division 5
	Upper Shale	5– 16	
	Upper Jasper	40– 64	
	Upper Algal chert	8– 22	Division 4
	Lava flow locally	0– 40	
	Total Upper Gunflint	250–350	
Lower Gunflint	Lower Taconite	150–210	Division 3
	Lower Shale	4– 20	Division 2
	Lower Algal chert	2– 15	Division 1
	Basal Conglomerate	0– 1	
	Total Lower Gunflint	210–240	
	Total thickness of Gunflint iron formation	460–540	

[1]The Upper Gunflint in this report includes the Upper Jasper, Upper Algal Chert, and Lava Flow, which have not been recognized at or east of Kakabeka Falls, and the Upper Shale which has been classed as a distinct unit in the report by W. W. Moorhouse.

BASAL CONGLOMERATE MEMBER

The basal conglomerate is well exposed along the north fringe of the iron formation, where it forms a thin skin on top of the basement complex. The thickness of the conglomerate is seldom more than one foot, even where completely preserved, and is usually only a few inches.

The pebbles of the conglomerate are formed of white vein quartz, milky white chert, and occasionally jasper. Most pebbles are ½–1 inch in diameter, although several with diameters of 6 inches were observed, and the majority are well rounded. The matrix consists of sandy quartz grains with considerable admixed chloritic material.



Reef-like mound of algal chert (left) resting on granite basement (right).

LOWER ALGAL CHERT MEMBER

Algal chert rests directly upon the basal conglomerate, or where this is absent, upon the granitic basement. There are excellent exposures north of Burnt Bridge on the Whitefish River. The total thickness of the member ranges from 2 to 15 feet.

The algal chert is commonly in the form of reef-like mounds, which are roughly elliptical in plan view and average 10 feet long, 4 feet wide, and 2 feet thick. The chert forming the mounds is finely contorted in the manner typical of algal structures. Small brown, white, and red granules are often closely associated. The algal chert typically grades upwards into green and white banded chert with massive texture.

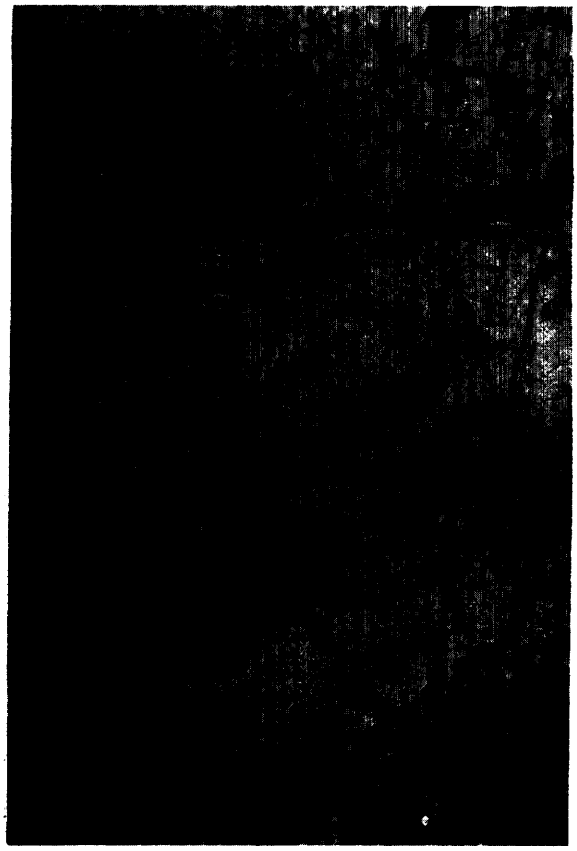
LOWER SHALE MEMBER

The Lower Shale member outcrops in only a few places because of the soft nature of the rocks. The best exposures observed are on the ridge near the south shore of Little Gull Lake where a maximum thickness of 18 feet is exposed. Drilling records indicate that the member thins eastward. At Nolalu, on the east border of the map area, it is 3.5 feet thick.

The shale is soft, black and typically fissile. Thin-section examination reveals much fine-grained clastic material together with carbonaceous matter. Bands of grey to black chert, commonly flecked with pyrite, are present near the top of the member.

LOWER TACONITE MEMBER

Rocks of the Lower Taconite member are exposed along the north slope of Mink Mountain, on the banks of the Whitefish River, and on numerous small



Typical algal structures of the Lower Algal chert member.

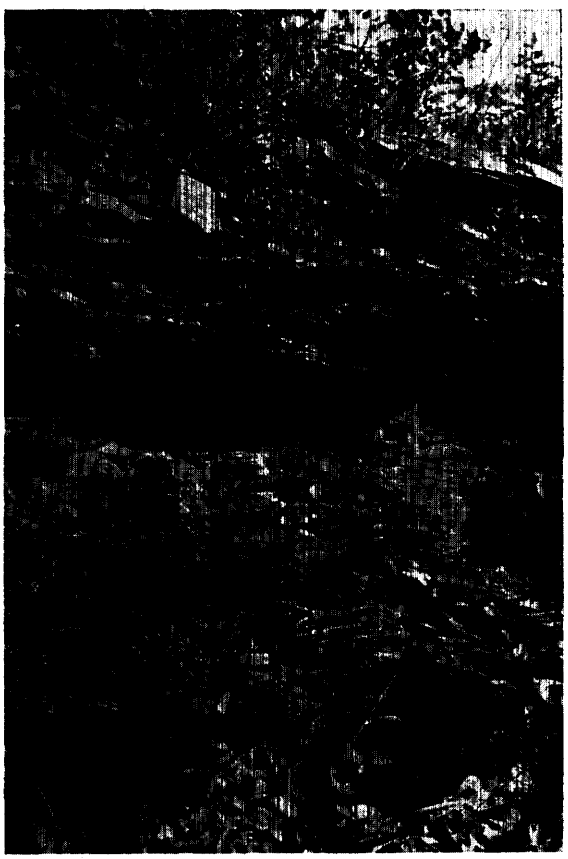
hills and ridges north of this river. The thickness of the member ranges from 150 to 210 feet and is remarkably uniform throughout the map area.

Weathered rocks of the member are characterized by a shingly appearance due to numerous closely spaced parting planes, rusty colour, and finely granular texture. The thickness of the beds can only be determined in very fresh exposures because of the strong tendency for parting. An individual bed is lenticular; the maximum thickness is 6–15 inches, and the lateral extent is up to 50 feet. The beds are separated by very thin partings usually no more than 2 inches thick.

Under the microscope, the typical rock of this member is seen to consist of small granules up to 2 millimetres in diameter, in a fine-grained chert or carbonate matrix. The granules consist of a mixture of fine-grained chert, a green silicate mineral (probably greenalite), and iron oxide. The iron oxide is commonly an intimate mixture of hematite and magnetite, or near the weathered

surfaces, the hydrated equivalents. The oxides often form the rims of granules. The matrix to the granules is fine-grained chert or ferruginous carbonate. Where the carbonate is present the granules are not well formed.

Carbonate nodules are common in certain beds. In cross-section, the nodules are characteristically round and occasionally slightly elliptical. They range in diameter from a fraction of an inch to 1 inch and average ¼ inch. The individual nodule when fresh is typically composed of salmon pink, finely crystalline car-



Shingly granular rocks of the Lower Taconite member.

bonate, commonly with a rim of greenalite (?). The carbonate is rusty weathering, the colour being yellow, orange, brown, or black, depending on the degree of oxidation and hydration.

There is a variation in the relative proportions of chert, greenalite, hematite, and magnetite, within the unweathered beds of the member. Some beds are unusually rich in the iron oxide minerals, whereas adjacent beds contain a high proportion of chert and greenalite. However, no large-scale mineral zoning was recognized, and there is here no attempt to subdivide the member.

UPPER ALGAL CHERT MEMBER

Rocks of the Upper Algal chert member are exposed on the west and east flanks of Mink Mountain, beneath the diabase sill of Divide Ridge, along the banks of the Whitefish River, and within the North River downfaulted block. The thickness of the member ranges from 8 to 22 feet.

The beds of the member are divided into the following groups, in descending order:

Group	Feet
3. Coarse granular ferruginous chert	2– 6
2. Algal-oölitic chert, lava flow locally	4–50
1. Granular chert with jasper veinlets	2–10

Group 1

The beds of this group are 2–10 feet thick. They are predominantly cherty with abundant red, grey, and black granules. The granules are formed of chert and iron oxides, the latter an intergrowth of hematite and magnetite. The matrix is predominantly fine-grained chert.

The beds are characterized by jasper veinlets. These veinlets are up to 1 inch thick; some are parallel to the bedding planes, but the majority are subhorizontal to vertical.

Group 2

The algal group is characterized by finely banded, red and white algal chert. In places, there are three distinct beds of algal banding, each being about 4 inches thick, and separated by 6–12 inches of granular chert; elsewhere, only one algal bed was observed, the thickness ranging from 1 to 6 feet. Intimately associated with the algal bandings, there are unusually coarse red and black oölitic granules up to ¼ inch in diameter; these are typically concentrically banded and consist of chert, hematite, and magnetite, the iron oxides being usually intermixed and concentrically interbanded with the chert.

Basic flow rock is exposed intermittently in a belt ½ mile wide, which extends from the northeast corner of Mink Mountain northward for ¾ mile to the south bank of the Whitefish River. Here, the base of the lava rests upon 7 feet of granular chert, which in turn grades downward into magnetite-bearing greenalite taconite rock of the Lower Taconite member.

Near an abandoned cabin on the east side of Mink Mountain, the flow rock is in contact with, and appears to plunge beneath, red granular chert. Within 50 feet of this contact, there are scattered outcrops of algal-banded chert.

Thus the flow rock occupies a stratigraphic position within, and slightly above, the base of the Upper Algal chert member.

The flow rock contains pillow-type structures up to 2 feet in diameter, which are commonly encased in a rim of red and green chert up to ½ inch thick.

Amygdules are common in the upper 10 feet of the flow rock. The filling is white chert, jasper, or a greenalite-like mineral. The amygdules range up to ⅛ inch in diameter. There is commonly a bleached zone surrounding each amygdule, up to ¼ inch in diameter, from which the iron appears to have been removed.

Hematite-bearing veinlets were observed in the flow rock. A typical veinlet is 1 inch thick and follows sinuous joints in the lava. The vein material is red and has a distinct granular texture. Thin-section study reveals oölitic granules formed of concentrically banded red hematite and chert up to 5 millimetres in diameter, in a fine-grained chert matrix.

There is a scattering of large boulders containing considerable amounts of hematite and magnetite, distributed over the area that is apparently underlain by flow rock. The boulders are up to 6 feet in diameter, and typically contain hematite and magnetite in the form of large granules up to ¼ inch in diameter, and lenticles as much as 2 inches long. Under the microscope, the granules and lenticles are seen to consist of an intimate intergrowth of specular hematite and magnetite. Commonly, magnetite forms most of the core of a granule, the pro-

portion of hematite increasing towards the border. The matrix to the granules consists of chert, often radiating, with a sprinkling of earthy red hematite.

Some boulders contain zones up to 1 foot in diameter that consist of granular specular hematite with sparse matrix. It forms a spectacular rock, consisting as it does of abundant, closely packed "globules" of steel-grey hematite. Thin-section examination reveals granules up to 5 millimetres in diameter that consist largely of hematite with some intermixed magnetite and fine-grained chert. The sparse matrix is chert.

The iron-bearing boulders are restricted to the area designated above, so far as is known. Since the rock has not been observed in place, its stratigraphic position cannot be determined; however, its unique character, restricted distribution, and close association with basic flow rock, suggest a close genetic association. Accordingly, the boulders are interpreted as remnants of a rock unit that was originally situated immediately above the flow rock.

Group 3

The beds above the algal chert group are similar to those below it. They consist of chert with a coarse granular texture; there is often hematite and magnetite associated with the chert. Jasper veinlets similar to those in the rocks of Group 1 are present, but in smaller numbers.

UPPER JASPER MEMBER

Beds of this member are well exposed in numerous test pits and adits along the east and west sides of Mink Mountain. There are also good exposures beneath the capping sill of Divide Ridge. The member ranges in thickness from 40 to 64 feet.

The lower beds of the member are characterized by granules and small lenticles, or beads, of jaspery chert; this grades upwards into beds consisting of thick lenses of granular jaspery chert with shaly partings.

The granular or beaded jasper beds are 2–6 inches thick and consist of many small jasper granules and beads in a dark-red, very finely granular matrix. The typical jasper bead is lenticular in form and is up to ¼ inch in length; it is well rounded and elongated parallel to the bedding.

Thin-section examination reveals that the beads are irregularly shaped granules consisting of a core of fine-grained chert and a green silicate mineral (greenalite?) with a rim of intermixed hematite and magnetite. The matrix to the beads is composed of fine-grained chert speckled with earthy red hematite.

Large jasper lenses occur in the upper beds of this member; these are 4–8 inches thick, and 2–10 feet long, and are all elongated parallel to the bedding planes. An individual lens often pinches to a fraction of an inch before swelling again to maximum thickness, continuing thus laterally for many yards. There is often a succession of lenses along a particular horizon.

The jasper lenses consist of abundant, close-packed, small red granules in a chert matrix. All lenses observed have a granular texture. Not all granules are red; occasionally a lens has a local concentration of green granules or a general intermixture of red and green. The granules are seen in thin section to consist of chert with red iron oxide or a greenalite-like mineral, the colour of the granule varying accordingly. There is an increase of green granules relative to red granules towards the top of the member, and the uppermost lenses are predominantly green.

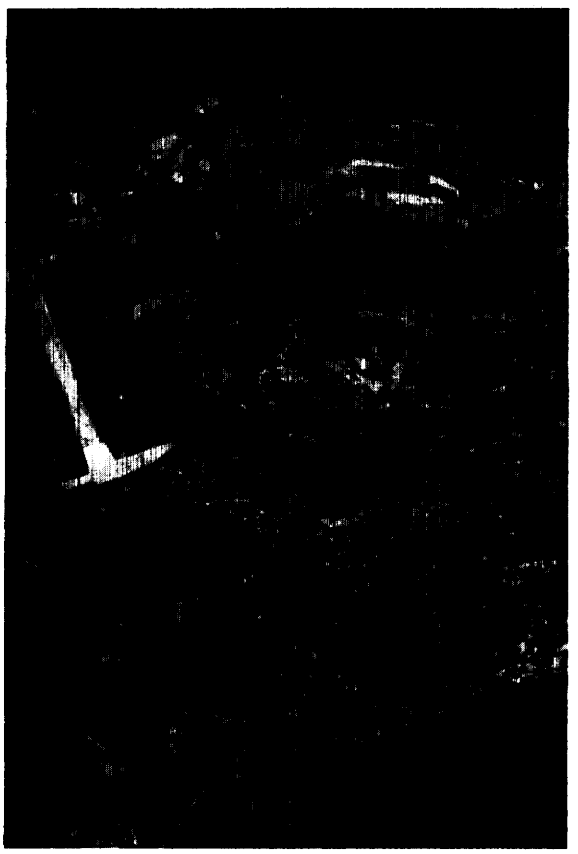
Both red and green chert lenses are separated by fine-grained shaly material, some with recognizable clastic matter.

The rocks of this member grade upwards by increase in shaly material to shale of the overlying member.

UPPER SHALE MEMBER

The Shale member is exposed in the same localities as the underlying Jasper member. It ranges in thickness from 5 to 16 feet and is persistent throughout the map area.

The member consists largely of black, fissile shale. Locally, small concretions are present; they are generally 2–3 inches in diameter and composed of black sideritic carbonate.



Upper part of Upper Shale member. Thick pisolite bed below hammer head, jasper lens immediately above handle.

A prominent feature of the Shale member, and a good horizon marker, is the presence of a pisolite layer near the top of the member. The layer is 9–18 inches thick. It consists of pisolites averaging ⅛ inch in diameter that are somewhat flattened along the bedding plane. They weather characteristically to a rusty brown colour and are easily noticed against the background of black shale.

Thin-section examination reveals that an individual pisolite consists of fine-grained, angular clastic material in a greenish clay matrix. The tabular clastic fragments tend to be oriented with their long dimension perpendicular to the radius, thus developing a crude concentric banding.

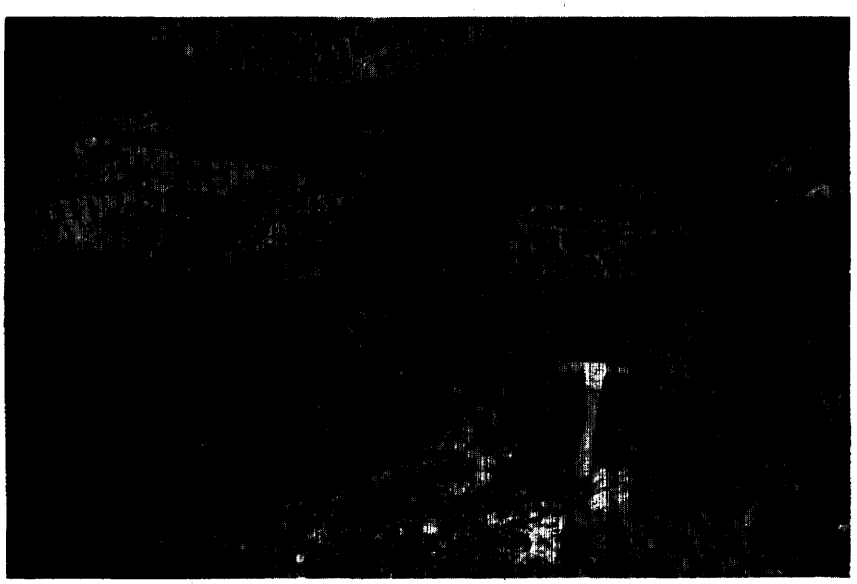
The shale grades upwards within a vertical distance of 2 feet to the granular rock of the overlying member.

UPPER TACONITE MEMBER

Upper Taconite beds are exposed beneath the capping sills of the hills and ridges of the area. There are particularly good exposures on the north face of Silver Bluff. The member is 150–180 feet thick.

The typical rocks of this member consist of thick-bedded granular chert with shaly partings.

The chert layers are commonly green in colour, due to abundant greenalite granules. The thickness of the chert layers ranges from 5 to 24 inches. An occasional layer is of uniform thickness, but most are noticeably wavy banded; such bands pinch and swell within a lateral distance of 10–20 feet. The thinner



Lenticular chert beds with their shaly partings of the Upper Taconite member. The chert is granular.

chert beds are often segmented into discreet chert lenses, 5–10 inches thick and up to 20 feet long. Within a vertical section, chert lenses are arranged so that the thick part of a particular lens rests in the hollow formed by the tapered extensions of subjacent lenses. The plan view of a lens is typically circular to elliptical, so far as was determined.

In all cases observed, lenticular, or wavy-banded chert has a distinct granular texture.

Under the microscope, the fresh material is seen to consist of granules formed of greenalite intermixed with some chert and iron oxide, in a matrix of fine-grained chert.

The shaly partings that separate chert beds range in thickness from 1 to 12 inches, most commonly about 4 inches. The partings are dark-brown to black and very fine grained. They consist of an intermixture of ferruginous carbonate, magnetite, and occasional fragmental grains.

Beds within 80 feet of the diabase sills have a considerably higher magnetite content than normal. In such beds, the magnetite grains are up to 3 millimetres

TABLE IV—PARTIAL CHEMICAL COMPOSITION, LOWER TACONITE MEMBER

(All figures are percentages)

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18
Iron (Fe)	19.27	25.09	31.81	34.41	26.94	25.00	25.00	25.97	31.16	28.57	26.97	23.33	20.74	20.09	22.98	22.18	26.86	25.48
Silica	53.99	46.36	44.60	42.40	51.80	45.60	45.60	54.80	43.40	59.10	44.08	46.24	46.44	51.41	46.71	46.61	37.14	39.68
Phosphorus	nil	nil	0.027	0.021	0.021	0.061	0.061	0.014	0.023	0.020	0.015	0.009	0.005	0.006	0.010	0.009	0.012	0.009
Sulphur	0.11	0.08	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Manganese	0.27	0.32	0.21	0.31	0.19	0.71	0.71	0.12	0.21	0.31	.....	.....	.....	.....	.....	.....	.....	.....

No. 1—Falls on Whitefish River, W. of Burnt Bridge.
2—Small hill, NE. of Burnt Bridge.
(*Nos. 1 and 2 by Ont. Dept. Mines, Provincial Assay Office, 1952.*)
3–10—Pits and trenches on NW. flank of Mink Mountain.
(*Nos. 3—10 from M. W. Bartley, 1951.*)
11—Small hill NE. of Burnt Bridge.
12, 13—Falls on Whitefish River, W. of Burnt Bridge.
14—Roadside outcrop, W. of North River.
15—1943(?) drill core, W. side of Mink Mountain; 20–40 feet.
16—1943(?) drill core, W. side of Mink Mountain; 40–60 feet.
17—1943(?) drill core, W. side of Mink Mountain; 60–100 feet.
18—1943(?) drill core, W. side of Mink Mountain; 100–125 feet.
(*Nos. 11–18 from L. K. Johnson Explorations, 1952*).

TABLE V—PARTIAL CHEMICAL COMPOSITION, UPPER JASPER MEMBER AND UPPER TACONITE MEMBER

(All figures are percentages)

	Upper Jasper Member					Upper Taconite Member												
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18
Iron (Fe)	24.44	24.16	24.84	24.37	28.36	26.68	28.61	32.24	26.89	23.95	26.41	29.89	39.85	32.34	30.36	33.89	34.08	33.91
Silica	50.49	51.14	44.66	39.17	.....	54.60	56.52	44.96	49.16	51.41	46.50	43.96	33.24	28.36	42.78	35.89	38.07	35.69
Phosphorus	nil	0.41 (P_2O_5)	.....	.....	.....	0.17	0.26	0.009	0.008	0.014	0.015	0.060	0.025	0.083	0.141	0.178	0.154	0.138
Manganese	0.08 (MnO_2)	0.03	.....	.....	.....	0.15	0.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sulphur	0.52	0.16	.....	.....	.....	0.17	0.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

No. 1—Large pit; NW. flank of Mink Mountain.
2—N. face of Divide Ridge; NE. corner, Unit 3.
(*Nos. 1 and 2 by Ont. Dept. Mines, Provincial Assay Office, 1952.*)
3—Drill core—Hole No. 1; average of six 5-foot sections, 262–92 feet.
4—Drill core—Hole No. 2; average of seven 5-foot sections, 240–75 feet.
5—Drill core—Hole No. 5; average of four 5-foot sections, 220–40 feet.
(*Nos. 3–5 from Gunflint Iron Mines Ltd., 1943.*)
6—N. face of Divide Ridge; NE. corner, Unit 4.
7—N. face of Silver Bluff.
(*Nos. 6 and 7 by Ont. Dept. Mines, Provincial Assay Office, 1952.*)
8—S. shore of Addie Lake.
9—SW. shore of Addie Lake.
10—N. face of Divide Ridge; NW. corner, Unit 1.
11—E. face of Divide Ridge.
12—N. face of Divide Ridge; NW. corner, Unit 3.
13—Fire Tower outlier.
14—N. face of Silver Bluff; 0–24 feet below diabase.
15—N. face of Silver Bluff; 24–94 feet below diabase.
16—W. side of Mink Mountain.
17—NW. face of Divide Ridge; 0–8 feet below diabase.
18—NW. face of Divide Ridge; 8–18 feet below diabase.
(*Nos. 8–18 from L. K. Johnson Explorations, 1952.*)

in diameter; they occur in both the chert layers and shaly partings, but more abundantly in the partings. Bands up to 5 inches thick, rich in magnetite, were observed; however, cherty material is usually intimately associated.

The upper 20 feet of this member consists locally of beds that have been highly contorted and brecciated. The rock now consists of chert fragments, up to 6 inches thick and 2 feet long, within a matrix of magnetite, secondary iron-bearing amphibole minerals, and calcite. The chert of the fragments is commonly dark-grey to black and finely laminated. The rock appears to have consisted originally of thinly interbanded chert and ferruginous carbonate.

UPPER LIMESTONE MEMBER

The Limestone member is exposed immediately north of the abandoned railway on the south slope of Sun Mountain; the thickness is estimated to range from 5 to 20 feet.

The limestone is typically dark-grey to black and very fine grained. It is easily confused with the finer-grained phases of diabase. There are usually thin interbandings of grey-to-black massive chert up to 2 inches thick.

Chemical Composition

Sufficient partial analyses are available to determine with considerable accuracy the average composition of potential ore-making beds of the Gunflint iron formation. The members considered in this respect are the Lower Taconite member, Upper Jasper member, and the Upper Taconite member. The other members of the formation are relatively thin and contain less iron. Tables IV and V present the available analyses of the three members.

The rock samples from which the analyses were determined represent a fairly wide distribution within each member in respect to both thickness and lateral extent. A study of the tables reveals the essential chemical uniformity within each member. The average iron and silica content of the three members calculated from the above analyses is as follows:

TABLE VI—AVERAGE IRON AND SILICA CONTENT

Member	Number of Analyses	Fe	SiO_2
		percent	percent
Lower Taconite	18	25.71	46.44
Upper Jasper	20	25.50	46.36
Upper Taconite	20	30.70	43.16

Economic Considerations

Since the average composition of the iron-bearing rock contains too much silica for its use as ore material, searchers for ore material look for parts of the iron-bearing rock that have been concentrated by natural processes or are amenable to commercial beneficiating methods. The evidence is examined with this in mind.

POSSIBILITIES OF NATURAL CONCENTRATIONS

There is no direct evidence that natural concentrations of ore material have formed within the map area. The iron-bearing rocks show little evidence of oxidation of the iron minerals and leaching of the silica content.

Rocks of the Lower Taconite member appear to have been weathered more than other parts of the formation, particularly in the ridges and mounds north of the Whitefish River. However, close inspection of the outcrops reveals that alteration is restricted to a rim 1–2 inches thick. The chemical analyses demonstrate that there has been little, if any, removal of silica and other impurities.

Outcrops and drill core of Upper Jasper rocks inspected give no indication of more than slight surface alteration, and hold little promise of large scale, natural concentrations. A 1-foot bed of soft hematite ore, assaying 52 percent iron and 3–8 percent silica, was reported to have been encountered at a depth of 250 feet, in the region south of Mink Mountain, by Gunflint Iron Mines Limited, in 1943. Thus, local concentrations of soft ore are possible within this member at depth.

The Upper Taconite rocks show the least signs of oxidation and leaching. The member typically occupies a high topographic position beneath diabase sills of considerable thickness, and oxidizing activity may have been restricted for this reason.

It is possible that rocks of the Upper Taconite member that formerly overlay the diabase sill underwent oxidation and leaching of impurities before removal. Such iron-enriched material might have been concentrated in low-lying areas, such as Whitefish Lake and vicinity, and thus protected from erosion. However, there is no direct evidence that such a concentration exists. On the contrary, an erosional remnant of Upper Taconite rock, overlying sill rock on the north shore of Whitefish Lake, shows no sign of extensive oxidation and leaching.

It is possible that concentrations of iron-rich material occur along fault planes. Here again, with one possible exception, there is no direct evidence of such a process of enrichment.

This exception occurs ½ mile southeast of the falls on the Whitefish River, in lot 4, concession IV, Strange township, where, in the farmyard of Mr. Youman, there are scattered fragments of possible fault breccia. The material is rusty weathering, and consists of angular jasper fragments up to 2 inches in diameter in a dark-brown, powdery matrix. The partial analysis of this material is as follows:

	Percent
Fe	20.01
SiO_2	51.80
Al_2O_3	1.84
CaO	4.15
MgO	1.16
TiO_2	0.35
MnO	0.19
S	0.03
P	0.071
Ignition loss	0.35

Although the material is far from ore grade, it is possible that richer iron-bearing zones occur elsewhere. Fault zones that might repay investigation lie between Silver Bluff and Divide Ridge, between Silver Bluff and Silver Mountain east of North River where the iron-bearing rocks abut on granite, and southeast of Mink and Sun mountains.

Several analyses were obtained of the granular hematite-magnetite-bearing boulders described on page 52. They are listed below.

	Sample			
	No. 1	No. 2	No. 3	No. 4
	percent	percent	percent	percent
Fe	51.94	57.36	11.75	59.08
SiO_2	20.00	19.95	32.31	14.20
P	0.031	0.023	nil	0.034
MnO	0.21	0.15	0.89 (MnO_2)	0.19
Al_2O_3	.....	0.33	.....	.....
S	.....	0.010	0.06	.....
Ca	.....	0.75	.....	.....
Mg	.....	0.10	.....	.....

Samples Nos. 1, 2, and 3 are natural material.
Sample No. 4 is magnetic concentrate.

The high silica content and apparently restricted distribution of the boulders render them of no value.

POSSIBILITIES OF MATERIAL AMENABLE TO BENEFICIATION

To be of value as concentrating material, the iron-bearing rock must be of appropriate chemical and textural composition and readily available in large quantities, and iron-bearing rocks of the Lower and Upper Taconite members were considered with this in mind.

Lower Taconite Member

There are widespread exposures of Lower Taconite rocks in the general area north of Mink Mountain and Whitefish River. Thicknesses up to 230 feet have been encountered in drill holes. Furthermore, the material is relatively soft and friable, and is exposed over a large area without capping rock to hinder extraction.

Samples of the Lower Taconite rock have been tested with magnetic tubes. Table VII shows the results of test made on material ground to minus 100- and minus 200-mesh. The tests show that in general the over-all recovery by magnetic separation is not high, and the concentrate is prohibitively siliceous, even at minus 200-mesh grinding.

The concentrate, of course, consists principally of the magnetic portion of the total iron content of the rocks. It may prove possible to obtain a higher grade concentrate by using roasting and flotation processes. However, the intimate relation between iron minerals and silica does not suggest that such a concentration is feasible without unduly fine grinding.

Upper Taconite Member

The analyses of Upper Taconite rocks indicate that they contain more iron and less silica than the Lower Taconite rocks, and the magnetite content in proximity to diabase sills is considerably higher. However, a deterrent to the possible use of such material is its location beneath capping sills of diabase up to 200 feet thick, which would probably have to be removed before extraction; moreover, there are no known exposures, or near-exposures, of Upper Taconite rocks not capped by diabase.

Table VIII gives the results of magnetic concentrating tests, run on rocks of this member at minus 100- and minus 200-mesh.

TABLE VII—MAGNETIC TUBE TESTS, LOWER TACONITE ROCKS

(Sample Nos. 1–4 are respectively equivalent to Nos. 15–18 in Table IV.)

	minus 100-mesh						minus 200-mesh					
	Magnetic Concentrate				Non-magnetic Tails		Magnetic Concentrate				Non-magnetic Tails	
Sample No.	Percentage Weight of Sample	Total Iron	Phos-phorus	Fusion Silica	Percentage Weight of Sample	Total Iron	Percentage Weight of Sample	Total Iron	Phos-phorus	Fusion Silica	Percentage Weight of Sample	Total Iron
		percent	percent	percent		percent		percent	percent	percent		percent
1	24.83	38.87	0.010	35.40	75.17	17.73	14.28	54.44	0.009	19.64	85.72	17.74
2	24.43	34.68	0.009	38.46	75.57	18.14	11.51	50.08	0.008	23.08	88.49	18.55
3	25.21	48.07	0.010	23.30	74.79	19.71	15.13	59.92	0.009	12.20	84.87	20.97
4	18.23	52.26	0.010	16.91	81.77	19.51	12.64	62.26	0.009	9.00	87.36	20.16

TABLE VIII—MAGNETIC TUBE TESTS, UPPER TACONITE ROCKS

(All iron determinations are total assays; all silica determinations are fusion assays.)

Sample No.	minus 100-mesh						minus 200-mesh					
	Magnetic Concentrate				Non-magnetic Tails		Magnetic Concentrate				Non-magnetic Tails	
	Percentage Weight of Sample	Total Iron	Phosphorus	Fusion Silica	Percentage Weight of Sample	Total Iron	Percentage Weight of Sample	Total Iron	Phosphorus	Fusion Silica	Percentage Weight of Sample	Total Iron
		percent	percent	percent		percent		percent	percent	percent		percent
1	43.81	49.68	0.014	26.30	56.19	18.64	36.48	55.50	0.012	15.50	63.52	18.88
2	35.28	47.60	0.014	29.22	64.72	15.60	29.03	51.95	0.012	22.78	70.97	16.64
3	18.40	51.76	0.021	17.79	81.60	17.68	14.38	54.13	0.022	15.33	85.62	18.88
4	48.49	38.66	0.026	35.62	51.51	14.88	39.55	43.42	0.026	29.83	60.45	15.28
5	38.37	50.66	0.075	21.36	61.63	16.96	33.51	54.77	0.062	16.73	66.49	17.35
6	22.91	49.20	0.189	19.47	77.09	27.20	16.24	51.63	0.163	17.70	83.76	28.48
7	22.73	46.08	0.165	23.45	77.27	22.72	17.32	49.94	0.150	19.49	82.68	23.44
8	30.17	50.24	0.038	24.50	69.83	35.36	23.51	53.16	0.044	20.20	76.49	35.76
9	53.31	49.33	0.064	25.74	46.69	12.94	47.23	53.61	0.066	22.97	52.77	13.30
10	35.11	45.58	0.168	27.32	64.89	22.13	27.11	50.36	0.189	23.00	72.89	22.92
11	32.48	52.10	0.144	16.62	67.52	25.41	30.17	54.01	0.144	16.40	69.83	25.47
12	40.96	49.00	0.152	23.64	59.04	23.44	35.24	50.93	0.147	17.36	64.76	24.65
13	43.77	54.21	0.180	12.66	56.23	18.07	40.86	56.77	0.168	12.05	59.14	18.08

Nos. 1–5—Equivalent to Nos. 8–12 in Table V.
6, 7—SE. shore of Prelate Lake, below the diabase.
8–10—Equivalent to Nos. 13–15 in Table V.
11, 12—Equivalent to Nos. 17–18 in Table V.
13—Equivalent to No. 16 in Table V.

The results demonstrate that the magnetic concentrate is low in total recovery, low in iron, and high in silica. It is also significant that the finer grinding has not resulted in an appreciably richer concentrate, demonstrating the intimate association of iron and silica within the rocks of this member.

CONCLUSION AND RECOMMENDATIONS

The average chemical composition of the iron-bearing rocks of the Gunflint iron formation within the map area, the apparent lack of oxidation and leaching, and the negative results of magnetic concentration tests, are not encouraging for the discovery of ore material within the map area.

It is possible that natural concentrations of ore material occur in the low-lying areas in the vicinity of Whitefish and Round lakes, or along fault zones.

However, the economic future of the iron-bearing rocks appears to depend upon a process that will produce a commercial concentrate. More detailed experimental investigation might reveal such a process.

The rapid development of beneficiating methods suggests that future improvements might be sufficient to bring the iron-bearing rocks of the Gunflint iron formation within the range of commercial exploitation.

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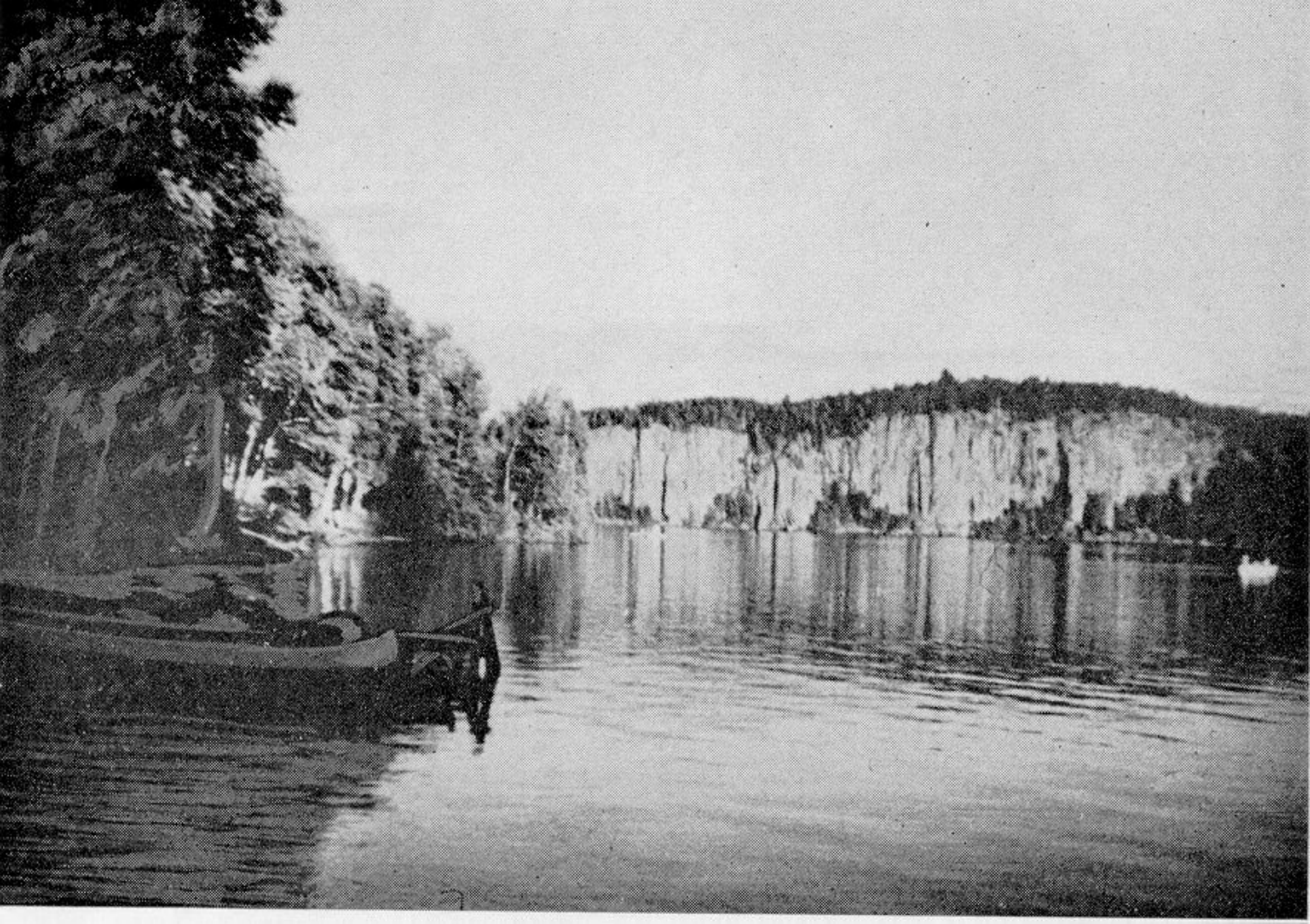
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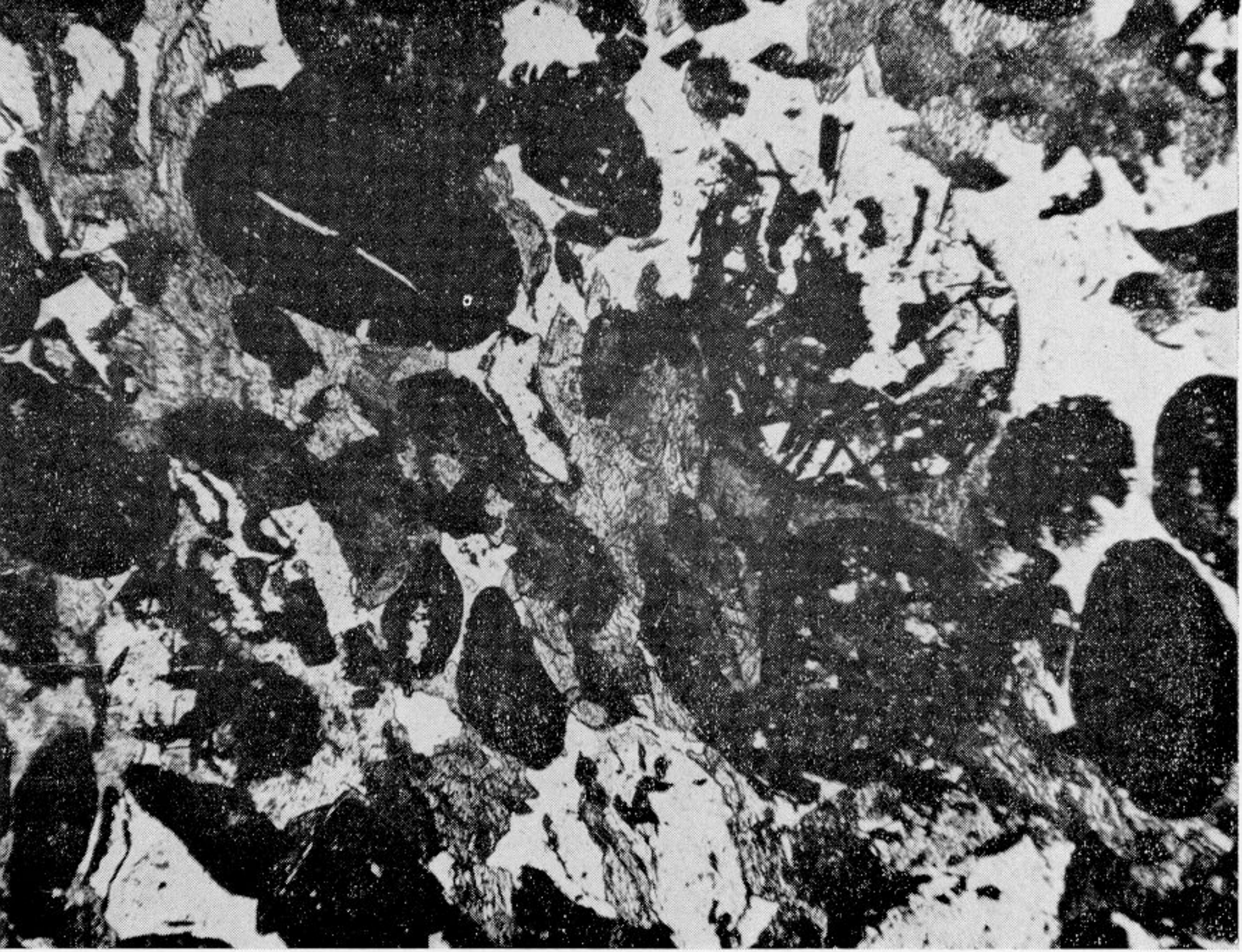


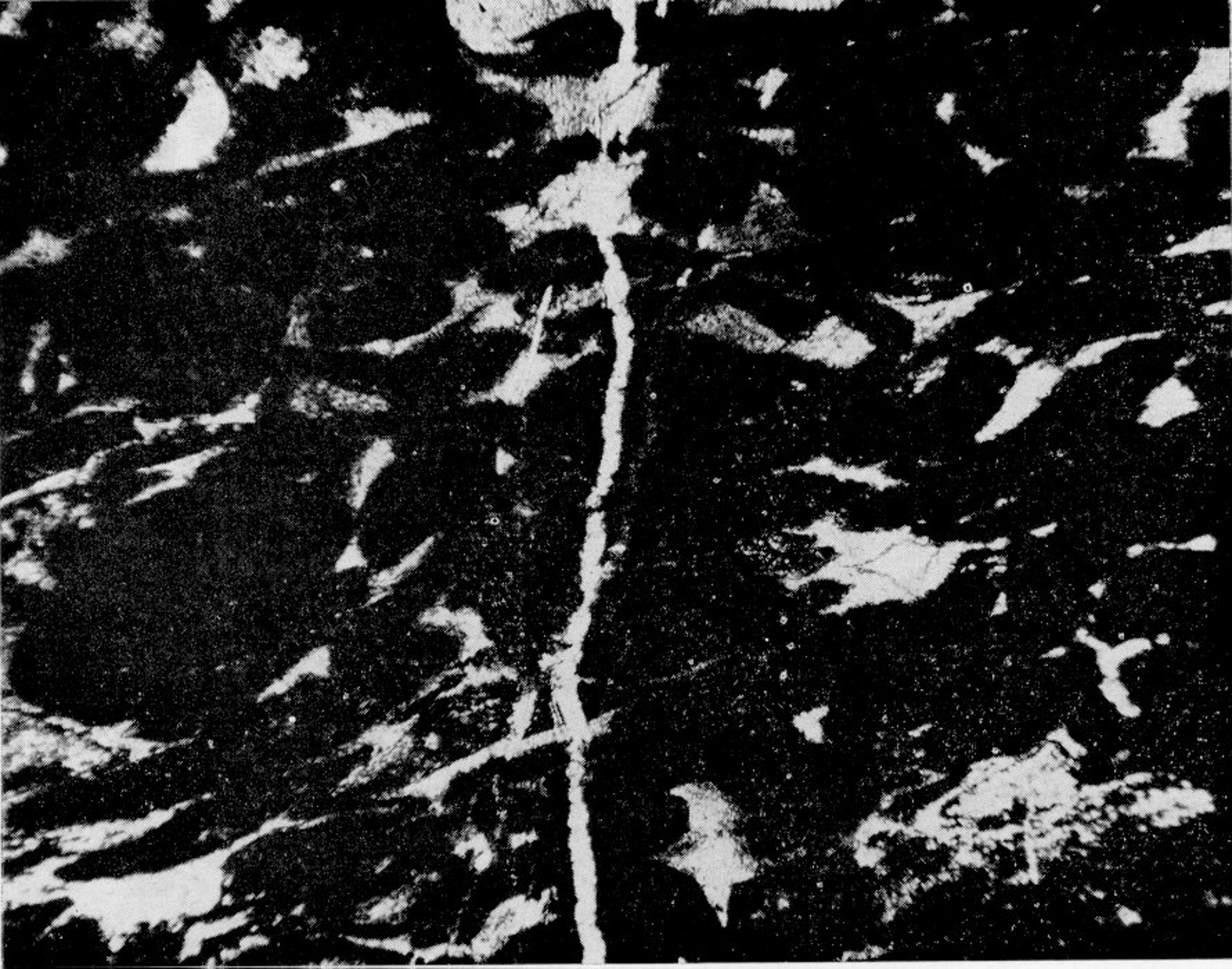


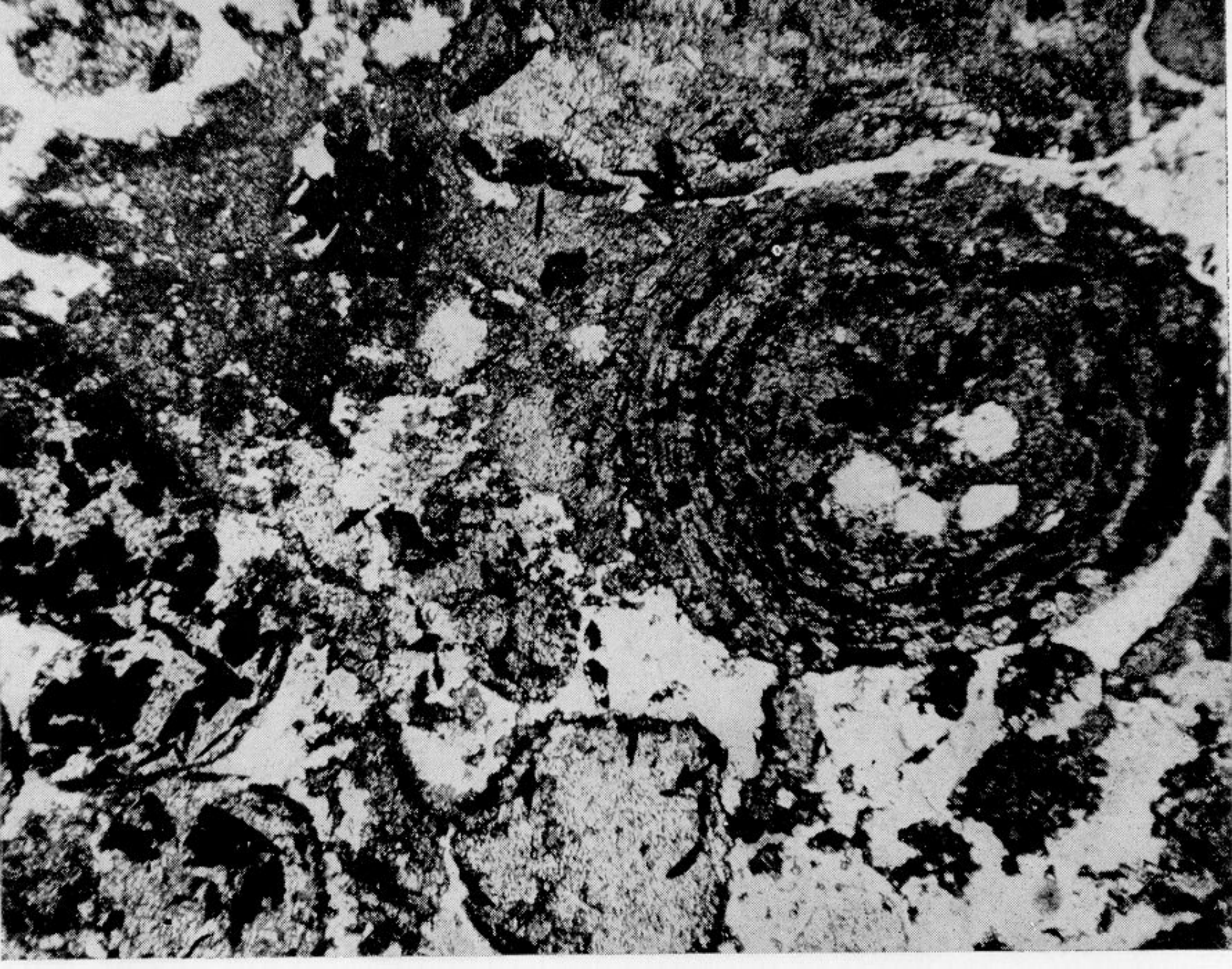


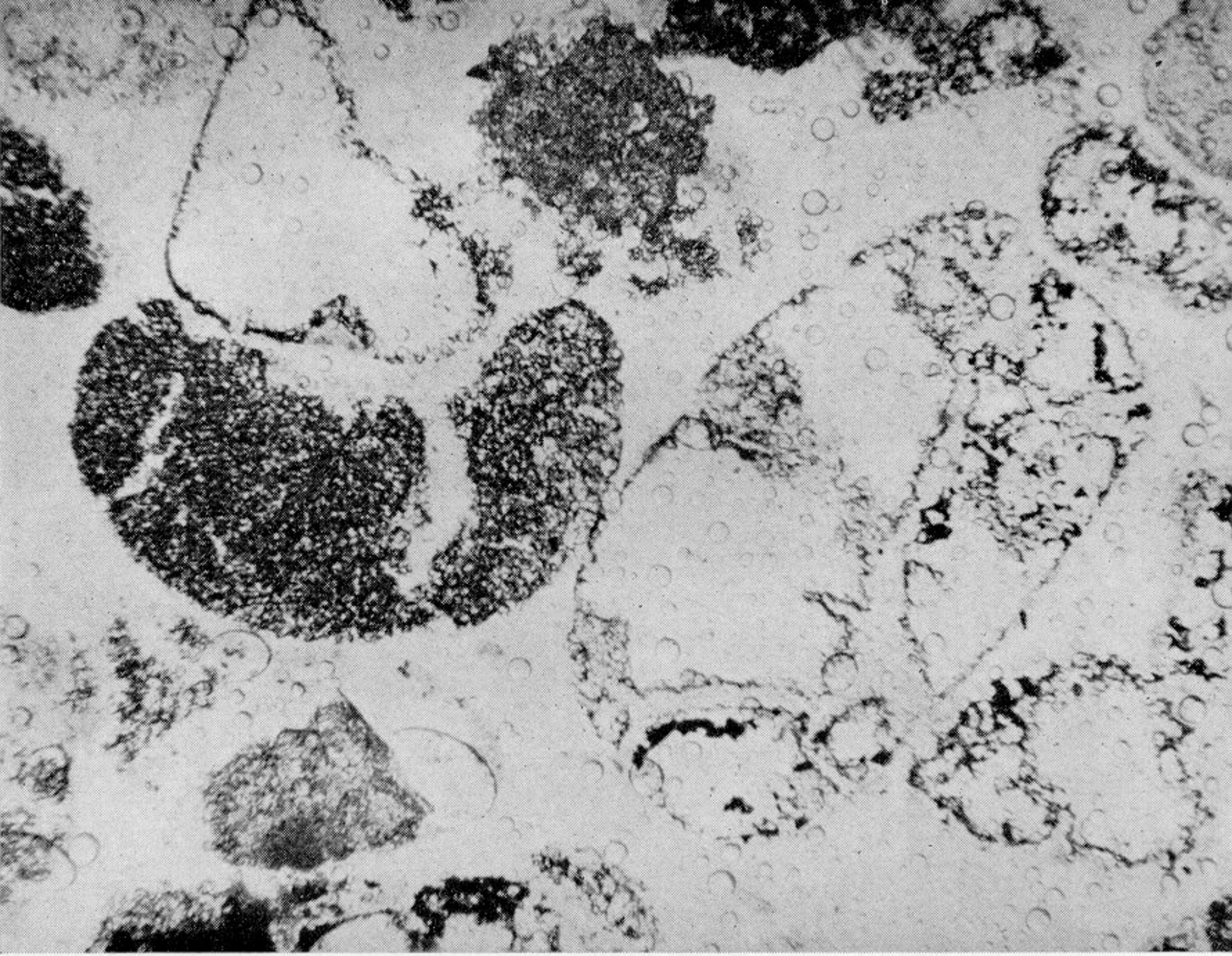


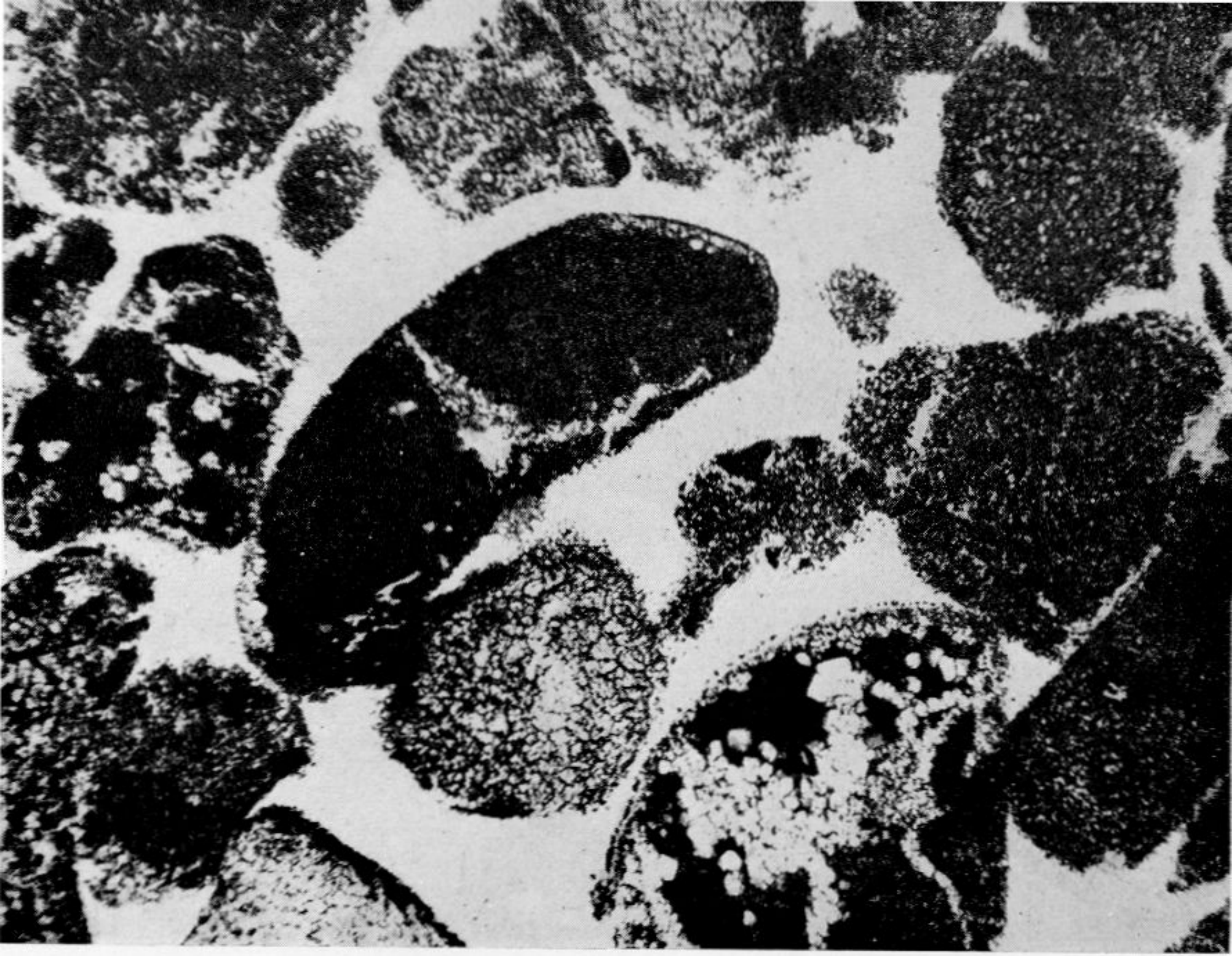


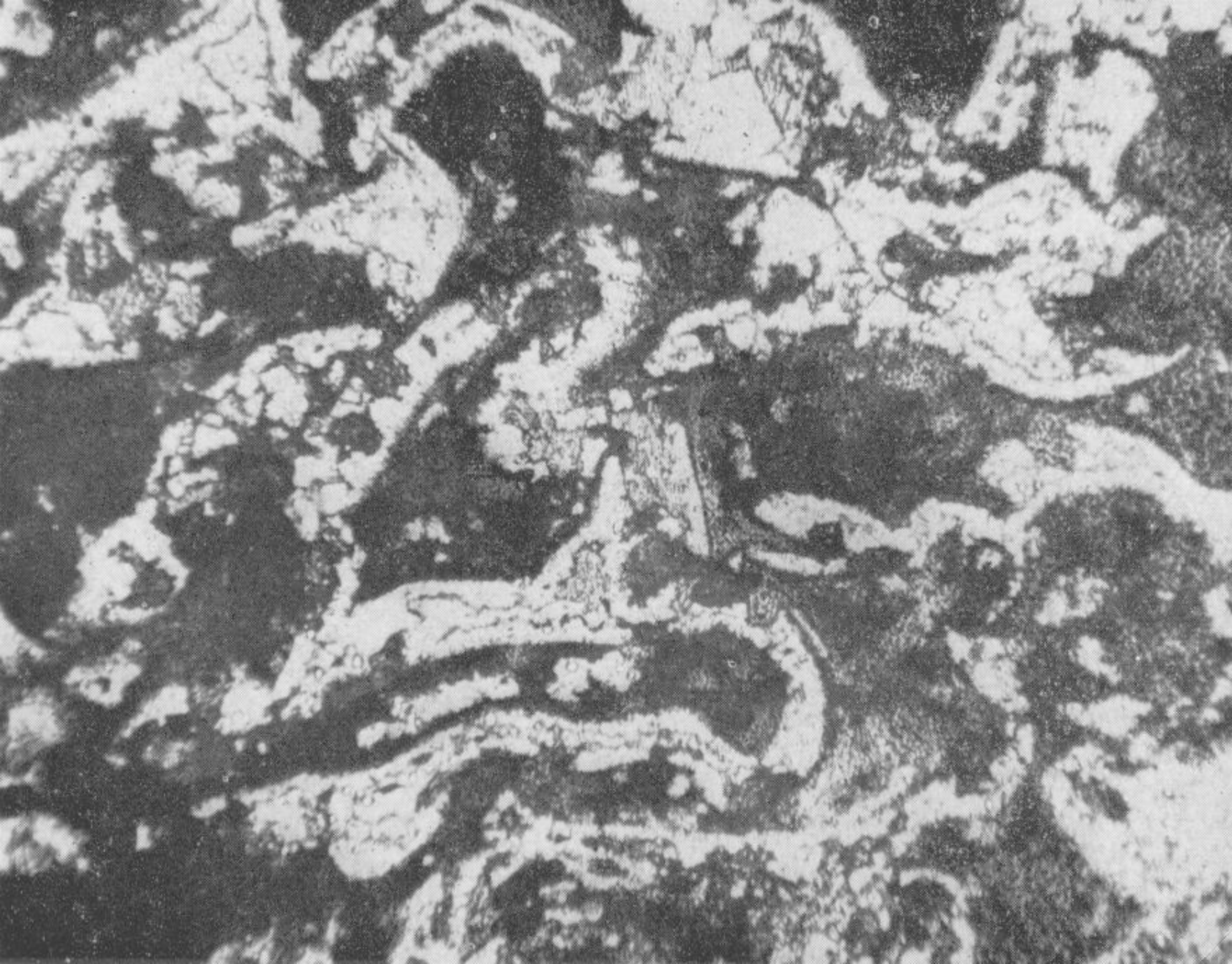


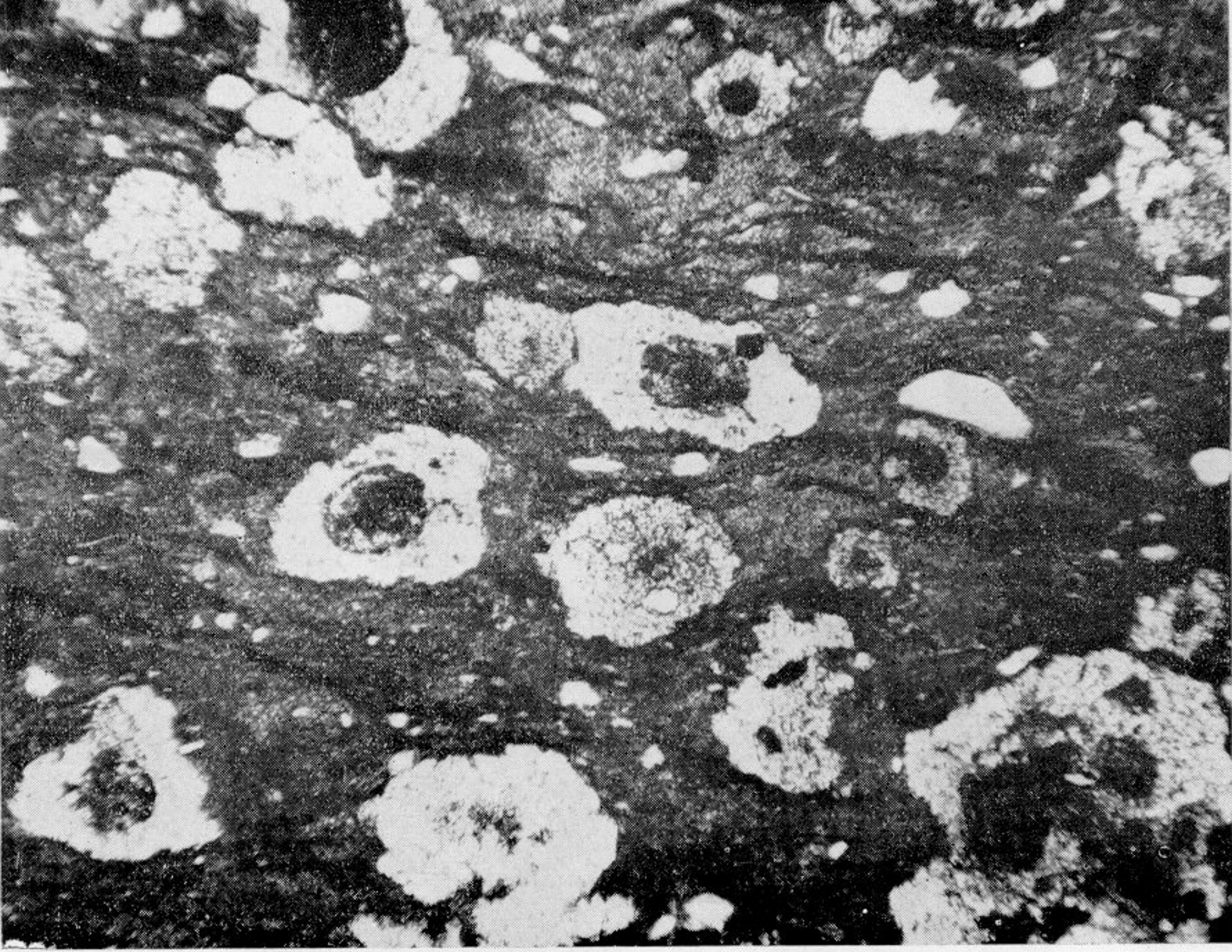


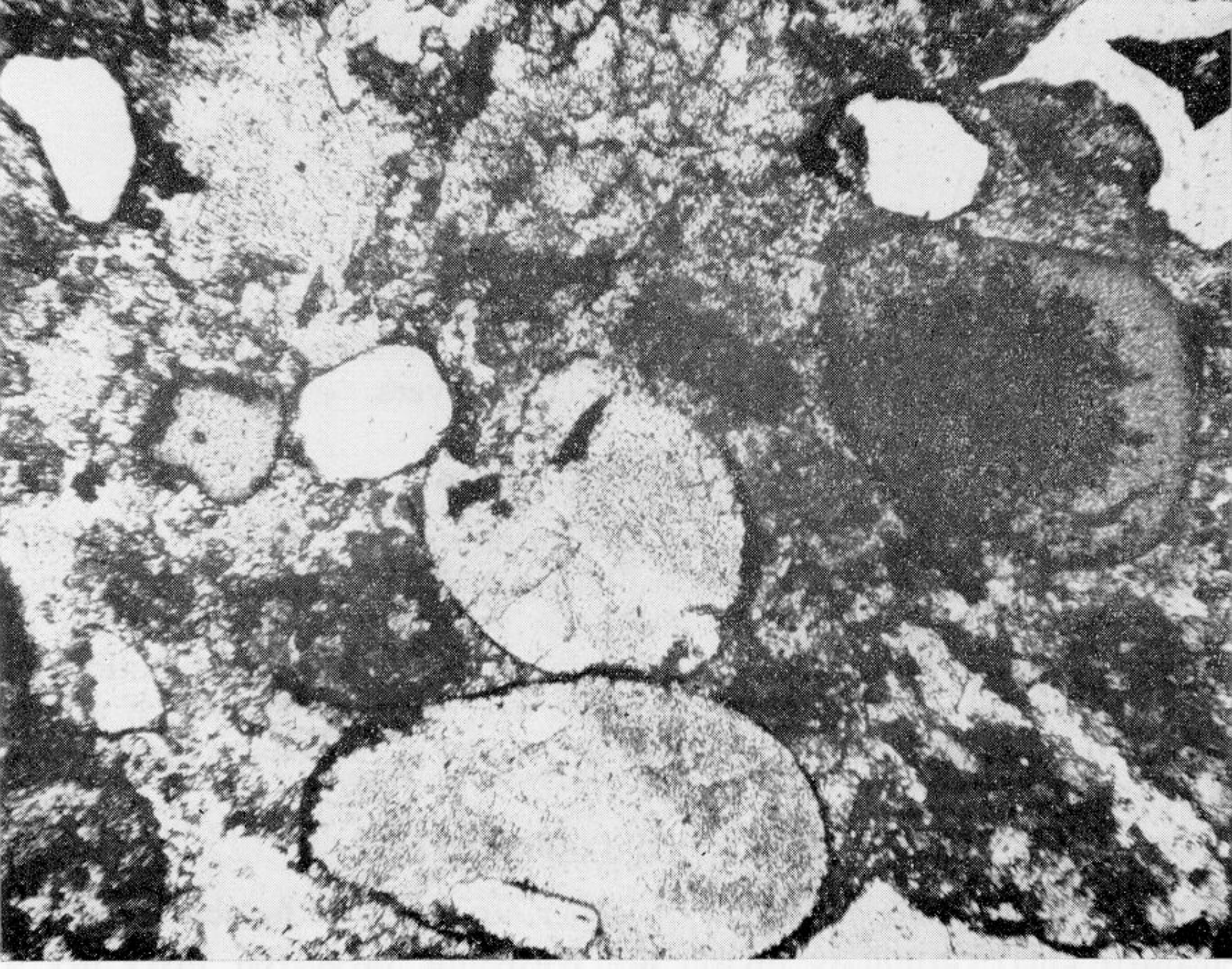




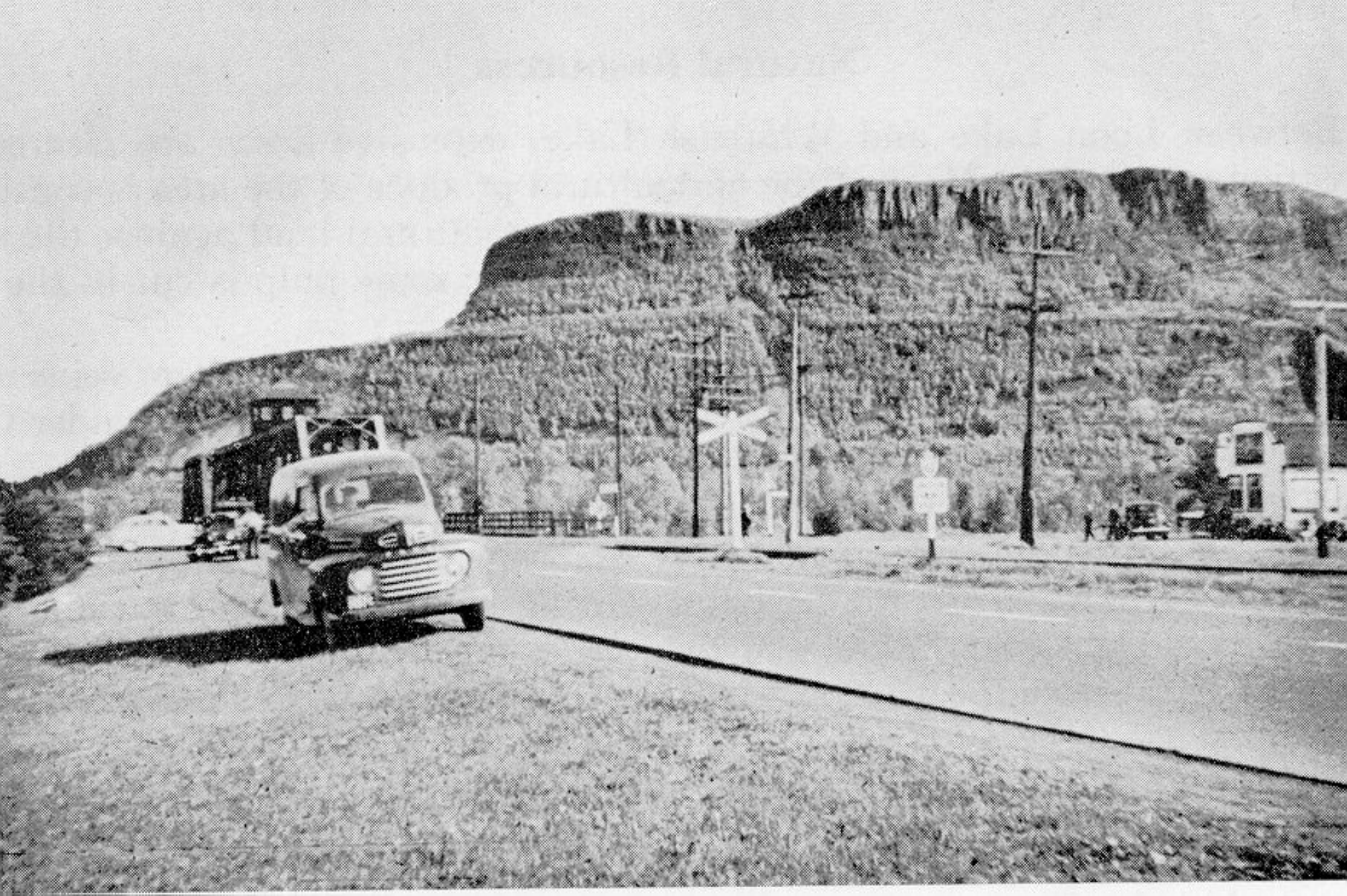






























ONTARIO
DEPARTMENT OF MINES

HON. JAMES A. MALONEY, *Minister* D. P. DOUGLASS, *Deputy Minister*
M. E. HURST, *Provincial Geologist*

Nepheline Syenite Deposits of Southern Ontario

By
D. F. HEWITT

With Contributions by H. S. Armstrong and C. E. Tilley

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Aerial photograph of the Blue Mountain nepheline syenite, Methuen township. (With overlay showing geology.)

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ABSTRACT

The report entitled Nepheline Syenite Deposits of Southern Ontario is divided into two parts.

Part I describes the economic development of nepheline syenite deposits in Ontario, including a history of development of the industry and the history of both the active producing companies at Blue Mountain in Methuen township, Peterborough county. The chemical and mineralogical composition of nepheline syenite is dealt with. Specifications and uses of nepheline syenite in various commercial applications are described. The occurrences of nepheline syenite deposits in Ontario are very briefly described. Sections on grade and evaluation of nepheline syenite deposits, quarrying, and milling complete this part.

Part II, which deals with the geology of nepheline syenite deposits of southern Ontario, is divided into four chapters.

Chapter I is introductory and describes general features of the mineralogy, lithology, weathering, age relations, and field relationships of the Blue Mountain, Haliburton-Bancroft, and French River nepheline syenite occurrences described in the ensuing chapters.

Chapter II describes the geological occurrence and characteristics of the nepheline syenite deposits of the Haliburton-Bancroft area. The description is by area from west to east over a length of 80 miles.

Chapter III deals with the geology of Methuen township where the extensive Blue Mountain nepheline syenite deposit occurs. Considerable detail is given on the structure and geological history of the area, as well as the field relations of the nepheline syenite body.

Chapter IV describes the geology of the French River nepheline syenite deposits in Bigwood township, District of Sudbury. A discussion of the origin of these nepheline syenite bodies is included. The author's work indicates that, although the bodies are mainly emplaced by intrusion of a nepheline syenite magma, some replacement has occurred.

NEPHELINE SYENITE DEPOSITS
Southern Ontario

BY

D. F. HEWITT[1]

PART 1—ECONOMIC DEVELOPMENT OF NEPHELINE SYENITE DEPOSITS

INTRODUCTION

Part 1 of this report describes the nepheline syenite deposits of southern Ontario and their economic development. In the late 1920's and early 1930's considerable interest was aroused in nepheline syenite as a potential source of ceramic raw material to compete with feldspar in glass and ceramic bodies. Attention was given to the extensive nepheline syenite deposits of the Haliburton-Bancroft area of eastern Ontario described in detail in the Geological Survey memoir by F. D. Adams and A. E. Barlow.[2]

In 1936 the Blue Mountain nepheline syenite body in Methuen township, Peterborough county, became the site of the first commercial development of nepheline syenite in Ontario, and the industry has steadily expanded since that time. In 1961 there are two producers, American Nepheline Limited and International Minerals and Chemical Corporation (Canada) Limited, producing a total of over 200,000 tons of nepheline syenite annually. Although many other nepheline syenite deposits have been examined, and a few even opened up commercially, only the Blue Mountain deposit is being exploited. This is due to its high purity, the large tonnages of ore reserves available, and the favourable location of the deposit.

History of Development

Some of the earliest papers dealing with utilization of nepheline syenite in the ceramic industry were published in Russia. These papers are reviewed by C. J. Koenig:

C. J. Koenig, *Literature Abstracts of Ceramic Applications of Nepheline Syenite*, Ohio State Univ., Engineering Experiment Station, Bull. 167, 1958.

Koenig's paper gives an excellent summary of many articles on nepheline syenite, particularly those dealing with its ceramic applications; accompanying references are largely drawn from this paper.

---

[1]Geologist, Ontario Department of Mines.

[2]F. D. Adams and A. E. Barlow, *Geology of the Haliburton and Bancroft Areas, Province of Ontario*, Geol. Surv. Can., Memoir No. 6, 1910.

In 1928 a paper on glass manufacture in Russia appeared describing experiments in the use of nepheline syenite in the glass batch to replace soda ash:

Anon., "Glass Manufacture in Russia," *Chem. Trade Jour.* and *Chem Engr.*, 82 (2122) 57 (1928; *Ceramic Abstracts*, 7 (6) 355 (1928).

A second paper by W. Warghin in 1929 was reported in *Ceramic Abstracts*. The conclusions were that these rocks are excellent for use in the glass industry as an economical replacement for soda ash:

W. Warghin, *Applications of Nepheline Syenites of the Murman Coast in the Glass Industry*, U.S.S.R. Scientific-Technical Dept. of the Supreme Council of National Economy, Trans. Ceram. Res. Inst. (Moscow), Vol. 15, 1929, in *Ceramic Abstracts*, Vol. 8, 1929, p. 565.

In 1930, F. W. Preston reported the successful use of nepheline syenite in a Leningrad glass factory:

F. W. Preston, "Making Glass from Nepheline," *Glass Industry*, Vol. 11, 1930, No. 6, p. 131.

In 1931 and 1932, *Ceramic Abstracts* reviewed ten Russian papers on further uses of nepheline in the ceramic and glass industries of Russia:

V. M. Permiakov, *Nepheline Syenite and Nepheline Apatite in the Porcelain Industry*, Keram. i Steklo, 6 (9) 456 (1930); in *Ceramic Abstracts*, Vol. 10, 1931, No. 3, p. 201.
A. I. Zhilin, *Use of Nepheline for Enamels*, Keram. i Steklo, 6 (10) 485-88 (1930); in *Ceramic Abstracts*, Vol. 10, 1931, No. 4, p. 254.
A. H. Dauvalter and N. D. Zavialov, *Bottle Glass Batches with Nepheline Syenites*, Keram i Steklo, 6 (11-12) 504-506 (1930); in *Ceramic Abstracts*, Vol. 10, 1931, No. 5, p. 388.
Samsonov, *Use of Nepheline Batch in the Proletary Glass Works*, Keram i Steklo, 7 (3) 3 (1931); in *Ceramic Abstracts*, Vol. 10, 1931, No. 10, p. 688.
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G. I. Levenfisch, *Manufacturing Glass containing Nepheline*, Keram i Steklo, 7 (1) 1-2 (1931); in *Ceramic Abstracts*, Vol. 10, 1931, No. 11, p. 762.
A. I. Motchalov, *Glass containing Nepheline*, Keram i Steklo, 7 (5) 11-13 (1931); in *Ceramic Abstracts*, Vol. 10, 1931, No. 12, p. 832.
S. N. Solovianov, *Using Nepheline in Glass Manufacture*, Zhur. Khim. Prom., 8 (2) 135-41 (1931); in *Ceramic Abstracts*, Vol. 11, 1932, No. 1, p. 15.
A. D. Bogooslovski and L. G. Resnikov, *Low-Tension Porcelain Insulators with Wooden Sockets*, Keram i Steklo, 8 (1) 38-41 (1932; in *Ceramic Abstracts*, Vol. 11, 1932, No. 7, p. 422.
P. A. Volkov, *New Ideas for Utilization of Nephelite in Industry*, Compt. rend. Acad. Sci. (U.S.S.R.), A, 165-72 (1932); in *Ceramic Abstracts*, Vol. 12, 1933, No. 7, p. 276.

AMERICAN NEPHELINE LIMITED

Initial interest in the nepheline syenites of Ontario resulted from the discovery of corundum in these rocks and in associated alkaline syenites in 1897. During the period from 1897 to about 1905 there was intensive prospecting in central-eastern Ontario for corundum-bearing nepheline and alkaline syenites, and most of the known deposits were discovered and examined at that time. Willet G. Miller, Provincial Geologist of Ontario, spent parts of the field seasons of 1897 and 1898 examining these deposits, and described many of the nepheline syenite occurrences of the Bancroft-Renfrew area and Methuen township, in his early reports on corundum.[1] Adams and Barlow[2] give a detailed description of the nepheline syenite deposits. In the 1930's when interest was aroused in these alkaline rocks as a potential source of glass and ceramic raw material, these early reports and maps proved invaluable as a guide to prospecting.

[1]Willet G. Miller, "Corundum and Other Minerals," *Annual Report*, Ont. Bur. Mines, Vol. VIII, 1899, pt. 2, pp. 206–17.
[2]F. D. Adams and A. E. Barlow, *op. cit.*

In 1932 and 1933, William Morrison prospected and staked part of the Blue Mountain nepheline syenite deposit in Methuen township, Peterborough county, and in 1934 organized Nepheline Company Limited. They interested H. R. Deeth who organized Canadian Nepheline Limited in 1935 to finance and develop the property. During the winter of 1935–36 quarrying was begun at Blue Mountain; a mill was built at Lakefield, and nepheline syenite production from this property has continued since that time.

In 1937 an American subsidiary, American Nepheline Corporation, was formed to carry on business in the United States, and a mill was erected at Rochester, N.Y., for crushing and grinding crude nepheline syenite from the Blue Mountain quarries. When the Cobourg-Rochester ferry service terminated in 1951, the Rochester mill was closed and moved to Lakefield. In 1956 the fine-grinding division at Lakefield was moved to the mine site at Nephton, where the whole operation is now carried on. From 1940 to 1945 the company operated in Canada under the name American Nepheline Corporation; in 1945 reorganization and expansion created American Nepheline Limited. A new mill with an increased capacity was built at Nephton in 1947.

Until 1946 all the ore was mined by open-pit methods, but from 1946 to 1948 several large underground stopes were opened up. Since 1948 all production has been from open-pit quarries. Since 1950 production has been entirely from the Cabin Ridge quarries north of Big Mountain Lake. In 1955 a Canadian Pacific Railway 17-mile spur line was built to the property from Havelock. In 1956 a large expansion program involving the erection of a new $2,500,000 plant was completed.

The first of a series of papers on Canadian nepheline syenite and its applications in the ceramic industry was published in 1935 by C. J. Koenig of the Ohio State University Engineering Experiment Station.

C. J. Koenig, "Syenite in Ceramic Bodies," *Ceramics Industry*, Vol. 25, 1935, pt. 6, pp. 338–39. Canadian Nepheline Limited, "Nepheline Syenite, a new Batch Material," *Glass Industry*, Vol. 17, 1936, pt. 3, p. 80.

This paper was followed by several describing the new Ontario deposit operated by Canadian Nepheline Limited:

Canadian Nepheline Limited, "Nepheline Syenite, a New Batch Material," *Glass Industry*, Vol. 17, 1936, pt. 3, p. 80.

C. L. Cruikshank, "Nepheline Syenite," *Bulletin*, Amer. Ceram. Soc., Vol. 15, 1936, No. 4, pp. 167-68.

N. B. Davis, "Nepheline Syenites of Ontario," *Journal of Canadian Ceramic Society*, Vol. 6, 1937, pp. 50–53.

R. B. Ladoo, "Nepheline Syenite," *Glass Industry*, Vol. 18, 1937, pt. 6, pp. 204–6.

C. M. Nicholson, "Nepheline Syenite—A New Industrial Mineral," *Canadian Chemical Process Industry*, Vol. 22, 1938, pp. 33–35.

H. S. Spence, "Nepheline Syenite from Ontario," *Mining Technology*, Amer. Inst. Min. Eng., Tech. Pub. No. 951, 1938, pp. 1–9.

C. M. Nicholson, "Developing Canada's Nepheline Syenite," *Canadian Mining Journal*, Vol. 61, No. 3, 1940, pp. 135–36.

J. Satterly, *Mineral Occurrences in the Haliburton Area*, Ont. Dept. Mines, Vol. LII, 1943, pt. 2, pp. 78–81.

The complete operation and the mill installed at Nephton in 1947 were described by Deeth and Koenig in 1948.

H. R. Deeth and C. J. Koenig, "Recent Developments in Mining, Processing and Application of Nepheline Syenite from Blue Mountain, Ontario," *Mining Technology*, Amer. Inst. Min. Eng., Tech. Pub. No. 2406, July 1948, pp. 1–8.

The new 600-ton-per-day mill of American Nepheline Limited, opened at Nephton in 1956, is described in three recent papers.

J. J. Mather and H. Maidment, "Milling and Process Methods of American Nepheline Limited," *Transactions*, Can. Inst. Min. Met., Vol. LX, 1957, pp. 217–24.
H. R. Deeth, "Nepheline Syenite at Blue Mountain," *Mining Engineering*, Amer. Ins. Min. Eng., Nov. 1957, pp. 1241–44.
W. E. Trauffer, "Nepheline Syenite," *Pit and Quarry*, Jan. 1958.

The initial work on the ceramic applications of nepheline syenite carried out by C. J. Koenig at the Ohio State University Engineering Experiment Station in 1935 has already been mentioned. In 1937 when American Nepheline Corporation was formed as an American subsidiary of Canadian Nepheline Limited, a co-operative research project on nepheline syenite was started at the Engineering Experiment Station by Koenig under the direction of G. A. Bole, and several papers were published leading to the expansion of the potential market for nepheline syenite:

C. J. Koenig, *The Use of Syenites in Semivitreous Ware*, Ohio State Univ., Eng. Exp. Sta., Bull. No. 94, 1937, pp. 1–22.
C. J. Koenig, "Use of Nepheline Syenite in Ceramic Products," *Journal of Canadian Ceramic Society*, Vol. 7, 1938, pp. 36–39.
C. J. Koenig, "Nepheline Syenite in Sanitary Porcelain," *Journal of American Ceramic Society*, Vol. 22, 1939, No. 2, pp. 38–46.
C. J. Koenig, "Fundamental Properties of Nepheline Syenite," *Journal of American Ceramic Society*, Vol. 22, 1939, No. 2, pp. 35–38.
C. J. Koenig, "Use of Nepheline Syenite in Floor Tile and Wall Tile Bodies," *Journal of American Ceramic Society*, Vol. 23, 1940, pt. 3, pp. 86–91.
J. H. Chilcote and C. J. Koenig, "Use of Nepheline Syenite in Heavy Clay Products," *Journal of Canadian Ceramic Society*, Vol. 8, 1939, pp. 53–58.
C. J. Koenig, *Nepheline Syenite in Ceramic Ware*, Ohio State Univ., Eng. Exp. Sta., Bull. No. 103, 1939, pp. 1–74.
C. J. Koenig, *Nepheline Syenite in Low-Temperature Vitreous Ware*, Ohio State Univ., Eng. Exp. Sta., Bull. No. 112, 1942, pp. 1–36.
C. J. Koenig, "Nepheline Syenite in Hotel Chinaware Bodies," *Journal of American Ceramic Society*, Vol. 25, 1942, No. 3, p. 90.
C. J. Koenig, "Low Temperature Vitreous Bodies," *Journal of American Ceramic Society*, Vol. 25, 1942, No. 4, pp. 230–36.
C. J. Koenig, "Development Regarding Nepheline Syenite in Ceramics," *Journal of Canadian Ceramic Society*, Vol. 16, 1947, pp. 17–25.
C. J. Koenig, "*Influence of Grain-Size Distribution, and Fluid-Energy Reduction on the Properties of Lakefield Nepheline Syenite*, Ohio State Univ., Eng. Exp. Sta., Bull. No. 156, 1955.
R. C. Wilson and C. J. Koenig, "Use of Nepheline Syenite in High Talc Ball Clay Bodies," *Bulletin of American Ceramic Society*, Vol. 36, 1957, No. 9.
R. C. Wilson and C. J. Koenig, *The use of Nepheline Syenite Tailings in Sewer-Pipe Bodies*, presented at American Ceramic Society meeting at Dallas, Tex., May, 1957.

INTERNATIONAL MINERALS AND CHEMICAL CORPORATION (CANADA) LIMITED (CANADIAN FLINT AND SPAR DEPARTMENT)

In 1912, N. B. Davis became interested in nepheline syenite and tested deposits in the Haliburton-Bancroft area as potential sources of alumina. In 1928 and 1929, when the possibilities of utilizing nepheline syenite as a ceramic raw material became apparent, Mr. Davis, then manager of Canadian Flint and Spar Company of Ottawa, sent sample shipments of nepheline syenite to the Mines Branch at Ottawa for magnetic separation tests. Subsequently this company acquired nepheline syenite deposits in the Haliburton-Bancroft area, and in 1936 the property at the northeast end of Blue Mountain in Methuen township, where the plant now stands, was staked. A 4-mile road was built in to this property by the company in 1938, and some test work was done. However, from 1939 to 1942 the company produced nepheline syenite pegmatite from other deposits acquired near Bancroft, and no further work was done on the Methuen deposits until after World War II.

In 1939, Canadian Flint and Spar Company was sold to Consolidated Feldspar Corporation of Trenton, N.J., and in 1953, this firm, in turn, was bought by International Minerals and Chemical Corporation, of Chicago. Interest was renewed in the Blue Mountain property, and in 1954 and 1955 this company carried out extensive diamond-drilling and mill tests on the Methuen deposit. In 1956, a 300-ton-per-day mill was opened at Blue Mountain and is operated by the Canadian Flint and Spar Department of International Minerals and Chemical Corporation (Canada) Limited. The Canadian Pacific Railway spur line from Havelock to Nephton was extended 4 miles to this new operation in 1956.[1]

OTHER PRODUCERS

There were a number of small producers of nepheline syenite active in the Bancroft area from 1937 to 1942. Gooderham Nepheline, operating the Fraser and Gill nepheline pegmatite quarries in Glamorgan township, Haliburton county, produced 3,178 tons of nepheline pegmatite in 1937 and 1938. The Golding-Keene and Vardy quarries in Dungannon township, Hastings county, operated from 1937 to 1939 by New England Nepheline Company, an affiliate of Golding-Keene Company of New Hampshire, produced 11,092 tons of nepheline syenite and nepheline pegmatite. In 1939, 1940, and 1942, Canadian Flint and Spar Company produced 1,694 tons of nepheline pegmatite from the Davis quarry in Dungannon township. Temagami Development Company, operated by William Morrison, produced a total of 1,663 tons of nepheline pegmatite in 1939 and 1940 from the Morrison quarry in Dungannon township. Although some of these deposits in the Bancroft area are somewhat richer in nepheline than the Blue Mountain deposit, they were abandoned owing to a higher iron content and the presence of irregularly distributed calcite blebs in the nepheline of the pegmatites.

During World War II the Aluminum Company of Canada Limited and Ventures Limited examined nepheline syenite deposits as a potential source of alumina, and considerable diamond-drilling was carried out in the Bancroft area.

A nepheline-corundum gneiss deposit in Monteagle township was investigated in 1947 by Louis Moyd, consulting geologist, Yonkers, N.Y. The property was optioned to Ortona Gold Mines Limited in 1950, and a company, Monteagle Minerals Limited, was formed to carry on further exploration. Diamond-drilling was carried out in 1950, and mill tests were run during 1951, 1952, and 1953, but the property has not been brought into production.

OUTLOOK

Due to the persistent work of American Nepheline Limited in pioneering the expansion of the use of nepheline syenite in America in the glass and ceramic trade, a demand for nepheline syenite has been built up, and a substantial and steady market now exists both in America and Europe. In the glass batch, nepheline syenite is used as an economical source of alkalis and alumina. It replaces feldspar in some ceramic bodies, glazes, and enamels, and is also used in floor and wall-tile bodies. The lower fusion point and greater fluxing action of nepheline syenite, compared with feldspar, allows firing at lower temperatures, or with a smaller quantity of the vitrifying agent. In the glass batch nepheline imparts greater workability per unit alumina than does potash feldspar. Nepheline syenite is now widely accepted as an important ceramic raw material in the glass and ceramic industries.

[1]The operation was described by W. E. Trauffer in *Pit and Quarry*, October 1956, pp. 84–90.

COMPOSITION OF NEPHELINE SYENITE

Nepheline syenite is an alkaline igneous rock characterized by the presence of the feldspathoid mineral, nepheline, which has the chemical formula, $NaAlSiO_4$.

When a rock magma deficient in silica crystallizes, the orthosilicate, nepheline, forms instead of albite feldspar. In the presence of silica, nepheline will react to form albite according to the formula:

$$\underset{\text{(nepheline)}}{NaAlSiO_4} + \underset{\text{(quartz)}}{2SiO_2} \rightarrow \underset{\text{(albite)}}{NaAlSi_3O_8}$$

COMPOSITION OF NEPHELINE SYENITES IN RELATION TO SYENITES AND GRANITES

Condition of Magma	Undersaturated in Silica	Saturated in Silica	Oversaturated in Silica
Percent SiO_2 in the Magma	Less than 63 percent	63–68 percent	Over 68 percent
Characterizing Minerals	Feldspathoids crystallize: Nepheline	Feldspars crystallize: Plagioclase Orthoclase	Quartz crystallizes: Quartz + Feldspars
	Leucite	No feldspathoids	No feldspathoids
	No quartz	No quartz	
Rock Name	Nepheline syenite Leucite syenite	Syenite	Granite

Nepheline syenites vary greatly in mineralogy but are composed essentially of nepheline, sodic plagioclase (usually albite or oligoclase), and microcline. Biotite, magnetite, hornblende (often hastingsite), and pyroxene are characterizing accessories. Scapolite, muscovite, calcite, garnet, zircon, corundum, titanite, vesuvianite, tourmaline, apatite, pyrite, ilmenite, graphite, sodalite, cancrinite, hydronephelite, chlorite, and zeolites may occur as accessories.

MINERALOGICAL COMPOSITION OF BLUE MOUNTAIN NEPHELINE SYENITE DEPOSIT

(Average of 112 Rosiwal analyses by M. L. Keith, "Petrology of the Alkaline Intrusive at Blue Mountain," *Bulletin*, Geol. Soc. Amer., Vol. 50, 1939, No. 12, pt. 1, p. 1806).

	Modal	Range
	percent	percent
Albite	54	35–80
Microcline	20	2–40
Nepheline	22	0–40
Muscovite	2	.....
Mafic minerals (biotite, hastingsite, pyroxene, magnetite)	2	.....

COMPARATIVE DATA, BLUE MOUNTAIN NEPHELINE SYENITE DEPOSIT

(M. L. Keith, "Petrology of the Alkaline Intrusive at Blue Mountain," *Bulletin*, Geol. Soc. Amer., Vol. 50, 1939, No. 12, pt. 1, pp. 1809–13.)

	Albite	Microcline	Nepheline
SiO_2	67.90	64.50	43.01
Al_2O_3	20.60	19.31	34.01
MgO	0.06	0.42	0.04
CaO	0.24	0.07	0.36
Na_2O	10.78	2.03	15.42
K_2O	0.15	13.59	6.15
H_2O+	0.22	0.28	0.99
Fe_2O_3	nil	nil	0.14
FeO	nil	nil	nil
Total	99.95	100.20	100.12
Formula	$Na\left(\frac{Al}{Si_3}\right)O_8$	$K\left(\frac{Al}{Si_3}\right)O_8$	$\left(\frac{Na_4}{K}\right)\left(\frac{Si_5}{Al_5}\right)O_{20}$ slight silica excess
Specific Gravity	2.59	2.55	2.62
Anorthite Content	An_1 (chemical)	.....	.....

A chemical analysis of typical white crude nepheline syenite from the Cabin Ridge quarry of American Nepheline Limited is given by Derry and Phipps:[1]

	PERCENT
SiO_2	59.18
Fe_2O_3	2.15
Al_2O_3	23.06
Na_2O	10.48
K_2O	3.94
CaO	0.76
MgO	0.17
TiO_2	0.064
ZrO_2	0.05
P_2O_5	0.021
Loss on ignition	0.40
	100.275

On removal of the iron-bearing minerals by dry magnetic separation after grinding, the chemical composition of finished Grade A "Lakefield" nepheline syenite produced by American Nepheline Limited is given as follows:

CHEMICAL ANALYSIS OF GRADE A "LAKEFIELD" NEPHELINE SYENITE

(Average of 12 monthly composite samples of commercial shipments, 1955. From an unpublished quality control report by American Nepheline Limited, 1956.)

	Percent	Range in percent
SiO_2	60.56	0.78
Al_2O_3	23.68	0.40
Fe_2O_3	0.083	0.019
CaO	0.75	0.32
MgO	0.12	0.10
Na_2O	9.78	0.50
K_2O	4.37	0.23
Loss in ignition	0.69	0.10

[1]D. R. Derry and C. V. G. Phipps, "Nepheline Syenite Deposit, Blue Mountain, Ontario," *Geology of Canadian Industrial Mineral Deposits*, Sixth Commonwealth Mining and Metallurgical Congress, 1957, p. 191.

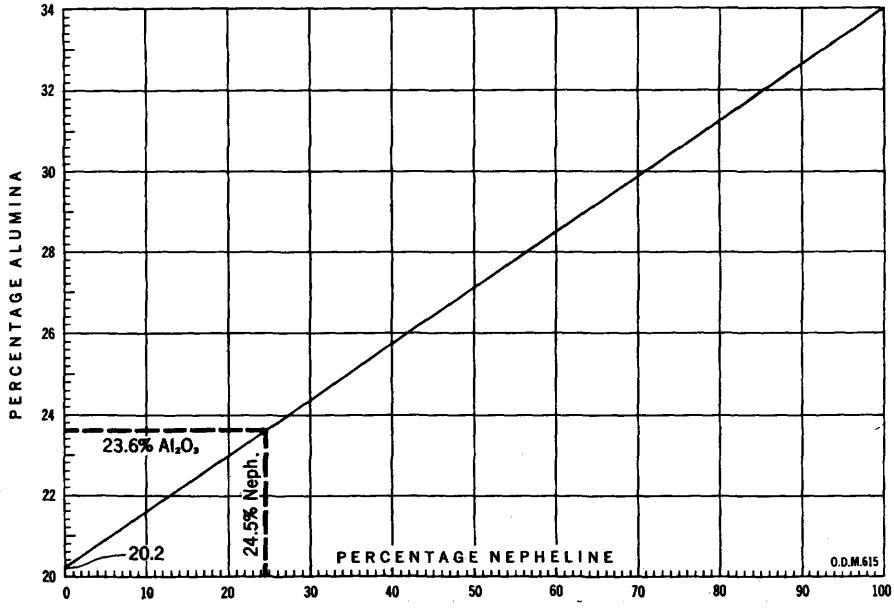
Chemical analyses of the crude rock and the refined product of Canadian Flint and Spar Department, International Minerals and Chemical Corporation (Canada) Limited, are very similar:

COMPARISON OF CRUDE ROCK AND REFINED PRODUCT
(International Minerals and Chemical Corp. (Canada) Ltd.)

	Crude Rock	Refined Product
	percent	percent
SiO_2	58.8	59.6
Al_2O_3	23.5	23.9
Fe_2O_3	1.4	0.067
CaO	0.3	0.2
MgO	trace	trace
Na_2O	10.8	11.0
K_2O	4.9	5.0
Ignition loss	0.3	0.3
Total	99.9	100.67

If the ratio of potash feldspar to albite is taken as 2:5, the accompanying graph illustrates the relation between nepheline content of the nepheline syenite and percentage of alumina in the rock.

An alumina content of 23.6 percent indicates a nepheline content of about 24.5 percent. A 10 percent increase in nepheline content increases the alumina by 1.4 percent. Since the alkali and alumina content are important selling factors, the control of the nepheline content, as well as the iron, in the rock mined, is important.



Relationship of nepheline content to alumina content in Blue Mountain nepheline syenite.

Quality Control[1]

Uniformity in the milled product is maintained by careful quality control. Complete chemical analyses of diamond-drill core are carried out to determine the variability of the deposit before laying out the quarrying program. Sampling of the quarry faces is carried out during quarrying. Chemical analysis of these samples allows blending of material from different parts of the quarry.

SPECIFICATIONS AND USES

Chemical and Physical Specifications

A summary of the grain-size specifications for glass and pottery grade nepheline syenite produced by American Nepheline Limited is given by Mather and Maidment:[2]

GRAIN-SIZE SPECIFICATIONS FOR GLASS- AND POTTERY-GRADE NEPHELINE SYENITE

Product	No.	Fe_2O_3	Grain Size
		percent	
Grade A	A-30 (glass)	0.08	minus 30-mesh
	A-200 (pottery)	0.08	95 percent minus 325-mesh
	A-270 (pottery)	0.08	98 percent minus 325-mesh
	A-400 (pottery)	0.08	100 percent minus 325-mesh
Grade B	B-25	0.40	minus 25-mesh
	B-100	0.50	minus 100-mesh
	B-200	3.00	95 percent minus 325-mesh
	B-1000	0.12	minus 1,000-mesh
Grade C	C	0.40	minus 25-mesh
	Crude	2.00	minus 2-inch
Magnetite concentrate		56 (Fe)	minus 25-mesh

Chemical analyses of the Grade A "Lakefield" nepheline syenite of American Nepheline Limited and comparable Blue Mountain nepheline syenite of International Minerals and Chemical Corporation, given in the previous section, indicate an alumina content of about 23.5 percent and a maximum iron content of 0.08 percent Fe_2O_3. The "glass grade" product is of sand size (A-30 above), whereas the "pottery grade" is flour size (A-200, A-270, etc.).

Effect of Fineness of Grind

"Fine grinding of nepheline syenite improves its ceramic properties. The temperature at which it becomes active in the porcelain bodies is lowered, and the maturing range is lengthened. This improves the pitch or 'ring' of the ware. Warpage is decreased and strength increased."[3]

[1] J. J. Mather and H. Maidment, "Milling and Process Methods of American Nepheline Limited," *Transactions*, Can. Inst. Min. Met., Vol. LX, 1957, p. 223.

[2] *Ibid.*

[3] C. M. Nicholson, "Developing Canada's Nepheline Syenite," *Canadian Mining Journal*, Vol. 61, 1940, No. 3, p. 144.

Pyrometric Cone Equivalent of Nepheline Syenite

"Nepheline syenites fuse on an average several cones lower, are more active in dissolving silica and have sintering ranges several cones longer than potash feldspar. Lakefield nepheline syenite starts to sinter at cone 08 and has a P.C.E. [pyrometric cone equivalent] of 6, a sintering range of about 13 cones. Koenig points out that the longer maturing range of bodies fluxed with nepheline syenite is due to the fact that it is a mixture of three minerals, albite, microcline and nepheline. There is apparently a progressive vitrification started by the nepheline and followed in order by the albite and microcline, and a glass formed by a combination of the three."[1]

The following other physical properties are given for nepheline syenite:[2]

Specific gravity	2.61
Refractive index (average of minerals)	1.53
pH value (5 gm. in 6 cc. water)	9.6
Hardness (Mohs scale)	5.5

Uses of Nepheline Syenite[3]

1) Glass.—The main use of nepheline syenite is in the glass batch to introduce alumina and alkalis. It is low in silica (no free quartz), low in iron content, and has a favourable soda to potash ratio (2:1). Compared with potash feldspar, nepheline syenite decreases the viscosity of the glass batch, allowing easier workability. Its lower fusion point lowers melting temperatures of the glass batch. This results in faster melting and higher productivity for the glass tank as well as fuel savings.

2) Sanitary Porcelain; High and Low-Tension Electrical Porcelain; Semi-vitreous Dinnerware; Hotel Dinnerware; Floor and Wall Tile; Dental Porcelain; Art Pottery; Translucent China; Porcelain Liners and Balls.—Nepheline syenite in the body allows lower maturing temperatures and a longer vitrifying range, resulting in less warpage of ware. Substitution of nepheline syenite for potash spar may result in an improvement of glaze fit where crazing tendencies existed in semivitreous ware. The products show good impact strength, adsorption, density, shrinkage, and warpage qualities. The longer maturing range promotes more uniform ware under commercial firing conditions. Recently formulas were worked out for low temperature vitreous bodies firing at cone 3–5 (2,140°–2,200°F.) to produce a highly translucent hard dinnerware.

3) Porcelain Enamels.—Enamel frits using nepheline syenite fuse readily; the enamels have good adherence and apply well.

4) Mineral Wool; Glass Fibre.—Nepheline syenite is used as a raw material for the batch in manufacturing mineral wool and glass fibre.

5) Structural Clay Products.—The addition of a small amount of nepheline syenite may lower absorption and increase firing shrinkage and mechanical strength. The increased vitrification may improve resistance to weather. Lower maturing temperatures may save fuel. Recently nepheline syenite has been used with success as a body and glaze addition in the sewer pipe industry.

6) Mineral Filler.—Finely ground nepheline syenite may be used as an inert mineral filler in plastics, rubber goods, insecticides, etc. The very fine-grained A-400 type product has been used as an extender in paints.

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[1] C. M. Nicholson, *op. cit.*
[2] J. J. Mather and H. Maidment, *op. cit.*, p. 224.
[3] C. M. Nicholson, *op. cit.*, pp. 145–46.

OCCURRENCE OF NEPHELINE SYENITE DEPOSITS

Nepheline syenite deposits are not uncommon in Ontario, but they are rarely of large size and never occur in the large batholithic bodies characteristic of the granitic intrusives. The nepheline syenites occur mainly as igneous intrusive bodies. A limited amount of "nephelinization" may accompany intrusion, and some nepheline syenite bodies are considered to have been formed by "nephelinization," although there is considerable controversy as to how extensive the results of this process have been.

Nepheline syenite deposits have been reported in the following Ontario localities:

Southern Ontario (Grenville Province)

1. BLUE MOUNTAIN DEPOSIT, Methuen Township, Peterborough county.
2. HALIBURTON-BANCROFT AREA:
   a) Glamorgan-Monmouth Area, Haliburton County.
   b) Cardiff-Faraday Area, Hastings and Haliburton Counties.
   c) Dungannon-Monteagle-Carlow Area, Hastings County.
   d) Brudenell-Raglan Area, Renfrew County.
   e) Wolfe Nepheline Belt, Lyndoch Township, Renfrew County.
   f) Mount St. Patrick Area, Renfrew County.
3. FRENCH RIVER DEPOSIT, Bigwood Township, District of Sudbury.
4. CALLANDER BAY, North Himsworth Township, District of Nipissing.

Northern Ontario

1. OTTO TOWNSHIP, District of Timiskaming.
2. NEMEGOS DEPOSIT, Lackner and McNaught Townships, District of Sudbury.
3. NEMEGOSENDA LAKE, Chewett and Collins Townships, District of Sudbury.
4. HERMAN LAKE, GOUDREAU AREA, Township 49, District of Algoma.
5. PORT COLDWELL AREA, District of Thunder Bay.
6. STURGEON LAKE, District of Thunder Bay.
7. POOHBAH LAKE AREA, District of Rainy River.

Southern Ontario (Grenville Province)

1. BLUE MOUNTAIN DEPOSIT

An easily accessible, irregular-shaped stock of nepheline syenite about 2½ miles long and 1½ miles wide, with an elongated arm, extends 3½ miles to the southwest. The nepheline syenite is an excellent white colour, composed essentially of nepheline, microcline, and albite, with less than 5 percent easily removable mafic minerals, mainly biotite and magnetite. There are two commercial producers.

2. HALIBURTON-BANCROFT AREA

a) Glamorgan-Monmouth Area, Haliburton County

Nepheline syenite gneiss and pegmatite occur as narrow bands and small bodies in a belt of alkaline syenite about 13 miles long extending from a point south of Gooderham in Glamorgan township to Wilberforce in Monmouth township. These gneisses are composed essentially of nepheline and albite, with biotite and hornblende as essential minerals. Microcline, scapolite, pyroxene, garnet, magnetite, and graphite, are often present. These rocks are strongly gneissic and extremely variable in composition, especially in nepheline content; there are some mafic facies. Formerly there was some small production from two nepheline pegmatites.

b) Cardiff-Faraday Area, Hastings and Haliburton Counties

Minor narrow bands of nepheline-plagioclase gneiss occur in Cardiff and Faraday townships. None are of large size.

c) Dungannon-Monteagle-Carlow Area, Hastings County

The largest deposits of nepheline gneiss in the Haliburton-Bancroft area occur in Dungannon township. Two main bands of nepheline rocks occur: the Bancroft band extending from Bancroft eastward to the York River, and the York River band extending northward up the York River valley into Monteagle township. These deposits are easily accessible; the Bancroft band, which is the larger, has a length of about 3 miles and a maximum width of ½ mile. The gneisses are strongly banded and have an extremely variable nepheline content, ranging from 0 to 80 percent. Alumina content may range as high as 30 percent, but mafic-mineral content may also be high; the plagioclase may be as basic as andesine, and scapolite may be an important mineral; its colour is sometimes white, frequently grey. Owing to their variability and the somewhat higher iron content, the gneisses are not as attractive commercially as the Blue Mountain deposit. Four pegmatite deposits and one of nepheline syenite gneiss were formerly quarried. Considerable exploration work, diamond-drilling, and milling test work has been carried out in this area.

d) Brudenell-Raglan Area, Renfrew County

Several small nepheline syenite bands occur in Raglan and Brudenell townships, Renfrew county. They are frequently associated with corundum-bearing syenites. They are not likely to be of commercial interest because of their small size.

e) Wolfe Nepheline Belt, Lyndoch Township, Renfrew County

This is a narrow band of nepheline and alkaline syenite gneisses from 200 to 1,000 feet wide extending for a distance of over 4 miles in northeastern Lyndoch township. The nepheline content ranges from 5 to 40 percent. Mafic minerals range from 5 to 50 percent and include hornblende, pyroxene, garnet, biotite, and magnetite.

f) Mount St. Patrick Area, Renfrew County

A small band of nepheline gneiss occurs near Mount St. Patrick, Brougham township, Renfrew county.

3. FRENCH RIVER DEPOSITS

Nepheline syenite and associated pink alkaline syenite occur in a body 6 miles long and ½ mile wide in Bigwood township, District of Sudbury. The nepheline-bearing rocks occur in two zones: a north one consisting of nepheline, plagioclase, and hornblende, and a south one consisting of nepheline, plagioclase, and biotite. The north zone is characterized by pink nepheline, rather high in iron content. The south zone contains less pink nepheline, but the nepheline content is lower, about 15–20 percent where sampled.

4. CALLANDER BAY

On lots 2 and 3, concession XXV, North Himsworth township, District of Nipissing, there are several small outcrops of pink and grey nepheline syenite cutting the foliated hybrid granitic country rock gneisses. The main occurrences are on the southeast shore of Southeast Bay of Lake Nipissing at Callander, but a small island in the bay is also composed of nepheline syenite.

This nepheline syenite is fresh and unfoliated in contrast to the surrounding gneisses. It is composed of nepheline, plagioclase, prominent laths of pink potash feldspar, and biotite. The texture is that of the original igneous intrusion, and the rock is probably post-Grenville orogeny. In character and tectonic style this intrusive differs from the other nepheline syenites of the Grenville Province and may be associated with the niobium(columbium)-bearing nepheline syenite diatreme ring complexes of northeastern Ontario (Nemegos, Nemegosenda).

The deposit is of no commercial interest for ceramic-grade nepheline syenite because of its high iron content.

Northern Ontario

1. OTTO TOWNSHIP,[1,2]

The Otto stock, a satellitic quartz syenite and porphyritic syenite intrusion of the Round Lake batholith, is located in Otto township. It intrudes basic volcanic rocks, and the hybrid border zone along its north side contains nepheline. The nepheline occurs as a constituent of narrow sill-like masses of nepheline syenite intruded into volcanics and injection gneiss adjacent to the contact of the Otto stock, and as a constituent of the injection gneiss. The nepheline syenite consists of nepheline, microcline phenocrysts, albite, biotite, and aegirine-augite, with accessory muscovite, garnet, magnetite, titanite, and apatite. The longest band in lots 7 and 8, concession V, Otto township, can be traced ½ mile.

The nepheline occurrence apparently resulted from desilication of the syenitic Otto stock magma by the basic volcanic country rock. The occurrence is of no commercial interest.

2. NEMEGOS DEPOSITS, LACKNER AND McNAUGHT TOWNSHIPS[3]

The Nemegos niobium (columbium) deposit occurs in a nepheline syenite ring complex intruding foliated country rock gneisses in Lackner and McNaught townships, District of Sudbury, near the village of Nemegos. The alkaline ring complex is about 3 miles in diameter and consists of an outer ring of coarse-grained grey-to-white nepheline syenite, a central ring of mafic alkaline rocks including ijolite and dark foliated nepheline gneiss, and a core of pinkish-brown to grey nepheline syenite. The apatite-magnetite-pyrochlore orebodies occur in the central ring of mafic rocks.

The outer ring of nepheline syenite consists of nepheline, 35 percent; alkali (potash) feldspar, 45 percent; with accessory biotite and aegirine-augite, up to 15 percent; and sodalite, apatite, magnetite, calcite, perovskite, and albite.

The ijolite and dark-coloured alkaline rocks of the central ring consist of 50 percent aegirine-augite and 35 percent nepheline with minor biotite, apatite, titanite, calcite, magnetite, sodalite, cancrinite, and pyrochlore. In the non-ijolitic facies up to 50 percent alkali feldspar may be present with 12–40 percent nepheline and 15–30 percent aegirine-augite. Olivine may also be present in amounts up to 15 percent.

The inner core of nepheline syenite consists of alkali feldspar (microcline and perthite), up to 50 percent; nepheline, to 40 percent, and aegirine-augite, 20 percent; with accessory biotite, magnetite, calcite, cancrinite, apatite, and altered plagioclase.

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[1]H. C. Cooke, *Kenogami, Round, and Larder Lake Areas, Timiskaming District, Ontario*, Geol. Surv. Can., Memoir No. 131, 1922.

[2]K. D. Lawton, *The Round Lake Batholith and Its Satellitic Intrusions in the Kirkland Lake Area*, unpublished Ph.D. thesis, Univ. of Toronto, 1954.

[3]R. W. Hodder, *Alkaline Rocks and Niobium Deposits near Nemegos, Ontario*, Geol. Surv. Can., Paper 57-8, 1958.

3. NEMEGOSENDA LAKE, CHEWETT AND COLLINS TOWNSHIPS[1]

The nepheline syenites of the Nemegosenda Lake area in Chewett, Collins, McGee, and Pattinson townships, District of Sudbury, occur as the central alkaline plug of a circular ring complex about 4 miles in diameter intruding country rock gneisses. The alkaline plug is surrounded by a metasomatic-metamorphic aureole of fenitic gneisses.

The nepheline syenite central plug, which has a diameter of about 3 miles, consists of several distinct rock types differing in texture and in percentage of constituent potassic and sodic feldspars, nepheline, biotite, and aegirite. These rocks are brecciated and cut by carbonate zones.

The metasomatic aureole surrounding the central alkaline plug consists of a syenitic contact zone, a pyroxenitic fenite zone, and an outer alkalic fenite zone. These are interpreted by Parsons[2] as an initial phase, which preceded the intrusion of the central alkaline plug in a volcanic vent-like structure or diatreme.

4. HERMAN LAKE, GOUDREAU AREA

A small body of nepheline syenite containing biotite, pyroxene, and occasional calcite is described by T. L. Gledhill[3] on the east shore of Herman Lake. "Domino-shaped" microcline microperthite crystals are arranged in a subparallel fashion with interstitial nepheline and biotite. Two chemical analyses are given by Gledhill.

In describing the occurrence in 1931, E. S. Moore[4] stated that nepheline and cancrinite syenite occur at the end of a long tongue of granite intruding greenstone.

5. PORT COLDWELL AREA[5]

The nepheline syenite–syenite complex at Port Coldwell occupies an area of over 100 square miles extending from 3 miles east of Peninsula Harbour westward to Middleton Station on the C.P.R. and outcrops also on Big and Little Pic Islands. These rocks intrude the Keewatin volcanic complex.

Kerr describes the nepheline syenites as holocrystalline, medium-grained granitoid rocks, pale to dark grey in colour, often reddish or purplish due to hydronephelite. They often have a trachytic or semi-porphyritic texture due to alignment of large alkalic feldspar crystals. They are composed essentially of nepheline, microperthite, albite, hornblende, aegirine-augite, and magnetite, with accessory biotite, sodalite, muscovite, and titanite. The nepheline syenites appear to be the youngest of the syenitic complex and grade into dark-coloured syenitic rocks and diorite.

6. STURGEON LAKE[6]

A small stock of nepheline syenite on the east shore of the narrows of Sturgeon Lake occurs associated with augite syenite. It is a light-coloured, medium- to coarse-grained rock consisting of nepheline, microcline, orthoclase, microperthite, augite, biotite, cancrinite, and titanite.

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[1]G. E. Parsons, "Nemogosenda Lake Columbium Area," *Canadian Mining Journal*, Aug. 1957, pp. 83–87.

[2]*Ibid.*

[3]T. L. Gledhill, *Michipicoten Gold Area*, Ont. Dept. Mines, Vol. XXXVI, 1927, pt. 2, pp. 58, 59.

[4]E. S. Moore, *Goudreau and Michipicoten Gold Areas*, Ont. Dept. Mines, Vol. XL, 1931, pt. 4, p. 9.

[5]H. L. Kerr, "Nepheline Syenites of Port Coldwell," *Annual Report*, Ont. Bur. Mines, Vol. XIX, 1910, pt. 1, pp. 194–232.

[6]T. L. Gledhill, *Geology along an Eastward Continuation of Niven's 4th Base Line*, Ont. Dept. Mines, Vol. XXXIII, 1924, pt. 6, pp. 33–38.

7. POOHBAH LAKE AREA

A. C. Lawson[1] has described a nepheline pyroxene malignite from Poohbah Lake in the District of Rainy River.

Commercial Exploitation

Although nepheline syenite deposits are of widespread occurrence throughout the world, very few are worked commercially. The two companies operating at Blue Mountain, Methuen township, are the only producers of nepheline syenite in Canada.

Nepheline syenite is quarried in Arkansas for the manufacture of roofing granules. Nepheline syenite deposits are reported to be worked in the Kola Peninsula, U.S.S.R., for the ceramic industry.

GRADE AND EVALUATION OF NEPHELINE SYENITE DEPOSITS

Many factors must be considered in the evaluation of nepheline syenite deposits for commercial exploitation. There are the usual considerations of size, tonnage, and access. The deposit should be of large size, with a sufficient tonnage of ore reserves to sustain operation of a mill of the size planned for a period of years. Adequate open-pit quarry sites are essential. The deposit should be easily accessible by road and rail. Since the product is a low-cost, high-bulk commodity, it should be located close to markets where freight rates allow advantages over other competitive products such as feldspar.

With respect to grade, the major considerations are iron, alkali, and alumina content. The deposit should be amenable to dry magnetic beneficiation, and the iron content of the ceramic product should be 0.08 percent Fe_2O_3 or less. An alumina content of 23 percent or better is desirable. The higher the alkalis, the better.

It is of primary importance that the deposit have uniformity. The product delivered to the consumer must be uniform in physical, chemical, and mineralogical composition; to achieve this there must be reasonable uniformity at the quarry faces and close quality control throughout the processing. Quarry faces should be reasonably free from mafic dikes, sedimentary mafic inclusions, and syenite intrusives. Alteration along joints frequently introduces iron into the rock; these alteration zones are objectionable. For economic quarrying operations, the proportion of waste rock to be moved must be kept to a minimum.

Objectionable minor mineral constituents in the rock include zircon and corundum. If these minerals are present in the rock even in very small quantities, they appear in the ceramic product. Owing to their refractory character they may appear in glass products made from nepheline syenite as small black specks or flaws in the glass. The presence of other refractory heavy minerals not readily soluble in the glass batch would also be objectionable.

The nepheline syenite should be amenable to beneficiation; at Blue Mountain it has been observed that biotite and magnetite are easily removed magnetically. However, hastingsite and aegirine-augite present in some zones in the body are often intimately intergrown with the feldspar and are difficult to remove so as to get a clean iron-free separation. For this reason these mafic minerals are objectionable. In some areas the iron content of the mineral nepheline itself may rise to objectionable proportions. When this is the case the nepheline often has a noticeable pink or buff tinge.

[1] A. C. Lawson, Bulletins of the Department of Geology, University of California, Vol. I, p. 337.

QUARRYING

Although nepheline syenite was mined by underground methods for a short time at American Nepheline Limited both the companies now producing use only open pit quarrying methods.

American Nepheline Limited

Quarrying methods at American Nepheline Limited are described by Mather and Maidment[1] as follows:

Open pit mining methods are employed, as they are particularly well suited to the ridge-like nature of the rock formation. Mining is presently active on four 40-foot benches over a length of 2,000 feet.

Overburden, consisting of soil of little depth, and light vegetation, is removed primarily by bulldozer, the remainder manually. Hydraulic stripping methods are under investigation.

Bar and arm-mounted Leyner drills are used for ground preparation and isolated drilling, and jack hammers for block-holing. Detachable, throw-away bits are used in both operations.

A self-propelled Joy Challenger drill mounted on rubber is used for the major portion of the drilling. Four and one-half inch holes are drilled to a depth of 45 feet, the normal drilling pattern being two rows of holes, each having an 8½ foot burden and 10 foot spacing. Tungsten carbide *X*-type bits enable a drilling speed of 20 feet per hour.

A 1,200 c.f.m. two-stage compressor located at the mill site supplies all air. A second compressor of 750 c.f.m. is maintained for stand-by duty.

For all blasting operations 60-percent Forcite in two sizes, 1⅛ inch by 8 inch and 3 inch by 16 inch, is standard.[2] Primary shots, breaking 10,000 tons or more are detonated electrically, using short-period delay caps and twin lead Primacord.

Two shovels of 1 cubic yard and 1¼ cubic yard capacities load 15-ton diesel trucks. The rock is transported some 3,000 feet from the mining area to the rock slip at the crusher building.

International Minerals and Chemical Corporation (Canada) Limited (Canadian Flint and Spar Department)

Three quarries have been developed, but the main production is now from a large quarry immediately northwest of the primary crusher building. Overburden is light and stripping is by bulldozer and hand shovels. The quarry face averages 30 feet in height. Drilling is done by a Gardner Denver D99 wagon drill using 3-inch bits, and supplied with air by a 315-cfm. Gardner Denver compressor. Prilled ammonium nitrate and 50-percent Forcite are the blasting agents. Millisecond electric caps are used for detonation. Secondary breaking is done by a 5,500-pound drop ball mounted on a ¾-cubic-yard Northwest diesel shovel boom. The stone is loaded by a second ¾-yard Northwest diesel shovel into three 5-ton G.M.C. dump trucks.

MILLING NEPHELINE SYENITE

Beneficiation of nepheline syenite is entirely by dry magnetic separation methods, and the whole milling process is dry.

American Nepheline Limited[3]

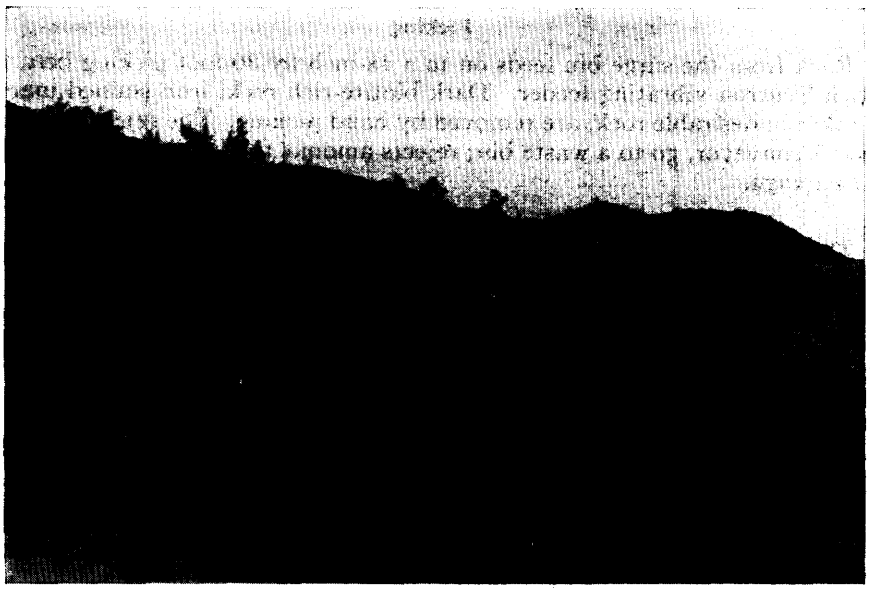
Primary Crushing

Trucks haul from the quarry dump into a 40-ton ore slip at the primary crusher building, on to a 4-foot wide pan feeder discharging over a 5-inch stationary bar grizzly into a 48- by 42-inch Allis-Chalmers jaw-crusher set at 6

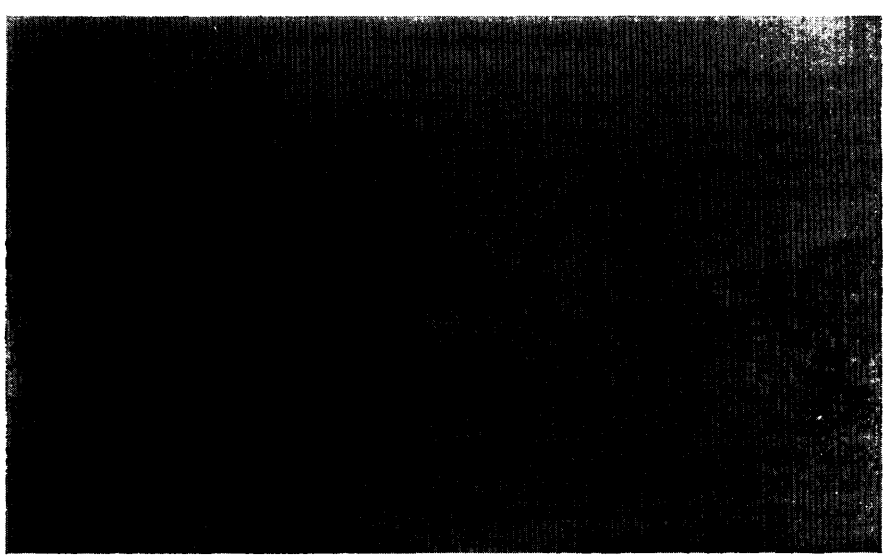
[1]J. J. Mather and H. Maidment, "Milling and Process Methods of American Nepheline Limited," *Transactions*, Can. Inst. Min. Met., Vol. LX, 1957, pp. 398, 399.

[2]Ammonium nitrate in prilled form is now being used as the chief blasting agent.

[3]Abstract after J. J. Mather and H. Maidment, *op. cit.*



Nepheline syenite quarry at Cabin Ridge, Blue Mountain. American Nepheline Limited.



Nepheline syenite quarry at the International Minerals and Chemical Corporation (Canada) Limited property at Blue Mountain.

inches. The minus 5-inch throughs from the grizzly together with the minus 6-inch crusher product are carried on a 30-inch belt conveyor to a 75-ton surge bin in the picking-belt building.

Picking

Rock from the surge bin feeds on to a 48-inch by 30-foot picking belt, via a 36-inch Syntron vibrating feeder. Dark biotite-rich rock, iron stained material, and other undesirable rock, are removed by hand picking. The rejects, which fall to No. 7 conveyor, go to a waste bin; rejects amount to about 1½ percent of the total tonnage.

Secondary Crushing and Rock Storage

The remaining rock is returned to the crusher building via No. 3 conveyor, a 30-inch by 159-foot conveyor, which feeds a 4¼-foot Symons standard cone, the secondary crusher. The minus 2-inch product of this crusher is conveyed on the 30-inch No. 4 conveyor to the 4,500-ton rock storage building where another 30-inch conveyor distributes the rock uniformly over the 96-foot length of the rock storage building by a self-propelled automatic tripper. A rough blending of the storage rock is achieved by controlled charging and withdrawal. The crushing department has a capacity of 300 tons per hour. The mining and crushing departments work a 5-day, 40-hour week, and the 4,500-ton rock storage enables the mill to operate continuously.

Drying

Rock is reclaimed through four chutes in the bottom of the rock storage bin by a movable Syntron feeder discharging on a 20-inch conveyor to be carried to the 100-ton dryer feed bin in the dryer building. Through a Syntron feeder the rock is delivered from this bin to a 70-inch by 50-foot parallel flow, oil-fired dryer. Dried rock is carried by two 20-inch conveyors to a 300-ton bin in the tertiary crusher building.

Tertiary Crushing and Screening

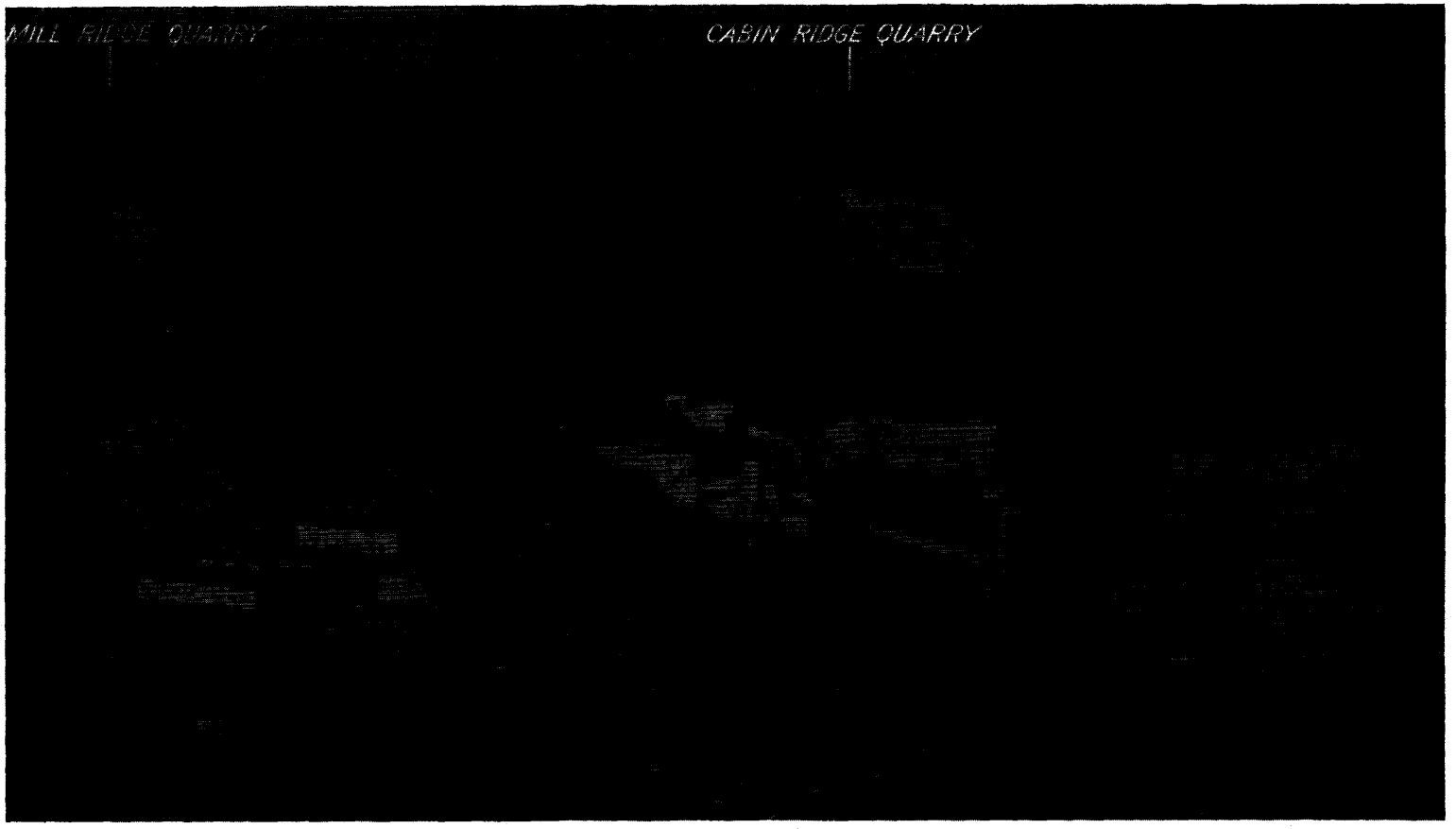
Two parallel circuits carry minus 2-inch rock from the bin to the third stage crushing. Each circuit consists of a vibrating feeder and a Seco two-deck, 3- by 10-foot screen, with ⅜- and 5/16-inch openings, followed by a Tyler two-deck 4- by 10-foot screen with 25-mesh openings on the lower deck.

The minus 2-inch plus ¼-inch product from the first screens flows by gravity to the tertiary crusher, a 4-foot Symons short head cone. The crusher discharge returns to the 300-ton feed bin and the screening circuit.

The undersize (minus ¼-inch) from the Seco screens goes to the Tyler screens where two products, minus ¼-inch plus 25-mesh, and minus 25-mesh, are produced. The minus ¼-inch plus 25-mesh material, now suitable as rolls feed, discharges on an 18-inch conveyor, is carried to bucket elevator No. 3, elevated to the 30-inch belt conveyor No. 17, which distributes it by means of a self-propelled automatic tripper to each of twelve, 30-ton, rolls feed bins.

The undersize (minus 25-mesh) from the Tyler screens, having reached the final stage of grind, is carried along a 14-inch conveyor to bucket elevator No. 14. The material discharges from the elevator to a 30- by 30-inch Stearns MD I electromagnetic drum separator where the highly magnetic minerals are removed and either wasted or binned for marketing as a byproduct.

The non-magnetic cleaned product from the drum separator, known as grade B-25, either goes via 14-inch conveyor No. 36 and bucket elevator No. 2 to a 150-ton storage bin for shipping, or goes via 14-inch conveyors Nos. 72 and 21 to the 30-mesh processing circuit for glass-grade A-30 material.



Mill and quarries of American Nepheline Limited at Blue Mountain. The Cabin Ridge quarry is shown in the distance; the Mill Ridge quarry is on the left.

Production of Glass-Grade Material

Minus ¼-inch plus 25-mesh material is delivered by Syntron feeders from the rolls feed bins to ten- 24-inch by 14-inch Exolon rolls. The rolls discharge on two-deck 4- by 10-foot Hummer screens for separation of the plus and minus 30-mesh fractions.

The oversize, plus 30-mesh, returns to the rolls feed bins. The minus 30-mesh material, a finished size, is chuted to one of six 30- by 30-inch Stearns drum-type magnetic separators. The cleaned product B-30 is conveyed to 12-ton surge bins.

Any oversize particles are removed by 48-inch Sweco circular screens and returned to the rolls. The undersize drop to 12-ton surge bins that feed via oscillating conveyors to the high-intensity Exolon magnetic separators. These final magnetic separators of the high-intensity induced roll type, remove biotite and hastingsite in a sucession of three separations, leaving the finished A-30 product, a low-iron, glass-grade nepheline syenite.

The magnetic or reject material is collected on conveyor No. 46 and carried to a re-treatment circuit that produces grade C material, by passage of the rejects through a pair of Dings 4-roll re-treatment separators.

The A-30 glass-grade product is conveyed to one of four 800-ton finished material bins.

Production of Pottery-Grade Material

Two methods are employed for producing pottery-grade material from the A-30 product. For the production of A-200 and A-270 (see page 9), pebble mills and air classification are used. Six conical pebble mills (four 8 feet by 48 inches, one 9 feet by 60 inches, and one 10 feet by 66 inches) operate in closed circuit with Hardinge air classifiers. The mills have Jasper Silex silica block lining and flint pebbles as the grinding media. The oversize from the air classifiers return to the pebble mills. The undersize and air continue to the cyclone product collector and are conveyed by airslide to the pottery-grade finished product bins; four 600-ton bins and two 150-ton bins.

A-400 Product—Fluid Energy Circuit

The second pottery product circuit producing A-400 material is a "fluid energy" grinding system in which grinding is accomplished by using heated air to circulate the material at high velocities in a doughnut-shaped chamber. Reduction is accomplished by self-attrition.

The A-30 product is ground in an 8-foot by 36-inch Hardinge conical pebble mill operating in open circuit. The pebble mill product goes to two 12-ton storage bins that feed two Wheeler fluid energy mills. Each mill uses compressed air (1,350 cfm. at 100 psi.) superheated to 850°F. by Todd air heaters.

The product of these mills is collected by two small-diameter cyclones in series and conveyed to storage silos.

The storage capacity for finished material consists of four 800-ton bins, four 600-ton bins, and three 150-ton bins for a total of 6,050 tons. Shipments are made in bulk or bagged.

Courtesy of Industrial Minerals & Chemical Corp. (Canada) Ltd.



Mill and quarries at International Minerals and Chemical Corporation (Canada) Limited property at Blue Mountain.

International Minerals and Chemical Corporation (Canada) Limited (Canadian Flint and Spar Department)[1]

Primary and Secondary Crushing

Trucks, hauling from the quarry, dump over a 20-inch grizzly into a 20-ton hopper feeding via an apron feeder to the 30- by 42-inch Pioneer primary jaw-crusher, which is set at 4 inches. The product from the jaw-crusher goes to a 3-foot Symons standard cone-crusher, which produces minus 1½-inch material. This product is conveyed by a 24-inch conveyor from the crusher building to a 500-ton bin in the main mill building.

Drying

The rock from the 500-ton rock storage bin feeds via two Hardinge constant weight feeders to a 5 by 50-foot counterflow Louisville oil-fired rotary dryer.

Tertiary Crushing and Screening

From the dryer the minus 1½-inch stone is conveyed to a 3-foot Symons short-head cone-crusher. The minus ⅜-inch product is conveyed to a pair of two-deck 4- by 10-foot Tyler Hummer screens with ⅛-inch and 30-mesh deck openings. The plus ⅛-inch material goes to the 250-ton rod mill feed bin. The minus ⅛-inch plus 30-mesh material is split three ways and goes to three sets of 14- by 24-inch rolls for recrushing. One set of rolls is in closed circuit with the 4- by 10-foot screens mentioned above; the other two sets of rolls are in closed circuit with two 4- by 10-foot two-deck Tyler screens. The minus 30-mesh products all go via conveyor to one of four Dings magnetic separators.

Grinding and Screening

Material from the rod mill feed bin discharges via Syntron feeders into a 5- by 8-foot Denver rod mill, which is fed from both ends and has a peripheral control discharge. It is loaded with 3- to 2-inch rods and driven at 23 revolutions per minute. The product of this mill is elevated to a pair of two-deck 8- by 10-foot Hummer screens with 8-mesh and 30-mesh openings on top and bottom. The oversize from both decks is returned to the rod mill feeders. The minus 30-mesh material is fed by Syntron feeders to two of the four Dings drum-type magnetic separators and then to the six Exolon magnetic-separator feed bins.

Magnetic Separation—Glass-Grade Material

The six feed bins supply minus 30-mesh material to six double Exolon 3-roll magnetic separators. Each is fed at the rate of 2 tons per hour by an attached vibrating feeder. The cleaned product is conveyed to a single-deck Hummer 30-mesh control screen, which removes any oversize material. The product goes to one of four 300-ton glass-grade storage bins or to a 50-ton pebble mill feed bin for production of pottery-grade material.

Production of Pottery-Grade Material

The pebble mill bin feeds an 8-foot by 48-inch Hardinge conical pebble mill which is lined with Jasper flint lining and charged with French flint pebbles. It is driven at 27 revolutions per minute. The mill is in closed circuit with a 14-foot Sturtevant air separator. The minus 200-mesh classifier product, which is pottery-grade material, goes, at the rate of 1¾ tons per hour, to the bagging plant or to a 130-ton storage bin.

[1]After W. H. Hood, manuscript, 1959.

PRODUCTION OF NEPHELINE SYENITE IN ONTARIO

Year	Tonnage	Value
1933	27	$ 324
1936	3,988	37,426
1937	15,422	121,481
1938	31,205	142,701
1939	30,766	140,138
1940	20,510	117,849
1941	39,657	227,583
1942	42,206	246,893
1943	49,901	292,010
1944	47,625	217,989
1945	61,345	275,766
1946	61,261	229,198
1947	66,995	341,635
1948	74,386	506,462
1949	78,783	623,002
1950	65,638	842,886
1951	81,108	1,114,943
1952	82,681	1,111,950
1953	113,345	1,576,271
1954	123,669	1,770,528
1955	146,068	2,099,512
1956	180,006	2,574,140
1957	200,016	2,754,060
1958	201,306	2,613,446
1959	228,722	2,930,932

PART 2—GEOLOGY OF NEPHELINE SYENITE DEPOSITS OF SOUTHERN ONTARIO

CHAPTER I

Introduction

The Blue Mountain, Haliburton-Bancroft, and French River nepheline syenite deposits have much in common as to lithology, texture, mineral assemblages, and field relations. Their gneissic structure and metamorphic texture are compatible with the high degree of metamorphism of the gneissic terrane of the Grenville Province of the Canadian Shield in which they occur. Because the Grenville orogeny took place after the emplacement of the nepheline syenites, their original mode of occurrence (whether of intrusive or replacement origin) and their primary structure and texture, strongly modified by regional metamorphism, may now be difficult or impossible to discern. In many cases the nepheline syenite gneisses now occur as relicts engulfed in later syenitic and granite gneisses, which have invaded and replaced them. This complex geological history of the nepheline syenites, with attendant strongly developed metamorphic foliation and lineation, has led to much difficulty in geological interpretation.

The nepheline syenite gneisses of the Grenville Province of southern Ontario differ markedly from the nepheline syenites of the Monteregian Hills of Quebec and the niobium-bearing nepheline syenite plugs of northeastern Ontario, which are late intrusive volcanic plugs emplaced by forceful intrusion into rocks of varied geological terranes.

AREAL DISTRIBUTION

The distribution of nepheline syenite deposits in the Blue Mountain and Haliburton-Bancroft area is indicated on map No. 1957b, Haliburton-Bancroft Area.[1]

The areal relationship of the nepheline syenite deposits is apparently much more complex than that suggested originally by Adams and Barlow, viz., that the nepheline syenites occur at the borders of granite batholiths where these intrude limestones, the basis of the Daly limestone syntexis theory of the origin of alkaline rocks. The author believes that the nepheline syenite deposits here occur marginal to areas of contrasting metamorphic grade and tectonic style. These happen to be the border zones between high-grade metamorphic "granitization granite" terranes and lower grade sedimentary basins largely occupied by marble and associated rocks.

MINERALOGY AND LITHOLOGY

The nepheline syenites are mostly gneissic in structure, and although their mineralogy is usually simple, there may be a considerable variation in the relative proportions of nepheline, plagioclase, and mafic minerals in adjacent gneissic bands. Textures range from hypidiomorphic granitoid to granoblastic. Poikilitic textures sometimes occur. The rocks are never porphyritic, and in this they differ markedly from the nepheline syenites of northern Ontario.

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[1] Map No. 1957b, *Haliburton-Bancroft Area*, Ont. Dept. Mines, 1957.

The common mineral assemblages of the nepheline syenites of southern Ontario are given, for each of the areas described, in the accompanying table. At Blue Mountain and French River the rocks consist predominantly of plagioclase, nepheline, and microcline (often microperthite). Biotite, magnetite, hastingsite, and aegirine pyroxene are the common mafic minerals. These rocks are usually leucocratic.

The mineral assemblages of the nepheline rocks of the Bancroft area are more complex, and both leucocratic and melanocratic facies occur. The common assemblage is nepheline and plagioclase, ± biotite, muscovite, and magnetite. Microcline is usually present in minor amounts, frequently introduced from nearby pink syenites. Mafic facies, carrying hornblende, pyroxene, garnet, vesuvianite, titanite, biotite, and magnetite, in addition to essential nepheline and plagioclase (ranging from albite to andesine), occur commonly in Glamorgan and Monmouth townships, in the York River nepheline belt in Dungannon and Monteagle townships, and in the Wolfe nepheline belt in Lyndoch township. Scapolite is also an important constituent in certain bands. Corundum may be present as a characterizing accessory particularly in nepheline-plagioclase-biotite-muscovite rocks. Calcite is frequently present in both the leucocratic and melanocratic facies. The secondary minerals, sodalite, cancrinite, hydronephelite, gieseckite, natrolite, and analcite also occur frequently.

Alkaline skarns rich in garnet and pyroxene occur at the Wolfe nepheline belt in Lyndoch township, at the Wasmund property in Raglan township, at Siddon Lake in Faraday township, and in the Troopers Lake nepheline belt in Glamorgan and Monmouth townships. Nepheline syenite mylonites occur in the Monck Road mylonite zone in Faraday township.

Nepheline

Nepheline often occurs as interstitial grains between feldspar and mafic minerals. Nepheline may form large irregular pegmatitic patches in nepheline syenite, replacing the fabric of the syenite to give a "residual sieve texture" where the replacement process did not go to completion. These nepheline "patch pegmatites" appear likely to have been formed by a process of remobilization or rheomorphism. Vermicular nepheline replacing plagioclase is described by C. E. Tilley.[1]

Nepheline ranges in colour from white or glassy, to dark grey, pink, or red. Iron content in five pure nepheline samples collected by the author varied from 0.05 percent Fe, in a white glassy nepheline from the Davis quarry, Dungannon township, to 0.34 percent Fe, in a pink nepheline from the nepheline syenite at Rutter Station, Bigwood township. This implies a relationship between pink colouration and iron content of the nepheline.

Nepheline crystals are rarely found, but crystals, up to 6 inches in size, line the walls of joint planes on Davis Hill and at the Princess quarry, Dungannon township.

Nepheline easily alters, and is often partially or completely replaced by a fine-grained micaceous aggregate usually identified as zeolites, hydronephelite, or micaceous minerals.

[1]C. E. Tilley, "Problems of Alkali Rock Genesis," *Quarterly Journal*, Geol. Soc. London, Vol. CXIII, 1958, p. 350.

COMMON MINERAL ASSEMBLAGES OF NEPHELINE SYENITES, SOUTHERN ONTARIO

(The commonest minerals and assemblages are given in capital letters)

Essential Minerals (over 20 percent)	Characterizing Minerals (5–20 percent)	Minor Accessories (0–10 percent, usually < 5 percent)
BLUE MOUNTAIN:		
ALBITE-MICROCLINE-NEPHELINE	± BIOTITE, MAGNETITE	MUSCOVITE, corundum
ALBITE-MICROCLINE-NEPHELINE	± HASTINGSITE, AEGIRINE	Garnet, calcite, zircon
BANCROFT:		
PLAGIOCLASE (albite-andesine)-NEPHELINE	± BIOTITE, CALCITE	Microcline, muscovite, corundum, graphite, fluorite, apatite, tourmaline, magnetite.
PLAGIOCLASE-NEPHELINE-HORNBLENDE	± GARNET, CALCITE	Microcline, vesuvianite
NEPHELINE-HORNBLENDE	± GARNET, TITANITE	Calcite
Nepheline-plagioclase-garnet		
NEPHELINE-PLAGIOCLASE-SCAPOLITE	± BIOTITE, HORNBLENDE, GARNET, TITANITE, CALCITE	Corundum, graphite, magnetite, microcline
NEPHELINE-PLAGIOCLASE	± SCAPOLITE, CORUNDUM	Calcite
Nepheline-scapolite	± Corundum, biotite, garnet	Calcite
NEPHELINE-HORNBLENDE-PYROXENE	± Garnet, calcite, plagioclase	Titanite, vesuvianite
NEPHELINE-PYROXENE	± Garnet, plagioclase	Calcite, titanite, vesuvianite
FRENCH RIVER:		
NEPHELINE-PLAGIOCLASE-MICROCLINE	± BIOTITE	Muscovite, magnetite, corundum, fluorite, calcite
NEPHELINE-PLAGIOCLASE-MICROCLINE	± HORNBLENDE, PYROXENE	Biotite, magnetite, muscovite

Plagioclase

Although albite is the most common plagioclase in the nepheline rocks, occasionally plagioclase as calcic as andesine, (An_{40}), may occur, particularly in facies high in scapolite and calcite, as in some parts of the York River and Wolfe nepheline bands.

Amphibole

Hastingsite is the most common amphibole, but ferrohastingsite and dark-green hornblende are also common.

Pyroxene

Aegirine, aegirine-augite, and hedenbergite have been identified in many of the nepheline rocks in all three areas described.

Biotite

Both green and brown biotite occur; the high iron siderophyllite is common.

Garnet

Garnet is common in the York River and Brudenell-Raglan areas, and is occasionally found at Blue Mountain. Generally it occurs as small hypidiomorphic grains, but in the skarns it may be in massive or patchy poikiloblastic aggregates with bright green diopside.

Titanite

Titanite is common in mafic facies carrying amphibole, pyroxene, garnet, scapolite or calcite.

Corundum

Corundum frequently occurs in the mica-bearing nepheline syenites, and stands up in bold relief on weathered surfaces. At the Lily Robertson property, lot 26, concession XIII, Dungannon township, bronze corundum crystals up to 2 inches in diameter make up 20 percent of the coarse-grained nepheline-albite pegmatite, over an exposed width of 10 feet. There is a well-known occurrence of blue and grey corundum in nepheline-plagioclase-muscovite gneiss at Egan Chute on the west side of the York River, lot 12, concession XII, Dungannon township. The best known locality for blue corundum is the "Dungannonite property," lots 11 and 12, concessions XIV and XV, Dungannon township, where corundum occurs in a nepheline-andesine gneiss with biotite and muscovite. An unusually rich nepheline rock, consisting predominantly of nepheline and corundum, with minor plagioclase, occurs at Congress Bluff, Klondike Cuts, Craigmont, lot 2, concession XIX, Raglan township. Other rich corundum-nepheline rocks occur at Reid Lake, lot 34, concession VII, Brudenell township, and at the Gutz farm, lot 34, concession V, Brudenell township. At the Gutz farm occurrence, slender, tapered six-sided corundum crystals, 3–6 inches in length and up to 1 inch in diameter, occur in nepheline-albite pegmatite.

Scapolite

Scapolite is common only in the York River and Brudenell-Raglan areas, but there it may form a very important constituent of the nepheline gneisses. Frequently scapolite may make up as much as 50 percent of the rock and may completely replace plagioclase in the mineral assemblage. On fresh surfaces

scapolite is often glassy grey-green to yellow-green. On exposure to sunlight this scapolite often turns bright blue or blue-grey, and may be difficult to distinguish on weathered surfaces from nepheline, since they both easily weather out on weathered surfaces, leaving the plagioclase and mafic minerals standing up in relief above them.

Calcite

Calcite is a common accessory in many of the nepheline syenites and nepheline pegmatites. In the pegmatites it frequently occurs as blebs in nepheline.

Magnetite

Magnetite is a common accessory in leucocratic nepheline syenites. At Blue Mountain and elsewhere, magnetite may occur as the only mafic accessory mineral. There is a strong suggestion that, under certain conditions of metamorphism, magnetite replaces biotite in nepheline syenite. In some facies of the nepheline syenite, particularly on the Canadian Flint and Spar property at Blue Mountain, the author has observed large magnetite grains up to ¼ inch in size in a biotite-nepheline-albite gneiss: a zone up to 2 inches around the magnetite crystals would be completely free of biotite, suggesting that the iron from this area had migrated to form the magnetite. Photos on page 146 show such segregations of biotite and formation of magnetite.

Graphite

Accessory graphite is found in nepheline syenite gneiss at Adams and Barlow's original "monmouthite" locality, lot 11, concession VIII, Monmouth township, and, in places, the French River nepheline syenite body.

WEATHERING AND ALTERATION

The characteristic diagnostic feature of nepheline is its appearance on weathered surfaces. Nepheline weathers easily, and the nepheline syenites display a typically pitted weathered surface, with dove grey to blue-grey nepheline occurring in the pits, and feldspar, corundum, and mafic minerals standing up in relief. Scapolite may weather out in the same way as nepheline, and in a gneiss containing both minerals it is often difficult to distinguish them on weathered surfaces.

Nepheline easily alters by hydration to form zeolites, hydronephelite, or a micaceous aggregate. This alteration frequently takes place along joints. At Blue Mountain strong hydrothermal alteration occurs along joints, especially in the vicinity of pink syenite. Green alteration occurs along the joint surface, and pink alteration extends 2–6 inches into the white nepheline syenite from the joint plane.

Where nepheline has been altered to chalky white or pink alteration products, it may no longer pit out on weathered surfaces to give the typical nepheline weathering. In these cases the altered nepheline can be recognized by its chalky white or opaque pink colouration, its lack of the usual glassy or greasy lustre, and its softness (it will easily pick out with the point of a knife). Under moss or soil cover the altered nepheline is usually stained yellow-brown by organic material.

NEPHELINE PEGMATITES

Most of the nepheline pegmatites are of small size and consist merely of patches of pegmatitic nepheline and albite a few feet in diameter in a matrix of nepheline gneiss. However, some giant nepheline pegmatites measuring 50–100 feet in width and several hundred feet in length do occur, in which nepheline and albite crystals, 1–6 feet, or over, in diameter, may be found. The Fraser and Gill pegmatites in Glamorgan township, the Mackay pegmatite in Monmouth township, and the Golding-Keene, Morrison, Davis, and Robbins pegmatites in Dungannon township are of the "giant" type.

These nepheline pegmatites consist primarily of nepheline and albite, with biotite, hornblende, zircon, calcite, apatite, sodalite, cancrinite, magnetite, galena, tourmaline, microcline, and allanite as accessories.

Small irregular pegmatitic patches of nepheline and albite are termed xenoblastic patch pegmatites, and are interpreted as replacement pegmatites produced by recrystallization and mobilization (rheomorphism) of the nepheline and albite of the gneisses, accompanied perhaps by the introduction of hydrothermal solutions along certain zones or fractures in the rock. They are endogenous to the nepheline gneiss units and never occur elsewhere. Some of the pegmatites show intrusive relations and sharp contacts with the enclosing nepheline gneisses, indicating that some mobilization, migration, and injection took place. The replacement origin of some of these pegmatitic patches is indicated by sieve textures with relict granoblastic albite grains of the original gneiss in the pegmatitic nepheline.

AGE RELATIONSHIPS AND FIELD RELATIONSHIPS

Age relationships of the nepheline syenites of the Blue Mountain, Haliburton-Bancroft, and French River areas are similar. The alkaline rocks intrude or replace metasedimentary rocks of the Grenville Province. They are themselves intruded and replaced by later syenitic and granitic rocks. A noteworthy feature of most of the nepheline syenite occurrences is the fact that syenitic facies intermediate in composition between nepheline syenite and granite often occur with, or enclose, the nepheline syenite. In the case of other nepheline syenite deposits, such as the Alnö deposit of Sweden, nepheline syenites intruding a granitic gneiss terrane are accompanied by a sheath or rim of hybrid alkaline syenites or "fenites." In the case of the nepheline syenites of the Grenville Province of Ontario, similar buffer or hybrid zones of syenites often occur between nepheline syenites and granitic gneisses. However, the syenitic and granitic rocks intrude and replace the older nepheline rocks. These nepheline rocks frequently occur as undestroyed relict patches in syenitic gneisses. The destruction of nepheline syenites by "syenitization" or "granitization" is a feature of the geology of the Blue Mountain, Haliburton-Bancroft, and French River areas.

In general, the nepheline syenite gneisses are conformable with the metasedimentary rocks in which they occur, and intrusive relations are uncommon. At Blue Mountain, tongues of nepheline syenite intrude sedimentary paragneiss and limy amphibolite. In places where the contacts between nepheline syenite and amphibolite are exposed, as at the American Nepheline and International Mineral and Chemical Corporation properties along the eastern contact of Blue Mountain, the nepheline syenite is seen to cut across the foliation of the paragneisses at a low angle. Along the northeast end of Blue Mountain, the metasedimentary sequence, which includes bands of marble up to 1,000 feet wide, is truncated against the nepheline syenite intrusive.

Photo by J. Satterly



Nepheline-albite pegmatite in the southern mass on the Mackay property, lot 14, concession VI, Monmouth township, Haliburton County. In the photograph the albite is white, and the nepheline is grey. Note weathering of the nepheline.



Nepheline-plagioclase gneiss showing development of nepheline pegmatite of the xenoblastic patch-replacement type at the Golding-Keene quarry, York River, Dungannon township.

In the Haliburton-Bancroft area, the nepheline syenites and pegmatites intrude and replace earlier gabbro intrusives in Glamorgan, Faraday, Dungannon, and Carlow townships. Nepheline pegmatites frequently cut nepheline gneisses.

One of the best examples of crosscutting intrusive relationships for the nepheline syenite may be seen in lot 17, concessions VII and VIII, Methuen township, where a nepheline syenite dike, 20–25 feet wide and exposed for a length of over 150 feet, cuts at right angles across para-amphibolite. The dike appears to be an offshoot of the main Blue Mountain nepheline syenite deposit.

Although there is evidence of intrusive relationships for the nepheline syenite, in many places there is also good evidence for "nephelinization" and replacement of metasediments, both para-amphibolite and marble, to form hybrid nepheline gneisses. The evidence that the York River nepheline gneisses are hybrid rocks produced by nephelinization of marble and amphibolite is clear from textural, mineralogical, and structural evidence.[1] In other areas a certain amount of replacement has frequently accompanied intrusion of the alkaline rocks.

[1]C. E. Tilley, *op. cit.*

CHAPTER II

Nepheline Syenites of the Haliburton-Bancroft Area

LOCATION AND EXTENT[1]

The nepheline rocks of the Haliburton-Bancroft area extend in a discontinuous band over 80 miles in length, from Glamorgan township, Haliburton county, on the west, to Brougham township, Renfrew county, on the east. They are best developed in Dungannon township, Hastings county, east of the village of Bancroft.

The deposits in the Haliburton-Bancroft area are much smaller in size than the Blue Mountain intrusive. Individual bands of nepheline syenite gneiss rarely exceed a few hundred feet in width and 2–3 miles in length.

CHARACTERISTICS

The nepheline rocks are more gneissic than at Blue Mountain, and in places mafic facies occur. Drilling results indicate that some of the nepheline gneisses of the Bancroft and York River bands grade 26–30 percent alumina, compared with 23–24 percent for the Blue Mountain body. However, the iron content is higher, and the percentage of recoverable nepheline plus feldspar is lower.

Most of the Haliburton-Bancroft nepheline gneisses are lower in potash and higher in soda and lime than the Blue Mountain body. Andesine, scapolite, and calcite contribute to the lime content. This higher lime content raises the fusion point and pyrometric cone equivalent (PCE) of the ceramic product and shortens the firing range, in comparison with Blue Mountain material.

Corundum is sometimes a common accessory, in places making up as much as 5 percent of the rock. The Monteagle Minerals deposits on the York River, in Monteagle township, is a potential source of a glass-grade ceramic product, with byproduct corundum and muscovite.

GENERAL GEOLOGY

The nepheline syenite deposits occur intruding and replacing earlier metasedimentary and basic intrusive rocks of the Grenville Province. The table of geological formations for the Haliburton-Bancroft area is given on page 34.

With the exception of the Paleozoic outlier near Mount St. Patrick, all the bedrock formations in the Haliburton-Bancroft area are of Precambrian age. They consist of Grenville-type metasediments (mainly marble, paragneiss, and amphibolite) and metavolcanics, cut by basic and acid plutonic rocks in the following order of intrusion from earliest to latest: basic intrusives (gabbro, diorite); early albite granite, granodiorite, tonalite; nepheline syenite; syenite; later potassic granite.

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[1]Map No. 1957b, Ont. Dept. Mines.

TABLE OF FORMATIONS

CENOZOIC	
RECENT AND PLEISTOCENE;	Sand, gravel, moraine, clay.
	Great Unconformity
PALEOZOIC	
ORDOVICIAN:	Limestone, dolomitic limestone, grit.
	Great Unconformity
PRECAMBRIAN	
PLUTONIC ROCKS:	Granitic Rocks: granite, granite gneiss, pegmatite, hybrid granite gneiss, migmatite.
	Intrusive Contact
	Syenitic Rocks: syenite, syenite gneiss, pegmatite, hybrid syenite gneiss.
	Intrusive Contact
	Nepheline Syenite: nepheline syenite, nepheline syenite gneiss, hybrid nepheline, gneiss, pegmatite.
	Intrusive Contact
	Early Granitic Rocks: Boulter and Weslemkoon albite granite, granodiorite, tonalite.
	Intrusive Contact
	Basic Intrusives: gabbro, diorite, ortho-amphibolite, metagabbro.
	Intrusive Contact
METASEDIMENTARY AND METAVOLCANIC ROCKS:[1]	Marble, paragneiss, para-amphibolite, pyroxene granulite, skarn, quartzite, argillite, schist, conglomerate.
	Basic and acid volcanics, pillow lava, basalt, etc.

All the rocks are highly folded, faulted, and metamorphosed. The last period of intrusion, granitization, and metamorphism probably occurred during the Grenville orogeny. The Haliburton-Bancroft area is a terrane of high-grade metamorphic gneisses, characterized by rocks of the amphibolite-granulite facies. In the metasedimentary rocks, original textural and structural features have largely been destroyed by metamorphism, and standard criteria for the determination of tops of beds, such as grain gradation and cross-bedding, cannot be applied. Consequently the stratigraphic succession in the metasediments is largely unknown.

GEOLOGY OF THE NEPHELINE SYENITE DEPOSITS

The nepheline syenite deposits of the Haliburton-Bancroft district are described in five separate areas, from west to east, as follows:

A. Glamorgan-Monmouth Deposits.

B. Cardiff-Faraday Deposits.

C. Dungannon-Monteagle-Carlow Deposits.

D. Brudenell-Raglan Deposits.

E. Eastern Extension of the Haliburton-Bancroft Nepheline Belt.

[1]Largely stratigraphically undifferentiated.

A. Glamorgan-Monmouth Deposits

(BY H. S. ARMSTRONG)[1]

The Glamorgan-Monmouth area lies within the Haliburton Highlands, a region of complex gneisses. The nepheline-bearing rocks, together with metasedimentary gneisses, amphibolites, quartzites, and marbles, comprise a wedge tapering towards the northeast corner of Monmouth township. To the north lies the Glamorgan batholith and related masses, including the Essonville granite. The wedge is flanked on the southeast by the Anstruther and Cheddar batholiths. A prominent feature of the wedge is the sheet of gabbro and metagabbro extending easterly from Greens mountain, in south-central Glamorgan, to the Hadlington road in central Monmouth.

The nepheline-bearing rocks occur chiefly in association with mixed syenitic gneisses, forming a part of the south-dipping succession of the wedge. The continuation of this southerly dip at the margin of both the Anstruther and Cheddar granite masses, suggests the validity of the term "wedge" rather than "trough," for the complex. The main, central, belt of nepheline rocks and associated syenite gneisses extends for 15 miles northeasterly from the south boundary of Glamorgan to its closure about 2 miles southwest of Wilberforce. Throughout much of its course this belt of mixed syenitic gneisses lies not far to the north of the Glamorgan gabbro and its satellites. To the north of the main belt, a band of syenitic gneisses flanks the Glamorgan granite gneiss, extending eastward 2½ miles from Gooderham just into Monmouth township, where it recurves northward to its termination in Glamorgan township to the east of Billings Lake. South of the main belt, a narrow band of syenitic gneisses cuts southwesterly through Hadlington Lake, in Monmouth township, to the southeast corner of Glamorgan. Both the main and the south belts are open at the southern limit of the area mapped, and may be expected to continue into Cavendish and Anstruther townships respectively.

The nepheline rocks are varied, ranging from the common gneissic types to the massive pegmatites. Of particular interest, however, are those in the main belt near the Glamorgan-Monmouth boundary, which have proved to be hypersolvus nepheline syenites with igneous texture and crosscutting field relationships.

The locations of the nepheline rock occurrences described herein are shown on the accompanying sketch map of the Glamorgan-Monmouth area. Numbers in text correspond with those shown on sketch map.

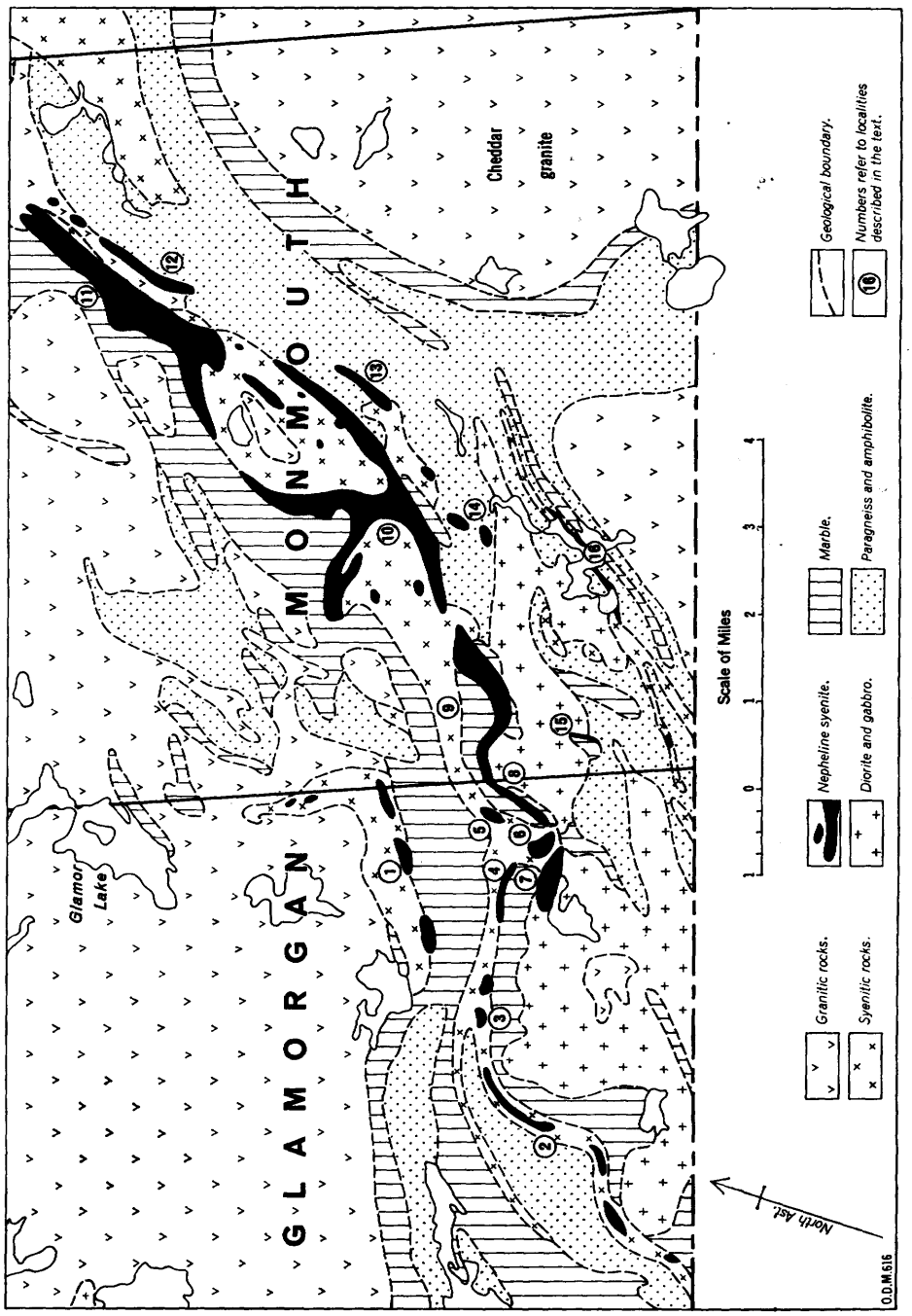
1. NEPHELINE SYENITE GNEISS

Lot 27, Concession V, to Lot 35, Concessions VI–VIII, Glamorgan Township; Lot 2, Concessions VII and VIII, Monmouth Township

Nepheline-biotite-plagioclase gneisses, light-grey to pinkish in colour, occur sporadically near the hanging-wall side of a curved body of pink to buff biotite (locally hornblende) syenite gneiss.

The syenite gneiss is bordered on the north by the Glamorgan granite gneiss complex, and on the south by a marble-paragneiss complex into which are intruded bodies of leucogranite and granite pegmatite. To the east of the syenite, in Monmouth township, is an area chiefly composed of hybrid granitic gneisses in which there are remnants of marble and paragneiss. The syenite gneiss dips south at 35–50 degrees and, after curving northward, shows a steep dip easterly.

[1]H. S. Armstrong, *Geology of Glamorgan and Monmouth Townships*, Ont. Dept. Mines (in preparation).



Glamorgan-Monmouth nepheline syenite deposits.

The syenite mass is about 30 chains in width at its widest place, at the boundary between lots 31 and 32. It tapers to about 6 chains at Gooderham village to the west, and to about 12 chains where it passes under the swamp in concession VIII. The grey nepheline rock forms discontinuous patches within the syenite gneiss; these occur in four groups as shown on page 36. The westernmost of these is about 12 chains in maximum width and about 30 chains in length; the central group has a maximum width of about 8 chains, and length about 40 chains; in the east group nepheline occurs over a maximum width of about 6 chains, and a length of 35 chains. The north group is about 1 chain wide and 17 chains in length.

The nepheline rock itself is generally nepheline-poor. Although clots of nepheline up to 1 by 3 inches have been noted, the mineral is usually sparsely disseminated. No nepheline pegmatites have been observed in this belt. Grains of magnetite up to ⅛ inch across were observed in the nepheline rock in lot 35, concession VI. In a 5- by 6-foot patch of white nepheline syenite in lot 35, concession VIII, corundum occurs in scattered crystals up to ⅛ inch in width and ¼ inch in length. The corundum is white in colour and shows good rhombohedral parting.

In addition to the patches of nepheline rock, the biotite syenite gneiss also contains relict patches of paragneiss and of marble with a deep brown phlogopite or biotite. The biotite syenite gneiss and patches of nepheline gneiss and metasediments are cut by irregular masses of pink to red granite, locally containing hornblende. All are cut, in turn, by pink to red granite pegmatite. It would appear that the biotite syenite intrudes a complex of marble, paragneiss, and nepheline rock, all of which occur as remnants within it. The granitic rocks represent the latest phase of igneous activity.

The discontinuity and generally low grade of these nepheline rock occurrences suggest that they cannot be regarded as of economic importance.

2. NEPHELINE SYENITE GNEISS

Lot 13, Concession I, to Lot 23, Concession IV, Glamorgan Township

Nepheline-biotite-plagioclase gneiss, white to pinkish in colour, occurs in four well-defined localities within this western part of the main belt of syenite gneisses. The syenite gneiss band is about 6 chains in width where it is crossed by the south boundary of Glamorgan township. Towards the north, the band increases to a width of about 15 chains, which is maintained to the northernmost occurrence of nepheline rock, about ½ mile north of the Buckhorn road, in lot 23, concession IV. Throughout most of this extent the nepheline rocks lie on a footwall of hornblende syenite gneiss, and are overlain in turn by biotite syenite gneiss. Both the hornblende syenite and the biotite syenite are buff to pink or reddish; the biotite syenite in some places, however, is white. The syenite gneiss band lies between an area of biotite paragneisses to the northwest, and a band of marble fringing the Glamorgan gabbro of Greens mountain on the southeast. Bodies of paragneiss and phlogopite marble occur within the syenite gneiss. They appear to be remnants, strongly suggesting a replacement origin for the syenite gneiss. The sequence dips southeast at 30 degrees, locally steepening to 45 degrees.

The southernmost occurrence of nepheline rock is represented by a few small outcrops of a white nepheline-poor biotite syenite gneiss, lying between pink biotite syenite gneiss to the northwest and phlogopite marble to the southeast. The next occurrence, to the north, extends continuously for 45 chains, tapering from a width of about 4 chains at its central part to about 1 chain at each end. The nepheline rock here includes both hornblende- and biotite-bearing varieties,

the nepheline content ranging from sparse to about 10 percent. An interesting feature of this occurrence is the presence of a pyroxene-garnet skarn in the marble at the southern portion. These skarn rocks are exposed within a band of hornblende syenite gneiss to the southeast of the biotite syenite gneiss. Marble containing phlogopite and graphite is exposed between this hornblende syenite gneiss and the gabbro of Greens mountain.

The third occurrence of nepheline rock lies about 7 chains to the northwest of the trail to the fire tower on Greens mountain. The body is almost pear-shaped, being 6 chains wide at the southwest, and 1 chain wide at the northeast end; the length is about 25 chains. The nepheline rock is a nepheline-poor gneiss, chiefly biotitic, but with hornblendic patches. In the latter the nepheline generally shows the characteristic blue-grey weathering, but in the biotite variety pink hydronephelite or a chalky-white altered nepheline occurs.

The northernmost occurrence consists of a narrow belt of many outcrops extending for 100 chains. Throughout most of its length nepheline rocks are found across a width of 1–2 chains, although near the south end they were found across 8 chains. The hornblende syenite gneiss of the footwall is generally rich in mafic minerals and is markedly darker coloured than the biotite syenite gneiss of the hanging wall. Reddish brown garnets, up to ⅛ inch, are abundant near the south end, while near the north end the hornblende syenite gneiss contains numerous grains of yellow idocrase. The nepheline rocks are mostly biotite-plagioclase gneisses containing sparse nepheline. Near the south end, however, a specimen containing about 50 percent disseminated nepheline was collected. The nepheline occasionally shows the characteristic blue-grey weathered surface, but throughout this occurrence, as in the other three at this locality, it occurs chiefly as pink hydronephelite or as a chalky-white altered nepheline. Near the north end the nepheline rock adjacent to the hornblende syenite footwall is itself hornblende-bearing, being overlain by the commoner biotitic nepheline rock. A special feature of this occurrence is the presence of pegmatitic nepheline in stringers up to 3–4 inches across and several feet in length. The blocky nepheline in these stringers, and in isolated clots, occurs as masses up to 1½ inches across and subhedral in shape. A prismatic crystal of brown zircon, ¼ inch long, was found in one of these clots.

Although the occurrences described above are regarded as being of no commercial value because of their small dimensions and generally low grade, they are of interest in that they represent a considerable extension of the previously-known nepheline belt.

3. BUCKHORN ROAD NEPHELINE ROCKS

Lots 25 and 26, Concession IV, Glamorgan Township

Nepheline-bearing hornblende-plagioclase and biotite-plagioclase gneisses and nepheline-plagioclase pegmatites occur within the main band of syenite gneisses in these two lots. The hornblende syenite gneiss of the footwall is characterized by abundant magnetite in octahedra up to ¼ inch across. The syenite gneisses here have a maximum exposed width of 18 chains, but swampy ground to the north and south makes width measurements uncertain. The gneisses strike generally east-west; the dips are generally southerly. Local reversals of dip and variations in strike were observed. Zones of mylonite, in the magnetite-hornblende syenite gneiss just west of the Buckhorn road, indicate later movements.

Near the west boundary of lot 25, three pits have been sunk on nepheline-plagioclase pegmatites in nepheline-biotite-plagioclase gneisses. Other outcrops

expose nepheline-hornblende-plagioclase gneiss to the north. The total width is about 2½ chains, and the length about 6 chains. The pegmatite bodies are generally lenticular or pod-like, with a maximum width of 2 feet, the average being about 1 foot; the lengths generally are less than 10 feet. Sodalite and cancrinite are common, as also are zircon crystals up to ¾ inch in length, magnetite up to 2 inches, and calcite. A 10-inch sill-like band of hornblende-biotite syenite gneiss containing numerous small grains of purple fluorite cuts the nepheline-hornblende-plagioclase gneiss in a small outcrop about 50 feet north of the easternmost pit.

Immediately west of the Buckhorn road there are exposures of red to pink hornblende syenite gneiss containing abundant magnetite grains. Some mylonite was noted here. Bordering these on the south are outcrops of coarse-grained white biotite-plagioclase gneiss containing disseminated nepheline, mostly chalky white, but with some patches and streaks of blue-weathering nepheline.

To the east of the Buckhorn road, a high ridge consists chiefly of magnetite-hornblende syenite gneiss, with some biotite syenite gneiss and syenite pegmatite. On the south slope of the ridge, 12–20 chains east of the road, nepheline-poor biotite-plagioclase and hornblende-plagioclase gneisses are exposed. In some of these the nepheline occurs as both pink hydronephelite and as chalky white altered nepheline. One outcrop of magnetite-bearing nepheline-biotite-plagioclase gneiss is bordered by magnetitic hornblende syenite on the north and magnetitic biotite syenite on the south. In this section the dips are generally south at about 30 degrees.

These occurrences may be regarded as evidence of the general continuity of nepheline rocks throughout this main band of syenite gneiss. The existence of pegmatitic nepheline in proximity to a zone of late fracturing, as is evident from the mylonitized hornblende syenite gneiss, is of interest in considering the origin of these rocks, which are so common farther east in this same central band.

4. FRASER NEPHELINE PEGMATITE

Lots 29–31, Concession IV, Glamorgan Township

Nepheline rocks are exposed in three occurrences over a length of about ½ mile, centering on the Fraser quarry in lot 30. The nepheline rocks are found along the contact between biotite syenite gneiss and the overlying marble, containing feldspar and biotite. The biotite syenite gneiss passes northward into a magnetite-rich hornblende syenite gneiss, which is bounded on the north by marble with numerous interbeds of paragneiss. The magnetite-bearing rock represents the eastward continuation of the similar rocks noted at Locality 3. The syenite gneiss sequence has a maximum width of about 20 chains, the formation trending generally north of east, and dipping south at 40–45 degrees. The syenite gneiss contains patches of marble similar to that of the hanging wall. White-weathering granite pegmatite bodies cut all these rocks.

The westernmost occurrence, in lot 29, is a single small outcrop of nepheline-albite pegmatite, in a sandy knoll 15 chains north of the concession road. The pegmatite contains a few inclusions of the hanging-wall marble. Nepheline crystals up to 2 inches across were observed.

The easternmost occurrence, in lot 31, consists of three outcrops of coarse-grained white nepheline-biotite-plagioclase gneiss, in the central part of the lot, 13 chains north of the concession road. Chalky-white altered nepheline is abundantly disseminated through the rock, which is cut by veins and irregular patches of blue-weathering nepheline, possibly representing remobilization of the nephe-

line. A 2-foot syenite pegmatite dike cuts one of these outcrops. An outcrop of the hanging-wall marble separates two outcrops of nepheline gneiss, with which it is directly on strike. This may represent an undigested mass of marble or, alternatively, a tongue injected during movement.

The main occurrence, the Fraser nepheline pegmatite, lies 18 chains north of the concession road. No work appears to have been done in this Fraser quarry since it was examined and described by J. Satterly in 1942.[1] The footwall biotite syenite gneisses are not exposed in the workings but lie 3 chains to the north. The hanging-wall marble is exposed immediately adjacent to the quarry on the south and east, and the quarry walls expose these marbles as part of the complex. The quarry rocks include not only the nepheline pegmatite bodies and marble,

Photo by J. Satterly



Scalloped border in black biotite-rich crystalline limestone on paragneiss (top right) adjacent to coarse nepheline pegmatite containing residual fragments of paragneiss (black), vertical face in upper Fraser quarry, lot 30, concession IV, Glamorgan township, Haliburton county.

but also nepheline-biotite gneisses, and biotite and hornblende paragneisses. The nepheline rocks forming the east wall of the upper quarry are cut by a 5-foot granite pegmatite dike. The quarry consists of two parts comprising an opening about 300 feet long and up to about 30 feet wide. The minerals present in the nepheline pegmatite are grey albite, nepheline, biotite, hornblende, zircon, calcite, sodalite, and corundum. Muscovite associated with the patches of pinkish purple hydronephelite may represent altered corundum.

Of the three occurrences at this locality only the Fraser property may be regarded as of economic significance. From 1937 to 1942 there was interest in quarrying nepheline pegmatites. Gooderham Nepheline operated the Fraser quarry in 1937 and 1938, shipping a total of 3,178 tons of nepheline pegmatite. However three adverse factors: the high iron content, the variable calcite content, and the difficulty of obtaining a uniform product, led to the abandonment of commercial exploitation.

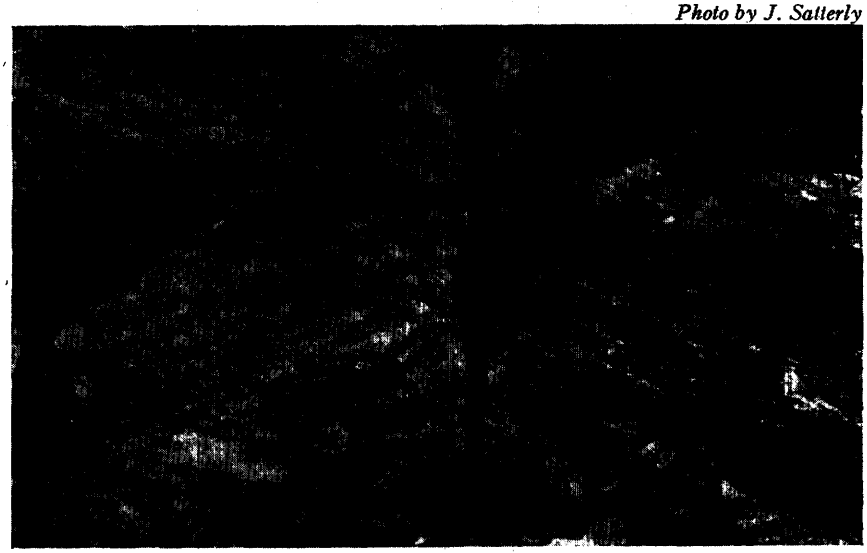
[1] J. Satterly, *Mineral Occurrences in the Haliburton Area*, Ont. Dept. Mines, Vol. LII, 1943, pt. 2, pp. 16, 17, 71, 73.

5. GILL NEPHELINE PEGMATITE

Lot 34, Concession IV, Glamorgan Township

Nepheline-plagioclase pegmatite containing some biotite occurs in numerous outcrops at the top, and on the eastern slope, of a ridge near Laronde Creek. The footwall rocks to the west are coarse-grained pink hornblende-biotite syenite gneiss. The hanging-wall rocks are poorly exposed, but include similar syenite gneisses, marbles containing nepheline, feldspar and biotite, and a dark, massive coarse-grained scapolitized hornblende syenite. Within the belt of nepheline pegmatite there are exposures of nepheline-biotite-plagioclase gneiss and, immediately northwest of the upper quarry, an exposure of biotite paragneiss and marble, both members of which contain nepheline. Syenite pegmatite, lacking

Photo by J. Satterly



Nephelinized and albitized crystalline limestone underlain by biotite-nepheline-albite gneiss, north end of the lower Gill quarry, lot 34, concession IV, Glamorgan township, Haliburton county. The hammer handle is at the contact.

either quartz or nepheline, cuts both the nepheline rock and the syenite gneiss. The body of nepheline rock has a north-south length of about 25 chains from the lower quarry to its northern limit just beyond the upper quarry. The width tapers from 6 chains at the lower quarry end to 4 chains at the upper quarry, near to which the band appears to terminate. The gneisses of the footwall strike nearly north-south and dip east at angles ranging from 25 degrees to vertical; at the north end, however, the trend curves to east-west, and the dip becomes more uniform at about 45°S.

The locality has been described and mapped by Satterly,[1] and little can be added to the details given by him. No further development work appears to have been done since his visit.

The upper quarry, which is 35 feet in diameter and 8 feet deep at the face, has been sunk in a stripped area 100 by 50 feet in dimensions. The nepheline pegmatite consists of dark-grey nepheline with blebs of carbonate, albite, and lesser amounts of biotite, green apatite, and zircon. Secondary minerals present are orange cancrinite, blue sodalite, and hydronephelite.

At the lower quarry nepheline pegmatite and associated biotite-nepheline-albite gneiss is seen in contact with coarse crystalline limestone containing biotite and metacrysts of nepheline and

[1] J. Satterly, *op. cit.*, pp. 73, 74, and Fig. 8.

albite. The largest metacryst of albite found measured 1 by 3 inches. The limestone and gneiss at the north end of the quarry strike N.10°W. and dip 20°E., but at the south end the dip is vertical. The nepheline pegmatite, therefore, underlies a curved shell of limestone and nephelinized paragneiss.

The feature of this locality is the abundance of carbonate disseminated in the nepheline rock, particularly in the vicinity of the lower quarry. Satterly considers that "the future of this property will depend on the possible use of a nepheline pegmatite containing a variable amount of carbonate. At the present time (1943) this is probably an undesirable feature."

6. NEPHELINE PEGMATITE

Lots 32 and 33, Concession III, Glamorgan Township

Nepheline-plagioclase rocks comprise the north part and east slope of an arcuate ridge in the north half of lot 32, continuing a few chains into the northwest corner of lot 33. The trend of the formation changes from northwest in the southern part of the ridge to north of east in the northern part. The dips are vertical to steeply inclined. The body of nepheline rock, roughly triangular in shape, has a length of 20 chains in a northwest-southeast direction. The width tapers from 15 chains at the north end, to 2 or 3 chains at the south end. The nepheline rocks are bordered on the south and west by biotite syenite gneisses. On the north the border rocks include, in addition, hornblende syenite gneiss and marble containing feldspar and biotite. The rock assemblage is cut by syenite pegmatite bodies some of which contain hornblende. At the extreme northeast a pink granite pegmatite dike cuts the nepheline-plagioclase pegmatite and a hornblende syenite pegmatite body. The nepheline rock exposures slope under swampy ground to the east. A single exposure of leucosyenite (albitite?) found in the swamp probably represents the border rocks to the east and southeast.

The nepheline-bearing rocks are of two types. The greater part of the exposure is a massive white albitite containing variable amounts of blue-grey-weathering nepheline in subhedral crystals up to two or three inches across. These may comprise as much as 10 to 15 percent of the rock over areas of several square feet. In some places very coarse pegmatitic nepheline occurs in blocky aggregates up to 12 inches or more across. The second type is the nepheline-albite pegmatite, which forms discontinuous irregular masses in the former type. Throughout most of the mass biotite is rare or lacking, but the southerly exposures contain sufficient amounts of this mineral that the rock may be designated a nepheline-biotite-albite rock. Carbonate aggregates, widely disseminated through the nepheline-bearing albitite, are readily weathered, leaving small cavities which characterize the weathered surface.

Two noteworthy features are the inclusions of marble and the local occurrence of zircon. Coarse-grained, white marble containing feldspar and biotite occurs as inclusions, up to several feet across, in the nepheline rock, particularly near the north and northwest margin of the mass. Pyramidal zircon crystals, up to ½ inch in length, were found to be localized within the nepheline-bearing albite on the slope to the east. Satterly[1] reports two patches of zircon-rich rock, "several square feet in area . . . containing 5 percent of that mineral . . ."

In his description of this locality, Satterly records: "Nepheline-poor pegmatite . . . has been stripped over an area 80 feet in diameter." Since his visit no further work appears to have been done on the property. The drift cover

[1] J. Satterly, *op. cit.*, p. 71.

is thin, however, and rock exposures are abundant. The discontinuity of the nepheline pegmatite bodies together with the variability of nepheline content in the albitite would suggest that this occurrence is of little economic importance at present. The rock relationships are, however, of interest in attempting to explain the origin of the nepheline rocks in this central band.

7. TROOPER LAKE NEPHELINE ROCKS

Lots 30–33, Concession III, Glamorgan Township

Nepheline-bearing rocks comprise a band extending nearly 1 mile from their contact with the metagabbro north of Trooper Lake, eastward almost to Laronde Creek. For most of its course the band maintains a remarkably uniform width of 20 chains, the width at the east end being difficult to establish because of topography and scarcity of outcrop. The band of nepheline rocks is bounded on the west and south by metagabbro. On the north, coarse-grained, blue-grey graphitic marbles form the border rocks in lots 30 and 31, but in lots 32 and 33 the syenite gneiss complex noted in Locality 6 delimits the nepheline band. On the east the topographic relief is sufficient to expose outcrops of graphitic marble, which appears to underly the nepheline rocks.

The predominant rock type, unlike those described for the preceding localities, is dark in colour, due to the abundance of amphibole (hastingsite?). This rock is adequately described as a nepheline-hornblende-plagioclase gneiss. The blue-weathering nepheline occurs as subhedral crystals averaging ¼ inch across, commonly grouped in clusters of three or four grains. The nepheline content varies from about 10–50 percent, but averages about 25 percent. The variation is due chiefly to the fact that the amphibole is commonly concentrated in bands or streaks several inches wide, the nepheline content of these bands being low. Deep-brown biotite is locally abundant, for example, along the farm road in central lot 32, where the nepheline has been altered to greenish grey gieseckite and pink hydronephelite. Exposures of the nepheline-hornblende-plagioclase gneiss have weathered in several places to produce a granular detritus.

Nepheline-bearing skarn rocks occur in the woods adjacent to the fields in the northern part of lots 30 and 31. The skarn rocks are typically coarse-grained containing a brown garnet (grossularite), clinopyroxene (partly altered to hornblende), scapolite, plagioclase, and nepheline. These rocks appear to be the result of nephelinization of a skarn formed at the contact of the gabbro and the limestone.

A third nepheline-bearing rock, occurring on the north shore of Trooper Lake was mapped as "essexite?" in 1952. It has since been examined in detail by J. Gittins, the author's assistant in 1955 and 1956. Gittins[1] identifies the rock as theralite, containing andesine, nepheline, and clino-pyroxene with titanium-rich cores and rims of hornblende and plagioclase. Apatite, magnetite, and olivine are common accessories, the latter appearing in every section examined. The rock is of particular interest because it is believed to be a hypersolvus nepheline rock of igneous origin. The identification of nepheline rocks of such demonstrably igneous origin, at both Locality 7 and at Locality 8, is of great significance in considering the origin of the other nepheline rocks in this area.

The considerable variability of nepheline content and the general abundance of amphibole, are considered to be detrimental features of the nepheline rock at this locality insofar as economic development is concerned.

[1]J. Gittins, personal communications, Sept. 1958 and Jan. 1959.

8. LARONDE CREEK NEPHELINE ROCKS

Lots 33 and 34, Concession III, Lots 34 and 35, Concession IV, Glamorgan Township; and Lots 2 and 3, Concession V, Monmouth Township

Nepheline-bearing rocks occur sporadically in a narrow belt, up to 3 chains in width, extending eastward from a point 8 chains west of Laronde Creek towards the metagabbro ridge to the east of the creek, and continuing as a fringing belt along the northwestern base of the ridge, into a conspicuous re-entrant at the position of the line between concessions III and IV of Glamorgan township. The heavy windfall, marking the path of a tornado that passed over this area in 1947, makes detailed mapping particularly difficult, but the belt of nepheline rocks has been traced farther northeast and then east, an additional distance of more than 60 chains before swinging southward into the area of exposures described in this report as Locality 9. The band of nepheline rocks is bounded on the north by graphitic marble. To the west of Laronde Creek the rocks to the south are biotite syenite gneiss. Immediately east of Laronde Creek exposures are rare, but graphitic marble is again encountered, overlain by metagabbro, which lies directly on the nepheline rock in eastern Glamorgan and western Monmouth townships. Throughout most of their length the nepheline rocks dip southeast under the metagabbro at about 40 degrees, locally the dip is as high as 60 degrees and, at the northern end, 30–35 degrees.

The nepheline rocks of this locality are of two main types. The more abundant is the gneissic variety that occurs throughout the length of the locality. The rock is generally a dark coloured nepheline-hornblende-plagioclase gneiss and in places contains biotite as well as hornblende. Locally biotite predominates over hornblende. The nepheline commonly shows the characteristic blue-grey weathered surface, although both pink and white hydronephelite may be found. The nepheline is very irregularly distributed through the rocks, some bands containing only a few percent, whereas in others the nepheline content is 60-70 percent. These bands, however, are generally only a few inches thick. In the most spectacular, subhedral nepheline grains up to ¼ inch in diameter are commonly grouped into aggregates up to several inches long, containing little mafic material. Most of the nepheline, however, is finer grained and not so conspicuously aggregated.

At the old Pusey property in eastern Glamorgan township, there is a most interesting relationship between graphitic marbles, nepheline rocks, and the gabbro mass. Gittins[1] has studied a number of specimens taken at this location and considers that the graphitic marble has been nephelinized to produce the nepheline-plagioclase-biotite gneiss. This separates the marble from a distinctly igneous-looking rock, identified by Gittins as theralite, consisting of andesine, nepheline, clinopyroxene, magnetite, apatite, and olivine. The feldspar forms tabular plates up to ½ inch in length containing small globules of nepheline. Scapolite has been developed at the expense of feldspar in places where shearing and granulation have occurred. Nepheline grains up to ¼ inch in diameter are subhedral to anhedral, and contain oriented needles of green pyroxene. The clinopyroxene grains in some specimens have titaniferous cores, and may contain abundant magnetite inclusions. Magnetite occurs as separate grains, also as inclusions in the clinopyroxene. A feature of this rock, conspicuous in thin sections, is the development of coronas between nepheline and clinopyroxene (plagioclase and hornblende), around olivine (clinopyroxene, plagioclase, and hornblende), and around magnetite (brown hornblende or, more rarely, deep brown biotite and blue-green amphibole).

[1]J. Gittins, personal communication, Sept. 1958.

A third type of nepheline rock occurs just below the "orebody" at the Pusey property. The "ore", generally a pyroxene-magnetite aggregate, has, associated with it, a nepheline-pyroxene-magnetite rock in which the nepheline occurs as gieseckite. The relationships are not clear and should be studied in detail. Extensive weathering and the growth of forest since the locality was examined by Foye[1] now conceal features more readily studied 40 years ago. It is felt, however, that a careful study would be petrologically rewarding. The rock complex here possibly represents interaction between the gabbro and its differentiates on the one hand, and the theralitic magma on the other.

As in other localities previously discussed, the nepheline content of the rocks is not sufficiently great or uniform to make them economically significant. Their petrological value, however, would seem to be considerable.

9. NEPHELINE SYENITE

Lots 3–9, Concession IV and V, Monmouth Township

Nepheline-bearing rocks of two major types comprise an elongate pear-shaped mass lying between the gabbro hills to the south, and Laronde Creek and the Irondale River to the north. The western part, about ½ mile long, is an arcuate band 10 chains wide extending southeast from the nepheline-gneisses of Locality 8 towards a small pond near the line between lots 3 and 4. The larger, eastern, part expands to a maximum width of about 30 chains before tapering out in lot 9, concession V. The total length is nearly 2 miles. The body dips south under the gabbro at angles of 20–60 degrees.

The underlying rocks in the western part are graphitic and phlogopitic marbles. Toward the east, however, as the body approaches the Irondale River the relationships are less clear. About ½ mile upstream from the confluence of Laronde Creek, outcrops on the river are of calcareous paragneiss cut by a red syenite. Farther east, other outcrops on the river are of red syenite, and it seems probable that the body of nepheline rocks is cut out here by the syenite. For 1 mile eastward from the pond near the lot line referred to above, scattered outcrops of graphitic marble separate the nepheline rocks from the overlying gabbro mass. West and northwest of the pond, outcrops of marble were not found in this position, and the nepheline rocks are shown in contact with the gabbro. It is possible, however, that closer mapping would show the marble to be continuous between the two bodies.

The arcuate band comprising the western part of the nepheline rock mass is characterized by an igneous texture, and the rock has been identified by Gittins[2] as olivine-bearing nepheline syenite (*sensu stricto*). The rock is medium to dark in colour, with a grain size of ½–12 millimetres. Tabular feldspar grains, generally 10 millimetres long, are rudely foliated in the coarser-grained varieties. Gittins states the mode of these rocks to be: "feldspar 54, nepheline 27, clinopyroxene (and hornblende) 17, olivine 0.5, iron ores 1.5."

The feldspar laths are Carlsbad-twinned microperthite (about Or_{47} Ab_{51} An_2). No other feldspar occurs, so the rocks are hypersolvus nepheline syenites. The nepheline grains are generally anhedral, although occasional euhedral grains are found. Nepheline is generally unaltered and is characterized by acicular inclusions of pale-green pyroxene amounting to 15–20 percent by weight. These

[1]W. G. Foye, "The Relation of the Titaniferous Magnetite Ores of Glamorgan Township Haliburton County, Ontario, to the Associated Scapolitic Gabbros," *Economic Geology*, Vol. 11, 1916, pp. 668, 669.

[2]J. Gittins, personal communication.

are oriented parallel to the c-axis of the nepheline. The clinopyroxene-hedenbergite with about 10 percent acmite is characterized by patches composed of hair-like inclusions of magnetite. Hornblende is a minor constituent occurring in rims separating nepheline and clinopyroxene from surrounding grains of magnetite. Olivine (about Fa_{70}) is pale straw-coloured, and is commonly rimmed by clinopyroxene, which is in turn rimmed by plagioclase and amphibole. A narrow rim of clear albite usually separates nepheline from microperthite where these minerals are in contact.

These one-feldspar nepheline syenites are believed by Gittins to constitute one end member of a differentiated series, of which the theralites described above (Localities 7 and 8) constitute the other end member. This series of distinctly igneous nepheline rocks is of considerable significance in clarifying the origin of the nepheline rocks in this area.

Most of the nepheline-rock mass at this locality consists of nepheline-plagioclase gneisses containing both hornblende and biotite; in some the biotite predominates, in others hornblende. Some of these gneisses are believed to be metamorphosed igneous rocks. One such rock, analyzed by Gittins, proved to be a biotite-hornblende-nepheline-feldspar gneiss. The analysis, by weight percent, shows microcline, 20.97; albite, 29.27; nepheline, 25.42; hornblende, 13.65; biotite, 8.30; calcite, 2.40. Most of the gneisses, however, are probably the result of nephelinization of the underlying marbles. The nepheline content of these, as of the other gneisses previously described, is highly variable; some bands are nepheline-poor, but in other bands nepheline is the predominant mineral. In some outcrops, nepheline-plagioclase pegmatites, with nepheline individuals up to 2 inches across, cut the nepheline gneisses. These nepheline gneisses occupy an area of generally low, wooded ground between the Irondale River and the gabbro hills to the south, and outcrops are scarce.

The variability of nepheline content in the gneisses, together with the possibility that the body is not very thick, suggest that these rocks are not likely to be economically important as a source of nepheline.

10. CENTRAL MONMOUTH NEPHELINE COMPLEX

Lots 10–16, Concession VI, Lots 10–19, Concession VII, Lots 10, 12, 14, 15, 20, and 21, Concession VIII, and Lots 15 and 16, Concession IX, Monmouth Township

This locality includes a variety of nepheline-bearing gneisses and nepheline pegmatites. The nepheline rocks comprise an outcrop area having roughly the shape of the Greek letter π, inverted. The two legs diverge northward and are underlain by the Tory Hill marble band, a coarse-grained phlogopitic, graphitic marble. To the south, and overlying the nepheline rocks, is a paragneiss complex, including some marble as the border rock in the middle part of the mass. Between these two bands of metasedimentary rocks the nepheline rocks are intimately associated with the central Monmouth syenite complex. The greatest length of the nepheline-rock complex, along the south border, is 3½ miles; the greatest width, in lot 15, is 1¾ miles. The two northward diverging legs, and the two southern arms, are each approximately ¼ mile across. Within the syenite complex are isolated small bodies of nepheline rock considered to be remnants of a formerly continuous sheet of nepheline rock.

(a) Northwest Leg

Two main types of nepheline rocks are found in this area. The first of these is a rather massive rock, consisting of nepheline, hornblende, garnet and calcite. The hornblende is an alteration product of pyroxene, and a gieseckitic alteration

of nepheline commonly occurs. Associated with these nepheline rocks are nepheline-hornblende-scapolite rocks. Both contain blocks of coarse silicated marble, consisting of hornblende, feldspar, calcite, with smaller amounts of biotite, garnet, and occasionally, gieseckite. The assemblage appears to represent a nephelinized skarn, but the origin of the skarn itself is not clear.

The second rock type in this area is the nepheline-bearing gneisses, ranging from dark to light in colour as the proportion of mafic minerals changes. Adams and Barlow[1] describe three varieties in some detail: a dark rock containing abundant hornblende, together with nepheline, albite, and calcite; and two light rocks, containing less hornblende, and differing from each other in the relative proportions of nepheline and albite; the albite-poor variety of these was given the name "monmouthite." In reviewing these rocks in the field, biotite was found to be abundant in some outcrops, in places even exceeding hornblende. These three varieties of gneiss appear to be gradational into one another and may represent nephelinization of sediments of somewhat different composition. The nepheline is commonly of the blue-grey-weathering variety, but locally is represented by pink hydronephelite or waxy white gieseckite. The content of nepheline is highly variable in the different bands, ranging from less than 25 percent, in some of the darker gneisses, to more than 75 percent in the lighter "monmouthite."

Satterly[2] has briefly described these occurrences, which have been opened up by stripping and trenching. A chip sample, representing 70 feet across the gneissic structure in one of the strippings, returned 59.1 percent of black minerals (dark-brown mica, hornblende, and magnetite), and 40.8 percent of light minerals (albite and altered nepheline). He regarded the economic possibilities as being "limited as long as large supplies of relatively pure nepheline syenite are available at low cost."

(b) Northeast Leg

Here nepheline-bearing gneisses lie between the large area of phlogopite-graphite marbles to the west and northwest and a syenite-quartz syenite-granite complex to the east. The nepheline rocks range from a nepheline-poor biotite-albite gneiss containing sparsely disseminated nepheline, to a nepheline-biotite-albite gneiss with a nepheline content of about 10 percent. The bordering syenite complex is a red biotite or hornblende syenite gneiss, grading into lighter quartz syenite which, in turn, locally grades into granite.

Exposures are excellent in the fields adjoining the old Hotspur Road, near the junction with the old Monck Road. The syenite complex contains numerous patches of nepheline gneiss up to about 50 feet long. The cores of these gneiss masses show the typical blue-weathering nepheline, but towards the border, pink hydronephelite appears, and the nepheline gneiss passes into grey-weathering peristerite syenite, which, in turn, passes into the red syenite. Similar changes to the peristerite syenite may be seen along fractures in the nepheline gneiss patches. Dikes of red syenite cut both the nepheline gneiss and the peristerite syenite. The whole aspect of the terrane strongly suggests invasion of nepheline gneisses by the syenite-granite complex. The nepheline gneiss patches are xenoliths, at the borders of which the nepheline has been converted to peristerite. Other rock types also occur as xenoliths, up to several feet long; these include biotite and hornblende paragneiss and black amphibolite.

[1]F. D. Adams and A. E. Barlow, *Geology of the Haliburton and Bancroft Areas, Province of Ontario*, Geol. Surv. Can., Memoir No. 6, 1910, pp. 269–78.

[2]J. Satterly, *Mineral Occurrences in the Haliburton Area*, Ont. Dept. Mines, Vol. LII, 1943, pt. 2, pp. 17, 77, 78, and Fig. 9.

It is of interest that Gittins' interpretation,[1] as outlined above, is in contrast to that of Adams and Barlow,[2] who regarded the occurrence as a stage in the development of nepheline rocks from granite. Satterly[3] also has briefly described this replacement relationship, both at this locality and at Locality 11 (Otter (Esson) Creek).

It is evident that the low nepheline content of these rocks reduces the possibility of their being developed economically. They are, however, of considerable interest from the standpoint of petrogenesis.

(c) The South Arms

Nepheline gneisses are the chief rock type found in this part of the locality. Mostly they are nepheline-hornblende-albite gneisses, characterized by extreme variability in nepheline content. Their general aspect is very similar to the occurrences described in the northwest leg, some of the rocks being strongly reminiscent of the type "monmouthite." The gneissic structure is less obvious in some outcrops where the rock appears to be much more massive. The rocks not only range from nepheline-rich to nepheline-poor varieties, but also show considerable variability in grain size, from less than 1 to more than 5 millimetres, within a few inches across strike. Under the microscope, relicts of pyroxene may be seen, most of the mineral having been altered to hornblende. Adams and Barlow[4] describe a rock from the eastern part of this section as containing considerable microcline and microperthite in addition to albite, and a little biotite as well as hornblende; they considered the biotite to have been replaced by the hornblende.

In the westernmost part of the south arm, nepheline pegmatite occurs, as described by Satterly.[5] Test pits and trenches have opened up the occurrence, in which nepheline masses up to 3 feet across are characterized by a well-defined columnar or prismatic structure (schiller structure), the closely packed nepheline prisms being separated by thin films of biotite. The colour of the fresh nepheline ranges from white to dark grey, even within a single crystal. The rock is a nepheline-albite pegmatite in which the nepheline content ranges from 10 to 50 percent. In addition to the major minerals, Satterly records "minor amounts of carbonate, yellow cancrinite, and sodalite" in one pit, whereas from a trench he notes "biotite in books from 1 to 2 inches in diameter, a little green apatite, and, rarely, zircon." The apatite prisms up to 2½ inches long are intergrown with the nepheline. The yellow cancrinite occurs as masses up to 2½ inches across, sometimes surrounding carbonate grains. Additional minerals noted include pyrrhotite, graphite, and a brown-weathering carbonate.

The dimensions of the pegmatite are unknown, but 20 chains southeast near an old dam on the Irondale River, a nepheline-albite pegmatite was found. Although very coarse grained (6 inches to 2 feet) the nepheline content of the rock is low, and the nepheline is altered to greenish-brown gieseckite. More development work is required on this body to justify exploitation.

11. EASTERN MONMOUTH NEPHELINE ROCKS

Lots 18–23, Concession X, Lots 21–24, Concession XI, Lots 24–26, Concession XII, and Lots 26–29, Concession XIII, Monmouth Township

The nepheline rocks at this locality appear to represent what is essentially the continuation to the northeast of the association that characterizes the northeast leg of Locality 10. Nepheline gneisses and more massive nepheline-biotite-

[1] J. Gittins, personal communication, Feb. 1959.
[2] F. D. Adams and A. E. Barlow, *op. cit.*, pp. 260, 261.
[3] J. Satterly, *op. cit.*, p. 16, and photos pp. 14, 15.
[4] F. D. Adams and A. E. Barlow, *op. cit.*, pp. 267, 268.
[5] J. Satterly, *op. cit.*, pp. 75, 76.

albite rocks form an almost continuous belt about 3½ miles long, and ranging from ¼ to ½ mile wide, generally averaging about ⅜ of a mile wide throughout most of the length. The belt bifurcates to the southwest at a point about 1 mile east of the village of Tory Hill, the north branch being traced in the hills south of the village, and the south branch (with an outlier) trending to the south of Tory Lake. Throughout most of its length the gneissic structure in this belt, as in that of Locality 10, dips south to east, although local reversals have been noted. The nepheline rocks are bounded on the north by the band of graphitic and phlogopitic marbles noted to the north at Locality 10. On the south they are separated from the elongate belt, described as Locality 12, by the syenite-granite complex continuous with that of Locality 10. The outlier mentioned above is completely enclosed by the syenite body.

The nepheline rocks at this locality are nearly all markedly gneissic, although more massive varieties have been found. Excellent exposures of the associations are to be observed in the roadcuts on highway No. 500 at Esson (formerly Otter) Creek 1¼ miles east of Tory Hill. At this point a strong north-south trending ridge has been cut through, exposing a complex of nepheline-biotite-feldspar rock and red biotite syenite. Both rocks are very coarse grained and range from gneissic to massive. Features of the rock in this occurrence are the abundant magnetite and the presence of both albite and microcline. Near the contacts with the syenite, the nepheline has been extensively altered to pink hydronephelite or to green gieseckite, imparting to the light-grey rock a strong reddish or greenish cast. Gittins[1] regards this mass as representing a distinct sill of igneous nepheline alkali feldspar rock (possibly having also contained some olivine) now regionally metamorphosed. Patches of silicated marble seen in the road cut represent xenoliths of the original country rock. The nepheline content of the rock here, as elsewhere, is highly variable, but seldom exceeds 40–50 percent, even over a few inches.

Esson (Otter) Creek Sill[2]

Excellent exposures showing the intrusive relationship of the red syenodiorite (syenite) into the nepheline-albite rock may be seen in roadcuts on highway No. 500 at Esson (Otter) Creek, 1¼ miles east of Tory Hill, in lot 23, concession XI, Monmouth township.

The nepheline rock forms a sill, about 200 feet thick, striking north-south and dipping 45°E. This sill stands up as a prominent ridge and is well-exposed in the highway cuts. The footwall and hanging wall of the sill are red alkaline syenodiorite. Crystalline limestone occurs to the west and probably underlies the red syenodiorite. The red syenodiorite intrudes the nepheline syenite sill, and apophyses and dikelets of the syenodiorite are seen, in places, cutting the white nepheline rock. The nepheline gneiss sill is cut by many well-developed transverse and longitudinal joints, which apparently provided access for potash-bearing solutions from the red syenodiorite.

The typical nepheline rock is a medium- to coarse-grained leucocratic rock of light-grey colour, composed of nepheline, albite, magnetite and biotite, with minor hastingsite, apatite, zircon, carbonate, microcline, sericite, zeolites, titanite, cancrinite, pyrite, and pyrrhotite. There is a slight linear parallelism evident in the rock, due to alignment of biotite flakes, but the usual gneissic character and extreme variability of the nepheline rocks of the Haliburton area is

[1] J. Gittins, personal communication, Feb. 1959.
[2] Abstracted from D. F. Hewitt, *A Petrologic Study of Alkaline Intrusives in Haliburton County, Ontario*, unpublished M.Sc. thesis, Univ. of Wisconsin, 1946.

lacking. Microscopically the nepheline rock is hypidiomorphic granitoid and is composed of well-twinned euhedral albite with large interstitial anhedral nepheline grains. The nepheline is fresh and unaltered except along the joints, where potash metasomatism has taken place.

The average nepheline rock of the sill has the following modal composition (average of three Rosiwal analyses):

	Percentage by Volume
Albite (An_8–An_{10})	50.2
Microcline and microperthite	2.7
Biotite	6.1
Magnetite	1.5
Nepheline	39.1
Carbonate	0.4
	100.0

The plagioclase in perthitic intergrowth with the microcline is albite (An_8).

Perhaps the most noteworthy contact effect of the red syenodiorite on the nepheline syenite is the widespread development of microcline microperthite in the nepheline rock in the contact zone and along the joint surfaces.

The accompanying photograph shows this perthitization of the nepheline rock along joints, by solutions from the red syenodiorite. Rosiwal analyses of the fresh nepheline rock (OC-1) preserved as relicts in the centre of the joint block and the perthitized nepheline rock along the joints (OC-2) are given in the accompanying table:

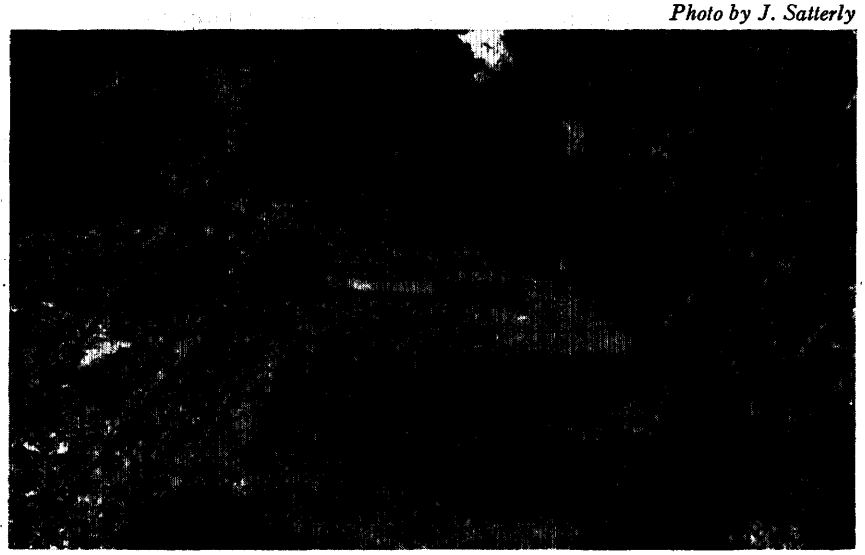
	Sample	
	OC-1 (unaltered nepheline rock)	OC-2 (perthitized rock along joints)
	percent by volume	percent by volume
Albite	54.9	13.6
Microperthite	1.5	37.9
Biotite	4.3	7.9
Carbonate	0.7	1.7
Opaques	1.9	1.3
Nepheline	36.7 (fresh)	37.6 (altered)

During potash metasomatism the fresh nepheline is completely altered to hydronephelite.

Other than in the Esson Creek occurrence, most of the nepheline rock in this locality is a light- to dark-grey nepheline-biotite-albite gneiss strongly resembling that of Locality 10 near the Hotspur road. It is intimately associated with later biotite syenites and biotite granite, the relationship being readily seen along the old Essonville road, about ½ mile east of the railway southwest of Wilberforce. Again the nepheline content of the gneisses is extremely variable; narrow patches up to a few inches long are nearly all nepheline, but in general the nepheline is sparsely disseminated.

The general aspect of the nepheline rocks at this locality is one of swamping of a nepheline rock terrane by a syenite-granite complex, probably representing generally a continuation of the same nepheline mass as in the northeast leg of Locality 10. The Esson Creek occurrence is possibly a separate intrusion but alternatively may represent a less extensively metamorphosed remnant of the original nepheline rock of the belt. The variable content of nepheline would indicate that these rocks are unlikely to be of economic importance at present.

Photo by J. Satterly



Outcrop showing replacement of nepheline-albite gneiss (dark grey) along intersecting joint planes by alkali syenite (light grey) south of the road near Esson creek in lot 23, concession XI, Monmouth township, Haliburton county. Note two isolated residual masses of nepheline-albite gneiss.

12. NEPHELINE GNEISS

Lots 25, Concession X, Lots 25 to 27, Concession XI, Lots 27 to 29, Concession XII, and Lots 29 and 30, Concession XIII, Monmouth Township

A band of nepheline-biotite-feldspar gneiss, averaging 5 chains wide, extends northeastward for 2 miles from its southernmost appearance in a roadcut on highway No. 500, about ¼ mile east of Esson Creek. Throughout most of its length the belt of nepheline gneiss is bordered on the northwest by granites of the syenite-granite complex. To the southeast, the bordering rocks are paragneisses of the main band of these rocks extending through Monmouth township. At the north end of the belt, isolated patches of nepheline rock are completely enclosed within the granite. At the south end, the roadcuts on highway No. 500 disclose a complex of dark silicated marble, nepheline rock, and syenite, much of the nepheline having been converted to green gieseckite. Although biotite is the common mafic mineral elsewhere, at this latter occurrence hornblende is the major mafic mineral. Albite appears in a microcline microperthite as well as in separate grains.

The southeasterly dip of the nepheline gneisses, together with their mineralogical similarity to those of Locality 11, suggest that this belt may represent the hanging-wall part of a formerly continuous broader band of nepheline rocks intruded by the syenite-granite complex.

The highly variable nepheline content, as well as the small size of this body, would indicate the unlikelihood of its being of economic importance at present.

13. RARE EARTH NEPHELINE GNEISS

Lots 19 and 20, Concession VI, Lots 20–22, Concession VII, Monmouth Township

A northeast-trending belt of nepheline gneisses, 2–5 chains wide, extends for a length of 3 miles, about ½ mile southeast of the south arm of Locality 10. The belt lies on the property of Rare Earth Mining Corporation of Canada Limited and is readily accessible, near its north end, on the mine road about 15 chains southeast of No. 1 shaft.

Throughout most of their length, the nepheline rocks dip 35°–40°SE. They lie within the broad band of paragneisses cut by hornblende syenite and granite pegmatite masses. At the south end, however, they are cut off by a body of hornblende syenite.

The nepheline rocks are predominantly nepheline-hornblende-feldspar gneisses in some of which there is considerable biotite. The nepheline content of these, as of other nepheline gneisses, is variable. This variability, together with the small extent of the belt, give the occurrence little economic value at present.

14. MACKAY NEPHELINE PEGMATITE

Lot 14, Concession VI, Monmouth Township

Nepheline pegmatite masses within a broad area of paragneisses have been exposed in two surface strippings. These were examined by Satterly,[1] who found the north exposure to measure about 400 by 250 feet, and the south exposure to be about 230 feet in diameter. The two exposures are about 700 feet apart.

The north body is a biotite-poor nepheline-albite pegmatite, the nepheline content ranging from 10 to 50 percent. Satterly estimates that "the best material would average 40 percent nepheline." The biotite occurs in masses up to 10 inches across, and constitutes up to 5 percent of the rock. In addition to the zircon noted by Satterly, deep blue sodalite, green apatite in slender prisms up to 2 inches long, and black tourmaline have been found.

The southern exposures are of a similar rock, in which nepheline individuals range from 2 inches to 3 feet across, some of it having the columnar structure noted in the pegmatite described under Locality 10. The plagioclase has been identified as potassic oligoclase (Or_{15} Ab_{77} An_8) by Gittins[2], who also found the biotite to be iron-rich. In addition to the sodalite, tourmaline, and green apatite noted by Satterly, zircon and brown-weathering carbonate have been observed here.

Satterly remarks that "the work to date has indicated that a relatively small tonnage of nepheline pegmatite could be obtained from these two masses." He points out, however, that the dark-mineral content is relatively low.

About ½ mile to the northeast of the north showing, outcrops of biotite-nepheline-plagioclase gneiss are exposed at the west end of a sharp, narrow ridge. The nepheline gneiss forms a folded structure plunging to the southwest. Outcrops of silicated marble indicate that the nepheline gneiss lies within a marble unit of the predominantly paragneiss sequence. Both members are cut by hornblende syenite and by minor granite pegmatite. The total length of nepheline rock exposed in the fold is about 700 feet; its width is about 50 feet.

About ¼ mile south of the south showing, Satterly[3] shows an occurrence of nepheline rock at the Irondale River. The occurrence includes not only the "hornblende-nepheline-syenite" noted by Satterly, but also biotitic gneisses and nepheline pegmatite, together with some scapolitic varieties. Diamond-drill core from drilling done during the winter of 1955-56 indicates the presence of a body of grey nepheline-biotite (with or without hornblende)–plagioclase gneisses of unknown dimensions, the core having been scattered. Presence of marble, in outcrops along the river and in pieces of core, suggests that this is the major

[1] J. Satterly, *Mineral Occurrences in the Haliburton Area*, Ont. Dept. Mines, Vol. LII, 1943, pt. 2, p. 77, and Fig. 10.
[2] J. Gittins, personal communication, Feb. 1959.
[3] J. Satterly, *op. cit.*, Fig. 10.

country rock. The cover of sands and gravels in the river valley, however, obscures the relationships. The nepheline pegmatite is a very coarse-grained nepheline-albite rock containing abundant hornblende. It is, therefore, quite unlike the Mackay bodies.

15. NEPHELINE GNEISSES

Lots 2 and 3, Concession III, Monmouth Township

Adams and Barlow[1] describe several varieties of nepheline syenite at this locality. The occurrence has been studied in some detail by Gittins,[2] who concluded, after further study, that the occurrence represents a breached anticline in which the base of the Glamorgan gabbro mass has been exposed in contact with underlying nepheline gneisses and marble.[3] The nepheline rocks form a band, 2–3 chains wide and about 12 chains long. The gneisses strike due north and dip east under the metagabbro at 30–45 degrees. Exposures are fair along an old lumber road.

The footwall rocks are phlogopitic and graphitic marble and skarn rocks resulting from the contact action of the gabbro on the limestone. Overlying these rocks, chiefly at the south end of the occurrence, are biotite-garnet-nepheline-feldspar gneisses, a few inches to a few feet in thickness. This rock is leucocratic, with 10-15 percent biotite and euhedral red-brown garnet; the latter commonly as prominent ¼-inch grains. The plagioclase is andesine (An_{45-50}), but microcline and a little microperthite are also found in this variety. Nepheline occurs both as fresh, blue-grey weathering anhedral grains and as a more altered opaque, waxy white material. Scapolite in variable amounts, and carbonate and apatite also occur. The rock is strongly gneissic and of medium grain size.

In the second variety of nepheline gneiss, hornblende and pyroxene are found instead of biotite. This is the major variety, forming most of the nepheline gneiss band. The hornblende is black and appears to be close to ferrohastingsite on the basis of its optical properties. It occurs as grains up to 1 inch across. The pyroxene close to hedenbergite, occurs in minor amounts as small, pale-green grains. The plagioclase in this variety is albitic (An_{10-15}), and little or no microcline is found. The other minerals noted in the biotite variety also occur in this. It is regarded as a nephelinized skarn.

A third variety of nepheline rock is the nepheline-bearing metagabbro, which forms a band about 50 feet wide, lying above the nepheline gneisses. In hand specimen it is virtually indistinguishable from the hornblende-nepheline-albite gneiss into which it grades. The characteristic mineral of this variety is pink augite, partly or completely altered to uralite with a corona of hornblende and plagioclase. Plagioclase is not abundant, occurring as oligoclase in the coronas referred to above and as large twinned laths of labradorite (An_{60-65}). The nepheline is fresh when immediately adjacent to the nepheline gneiss, but within a few feet of the contact it is completely altered. In addition to the minerals described above, the rock also contains garnet and scapolite, with accessory apatite, carbonate, sphene, spinel, sulphides, and zircon. Although the nepheline gneiss beneath it is foliated in outcrops, the nepheline-bearing metagabbro weathers readily, and its lack of foliation is not readily apparent. The rock is considered to be a nephelinized metagabbro.

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[1] F. D. Adams and A. E. Barlow, *Geology of the Haliburton and Bancroft Areas, Province of Ontario*, Geol. Surv. Can., Memoir No. 6, 1910, p. 282.

[2] J. Gittins, *Nepheline Metagabbro and Associated Hybrid Rocks from Monmouth Township, Ontario*, M.Sc. thesis, McMaster Univ., 1956.

[3] J. Gittins, personal communication, Feb. 1959.

Lying above the nephelinized metagabbro are, in succession, clinozoisite-garnet metagabbro, clinozoisite metagabbro, and normal metagabbro.

The nepheline rocks of this locality are too small in extent and too variable in nepheline content to warrant commercial exploitation, but the occurrence is of considerable petrological interest.

16. HADLINGTON LAKE NEPHELINE GNEISS

Lot 10, Concession II, Lots 10-14, Concession III, Monmouth Township

The south belt of syenitic gneisses at Hadlington Lake has been referred to on page 35. The occurrence is described by Adams and Barlow,[1] to whom the lake was then known as Pine Lake. On the east shore of the outlet bay (on the north side of the lake) very fine-grained paragneisses are exposed, striking N.20°E., and dipping steeply east. Directly overlying these paragneisses is an 80-foot band of coarse grey hornblende syenite, which comes out to the shore near the tip of the point. Disseminated throughout most of the rock is nepheline, some of it blue-grey-weathering, but most of it chalky white. The blue-grey-weathering variety is concentrated in the lower (west) half of the band. In addition to the disseminated nepheline, there are also threads and stringers of pale transparent pink nepheline, most of them only a few inches wide and about a foot long. The disseminated nepheline is more highly concentrated near these stringers, but generally the nepheline content of the rock is less than 10 percent. This nepheline-bearing rock is strongly gneissic, striking at about N.10°E., and dipping eastward at 60 degrees or more. Although most of it is hornblendic, there are also some biotite-rich bands. Magnetite is scattered through the band, but appears to be relatively concentrated in the footwall part. In thin section the hornblende is seen to be very dark-green, approximating hastingsite. It is accompanied by grains of a similarly coloured pyroxene. Albite, microcline, and microperthite are all present, the albite predominating. The nepheline gneiss band is overlain by biotite-rich and hornblende-rich paragneisses; it has been traced northward a little more than ½ mile from the shore.

On the south shore of the lake, on strike with the north shore exposures, are further outcrops of similar rocks, although here no nepheline was found as stringers. In addition to the grey type found on the north shore, there is also a dark, distinctly gneissic rock, containing lenticular clots of altered (pink and green) nepheline up to 1 inch long. As on the north shore, the rocks to the east are paragneisses, but to the west the rocks are fine-grained massive gabbro containing titanaugite.

As the band of syenitic gneisses is followed southerly its strike changes gradually towards northeast. Nepheline-poor masses were observed almost continuously for ¾ mile southwest from the south shore. About a mile from the shore the syenite gneiss band bifurcates. The more easterly band, trending N.30°E., is composed of yellow and dark-red hornblende syenite gneiss and contains no nepheline. The more westerly band, trending N.50°E., is grey, buff, or pink biotite syenite gneiss. At a point near the west boundary of Monmouth township, about 170 chains southwest of the nepheline occurrence at the south shore of Hadlington Lake, the band contains a small area of nepheline-biotite-feldspar gneiss. The nepheline is altered to pink hydronephelite or a chalky white mineral, no blue-grey-weathering nepheline being seen; it makes up less than 20 percent of the rock. Albite and microperthite are the chief feldspars present, the albite

[1]F. D. Adams and A. E. Barlow, *op. cit.*, p. 280.

predominating. Magnetite is a noteworthy accessory, being found not only in the nepheline gneiss at this point but also throughout most of the biotite syenite gneiss band.

Both the hornblende syenite gneiss and the biotite syenite gneiss lie within the paragneiss sequence, all members of which are cut by many granite pegmatite bodies.

The low nepheline content of these rocks makes their economic development unlikely. They are of interest from the petrological standpoint, but no good explanation of their origin has as yet been demonstrated.

B. Cardiff-Faraday Deposits[1]

The Cardiff-Faraday area is divided geologically into the Haliburton–Hastings Highland gneiss complex in the northwest, and the Hastings basin, an area of lower grade sedimentary rocks, mainly limestone and psammo-pelitic schists and gneisses, to the southeast. The rocks of the Highland gneiss complex are granites, granitic gneisses, syenites, syenitic gneisses, nepheline syenite, gabbro, metagabbro, and high-grade metasedimentary gneisses, amphibolites, and marbles.

There are three major centres of granitic intrusion in the Cardiff-Faraday area that dominate the geological structure of the Highland gneiss complex. These are the Cheddar granite batholith in western Cardiff; the Cardiff plutonic complex in northern Cardiff, consisting of a cylindrically shaped south-plunging series of granitic and syenitic intrusive sills interlayered with and replacing metasedimentary gneisses; and the Faraday granite sheet in northern Faraday township.

The nepheline syenite occurrences in Cardiff township lie in a south-dipping, syenitized, mixed gneiss zone along the north contact of the Cardiff plutonic complex, between the plutonic centre and the marble. The nepheline syenite deposits in Faraday township occur in a hybrid syenitized zone of mixed gneisses, forming the hanging wall flanking the south-dipping Faraday granite sheet.

Features of particular interest in Faraday township are the Stranyer Lake nepheline syenite mylonite, and the Bentley Lake nepheline skarn and nephelinized metagabbro.

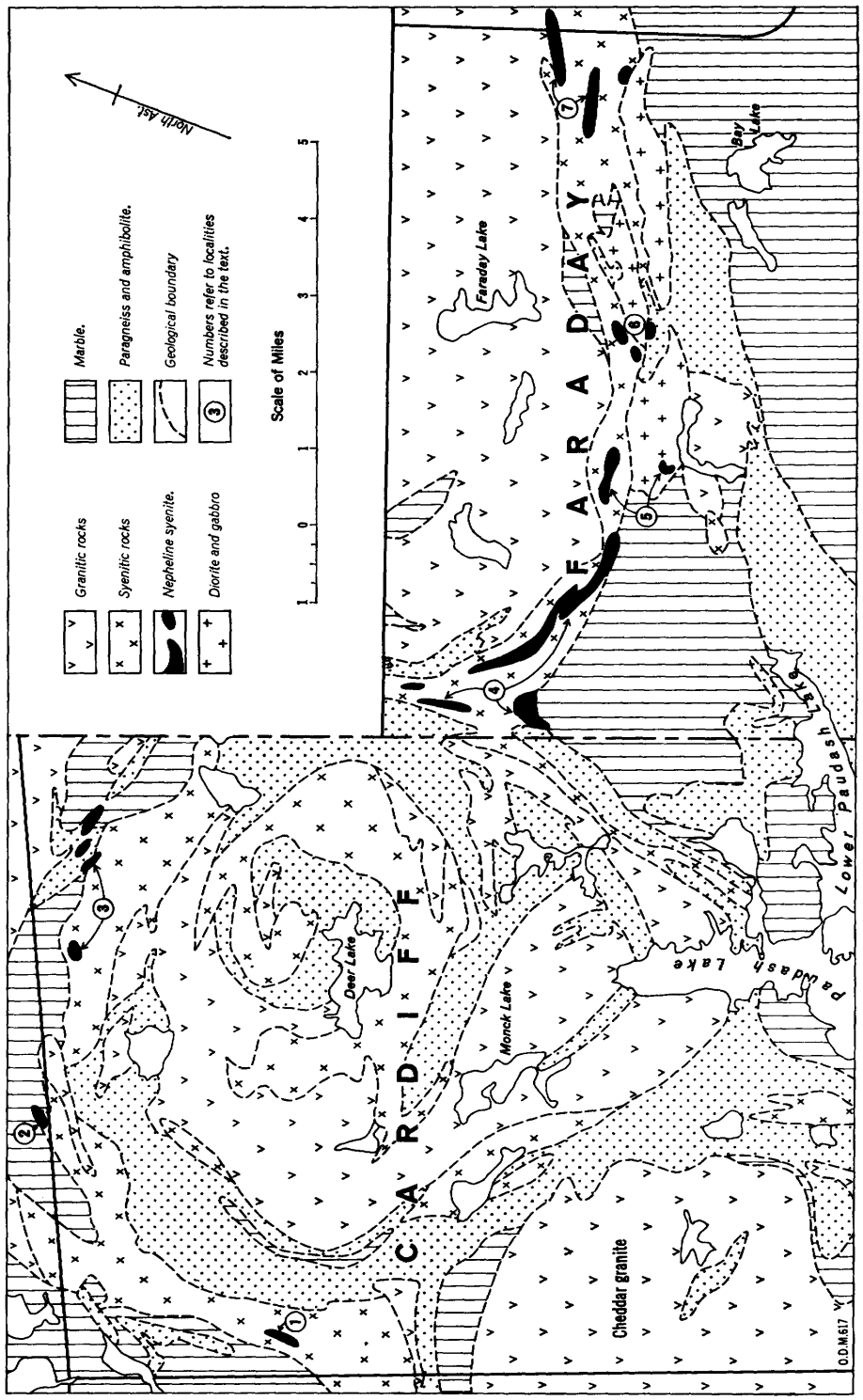
The locations of the nepheline syenite deposits here described are shown on the accompanying sketch map of the Cardiff-Faraday area. Numbers in text correspond with those shown on sketch map.

1. NEPHELINE SYENITE

Lot 1, Concession XVIII, Cardiff Township

A narrow band of biotite-nepheline-plagioclase gneiss is exposed in lot 1, concession XVIII, Cardiff township, on the property of Essential Minerals Prospecting Syndicate. The nepheline gneiss band is 20 feet wide and is exposed over a length of 350 feet. It strikes N.20°W. and dips 40°–50°E. It occurs interbanded with pink syenitic gneisses and is an unreplaced relict in this syenitic gneiss sequence. Corundum crystals of grey-brown colour, up to 3 inches in size, were observed in one outcrop of biotite nepheline gneiss near the north end of the band.

[1]D. F. Hewitt, *Geology of Cardiff and Faraday Townships*, Ont. Dept. Mines, Vol. LXVI, 1957, pt. 3; and accompanying Map No. 1957-1.



Cardiff-Faraday nepheline syenite deposits.

2. HARCOURT NEPHELINE SYENITE

Lot 15, Concession I, Harcourt Township

Near the Harcourt-Cardiff township boundary, in lot 15, concession I, Harcourt township, there is a good exposure of nepheline-hornblende-gneiss in contact with marble in the railway cut a few hundred yards west of Mumford Station. The regional structure strikes east-west and dips 20°–50°S. The nepheline syenite occurs on the north contact, underlying a zone of mixed paragneiss and syenitic gneiss, which flanks the north side of the Cardiff plutonic complex. The nepheline syenite is underlain by white crystalline marble; the contact is well exposed in the railway cut.

The nepheline syenite cuts and replaces the marble. Calcite occurs within the nepheline syenite; nepheline and albite are found in the marble, several feet from the nepheline syenite contact. No contact metamorphic or skarn minerals are developed here.

The occurrence is described by Adams and Barlow[1] as follows:

> The nepheline syenite has a banded structure, some bands consisting of almost pure nepheline, while in others the iron-magnesia constituents preponderate; there is also in many cases a variation in size of grain in different bands. Masses of coarsely crystalline calcite, evidently fragments from the adjacent limestones, are occasionally found as inclusions in the nepheline syenite, the nepheline and other consituent minerals of the latter growing into these inclusions, as if the latter were being replaced by them. Under the microscope, the nepheline syenite is seen to be composed essentially of nepheline and a deep green hornblende allied to hastingsite. The relative proportions of these two minerals vary in different slides. A considerable amount of calcite is present in large individuals, with irregular and usually curved outlines, which lie between the other constituents of the rock. A plagioclase feldspar and microperthite are present in very subordinate amount, together with a few rounded grains of sphene. The structure of the rock is allotriomorphic.

3. HIGHLAND GROVE NEPHELINE SYENITE

Lots 25–28, Concessions XXII and XXIII, Cardiff Township

On the concession road between concessions XXII and XXIII, northeast of Highland Grove, two narrow bands of nepheline syenite are exposed. One band, 50 feet wide and exposed over a length of 400 feet, is in lots 25 and 26. It strikes southeast and dips southwest, paralleling the structure of the enclosing hybrid syenite gneiss and amphibolite. The rock is a grey nepheline-plagioclase gneiss with accessory biotite.

One-quarter mile to the east, in lot 26, about 500 feet north of the road, there is a small outcrop of nepheline skarn consisting of nepheline, plagioclase, and garnet. A small outcrop of pink syenite to the southeast carries corundum.

Another narrow band of nepheline rock is exposed on the road in lot 28, and can be traced for ¼ mile to the west along strike. It dips 40°–50°S. and occurs with marble and amphibolite. This nepheline syenite consists of nepheline-plagioclase gneiss and garnetiferous nepheline-plagioclase skarn.

A small outcrop of nepheline-plagioclase gneiss was also seen, in lot 22, concession XXII, Cardiff township, 700 feet south of the highway.

4. LITTLEFOOLS LAKE NEPHELINE SYENITE

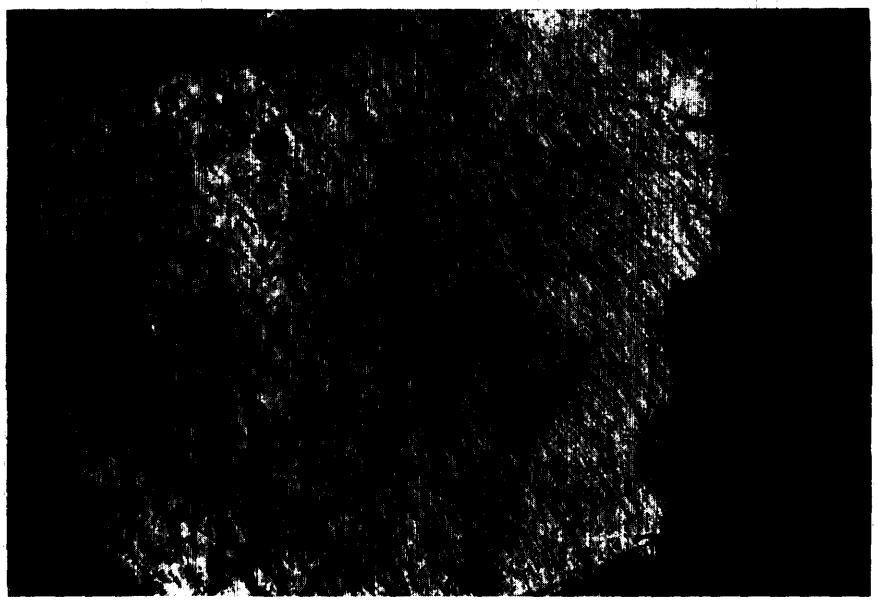
Lots 25–33, Concessions XIV–XVI, A, and B Faraday Township

A wide band of syenitic gneisses lies to the south of the south-dipping Faraday granite sheet, between the granite and the marble to the south. Relict bands of nepheline syenite gneiss occur in this syenitic gneiss complex. Two nepheline-plagioclase gneiss bands each having a maximum width of 600 feet extend northwest from the north end of Littlefools Lake, in lot 25, concession A, Faraday

[1] F. D. Adams and A. E. Barlow, *op. cit.*, p. 288.

township, for a distance of 2½ miles. These bands consist of white nepheline-plagioclase gneiss with accessory biotite and muscovite. The rocks are usually nepheline-poor, nepheline rarely exceeding 20 percent; occasionally the nepheline content may reach 40 percent. Pink microperthite syenite gneiss occurs interbanded with, and replacing, the nepheline gneiss. Nepheline pegmatite stringers a few inches across are sometimes seen. Magnetite patches up to 8 inches long also occur in the nepheline gneiss and associated syenite.

Nepheline syenite gneiss bands also occur south of the Silver Crater Basin property, in lot 31, concession XV, Faraday township, again associated with the same pink microperthite syenite. Narrow bands of nepheline syenite gneiss can be found in lots 31 and 32, concession XVI, south of the township boundary. South of the Silver Crater property the grey plagioclase-scapolite-biotite facies occurs with nepheline-scapolite-plagioclase gneiss. Grey corundum crystals up to ¼ inch in size were observed in a few places in this nepheline syenite band.



Nepheline syenite mylonite, lot 20, concession B, Faraday township.

5. STRANYER LAKE NEPHELINE SYENITE MYLONITE

Lots 19-21, Concession B, Faraday Township

Between Stranyer Lake and the Monck road, in lots 19, 20, and 21, concession B, Faraday township, there is a band of nepheline syenite gneiss, ¾ mile long and up to 700 feet wide, striking in a general east-west direction and dipping generally to the south in conformity with the regional structure in this hanging-wall syenitic gneiss zone above the Faraday granite contact, which lies 1,000 feet to the north. The nepheline syenite gneiss is flanked on both sides by pink and buff syenitic gneiss and hybrid syenite gneiss. Nepheline-plagioclase gneiss is the main facies present.

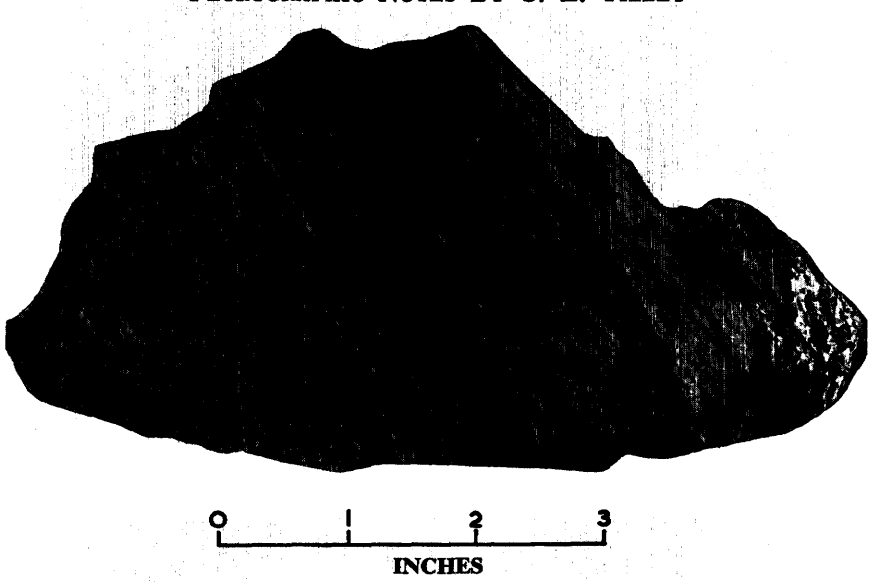
This band lies just north of the Monck mylonite zone and is highly folded and contorted. In lot 20, about 1,000 feet north of the Monck road, on the south side of a hill, there are several excellent exposures of nepheline syenite mylonite. The rock is strongly sheared and is characterized by a streaky banding. Undestroyed eyes and lenses of nepheline syenite occur in a streaky, banded, grey to

black cherty mylonite matrix. Along certain narrow veins and streaks parallel to the movement planes, the mylonite has fused or fritted into black vitreous ultramylonite, which is isotropic in thin section.

In places, boudins or "footballs" of undestroyed nepheline syenite have been rolled in the mylonitized matrix during shearing movements. Where this has occurred, the undestroyed unaltered boudins or "footballs" are surrounded or encased by a thin skin of cherty nepheline syenite mylonite.

A small outcrop of nepheline syenite occurs in lot 20, concession XI, Faraday township, on the Faraday Uranium Mines property.

PETROGRAPHIC NOTES BY C. E. TILLEY

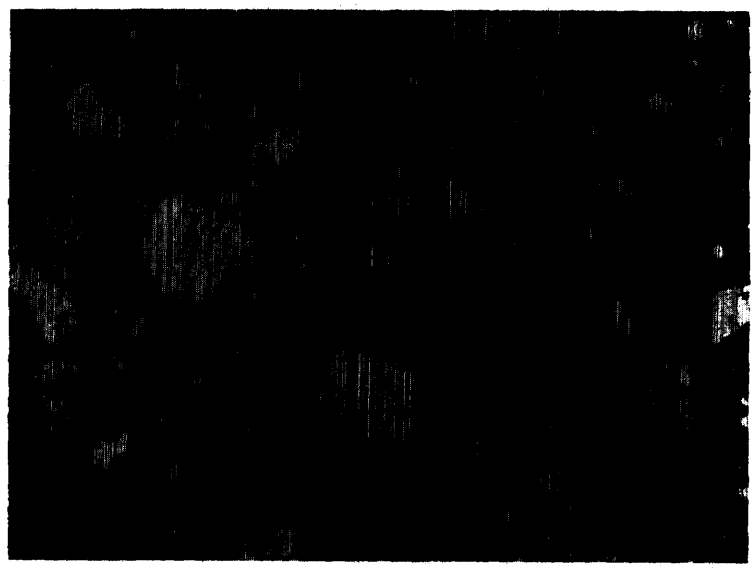


Nepheline Syenite Mylonite (64557), South of Stranyer Lake

Weathered surface of specimen, showing on the right a nepheline-rich band (light colour) and, in the ribbed mylonite to the left, a porphyroclastic aggregate of nepheline, which is itself partly mylonitized.

Two types of nepheline syenite gneiss have been recognized in this mylonite zone, characterized respectively by biotite and hastingsite as the chief mafic mineral. The first type is a coarse-grained foliated rock carrying nepheline, albite, microcline, and biotite, often with subordinate cancrinite. The second type carries hastingsite, scapolite, and some andradite garnet with a more basic plagioclase. An analysis of the second type by J. H. Scoon is given in the accompanying table. Microcline and oligoclase (An_{27}) and scapolite of low birefringence (0.010) and refraction (ω 1.548) are the chief felsic minerals, but sodalite is present as an accessory. The chief type of mylonite has been derived from the biotite-bearing nepheline syenite gneiss. Contorted plates of original biotite remain as relicts and may be surrounded by a wreath of fine biotite scales such as are found in the groundmass of the mylonite itself. In the process of mylonitization nepheline tends to be preferentially granulitized so that the feldspars, albite and microcline, tend to dominate among the porphyroclasts. The character of the mylonites of the zone is well illustrated in the photograph of a weathered surface of a specimen of a mylonite derived from a biotite nepheline syenite gneiss (above) and the accompanying photomicrographs (pages 60 and 61).

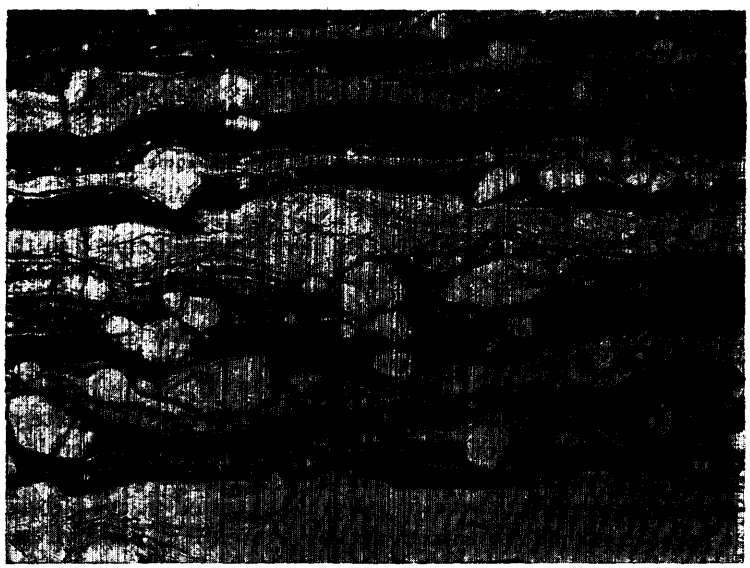
No. 1



Nepheline Syenite Mylonite (64558/2)

Porphyroclasts of albite and microcline microperthite set in a fine mylonitized aggregate of nepheline and feldspars with scattered fine biotite. A porphyroclast of nepheline, cut perpendicular to the optic axis, is shown above the centre on the left edge of the photograph. An analysis (No. 2) of the rock is given in the accompanying table. (27 diameters, crossed nicols.)

No. 2

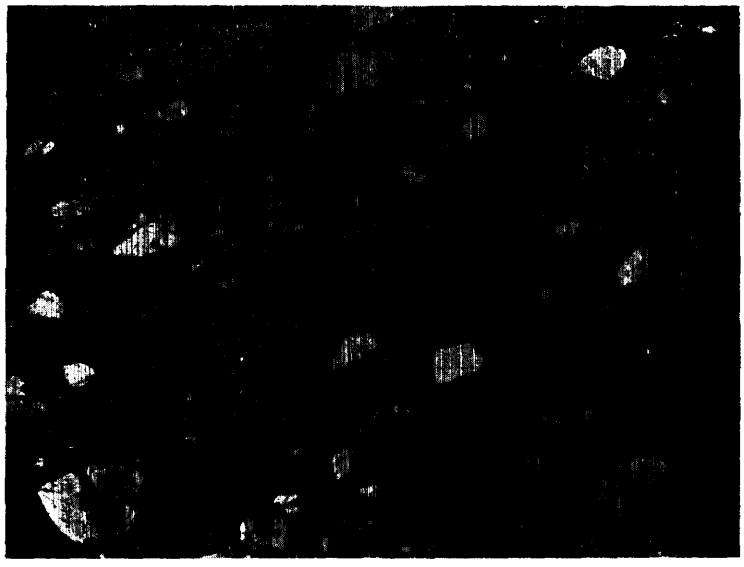


Nepheline Syenite Mylonite (64558/3)

This is the same rock as is shown in No. 1, cut perpendicular to foliation, showing thin bands rich in magnetite edged by lighter bands with fine biotite. The clear areas are granulitic nepheline and feldspars. Clear porphyroblasts of albite and microperthite are also shown. (27 diameters, ordinary light.)

STRANYER LAKE, FARADAY TOWNSHIP, HASTINGS COUNTY

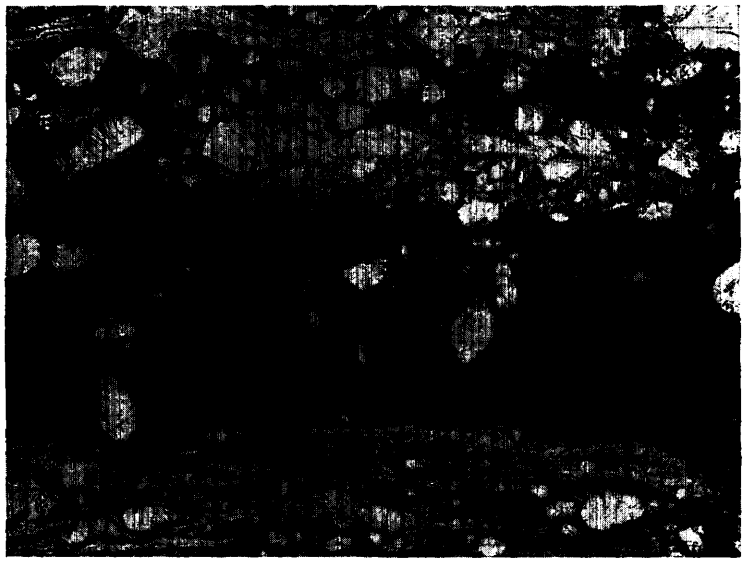
No. 3



Nepheline Syenite Mylonite with Biotite (64557/4)

Porphyroclasts of nepheline, albite, and microcline microperthite. The central porphyroblasts (dark) are of nepheline (extinguished). (27 diameters, crossed nicols.)

No. 4



Dark Band in Nepheline Syenite Mylonite (64613/2)

The porphyroclasts are albite; clear areas are granulitic (fine) nepheline, albite, and microcline. The analysis (No. 3) of the dark bands in this rock is given in the accompanying table. (27 diameters, ordinary light.)

ANALYSES OF THREE SAMPLES OF NEPHELINE SYENITE GNEISS

(Analyses by J. H. Scoon)

Chemical Analyses

	No. 1	No. 2	No. 3
SiO_2	55.02	56.85	45.99
Al_2O_3	21.06	22.44	21.00
Fe_2O_3	3.29	1.63	6.47
FeO	2.29	1.96	4.16
MnO	0.13	0.05	0.16
MgO	0.11	0.04	0.23
CaO	3.07	0.64	3.30
Na_2O	7.78	9.35	9.06
K_2O	5.28	5.81	5.42
H_2O+	0.83	0.47	0.63
H_2O-	0.11	0.04	0.03
TiO_2	0.14	0.23	0.29
P_2O_5	0.03	0.03	0.02
Cl	0.63	0.43	0.30
CO_2	0.29	0.10	2.96
Total	100.06	100.07	100.02
Less O = Cl	0.14	0.02	0.07
Total	99.92	100.05	99.95

Norm

	No. 1	No. 2	No. 3
Or	31.14	34.47	32.25
Ab	33.01	34.71	18.34
Ne	15.34	23.64	27.97
Hl	0.84	0.16	0.50
Cor	.....	0.66	1.48
An	9.17	0.56	.....
Di	3.38	.....	.....
Wo	0.12	.....	.....
Ol	.....	1.43	2.05
Mt	4.87	2.32	9.28
Il	0.30	0.46	0.61
Ct	0.70	0.98	5.90
Na_2CO_3	.....	.....	0.84
Rest	0.97	0.63	0.68
Total	99.84	100.02	99.90

Co-ordinates in System Ne-Ks-Qz

Ne	41.8	45.8	48.3
Ks	22.3	21.1	23.3
Qz	35.9	33.1	28.4

No. 1—Nepheline syenite gneiss with scapolite, andradite, and hastingsite; S. of Stranyer Lake, Con. B, lot 20, Faraday tp., Hastings co., Ontario. (1019/64559).

No. 2—Nepheline syenite gneiss mylonite; same locality as No. 1. (1018/64558).

No. 3—Dark (intensely mylonitized) bands in mylonitized nepheline syenite gneiss; same locality as No. 1. (1073/64613).

The black bands in these mylonites are ultramylonitic in character. Where their texture can be deciphered they consist of a fine colourless granulitic matrix studded with numerous granules of magnetite, but a second type of dark band occurs, in which the fine base is enriched in biotite as well as magnetite.

Analyses by Mr. Scoon have been carried out on bands of mylonite represented in photos Nos. 1 and 4 of pages 60 and 61, and these are set out in the accompanying table, analyses Nos. 2 and 3. The mylonite of analysis No. 2 has the composition of a common type of leucocratic nepheline syenite and can be matched in the Blue Mountain nepheline syenite gneisses. Analysis No. 3 represents the composition of the dark bands of the photomicrograph No. 4 on page 61. As compared with the preceding analyses it is seen to be enriched in iron oxides, lime, and carbon dioxide, expressed as magnetite and calcite. The presence of a small amount of Na_2CO_3 in the norm is suggestive of the presence of cancrinite. The rock nevertheless shows a high figure for the salic constituents of the norm (78.6 percent and, as with the preceding analyses of the table when plotted in the system $NaAlSiO_4$–$KAlSiO_4$–SiO_2, the bulk composition of these salic constituents falls close to the feldspathoidal ternary minimum of this experimental system.

C.E.T.

6. BENTLEY LAKE NEPHELINE SYENITE

Lots 13 and 14, Concession A, Faraday Township

At the south end of lot 13, concession A, Faraday township, between Bentley and Siddon lakes, on the south side of the Faraday metagabbro body, where it is in contact with the para-amphibolite and marble that lie to the south, there is an unusual alkaline skarn developed. Some of the metagabbro at the contact zone is replaced with interstitial grey nepheline. This seems to be a case of nephelinization of metagabbro and indicates that the period of nepheline syenite intrusion was post-gabbro. The alkaline skarn consists of bright-green pyroxene (possibly aegirine) mantled by garnet, blue amphibole, scapolite, nepheline, and plagioclase.

To the north of the Faraday metagabbro, in lots 13 and 14, concession A, several narrow bands of nepheline-plagioclase gneiss occur interbanded with pink syenite gneiss, hybrid syenite gneiss, and para-amphibolite. These bands are of small size.

7. BANCROFT NEPHELINE SYENITE

Lots 1 and 2, Concession A, Faraday Township; Hastings Road Lots 59 and 68 West

The extensive Bancroft nepheline syenite band of Dungannon township extends westward into Faraday township, and the location of four small outcrops of nepheline syenite gneiss in the vicinity of Bancroft village are shown on page 56.

One narrow band of grey nepheline-plagioclase gneiss with accessory biotite and magnetite strikes east-west and dips steeply to the south, across lots 1 and 2, concession A, Faraday township, on the hill just south of highway No. 28 in Bancroft village. It occurs in the mixed hybrid syenitic gneiss complex, with marble and amphibolite. A second small occurrence of nepheline gneiss may be observed in the railway cut just south of highway No. 28, on the west bank of the York River in Bancroft village. Here the nepheline gneiss occurs as a band in marble, and appears to be of replacement origin. This railway cut is illustrated in Guidebook No. 2 of the 1913 International Geological Congress.

A third small occurrence of nepheline-plagioclase-hornblende gneiss occurs 600 feet west of highway No. 62, in Hastings Road lot 58 or 59 west, on the south side of the Faraday metagabbro ridge.

A 300-foot-wide band of grey nepheline-plagioclase gneiss strikes northeast by east and dips 50°S. on the east side of the York River, in the north part of Bancroft village, a few hundred feet south of Snow Road. This band lies above the Faraday granite of the Eagles Nest hill and is interbanded with pink syenite and hybrid syenitic gneiss.

C. Dungannon-Monteagle-Carlow Deposits[1]

The nepheline syenite deposits in Dungannon and Monteagle townships are among the largest and most important in the Haliburton-Bancroft area. They occur within the margins of the Haliburton-Hastings Highland gneiss complex, and form the eastward extension of the band already described in Cardiff and Faraday townships. The nepheline gneisses are found mainly in the York River valley, and in the adjacent zone, 2–3 miles wide, to the north and west of the river. They occur in a metamorphic gneiss complex, associated with marble, amphibolite, syenite, granite, and gabbro.

Structurally, the strike of the nepheline syenite gneisses and enclosing gneisses follows generally the trend of the York River, and the dips are steeply to the south and east.

The nepheline syenite gneisses are mainly leucocratic, but dark-coloured facies carrying hornblende, pyroxene, and garnet are common in the York River nepheline belt, which occurs in marble. While albite and oligoclase are the common plagioclases of the nepheline syenite, plagioclase as basic as andesine (An_{45}) is frequently found in Dungannon and Monteagle townships, particularly in those facies containing calcite and scapolite and occurring in close association with marble.

The nepheline rocks of the Bancroft and York River areas have been studied in much detail, and several good papers have described them fully. These include:

F. F. Osborne, "The Nepheline Gneiss Complex near Egan Chute, Dungannon Township," *American Journal of Science*, 5th Series, Vol. 20, 1930, pp. 33–60.

Felix Chayes, "Alkaline and Carbonate Intrusives near Bancroft, Ontario," *Bulletin*, Geol. Soc. Amer., Vol. 53, No. 3, 1942, pp. 449–512.

W. K. Gummer and S. V. Burr, "Nephelinized Paragneiss in the Bancroft Area, Ontario," *Journal of Geology*, Vol. LIV, No. 3, 1946, pp. 137–68.

W. R. A. Barager, "Nepheline Gneisses of York River, Ontario," *Proceedings*, Geol. Assoc. Can., Vol. 6, 1953, pt. 1, pp. 83–115.

C. E. Tilley, "Problems of Alkaline Rock Genesis," *Quarterly Journal*, Geol. Soc. London, Vol. CXIII, 1958, pp. 323–60.

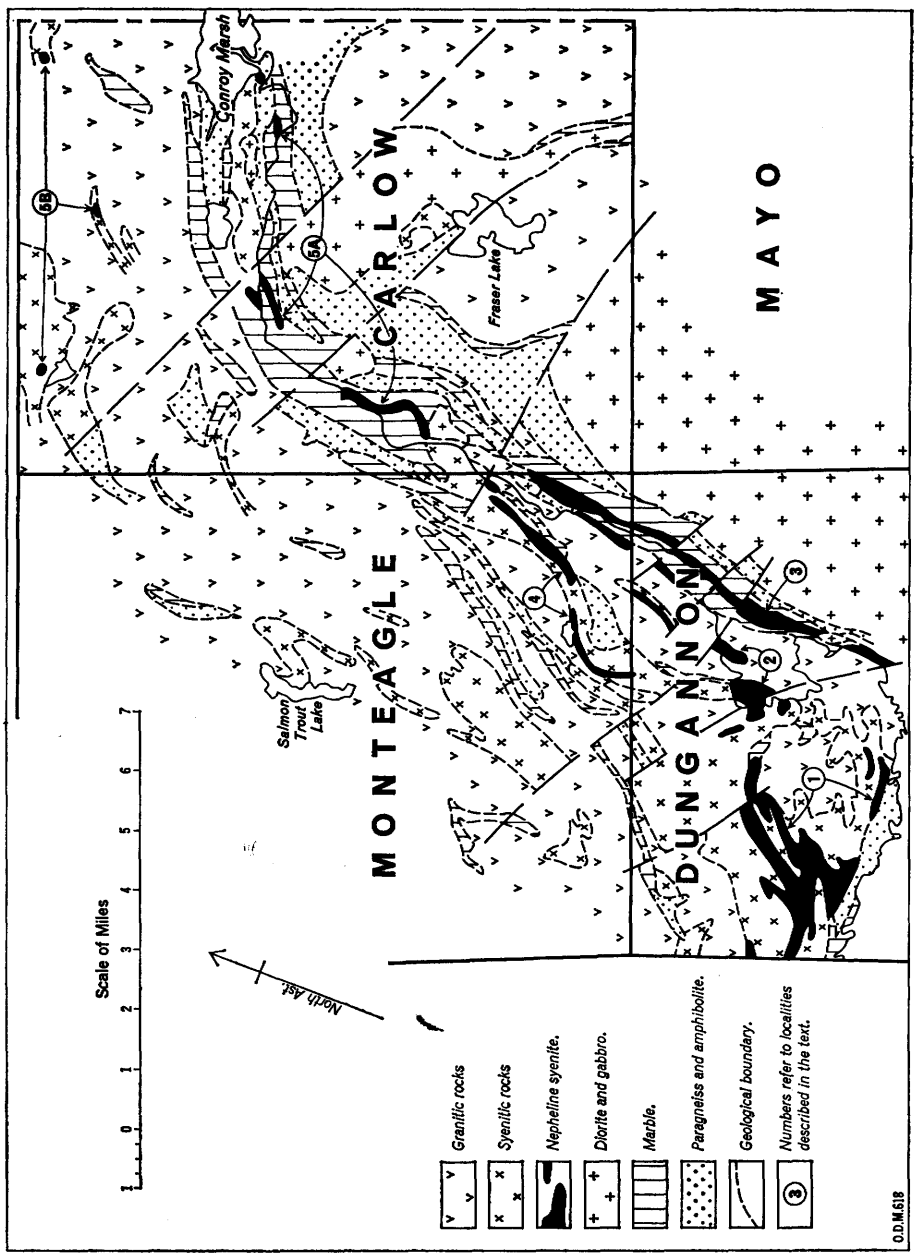
Features of particular interest in this area are: the nepheline syenite pegmatites of the York River band; the Princess sodalite quarry; Cancrinite Hill cancrinite deposit; the York River blue corundum deposits; and the Egan Chute section of nepheline gneiss replacing marble.

The locations of the nepheline syenite deposits here described are shown on the accompanying sketch map of the Dungannon-Monteagle-Carlow area. Numbers in text correspond with those shown on the sketch map.

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[1]D. F. Hewitt and W. James, *Geology of Dungannon and Mayo Townships*, Ont. Dept. Mines, Vol. LXIV, 1955, pt. 8; and accompanying Map No. 1955-8.

D. F. Hewitt, *Geology of Monteagle and Carlow Townships*, Ont. Dept. Mines, Vol. LXIII, 1954, pt. 6; and accompanying Map No. 1954-3.



Dungannon-Monteagle-Carlow nepheline syenite deposits.

1. BANCROFT NEPHELINE SYENITE

Lots 20 to 30, Concessions XI to XIV, Dungannon Township

The Bancroft nepheline band extends eastward from Bancroft village, on both sides of the East road (highway No. 500), for a distance of about 4 miles. The main development of this nepheline syenite band is between Bancroft and the Vardy quarry, in lot 23, concession XIV, Dungannon township. East of the Vardy quarry, the nepheline band is interrupted by the intrusion of the Bronson granite and pink syenites, and only small unreplaced relicts of nepheline gneiss occur in the syenite gneiss north and south of the Bronson granite. The nepheline gneisses occur in hybrid syenite gneiss, occasionally associated with amphibolite. Biotite paragneisses, although common in the area to the south of the York River, are rare or absent in the Bancroft nepheline belt; the prevalent mafic rock is amphibolite of possible sedimentary origin.

Gummer and Burr's paper[1] deals mainly with this nepheline syenite band. Their map of this band is reproduced on the scale of 660 feet to the inch in J. E. Thomson's report.[2]

The nepheline-bearing rocks consist essentially of nepheline and plagioclase (albite to oligoclase). Biotite and magnetite are characterizing accessories. Calcite, hornblende (hastingsite), microcline, corundum, scapolite, muscovite, apatite, zircon, sodalite, cancrinite, and tourmaline are minor accessories. Hornblendic, garnetiferous, and mafic facies are uncommon in this band, but are present as major facies in the York River area to the east. Textures range from hypidiomorphic granitoid to equigranular granoblastic.

Structure and Geological Relations

The nepheline rocks are strongly gneissic in structure and vary in nepheline content across and along strike. Structurally, the nepheline gneiss bands conform to the foliation of the amphibolites and syenitic gneisses with which they occur. Nepheline gneisses are not found cutting any other rock type. Nepheline pegmatites cut and replace nepheline-plagioclase gneisses and occur as irregular pegmatitic patches of rhemorphic material within the nepheline gneisses. In lot 21, concession XI, Dungannon township, a narrow dike of nepheline-albite pegmatite cuts metadiorite. This confirms the post-gabbro age noted in other areas.[3]

Nepheline gneisses are intruded and replaced by white alkaline syenite (albite or oligoclase gneiss), by yellow-brown hornblende syenite and granite, by pink syenite and granite, and by pegmatitic facies of all three of these rock types. Where nepheline gneisses are intruded and replaced by pink syenite, some microcline is frequently introduced into the nepheline rocks, and the nepheline often becomes altered in these zones to hydronephelite, or zeolites and a micaceous aggregate.

Chemical Composition

In their detailed study of the nepheline rocks of the Bancroft band for the Aluminum Company of Canada Limited, and American Nepheline Corporation

[1] W. K. Gummer and S. V. Burr, "Nephelinized Paragneiss in the Bancroft Area, Ontario," *Journal of Geology*, Vol. LIV, No. 3, 1946, pp. 137–68.

[2] Jas. E. Thomson, *Mineral Occurrences in the North Hastings Area*, Ont. Dept. Mines, Vol. LII, 1943, pt. 3, Fig. *facing* p. 12.

[3] D. F. Hewitt and W. James, *Geology of Dungannon and Mayo Townships*, Ont. Dept. Mines, Vol. LXIV, 1955, pt. 8, p. 29.

Limited, Gummer and Burr[1] had partial chemical analyses carried out on surface samples and diamond-drill core. Some of this analytical data is reproduced below:

PARTIAL ANALYSES OF NEPHELINE ROCKS

(n.d. = not determined)

Oxide	Sample No.					
	I	II	III	IV	V	VI
SiO_2	47.2	48.2	41.8	49.7	47.4	54.6
TiO_2	0.1	n.d.	0.3	0.1	0.2	0.2
Al_2O_3	28.1	26.3	29.5	22.4	27.4	21.6
Fe_2O_3	3.7	4.1	5.2	6.8	3.1	1.9
MnO	0.02	n.d.	0.02	n.d.	n.d.	n.d.
CaO	1.7	2.1	5.1	1.3	1.8	3.6
MgO	0.5	n.d.	1.3	n.d.	n.d.	n.d.
Loss on ignition	1.8	2.8	1.3	1.7	1.6	3.6
R_2O_3	31.9	30.4	35.0	29.3	30.7	23.7

Sample I—Surface sample, 11 feet width, Mountney Hill, lot 29, concession XIII, Dungannon township. Analyst, W. K. Gummer.

II—Surface sample, 360 feet width, Princess Hill, lot 25, concession XIV, Dungannon township. Analyst, E. M. Weaver.

III—Surface sample, 13 feet width, north half lot 8, concession XIV, Dungannon township. Analyst, W. K. Gummer.

IV—Core sample, 71.5 feet length, Davis Hill. Analyst, E. M. Weaver.

V—Core sample, 13.5 feet length, Bronson Hill, Hasting Road lot 60, Dungannon township. Analyst, E. M. Weaver.

VI—Core sample, 13.5 feet length, Bronson Hill. Analyst, E. M. Weaver. (Contains albitite dikes and altered [cancrinitic] nepheline.)

SAMPLE DRILL-CORE LOG

Hole 7 — Bearing N.72°W. ast. — Length 258 feet
Exolon Hill — Lot 24, Concession XIII, Dungannon Township — Angle 45°

Footage	Description	Sample	Width
0.0– 7.0	Casing		
7.0– 45.0	Medium- to fine-grained nepheline rock; small quantity of dark minerals, mainly hornblende; 0.5 feet biotite-calcite band at 9.5 feet; strong "gieseckite" alteration over last 10 feet		
	7.0–25.0, as above	40	18.0
	25.0–45.0, as above	41	20.0
45.0– 71.7	Coarser nepheline rock, with larger amount of biotite and hornblende; alteration to "gieseckite" common; apparently higher feldspar		
	45.0–71.7, as above	42	26.7
71.7–100.0	Finer-grained nepheline rock with lower ferromagnesian content; considerable pink and green alteration; feldspar content appreciable; 0.8 foot calcite-sodalite at 82.0		
	71.7–100.0, as above	43	28.3
100.0–105.0	Much biotite; hornblende and feldspar; small amount of nepheline		
	100.0–105.0, as above	44	5.0
105.0–111.5	Nepheline rock similar to 71.7–100.0		
	105.0–111.5, as above	45	6.5
111.5–141.0	Very patchy nepheline rock, locally rich in dark minerals; much "gieseckite" and natrolite alteration; pink syenite dikes 121–23, and 129–32; several small syenitic sections		
	111.5–141.5, as above	46	29.5
141.0–258.0	Syenitic rocks, little or no nepheline; calcite-biotite-cancrinite, 214.1–214.9; sampled		
	141.0–151.0, as above	47	10.0

[1]W. K. Gummer and S. V. Burr, *op. cit.*, pp. 155, 156.

PARTIAL ANALYSES OF SAMPLES 40–47 INCLUSIVE

Sample	Percentage							
	L.O.I.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	CaO	Total Determined	R_2O_3
40	3.7	48.5	0.28	24.3	5.2	5.9	87.9	29.8
41	3.3	46.7	0.30	26.1	5.4	2.7	84.5	31.5
42	6.4	44.9	0.32	19.2	9.0	7.6	87.4	28.5
43	3.6	49.3	0.28	24.0	5.3	3.3	85.8	29.6
44	2.4	46.9	1.54	17.3	11.5	7.5	87.1	30.3
45	4.3	50.6	0.26	25.5	4.5	2.6	87.8	30.3
46	2.7	51.8	0.92	17.1	8.9	3.7	85.1	26.9
47	1.4	54.3	0.50	19.9	7.8	3.0	86.9	28.2

The better sections grade 25–29 percent alumina.

Lily Robertson Corundum Deposit, Lot 26, Concession XIII, Dungannon Township

An interesting deposit in the Bancroft belt is the Lily Robertson corundum deposit, which occurs in nepheline rock in lot 26, concession XIII, Dungannon township. This deposit was opened up on the northwest slope of Robertson Hill by Louis Moyd in 1947 or 1948. In the south pit, tapering bronze corundum crystals up to 3 inches across occur in nepheline pegmatite. Pegmatitic nepheline, albite, and corundum occur as patchy segregations in nepheline-plagioclase gneiss. These rocks are cut by pink and buff syenite gneiss. Corundum crystals are mantled by nepheline, and occasionally by magnetite or spinel.

The best showing of corundum is in a stripping about 50 feet north of the south pit. Corundum crystals up to 2 inches in diameter make up 20 percent of the coarse-grained nepheline-albite pegmatite over an exposed width of 10 feet. The corundum is bronze-black in colour. The country rock nepheline-plagioclase-biotite-corundum gneiss contains purplish-blue scapolite. Other trenches, to the northeast, expose a sequence of nepheline-plagioclase gneiss, nepheline-poor alkaline syenite gneiss, syenite gneiss, and amphibolite.

Robbins Nepheline Pegmatite, Lot 27, Concession XIII, Dungannon Township

A nepheline pegmatite was opened up for quarrying by William Robbins, at the south end of lot 27, concession XIII, Dungannon township, ½ mile south of the East road. Well-banded, nepheline-rich plagioclase gneiss, striking N.60°E. and dipping 70°S., is cut by nepheline pegmatite, consisting essentially of nepheline and albite, in individual crystals up to 3 feet in diameter, with biotite, magnetite, calcite, apatite, sodalite, cancrinite, "gieseckite," and hydronephelite as accessories. The quarry is on the side of a hill, and the cut is 35 feet wide and 30 feet high, ascending the hill in six 8-foot benches. The pegmatite has the character of an irregular replacement body, with more than one age of introduction of nepheline and albite. Joints cut the nepheline gneiss and pegmatite, and late cancrinite and green "gieseckite" alteration along these joints is a very noticeable feature of the deposit.

Princess Sodalite Quarry, Lot 25, Concession XIV, Dungannon Township

Perhaps the best known and most often visited mineral locality in the Bancroft area is the Princess sodalite quarry, located 300 feet north of the East road, in lot 25, concession XIV, Dungannon township. The mineral sodalite has a beautiful deep-blue colour and is prized as an ornamental stone. It is often found with yellow cancrinite and pink hydronephelite. As sodalite usually occurs along fractures in nepheline syenite as a secondary alteration product, it is difficult to obtain in large blocks.

The Princess quarry was opened about 1906, and 130 tons of sodalite rock was shipped to England for use as a decorative stone. A north-south open cut about 200 feet long, with a face 5–10 feet high, is the main working. The country rock is nepheline syenite gneiss; it is cut by veinlets of sodalite, which may replace the even-grained granoblastic-textured nepheline syenite, grain for grain. Some coarse blue pegmatitic sodalite is also developed. Biotite, calcite, and apatite are common constituents. The main sodalite-bearing zone strikes N.15°E. and dips 40°E. The sodalite alteration zones have a maximum width of about 3 feet. Nepheline crystals up to 3 inches in size grow outward from some of the joint faces exposed in the quarry. The sodalite is irregularly developed and therefore difficult to quarry. Much of the material remaining has been damaged by blasting.

Cancrinite Hill, South Half of Lot 25, Concession XIII, Dungannon Township

Another well-known mineral locality in the Bancroft nepheline band is the yellow cancrinite pit located on the northwest face of Cancrinite Hill, lot 25, concession XIII. Here patches of yellow cancrinite and blue sodalite occur as replacement patches in a medium-grained biotite-nepheline-plagioclase gneiss. The even-grained granoblastic texture of the gneiss is preserved in the altered rock. There is some pegmatitic nepheline, sodalite, and cancrinite. Magnetite, tourmaline, cleavelandite, molybdenite, and hydronephelite are accessories.

Vardy Quarry, Lot 23, Concession XIV

In 1937 a small nepheline syenite quarry was opened up on the north side of the Clark (Clear) Lake road, in lot 23, concession XIV, Dungannon township, by the Golding-Keene Company, Keene, N.H.

The quarry measures 80 by 40 feet, with a quarry face of 10–16 feet. The rock is nepheline-plagioclase gneiss, striking N.65°E. and dipping 45°SE. On some outcrop surfaces the nepheline content exceeds 60 percent. The nepheline-rich facies occur interbanded with nepheline-poor plagioclase gneiss and are cut and replaced by white albite. Pink syenite dikes cut albitite and nepheline syenite. There is widespread development of albite along vertical joints in the rock, striking N.35°E. and N.80°W. The nepheline is destroyed by hydrothermal replacement. Magnetite and biotite are the chief accessory minerals.

2. GREAT BEND NEPHELINE SYENITE

Lots 11–17, Concessions XIII–XV, Dungannon Township

Several bands of nepheline syenite gneiss are exposed on the hills on either side of the Great Bend of the York River, in lots 14–16, concession XIV, Dungannon township. On the east side of the river, north of Bronson Landing, a hill rising 100 feet above the river is composed mainly of nepheline syenite with some pink leucosyenite. The nepheline syenite is foliated; the foliation strikes N.20°W. and dips 40°–50°E. White nepheline-plagioclase gneiss, with some accessory biotite, hornblende, and magnetite, is the common rock type. Nepheline content ranges from 10 to 40 percent. The nepheline syenite ridge is ⅜ mile long and ½ mile wide.

The area was restudied in 1957 and 1958 by G. R. Guillet of American Nepheline Limited, and a detailed assessment report describing the area is on file at the Ontario Department of Mines.[1] Guillet states that three or four small pits in the nepheline rock, near the crest of the main nepheline hill near the

[1]G. R. Guillet, *Nepheline Rocks of Dungannon Township, The York River–Great Bend Area*, American Nepheline Ltd., Dec. 1958, Ont. Dept. Mines File No. 63A. 359.

boundary of lots 14 and 15, in the north half of concession XIV, were evidently old corundum workings. Here an interesting occurrence of brownish corundum crystals sheathed in magnetite and spinel is described as occurring in medium-grained biotite nepheline gneiss.

Dungannonite Property, Lots 11 and 12, Concessions XIV and XV, Dungannon Township

An interesting and noteworthy locality on the south side of the York River, in lots 11 and 12, concessions XIV and XV, is the ridge where Adams and Barlow[1] described "dungannonite" in their memoir of 1910. It is also a well-known locality for blue corundum crystals. The 80-foot-high ridge extends southward from the York River for a distance of ½ mile. The rocks of the ridge are predominantly pink syenite and granite pegmatite, which cut and replace narrow relict bands of grey biotite-nepheline-andesine gneiss and nepheline-corundum gneiss. Some narrow bands of marble and amphibolite also occur in the metamorphic gneiss complex that makes up the ridge. The gneisses strike N.20°–50°E. and dip 50°–65°E.

Several pits and trenches were opened for corundum on the top of the ridge. The main workings consist of two open cuts in lot 12, concession XIV, about ¼ mile south of the river. The largest cut measures 40 feet long by 6 feet wide and is 4–5 feet deep. The blue-grey corundum crystals up to 2 inches in size occur in nepheline-andesine gneiss. Garnet, zircon, hornblende, biotite, apatite, muscovite, tourmaline, and scapolite occur as accessories. Scapolite-corundum-tourmaline nodules up to 8 inches in diameter occur in pegmatitic facies.

Adams and Barlow[2] give the following analysis of "dungannonite" from this locality:

Chemical Analysis	Percent
SiO_2	49.56
Al_2O_3	33.70
Fe_2O_3	0.93
FeO	1.42
CaO	5.89
MgO	0.97
K_2O	1.23
Na_2O	4.95
CO_2	0.17
H_2O	0.84
	99.66

Norm	Percent
Quartz	1.26
Orthoclase	7.23
Albite	41.92
Anorthite	29.19
Corundum	13.46
Hypersthene	4.12
Magnetite	1.39
Calcite	0.37
Water	0.84
	99.78

Mode	Percent
Andesine (Ab_3An_2)	72.00
Nepheline	3.00
Scapolite	2.00
Corundum	13.24
Biotite	5.00
Muscovite	3.00
Magnetite	1.39
Calcite	0.37
	100.00

3. YORK RIVER NEPHELINE GNEISS BAND

Lot 12, Concession XI, to Lot 4, Concession XVI, Dungannon Township; and Lot 4, Concession I, to Lot 1, Concession III, Monteagle Township

The York River nepheline gneiss band extends northward from the York River bridge on the East road, lot 12, concession XI, Dungannon township, for a distance of 6 miles, to lot 1, concession III, Monteagle township. For most of the distance the band follows the York River valley. The nepheline gneiss band is 500–1,000 feet wide. It strikes north and dips 30°–65°E. Throughout most of its length the York River band is overlain and underlain by marble, and narrow unreplaced marble bands occur within the nepheline gneiss. Above the hanging-

[1] F. D. Adams and A. E. Barlow, *Geology of the Haliburton and Bancroft Areas, Province of Ontario*, Geol. Surv. Can., Memoir No. 6, 1910, pp. 317–23.
[2] F. D. Adams and A. E. Barlow, *op. cit.*, pp. 317–23.

wall marble on the east side of the band, there is a narrow zone of paragneiss and amphibolite, followed by the large basic intrusive body, the Mallard Lake metagabbro. To the east the footwall marble is underlain by a pink leucogranite sheet, the Great Bend granite.[1]

Lithologically, this York River nepheline band differs from the Bancroft nepheline syenite in that the mafic nepheline gneiss facies are common; they include nepheline-hornblende-plagioclase, nepheline-hornblende-hedenbergite-plagioclase, and nepheline-hornblende-garnet-hedenbergite-plagioclase assemblages.

Structurally, the York River nepheline gneiss band differs from the Bancroft nepheline syenite in that it is overlain and underlain by marble and is separated from the main mixed gneiss complex of hybrid syenitic and granitic rocks; consequently replacement textures and mineral assemblages, indicating that these nepheline rocks in the York River band have been produced by metasomatic replacement of limy sediments, have been preserved, and the entire nepheline facies is available for study.

Three intrusions of pink syenite gneiss occur in the York River nepheline band, but they are small in size. A small gabbro body known as the Egan Chute gabbro,[2] 1,000 feet long and 600 feet wide, intrudes the gneissic sequence at Egan Chute. The marbles and paragneisses swing around the gabbro, and the nepheline gneiss band is interrupted. The gabbro is fresh. Although the contacts were examined, and it is clear that the gabbro intrudes the metasedimentary series, it was not possible to ascertain whether the gabbro was emplaced before or after the nephelinization of the marble-paragneiss sequence. In other parts of the area the gabbro is pre-nepheline syenite.

Detailed work on the York River band was done by F. F. Osborne,[3] W. R. A. Barager,[4] and C. E. Tilley.[5] The York River band was diamond-drilled by Ventures Limited in 1942 and 1943; in logging the core, Louis Moyd found that he could divide the nepheline gneiss into three major members and several minor units, on the basis of mineral assemblages. Petrographic work by Barager and Tilley confirmed this. Between the East road and the Davis quarry, 2¼ miles to the north, the nepheline band consists of a lower member 100–120 feet thick, a middle member 100–130 feet thick, and an upper member from 200 to over 350 feet thick.

The location of twelve diamond-drill holes, drilled by Ventures Limited in the Egan Chute section of the York River nepheline band, is shown on the accompanying sketch map supplied by the company. The diamond-drill sections are shown on the composite section (map case). The diamond-drill cores were analyzed for alumina content, and the average alumina content over various footages analyzed is given on the composite section. Nepheline-rich sections containing over 24 percent alumina are indicated by heavy stipple. These diamond-drill data and analyses were kindly supplied by Ventures Limited.

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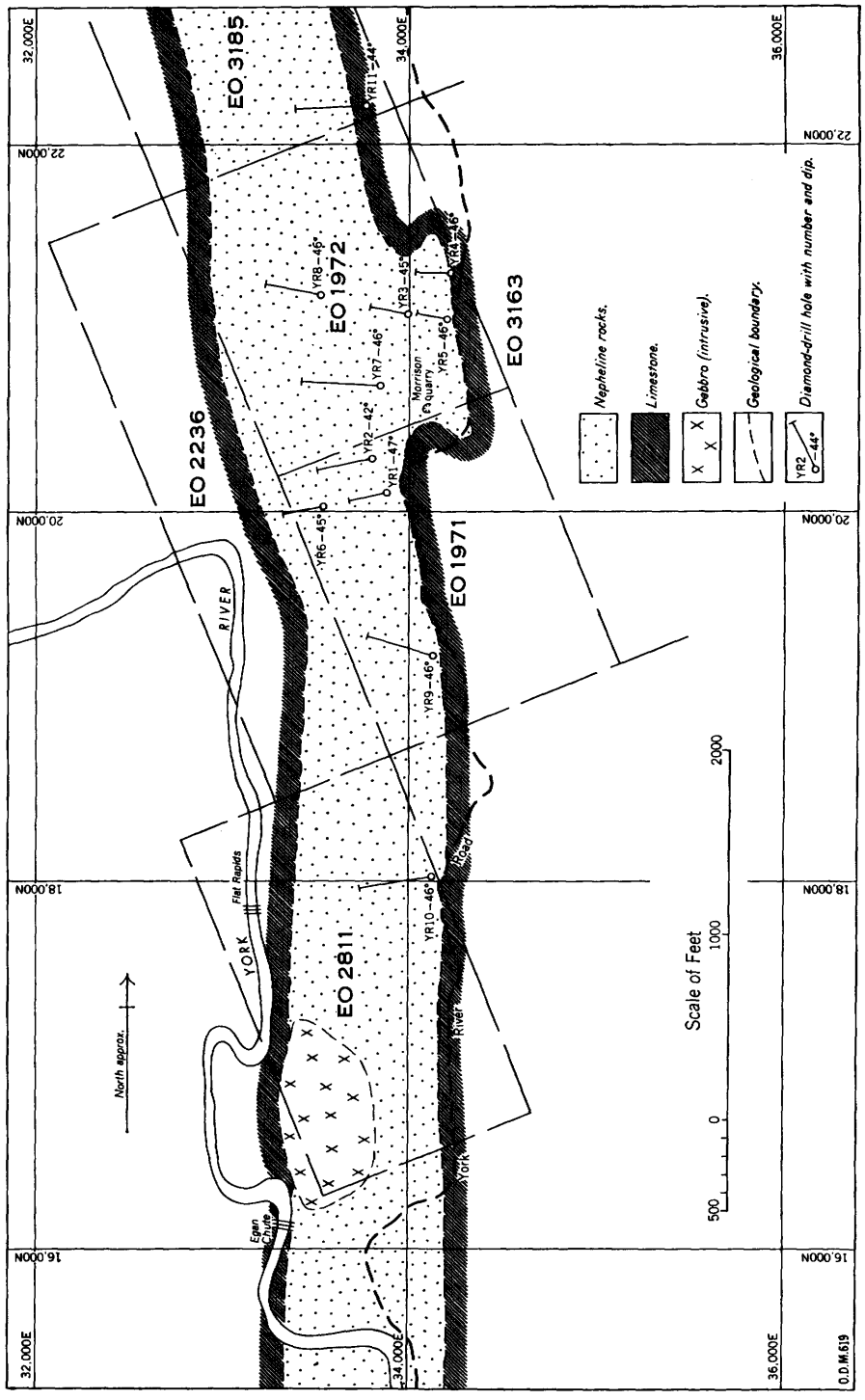
[1] D. F. Hewitt and W. James, *Geology of Dungannon and Mayo Townships*, Ont. Dept. Mines, Vol. LXIV, 1955, pt. 8, pp. 39, 40.

[2] *Ibid.*, p. 26.

[3] F. F. Osborne, *Non-Metallic Mineral Resources of Hastings County*, Ont. Dept. Mines, Vol. XXXIX, 1930, pt. 6, pp. 22–59.

[4] W. R. A. Barager, "Nepheline Gneisses of York River, Ontario," *Proceedings*, Geol. Assoc. Can., Vol. 6, 1953, pt. 1, pp. 83–115.

[5] C. E. Tilley, "Problems of Alkali Rock Genesis," *Quarterly Journal*, Geol. Soc. London, Vol. CXIII, 1958.



Sketch Map of York River nepheline band showing the location of diamond-drill holes.

The three members of the nepheline gneiss band are described as follows by Barager:[1]

> The lower member is rich in feldspar but contains little nepheline. Microcline, not observed elsewhere in the nepheline gneiss, is generally present in significant amounts, and biotite is the common ferromagnesian mineral. Scapolite is abundant in places and tourmaline was observed in one specimen.
>
> The middle member is comparatively uniform in appearance and has a distinctive texture which may be easily recognized in the field [clotted ferromagnesian aggregates.—D. F. Hewitt.] The rock contains nepheline, plagioclase, garnet, and pyroxene. The pyroxene is close to ferrosalite in composition and appears to be diagnostic of the middle member.
>
> The upper member, the least uniform of the three, is generally rich in nepheline and poor in plagioclase. Its characteristic ferromagnesian mineral is hornblende.

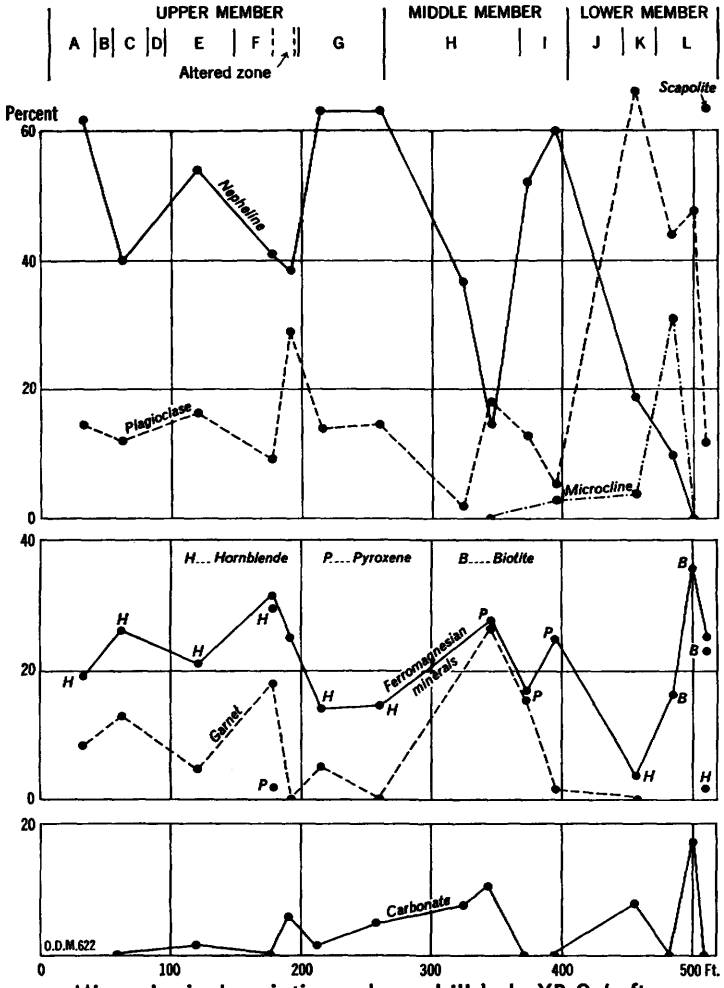
Barager's examination of diamond-drill hole YR-9 indicated that the plagioclase ranged from An_4 to An_{20}. Nepheline content was 0–63 percent; plagioclase content, 3–63 percent (generally less than 20 percent except in the lower member); microcline was absent except in the lower member where it reached 30 percent in one section; ferromagnesian mineral content averaged about 20 percent, ranging from 4 to 37 percent; garnet content was 0–26 percent; carbonate content was 0–17 percent. (See accompanying graphs of mineral variations in drill hole YR-9 page 74.)

Diamond-drill core YR-10 sectioned the nepheline belt just east of Flat Rapids, ¼ mile south of the Morrison quarry. This core was shipped to C. E. Tilley at the University of Cambridge, and a detailed examination of 1,500 thin sections from the drill core was made. The following table gives the principal mineral assemblages across the nepheline band as determined by Professor Tilley.[2]

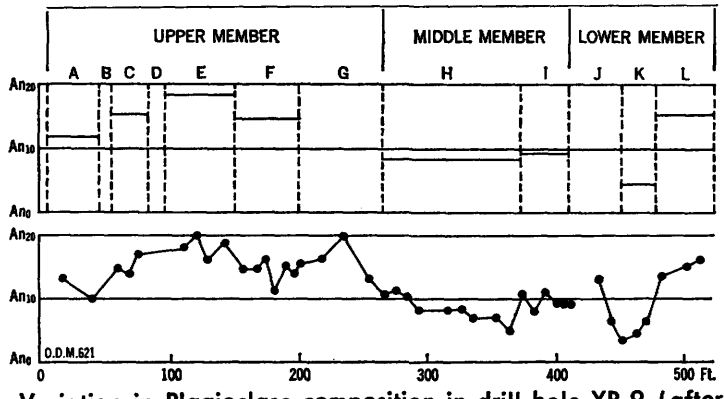
DRILL CORE YR–10 (570 FEET), YORK RIVER
PRINCIPAL MINERAL ASSEMBLAGES

Feet	
	UPPER MEMBER
15– 35	Hornblende–nepheline–plagioclase–calcite (except 28–32 feet, dolomitic limestone).
35– 79	Hornblende–garnet–nepheline–plagioclase–calcite.
79–117	Hornblende–garnet–plagioclase–nepheline–calcite (79–89 feet). Hornblende (clinopyroxene, biotite)–garnet–plagioclase–calcite (89–117 feet), with limestone section (103–104½ feet).
117–139	Plagioclase–biotite–calcite Plagioclase–nepheline } 117–22 feet = "pegmatite" zone. Hornblende–nepheline–plagioclase–calcite (122–31 feet). Plagioclase–biotite–calcite (131–39 feet) = "pegmatite" zone.
139–187	Nepheline–hornblende–plagioclase–calcite.
187–204	Limestone with biotite and diopside.
204–248	Biotite–plagioclase (nepheline)–calcite.
248–277	Hornblende–nepheline–plagioclase–calcite with some narrow limestone bands, some carrying nepheline.
277–298	Hornblende (clinopyroxene)–nepheline–garnet–plagioclase–calcite.
	MIDDLE MEMBER
298–372	Clinopyroxene (hornblende)–nepheline–garnet–plagioclase–calcite (idocrase important in this section).
372–426	Clinopyroxene–plagioclase–nepheline–calcite. Plagioclase–nepheline–biotite (hornblende)–microcline–calcite. Hornblende–nepheline–plagioclase–microcline–calcite.
	LOWER MEMBER
426–491	Hornblende (biotite)–plagioclase–microcline–nepheline–calcite.
491–522	Biotite–plagioclase–calcite (nepheline).
522–534	Biotite–plagioclase–calcite.
	FOOTWALL
534–570	Diopside–plagioclase–microcline (scapolite, biotite, calcite). These calc-silicate horizons frequently carry tourmaline and accessory quartz. Limestone with biotite and diopside: "pegmatite" zone (546–48 feet).

[1] W. R. A. Barager, *op. cit.*, p. 96.
[2] C. E. Tilley, *op. cit.*, p. 345.



Mineralogical variations along drill hole YR-9 (after Barager).



Variation in Plagioclase composition in drill hole YR-9 (after Barager).

Within the nepheline band, Professor Tilley reports gradations from marble to the assemblages biotite-plagioclase-calcite and hornblende-plagioclase-calcite. (The mafics are the exceptionally iron-rich varieties siderophyllite and hastingsite.) These assemblages grade into nepheline-plagioclase-hornblende and nepheline-plagioclase-biotite assemblages characteristic of the nepheline gneiss members. Hedenbergite-clinopyroxene-garnet-vesuvianite-nepheline assemblages have the characteristics of iron-rich alkaline skarns developed from marble.

Mineralogical, structural, and textural evidence indicates that the nepheline gneisses of the York River band were developed from marble by metamorphic-metasomatic processes. The alkaline metasomatism is of a distinctive type, the resulting assemblages being nepheline-bearing and iron-rich. The assemblages



Contact of nepheline gneiss with nepheline pegmatite at the Golding-Keene quarry on the York River, Dungannon township. On the left is mafic hornblende-nepheline-plagioclase gneiss. The hammer rests on nepheline-rich gneiss carrying over 80 percent nepheline. To the right is the albite (white) and the nepheline (grey) of the pegmatite.

biotite-plagioclase-calcite and hornblende-plagioclase-calcite are themselves in part metasomatic in origin and therefore should not be referred to as paragneisses, being polymetamorphic gneisses of hybrid origin.

From the Davis quarry north to the Monteagle boundary, the nepheline-hornblende-plagioclase facies predominates. Sometimes garnet and clinopyroxene are present. Corundum occurs in nepheline-plagioclase gneiss in lot 5, concession XVI, and in lot 7, concession XV. A garnet-plagioclase skarn lacking both nepheline and mafic minerals was noted at the former locality.

The following localities in the York River band are of special economic or mineralogical interest.

Golding-Keene Nepheline Pegmatite Quarry, Lot 12, Concession XI, Dungannon Township

The best development of giant nepheline pegmatites in the Haliburton-Bancroft area is in the York River nepheline band in Dungannon township. The Golding-Keene nepheline pegmatite in lot 12, concession XI, Dungannon

township, is a good example of this type of deposit. The quarry is located on the west bank of the York River about 100 yards north of the East Road. It was opened in 1937 by Golding-Keene Company, Keene, N.H., with its affiliate, the New England Nepheline Company. The company operated this quarry and the Vardy quarry in lot 23, concession XIV, from 1937 to 1939, and 11,092 tons of nepheline pegmatite and nepheline syenite were reported to have been shipped from both properties.[1]

The nepheline pegmatite intrudes and replaces nepheline-plagioclase and nepheline-hornblende gneisses. (See accompanying photo.) The pegmatite consists of nepheline and albite crystals, up to 8 feet in diameter. Biotite and calcite are the chief accessory minerals, with buff-weathering calcite occurring in blebs throughout the nepheline crystals. Zircon, sodalite, hydronephelite, and apatite are minor accessories.

The quarry measures 80 by 60 feet, with a 40-foot face. The nepheline gneisses strike north and dip nearly vertically or steeply to the east. The contacts of the nepheline pegmatite with nepheline gneiss are well exposed on stripped surfaces around the rim of the quarry, and the replacement character of the pegmatite is well shown.

Blue Corundum Locality, Egan Chute, Lot 12, Concession XII, Dungannon Township

The well-known blue corundum locality at Egan Chute is located on a path on the west side of the York River, about ¼ mile north of the East Road in lot 12, concession XII, Dungannon township. Here a small outcrop area of grey muscovite-nepheline-plagioclase gneiss, with corundum crystals up to 2 inches in size, is exposed on the west side of the path. Most of the corundum is grey in colour, but some crystals of blue can be obtained. The corundum crystals are mantled by muscovite. Flecks of galena occur in the nepheline gneiss as a minor accessory mineral.

Morrison Nepheline Pegmatite Quarry, Lot 10, Concession XIII, Dungannon Township

This property has been described in a previous report:[2]

The Morrison quarry is located on lot 10, concession XIII, Dungannon township, on the Davis quarry road on the east side of the York River, 1½ miles north of the East road. In 1939 and 1940 this quarry was operated by the Temagami Development Company, and 1,663 tons of nepheline pegmatite is reported to have been shipped to the United Feldspar Corporation of Maine, U. S. A. This property was acquired by the American Nepheline Corporation, and in 1941 and 1942, a considerable amount of trenching, stripping, and diamond-drilling was carried out along the nepheline band north and south of this quarry.

The quarry is in a massive nepheline-albite pegmatite which cuts nepheline-plagioclase gneiss. Biotite, sodalite, and concrinite are accessories. Some flatly dipping shears, along which biotite schist is developed, cut the quarry face. On stripped surfaces adjacent to the quarry a fairly uniform nepheline pegmatite with nepheline and albite crystals 2–8 inches in diameter is exposed.

A second small quarry, 20 feet long with a 10-foot face, was opened on the west side of the hill. A third quarry on the east side of the nepheline ridge 300 feet north of the Morrison quarry consists of a 40-foot slash along the side of the hill. The nepheline pegmatite consists of crystals of nepheline and albite 4-6 inches in diameter, together with biotite, sodalite, cancrinite, apatite, and a great many small calcite blebs.

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[1] Data supplied by the Statistician, Ont. Dept. Mines.

[2] D. F. Hewitt and W. James, *Geology of Dungannon and Mayo Townships*, Ont. Dept. Mines, Vol. LXIV, 1955, pt. 8, p. 58.

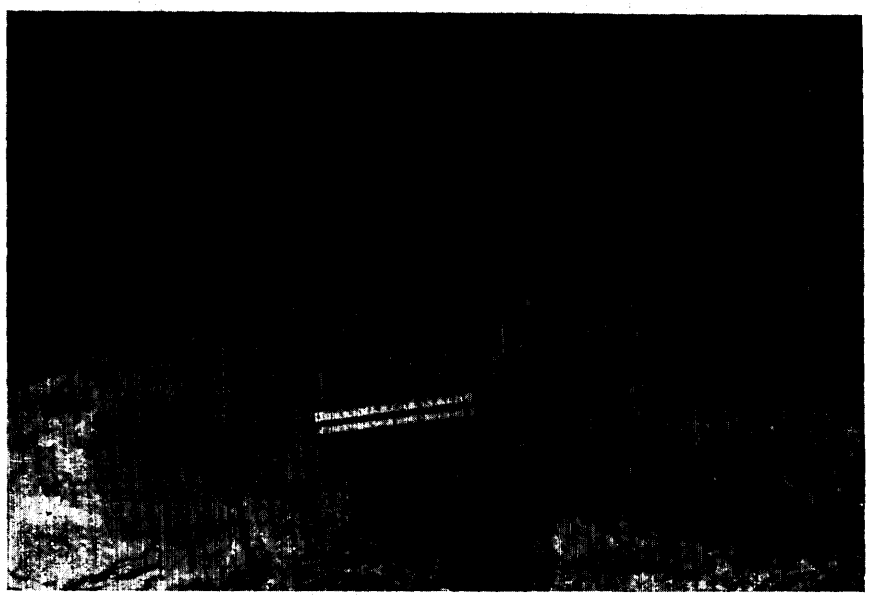
Davis Nepheline Pegmatite Quarry, Lot 9, Concession XIV, Dungannon Township

This property has been described in a previous report:[1]

In 1940 Canadian Flint and Spar Company, Limited, under the direction of N. B. Davis, opened a small nepheline pegmatite quarry on lot 9, concession XIV, 2¼ miles north of the East road. The quarry may be reached by road from the York River bridge at Egan Chute. Production of 944 tons of nepheline pegmatite was reported from the property between 1940 and 1942 when it was closed down.

The quarry is 100 feet long in a north-south direction and 30–40 feet wide. Quarry faces range from 10 to 25 feet in height. The quarry is in coarse-grained nepheline pegmatite, consisting of nepheline and albite, with accessory microcline, tourmaline, biotite, zircon, apatite, cancrinite, "gieseckite," muscovite, hackmanite, and galena. Some calcite and allanite were also noted. This quarry is well-known for its hackmanite and large zircon crystals.

Inclusions of amphibolite occur in the nepheline pegmatite at the south end of the quarry.



A large nepheline crystal of the nepheline pegmatite at the Davis quarry, Dungannon township. Albite is developed along a fracture in the nepheline.

Monteagle Minerals Limited, Nepheline-Corundum-Mica Gneiss Deposit, Lots 2 and 3, Concession II, Monteagle Township[2]

The north end of the York River nepheline band extends into Monteagle township. On the east bank of the York River, 1 mile north of the Monteagle-Dungannon townships boundary, in lots 2 and 3, concession II, Monteagle township, the nepheline rock forms a prominent north-south trending ridge. The nepheline band is 100 feet wide, strikes north-south, dips 70°E., and can be traced for a distance of 3,000 feet north of the river. The rock is strongly foliated, and consists essentially of andesine, nepheline, microcline, and scapolite, with biotite,

[1]D. F. Hewitt and W. James, *op. cit.*

[2]Louis and Pauline Moyd, *Monteagle Nepheline-Corundum-Mica Deposit*, private report on Monteagle Minerals Ltd., Jan. 1954.

D. F. Hewitt, *Geology of Monteagle and Carlow Townships*, Ont. Dept Mines, Vol. LXIII, 1954, pt. 6, pp. 60, 61.

hornblende, garnet, muscovite, and corundum as characterizing accessories, and apatite, spinel, calcite, magnetite, and sulphides occur as minor accessories. As shown in the plans and diamond-drill sections (in map case) supplied by Louis Moyd, the nepheline band is underlain and overlain by interbanded amphibolite, paragneiss, and marble.

The deposit is accessible by boat from Barlett's Landing, located on York River, 4 miles below the deposit.

History of Development.—In 1906, Canada Corundum Company examined the property as a corundum prospect. Stripping and trenching was carried out, and a bulk sample was taken. In 1915 some diamond-drilling is reported to have been done.[1]

In 1947 investigation of the deposit was begun by Louis Moyd for American Abrasive Company. A systematic program of trenching and sampling was completed, and a bulk sample of 5 tons was taken for testing.

In 1950 the property was optioned to Ortona Gold Mines Limited. Further trenching was carried out, and in 1951 four diamond-drill holes totalling 1,965 feet were drilled. Further surface work and bulk sampling followed, and detailed mill tests were made on a 67-ton bulk sample at the Bureau of Mines in Ottawa, during the winter of 1952-53. In 1953, Monteagle Minerals Limited was organized to take over the property.

The investigations carried out on the property are described in a detailed report by Pauline and Louis Moyd.[2]

Geology, Mineralogy, and Chemical Composition.—The main deposit consists of a ridge, 1,200 feet long and up to 70 feet high, extending north from the York River. The rock is well exposed in six trenches, which cross the ridge at right angles to the foliation of the nepheline-bearing gneisses. The gneisses strike north-south and dip 65°–70°E. The true thickness of the nepheline-bearing gneiss band, as indicated by diamond-drilling, is about 90 feet.

The main rock type exposed on the ridge is muscovite-biotite-corundum-nepheline-scapolite-plagioclase gneiss. The rock is of medium grain size and strongly foliated. On weathered surfaces it is grey in colour; on fresh surfaces the rock is a greasy yellow-grey owing to its content of nepheline and scapolite. After exposure to sunlight the scapolite on freshly broken surfaces turns a deep blue. Corundum is present in bands in the nepheline gneiss, and in places makes up as much as 5 percent of the rock. It occurs in fine-grained aggregates of grey crystals, which stand up in prominent knobs on the weathered surface of the rock. Along the west, or footwall, contact of the nepheline gneiss band, there is a zone containing hornblende as the chief mafic mineral, instead of biotite. Garnet also occurs in this zone. The footwall is amphibolite and marble. Narrow bands of amphibolite and marble occur within the nepheline gneiss zone, and diamond-drill sections supplied by Louis Moyd indicate that the main nepheline gneiss band is divided into two parts by a narrow band of amphibolite. The hanging wall, or east, contact of the nepheline gneiss band is made up of amphibolite,

[1]Louis and Pauline Moyd, *op. cit.*
[2]*Ibid.*

nepheline-poor plagioclase gneiss, and syenite gneiss. Nepheline-hornblende-plagioclase gneiss appears to be more common on the second ridge to the north, where some trenching has also been done.

Mr. Moyd[1] gives a rough approximation of the average mineralogical composition of the gneiss of the main ridge as follows:

Mineral	Percent
Andesine	49
Scapolite	7
Nepheline	7
Microcline	5
Muscovite	10
Biotite	14
Hastingsite	3
Corundum	2
Calcite	2
Spinel	0.1
Cancrinite	0.2
Magnetite	0.1
Sulphides	0.3

The surface plan (in map case), supplied by Mr. Moyd, shows the general geology of the main ridge deposit of Monteagle Minerals Limited and the location of the trenches and diamond-drill holes, identified by letter and number. Vertical sections are shown in a chart (in map case) and indicate by letter the location of samples taken for chemical analysis. Partial chemical analyses of 20 composite samples, taken as indicated on the diamond-drill sections, were carried out by Lakefield Research Limited. The accompanying tables supplied by Mr. Moyd indicate the position and length of the samples and their partial chemical analyses.

Sources of Samples

Sample	Source	Sample Length	Approximate True Width
		feet	feet
A	DDH Mo-1—235.7–287.4 ft	51.7	48
B	DDH Mo-1—292.8–327.5 ft	34.7	33
C	DDH Mo-2—633.2–661.8 ft	28.6	26
D	DDH Mo-2—661.8–685.5 ft	23.7	22
E	DDH Mo-2—685.5–714.5 ft	29.0	26
F	DDH Mo-3—232.4–274.4 ft	42.0	42
G	DDH Mo-3—285.0–293.9 ft —303.8–326.0 ft	31.1	28
H	Trench Mo-A—west ore-zone	61	50
I	Trench Mo-A—east ore-zone	33	30
J	Trench Mo-B—west ore-zone	33.5	30
K	Trench Mo-B—east ore-zone	48	44
L	DDH Mo-4—196.3–266.0 ft	69.7	65
M	Trench Mo-C—east ore-zone	63.5	50
N	Trench Mo-C—west ore-zone	19.5	19
O	Trench Mo-D—complete ore-zone	113	98
P	Trench Mo-E—east ore-zone	53	50
Q	Trench Mo-E—west ore-zone	29	26
R	Trench Mo-F—east ore-zone	60	52
S	Trench Mo-F—west ore-zone	31	30
T	65-ton sample, complete ore-zones in trenches Mo-A, C, D, E, and F	463	.....

[1]Louis and Pauline Moyd, *op. cit.*, p. 24.

PARTIAL CHEMICAL ANALYSES
(All figures percent)

Sample	Al_2O_3	SiO_2	Fe_2O_3	CaO	Na_2O	K_2O	CO_2	Corundum
A	29.97	45.06	5.09	6.72	6.11	3.42	1.46	1.66
B	28.30	45.16	6.51	7.52	6.18	2.98	0.62	1.59
C	28.06	42.19	6.75	7.97	5.45	3.53	2.70	1.68
D	28.36	35.97	10.10	10.52	4.14	3.18	2.20	trace
E	27.79	41.22	5.14	11.55	2.70	3.10	4.00	1.99
F	26.78	52.05	4.29	5.13	6.81	3.24	0.02	2.02
G	28.76	48.15	4.96	5.95	6.44	2.92	0.69	1.75
H	30.96	45.23	4.26	6.47	5.16	3.66	0.53	4.43
I	27.36	47.49	5.63	6.17	5.03	3.92	0.58	0.95
J	29.10	46.04	5.67	6.26	5.76	3.66	0.38	1.82
K	31.20	47.04	4.80	5.89	6.61	3.11	0.12	1.74
L	30.28	45.38	5.09	6.71	5.36	3.92	0.79	1.94
M	29.64	.....	5.14	.....	.....	3.74	0.49	3.10
N	26.51	.....	6.03	.....	.....	3.41	0.89	1.34
O	28.24	.....	4.64	.....	.....	4.10	0.33	2.34
P	27.46	.....	5.30	.....	.....	3.61	0.32	0.40
Q	27.84	.....	6.22	.....	.....	3.54	0.66	1.27
R	27.40	.....	5.84	.....	.....	3.70	2.14	0.57
S	25.66	.....	5.70	.....	.....	3.34	2.45	1.40
T	29.46	.....	.....	.....	.....	3.16	1.44	3.44

Results of Investigations.[1]—A few aspects of the results of the field exploration, milling tests, and market research, carried out under the supervision of Louis Moyd for Monteagle Minerals Limited, are summarized here by the author. Based on the 1951–3 exploration program, Mr. Moyd estimates tonnages in the Monteagle deposit as follows:

	Tons
Proven ore (to 250-foot depth)	1,857,582
Indicated ore (to 375-foot depth)	888,462

Milling and market research indicates that three products could be produced:

1) Nepheline-plagioclase-scapolite-microcline concentrate, averaging 29 percent alumina, 0.07 percent Fe_2O_3. This nepheline concentrate would be suitable for glass manufacture.
2) Corundum concentrate, a minus-50-mesh concentrate of grain corundum averaging not less than 85 percent Al_2O_3, suitable for the abrasive industry.
3) White mica concentrate, a minus-50-mesh flotation concentration suitable for paint extender, paper, plastics filler, etc.

Milling tests indicate that the expected recovery of each of the three marketable products would be as follows:

	PERCENTAGE RECOVERY FROM ORE
Nepheline concentrate	55
Corundum concentrate	2.4
White mica concentrate	8.0
Indicated total recovery	65.4
Waste	34.6

Mr. Moyd[2] states in his report that:

One of the objects of the large scale beneficiation test program was to provide enough nepheline concentrate for use in actual production in a glass plant under normal working conditions. At the completion of the program, 10 tons of the coarse-grained nepheline concentrate

[1]Louis and Pauline Moyd, *op. cit.* (abstracted.)
[2]*Ibid.*, pp. 58, 59.

was available for this purpose. A representative composite sample was submitted to the testing laboratory of Hartford Empire Company, Hartford, Conn., consultants to the glass industry. Their [chemical] analysis [of the product] was:

CONSTITUENT	PERCENT
SiO_2	52.5
Al_2O_3	29.05
CaO	6.84
MgO	trace
Na_2O	8.81
K_2O	1.91
Ignition loss (1,100°C.)	0.77
Fe_2O_3	0.07

(Leo E. Stadler, Chemist; June 18, 1953.)

Glass production tests are reported to have been successful.[1]

Milling Flowsheet.—Milling and beneficiation of the Monteagle Minerals ore, worked out at the Bureau of Mines, indicates that flotation, gravity concentration, tabling, and magnetic separation would be required to produce the intended products. The proposed flow sheet described in Mr. Moyd's report[2] is as follows:

Crushing to ¾ inch.
Stockpiling the crushed rock by conveyor belt and travelling tripper.
Reclamation by conveyor belt.
Daily storage.
Two-stage grinding to 50-mesh.
Wet magnetic separation.
Sulphide flotation.
Gravity concentration of corundum by spirals and tables.
Flotation of white mica.
Fine grinding and drying of white mica concentrate.
Flotation of remaining corundum and calcite.
Tabling of corundum flotation concentrate.
Drying, heat treating, and air-tabling of corundum flotation concentrate.
Drying of gravity-concentrated corundum.
Flotation of black mica.
Dewatering, filtering, drying, and dry magnetic separation of nepheline.
Reworking magnetic concentrates.

4. BRESNAHAN LAKE NEPHELINE SYENITE[3]

Lot 13, Concession I to Lot 8, Concession II, and Lot 6, Concession III to Lot 3, Concession IV, Monteagle Township

A narrow band of grey nepheline-poor plagioclase gneiss, rarely exceeding 30 feet wide, is exposed in lot 13, concession I, Monteagle township, near the Dungannon boundary. This band strikes north and dips 55°E.; to the north in concession II it swings in a wide arc to the northeast, passing just south of Bresnahan Lake. The nepheline gneiss is interbanded with, and grades into, pink and buff syenite gneiss. One-quarter mile east of Bresnahan Lake, the nepheline band is engulfed by pink syenite. However, ½ mile northeast the extension of this band is picked up, and can be traced in a northeasterly direction for a distance of 1½ miles through Goddard Lake. Here two nepheline bands occur in pink syenite. North of Goddard Lake the main band has a width of 400 feet. The second band, which occurs 400 feet west of the main band, has a width of 50 feet. These gneisses strike N.25°E. and dip 60°–70°E.

[1] Louis and Pauline Moyd, *Monteagle Nepheline-Corundum-Mica Deposit*, private report on Monteagle Minerals Ltd., Jan. 1954., pp. 59–62.

[2] *Ibid.*, p. 32.

[3] D. F. Hewitt, *Geology of Monteagle and Carlow Townships*, Ont. Dept. Mines, Vol. LXIII, 1954, pt. 6, pp. 60, 61.

Near Bresnahan Lake, biotite and hornblende-bearing facies of the nepheline gneiss contain as much as 25 percent of these mafic minerals. The nepheline content is usually about 20 percent, but is variable and may occasionally reach 50 percent. In the vicinity of Goddard Lake, the nepheline content of the nepheline-plagioclase gneisses reaches an average of about 30 percent, by visual estimate. Nepheline-hornblende-plagioclase facies may contain as much as 30 percent hornblende. Magnetite is a common accessory occasionally making up 10 percent of the rock. Small xenoblastic patch pegmatites composed of nepheline and plagioclase crystals, 4–6 inches in diameter, replace nepheline gneiss. The nepheline gneisses are invaded and replaced by pink and buff leucosyenites.

5. CARLOW NEPHELINE SYENITES

A. South or York River Group: Lots 4 and 5, Concessions VI and VII; Lots 12 and 13' Concession X; Lot 23, Concession X; and Lot 26, Concession X, Carlow Township
B. North or Carlow Corundum Range Occurrences: Lot 18, Concession XIV; Lots 7 and 8, Concession XVI; and Lot 28, Concession XVI, Carlow Township

Several scattered small occurrences of nepheline syenite gneiss occur in two belts in Carlow township. One group, indicated as 5A on the sketch map (page 65), occurs long the York River. The second group, labelled 5B, is small unreplaced nepheline syenite relicts in the Carlow corundum range in the northern part of the township. Those in the York River valley occur as bands in marble, but those in the Carlow corundum range appear to be engulfed and replaced by pink and buff leucosyenites.

The following four locations were described in a previous report[1] by the author.

Concessions VI and VII, Lots 4 and 5

Three outcrop areas of nepheline-plagioclase gneiss were examined on the east side of the York River on lots 4 and 5, concessions VI and VII, Carlow township. Nepheline-plagioclase gneiss occurs interbanded with nepheline-poor plagioclase gneiss, pink leuco-syenite, and syenite pegmatite. Stringers of nepheline pegmatite cut the nepheline gneisses. The nepheline-plagioclase rock is a medium-grained gneiss consisting of up to 50 percent nepheline, plus plagioclase and accessory magnetite, muscovite, and biotite. The gneissosity is not well developed. The rocks strike north and dip steeply east.

Concession X, Lots 12 and 13

On the north bank of the York River there is an outcrop of nepheline gneiss consisting of an interlocking aggregate of nepheline and albite, with some hornblende, biotite, and magnetite. The gneiss strikes N.50°E. and dips 30°E. On the south side of the river there is a long band of nepheline-plagioclase gneiss exposed across lots 12 and 13, the main rock types present in the band are nepheline-plagioclase gneiss averaging 20 percent nepheline, 75 percent plagioclase, and 5 percent biotite and magnetite; and nepheline-poor alkaline gneiss consisting of over 90 percent plagioclase. The rock is very similar to the Bresnahan Lake nepheline gneiss of Monteagle township.

Concession X, Lot 23

A small area of outcrop of melanocratic nepheline-pyroxene gneiss occurs on lot 23, concession X, Carlow township, 250 feet northeast of the York River, and 600 feet south of the wagon road shown on the map. The rock is composed predominantly of nepheline and pyroxene; the nepheline content ranges from 30 to 40 percent. The structure of the rock is slightly gneissic, but the nepheline rock is quite uniform in composition throughout the exposures.

Concession X, Lot 26

On the north bank of the York River at Dan Prentice's cabins on lot 26, concession X, Carlow township, there is a small outcrop of nepheline gneiss and crystalline limestone. Nepheline-scapolite-garnet-hornblende gneiss occurs interbanded with crystalline limestone and paragneiss. All these rocks appear to have been contorted and sheared.

[1] D. F. Hewitt, *op. cit.*, p. 62.

Concession XIV, Lot 18 (Logan Corundum Cuts)

The easternmost of three corundum workings at Logan cuts, lot 18, concession XIV, Carlow township, has an exposure of nepheline gneiss. It has been described in a previous report.[1]

The eastern cut is 200 feet long, 25 feet wide, and 12–15 feet deep. The rocks exposed are pink and buff syenite gneiss, enclosing a band of leucocratic nepheline-corundum-plagioclase gneiss 5–10 feet wide. The pinkish nepheline and grey plagioclase are aligned in rude nepheline-rich and nepheline-poor bands. Muscovite and large bronze corundum crystals, up to 6 inches in size, occur in the nepheline rock. The corundum crystals are usually oriented with long axes parallel to the foliation. The nepheline rick has been intruded and replaced by pink syenite. The fresh nepheline rock grades into a zone in which nepheline has been altered to pink hydronephelite; this zone in turn grades into a hybrid buff gieseckite syenite that is rich in corundum, muscovite, and biotite. This gieseckite zone grades into mottled pink and buff syenite with some corundum. Corundum occurs in the nepheline zone and in the hybrid alteration zones, giving a total width of corundum rock of about 12 feet. The amount of corundum is variable and may average 10 percent.

Concession XVI, Lots 7 and 8[2]

A quarter of a mile north of Hoover Lake, on lots 7 and 8, concession XVI, there is an outcrop area of interbanded grey and buff corundum syenite gneisses, cut and replaced by pink leucosyenite. The gneisses strike north-south and dip flatly to the east. At one place there is a narrow lense of nepheline-albite-corundum syenite, 2 feet wide and 15 feet long, enclosed in grey corundum syenite. The corundum-bearing bands range from 1 to 5 feet in thickness and are overlain to the east by barren pink hornblende syenite gneiss and amphibolite.

Concession XVI, Lot 28[3]

A narrow nepheline-biotite-scapolite gneiss band, 6 feet wide, occurs on a low bluff on the east shore of a small pond on lot 28, concession XVI, Carlow township. The band strikes north, dips flatly to the east, and can be traced for a length of 400 feet. The nepheline gneiss is interbanded with crystalline limestone and paragneiss. The nepheline content ranges from 0 to 50 percent and averages about 5 percent. The occurrence is of no commercial interest.

D. Brudenell-Raglan Deposits[4]

The nepheline rocks exposed in the Brudenell-Raglan area form the east end of the main Haliburton-Bancroft nepheline syenite belt described by Adams and Barlow.[5] Nepheline-bearing gneisses occur in two belts in the area. The larger and more continuous of these is the Wolfe nepheline belt, a narrow band of nepheline and alkaline gneisses, 200–1,000 feet wide, extending for a distance of over 4 miles in northeast Lyndoch township, from lot 14, concession XIV, eastward to lot 3, concession XII.

Six other small nepheline syenite occurrences are found in the Raglan-Brudenell corundum range, a belt of pink syenitic corundum-bearing gneisses extending eastward from Craigmont, through Jewellville and Rosenthal, to Rockingham and Brudenell.

The nepheline-bearing rocks are strongly gneissic and varied in mineralogy, both across and along their strike. Structurally, the nepheline gneiss bands are conformable with the marbles, paragneisses, para-amphibolites, and syenitic gneisses with which they are found. In this area, nepheline gneisses are not found cutting any other rock types. They are cut by nepheline pegmatites, some of which are the xenoblastic patch replacement type. The nepheline gneisses are intruded and replaced by white alkaline syenite, yellow-brown hornblende syenite and granite, pink syenite and granite gneiss, and granite pegmatite.

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[1] D. F. Hewitt, *op. cit.*, pp. 33, 34.
[2] *Ibid.*, p. 36.
[3] *Ibid.*, p. 62.
[4] D. F. Hewitt, *Geology of the Brudenell-Raglan Area*, Ont. Dept. Mines, Vol. LXII, 1953, pt. 5; and accompanying Map No. 1953-2.
[5] F. D. Adams and A. E. Barlow, *Geology of the Haliburton and Bancroft Areas, Province of Ontario*, Geol. Surv. Can., Memoir No. 6, 1910.

Just as the older sediments and basic intrusives in the area have been subjected to strong regional dynamothermal metamorphism, which has markedly changed their textures and structures, so too the nepheline rocks have been subjected to the same metamorphism during the orogenic period that affected most of the rocks of the area, i.e. the Grenville orogeny. These rocks are now tectonites with metamorphic texture and structure. They have the structure of a metamorphic gneiss, with its extremely varied banding. This banding may be due in part to original compositional differences or layering in the intrusive, or to metasomatic replacement of variable sediments, or more probably, it is due to metamorphic differentiation.

Textures range from the allotriomorphic and hypidiomorphic granitoid textures of little altered intrusives to the equigranular granoblastic mosaic of the metamorphic gneiss. Occasionally these are poikiloblastic or porphyroblastic. The dark-green amphibole (hastingsite), aegirine, nepheline, scapolite, oligoclase, and garnet minerals, common to the nepheline gneisses of the area, are stable under the high grade of metamorphism to which these rocks have been subjected. These rocks belong to the amphibolite-granulite metamorphic facies characteristic of this part of the Grenville province.

Features of particular interest in the Brudenell-Raglan area are: (1) the excellent evidence of replacement and destruction of the nepheline rock by pink and buff syenite at the Klondike corundum cut, Craigmont, Raglan township, and at the Gutz farm, lot 34, concession V, Brudenell township; (2) the blue scapolite-nepheline gneiss of the Reid Lake area, Brudenell township; (3) the scapolite-nepheline and garnet-scapolite plagioclase facies of the Wolfe nepheline belt in Lyndoch township.

The locations of the nepheline syenite deposits described here are shown on the geological map of the Brudenell-Raglan area (Map No. 1953-2). The following descriptions, somewhat revised and reorganized, are from the Brudenell-Raglan report.[1]

KLONDIKE NEPHELINE SYENITE

Craigmont Corundum Mine, Lot 2, Concession XIX, Raglan Township
Craigmont Mine Adit, Lot 3, Concession XVIII, Raglan Township
(See Map No. 1953-2)

Nepheline-rich gneisses are exposed at the Klondike corundum cuts, in lot 2, concession XIX, on the west side of Robillard Mountain, and in the adit at the Craigmont workings, in lot 3, concession XVIII, Raglan township.

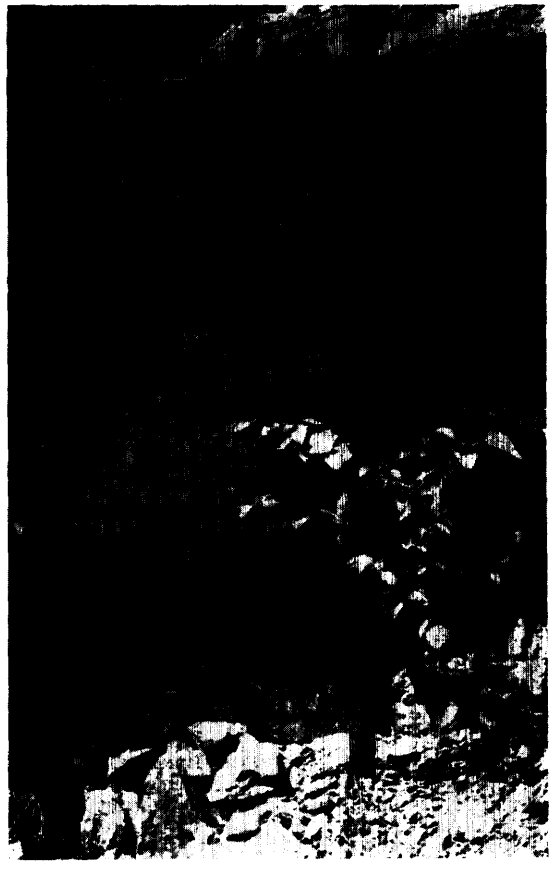
The nepheline rocks at these localities are composed chiefly of nepheline, with some oligoclase, magnetite, corundum, and muscovite; the mafic minerals are often less than 1 percent. Orientation of lineal streaks of white plagioclase and muscovite, together with elongate barrel-shaped corundum crystals, give the rock a foliated appearance.

The richest nepheline rocks in the area are those exposed in the Klondike cuts. There are large relict patches of nepheline rock, exposed in the walls of the cuts, consisting of about 80 percent nepheline, 15 percent plagioclase, and 5 percent corundum. The largest patches of nepheline-corundum and nepheline-plagioclase-corundum rock are 15–20 feet thick and nearly 100 feet long. They are replaced along strike by pink and grey leucosyenite.

[1]D. F. Hewitt, *op. cit.*, pp. 19–25, 77–83, 90, 94–101.

Adams and Barlow[1] described two new rock types, "Craigmontite" and "Raglanite," from the Klondike cuts as follows:

The nepheline syenite is composed chiefly of a salmon pink to flesh red nepheline, which is generally the most abundant constituent, a light grey almost white plagioclase (oligoclase), and very occasional scale and flakes of biotite. The nepheline where exposed shows the characteristic weathering, occurring in irregular sunken areas, with all the inequalities rounded off, leaving the white plagioclase in well marked angular relief. The corundum occurs in sharp, characteristic, often barrel-shaped hexagonal crystals, the longer axis of the abundantly distributed crystals lying at right angles to the foliation.



WEST WALL OF KLONDIKE CUT NO. 6

The photo shows a portion of the west wall in the central part of cut No. 6, the main upper cut of the west Klondike workings. This is a typical sequence of interbanded nepheline-corundum gneiss, pink and grey hybrid gieseckite-corundum syenite gneiss, and pink leucosyenite (gneiss).

In the lower portion of the photo there is a wide zone of banded, medium-grained, hybrid pink and grey gieseckite-corundum syenite gneiss (1). Corundum, mantled with muscovite, is common in this facies.

A narrow zone of massive, medium-grained, pink leucosyenite (2) replaces the gneissic sequence.

Between the pink syenite zone and the overlying zone of grey-white leucocratic nepheline-corundum gneiss (4), there is a series of interbanded nepheline-biotite (corundum) gneiss and pink leucosyenite gneiss (3).

This photo shows the extremely complex character of the interbanded alkaline syenite facies in this cut.

[1]F. D. Adams and A. E. Barlow, *op. cit.*, pp. 311–15.

The author, however, did not observe this to be the case. Many corundum crystals lie in the plane of foliation.

Two specimens, each containing corundum, were selected for examination, representing approximately the extreme phases of this rock. The thin sections show a rock made up of nepheline, oligoclase, muscovite, calcite, biotite, magnetite, and corundum. Some of the nepheline is comparatively fresh, but most of it has undergone more or less decomposition, the resultant products consisting of a brilliant polarizing aggregate of minute scales, chiefly of muscovite, developed along certain irregular lines and cracks. The plagioclase is likewise somewhat turbid from incipient alteration. Only occasional very small scales of biotite were noticed, and still more rarely small grains of magnetite. The corundum in the thin sections consists of irregular-shaped, apparently corroded individuals, embedded in plates and scales of muscovite.

Chemical and modal analyses of "Craigmontite" as given by Adams and Barlow are as follows:

Chemical Analysis		Mode	
SiO_2	48.38	Nepheline	63.18
TiO_2	trace	Oligoclase	29.66
Al_2O_3	30.54	Muscovite	4.39
Fe_2O_3	0.40	Calcite	1.42
FeO	0.06	Corundum	0.50
MnO	trace	Biotite	0.50
CuO	trace	Magnetite	0.10
CaO	1.87		99.75
MgO	0.19		
K_2O	3.70		
Na_2O	13.94		
P_2O_5	trace		
CO_2	0.62		
H_2O	0.50		
	100.20		

The chemical analysis and norm of "Raglanite" as given by Adams and Barlow are as follows:

Chemical Analysis		Norm	
Corundum	4.45	Orthoclase	9.45
SiO_2	55.45	Albite	56.59
TiO_2	0.30	Anorthite	12.51
Al_2O_3	21.65	Nepheline	11.93
Fe_2O_3	0.81	Corundum	4.45
FeO	0.49	Calcite	1.98
MnO	0.01	Magnetite	0.70
CaO	3.65	Ilmenite	0.61
MgO	0.13	Hematite	0.30
K_2O	1.62	Forsterite	0.21
Na_2O	9.31	Water	1.64
P_2O_5	0.01		100.37
CO_2	0.88		
H_2O	1.64		
	100.40		

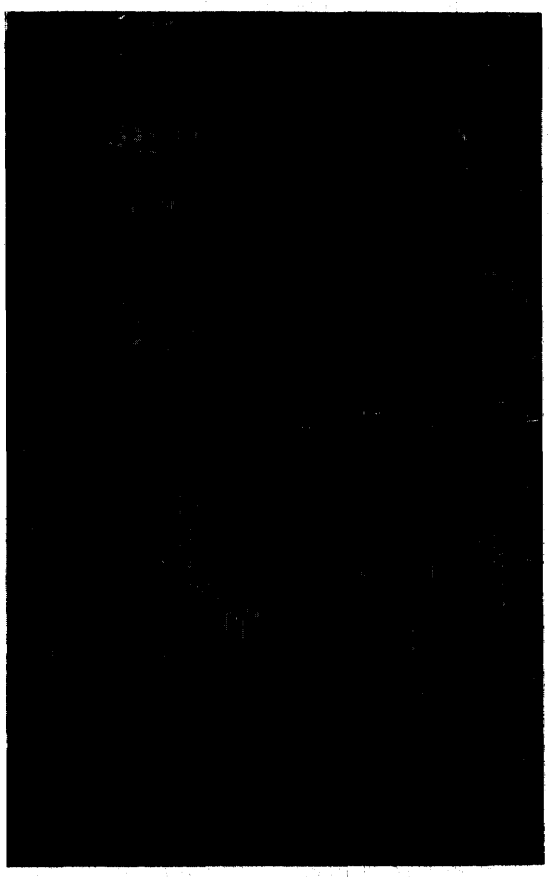
Adams and Barlow state that:

The mode or actual mineralogical composition of the rock is somewhat different from the norm—the difference being represented chiefly in the grouping of the feldspar molecules, and in the modal presence of micas. The rock is actually composed of oligoclase, nepheline, corundum (4.45 per cent), with small amounts of muscovite, biotite, calcite, magnetite, and apatite.

Destruction of the Nepheline Rocks by Potash Metasomatism

The relations between the pink syenite and the nepheline gneiss are well shown in the eastern Klondike cuts. Here a sequence of pink, buff, and nepheline syenite is exposed on the east wall of the cut. At the foot of the section, pink fine-grained microcline leucosyenite forms a band underlying a band of white nephe-

line-albite corundum gneiss. At the contact between the two, the pink syenite has altered the nepheline rock to a pink-buff "gieseckite" syenite gneiss. Microcline and microline perthite have been added, and the white nepheline altered to a dark-green, micaceous aggregate termed "gieseckite" in the field.[1] This zone



KLONDIKE CUT NO. 1

The photo shows a section of the east wall of the east Klondike cut (No. 1) at the extreme south end. The relations between the nepheline gneiss, the late pink leucosyenite, and the associated hybrid facies are shown clearly.

At the foot of the section, pink medium- to fine-grained leucosyenite (1) is in contact with the footwall of the nepheline-albite gneiss band. At the contact there is a 6- to 12-inch zone of pink gieseckite syenite and a 12- to 36-inch band of pink hydronephelite syenite.

Above this is a 9-foot zone of rather massive white to brownish nepheline-rich albite-corundum gneiss (2) showing a linear arrangement of albite and corundum. A little magnetite and muscovite are also present.

At the upper, or hanging-wall, contact of the nepheline gneiss (3), fingers of red leucosyenite intrude the rock from above and there is a pronounced development of pink hydronephelite.

Between the nepheline gneiss and the pink and buff syenite (6), there is a 3-foot zone of hybrid buff, pink, and greenish gieseckite-corundum syenite gneiss (4). Green gieseckite schist is strongly developed along flat shears in the section (5).

At the top of the section (6) there is a thick zone of pink, fine-grained, sugary leucosyenite mottled with buff and yellow-brown phases. The pink facies appears to replace the buff to yellow-brown syenite, which contains magnetite aligned to give the rock a distinct foliated appearance.

[1]The terms "gieseckite" and "hydronephelite" are used here to describe the green and pink alteration products of nepheline. Under the microscope these alteration products are seen to consist of fine-grained micaceous aggregates; the terms "gieseckite" and "hydronephelite" are not strictly correct mineralogically but serve as useful descriptive field terms.

is 6–12 inches wide. This is followed by 12–36 inches of nepheline gneiss in which the nepheline is altered to pink hydronephelite. Above this alteration zone is the fresh, relatively unaltered nepheline-albite gneiss in which nepheline makes up approximately 80 percent of the rock. The corundum and white albite in this gneiss are aligned parallel to the contact and general foliation of the gneiss complex. Some muscovite mantles the corundum crystals. In addition, there is less than 1 percent magnetite. This nepheline-rich zone is 9 feet wide and, as the upper contact is approached, the nepheline gneiss is invaded by fingers of pink syenite from the pink syenite band lying above it. As the pink syenite band and its offshoots and fingers are approached, the nepheline band again shows the typical pink hydronephelite alteration. At the contact of the pink syenite and nepheline gneiss there is a zone of 3–4 feet of pink and green hybrid gieseckite syenite gneiss containing corundum. Along its strike, the nepheline-rich band

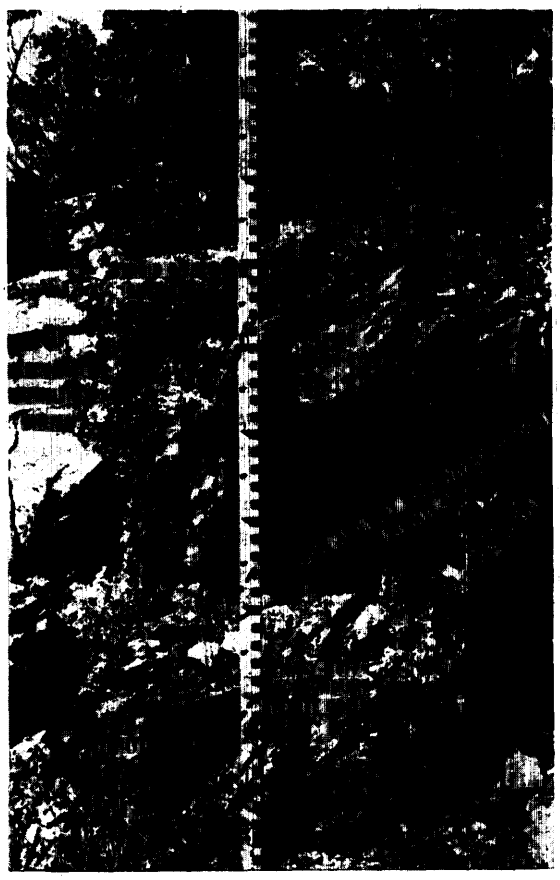


RELICT PATCHES OF NEPHELINE-ALBITE GNEISS IN PINK AND BUFF SYENITE

This shows the west wall of the lower part of cut No. 6, the main upper cut of the West Klondike workings. Leucocratic blue-grey to white nepheline-rich albite gneiss (1) consisting of over 80 percent nepheline, makes up the upper part of the section. The lower part of the section consists of pink and buff leucosyenite. Relict patches of unreplaced leucocratic nepheline gneiss up to 2 feet long, surrounded by irregular 2- to 4-inch rims of snow-white albite, occur in buff leucosyenite. The buff syenite in turn is replaced by pink syenite. Some gieseckite-rich zones occur in the hybrid buff zones near the nepheline gneiss.

A prominent feature of this section is the relict patches of unreplaced nepheline rock in the pink and buff mottled leucosyenite.

can be traced into hybrid gieseckite syenite gneiss, buff corundum-muscovite syenite gneiss, and pink leucosyenite in that sequence, with the complete change within 20 feet. The nepheline bands have no continuity and appear to be remnants and relict patches of a once much more extensive zone of nepheline gneisses.



FAULTING AT THE KLONDIKE WORKINGS

The photo shows part of the west face at the top of cut No. 6, the main upper cut, at the west Klondike workings; it shows the relations between pink leucosyenite, nepheline-rich gneiss, and the hybrid corundum gieseckite syenite gneiss.

At the left-hand side of the photograph is nepheline-rich, grey-white, medium- to coarse-grained leucocratic gneiss (1) containing less than one percent mafics. A little muscovite and lineal streaks of albite give the rock a foliated appearance. Little corundum occurs at this exposure.

The nepheline rock passes on strike into a 12- to 15-inch irregular zone of buff to grey, mottled muscovite-gieseckite hybrid gneiss (2), which lies between the nepheline gneiss and pink syenite.

In the central, lower, and upper right-hand part of the photo there is pink to red, mottled, *medium-grained, sugary, leucosyenite (3). Some biotite and patches of green gieseckite alteration* occur in the pink and buff, mottled syenite. The pink syenite grades into pink and grey-buff muscovite-corundum syenite gneiss. Near the 2-foot mark on the stadia rod, a patch of grey corundum-biotite syenite gneiss is cut by red leucosyenite. The contacts are sharply defined.

At (4) there is a sharp contact between intruding red leucosyenite and grey-buff corundum-biotite syenite gneiss.

White nepheline gneiss also outcrops just to the right of the photo.

Fractures and shears cut the outcrop as shown in the photo.

The main feature to be seen in this exposure is the gradation from early nepheline-albite gneiss, through a hybrid alteration zone of grey-buff, muscovite-biotite-corundum-gieseckite syenite gneiss, into relatively massive red and pink leucosyenite. A massive, equigranular, pink leucosyenite of igneous appearance replaces the gneissic alkaline syenite with the destruction of the gneissic fabric of the rock. The change appears to be accomplished without disturbance, discordance, or forceful intrusion of any kind by a process of replacement without significant change of volume in the rock.

The nepheline rocks exposed in the western Klondike cuts are extremely rich in nepheline and usually carry some corundum. These nepheline rocks occur as relict patches in the pink and grey syenite gneiss complex at Craigmont. They are intruded and replaced by pink, grey and buff leucosyenites. This replacement of nepheline gneiss by pink leucosyenite is illustrated in the accompanying photos of the west wall of cut No. 6 at the west Klondike workings.

This destruction of the nepheline gneisses by a process of potash metasomatism produces a pink syenite by a gradual process, which involves two steps: (1) hydration and silication first destroying the nepheline and then producing albite; (2) introduction of potash to form potash feldspar, usually in the form of microcline and microcline microperthite. The resulting rock is a pink or buff syenite.

This metasomatic alteration is well shown along the west wall of cut No. 6 at the Klondike workings. The accompanying photo shows this replacement of nepheline gneiss by pink syenite. Three samples were taken over a width of 6 feet to illustrate this change. The sample locations are shown in the photo. Sample KC-2 is a nepheline-rich albite gneiss; KC-1 is a pink microcline syenite; KC-3 is the intermediate hybrid facies. Chemical analyses of these three samples are given in the accompanying table.

POTASH METASOMATISM OF NEPHELINE ROCKS

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1952)

	From Klondike Workings		
	Sample KC-2	Sample KC-3	Sample KC-1
SiO_2	45.90	62.22	64.37
Al_2O_3	29.79	19.78	19.41
Fe_2O_3	1.82	1.07	1.10
FeO	1.44	0.68	0.80
MgO	0.71	0.60	0.06
CaO	3.16	1.50	0.31
Na_2O	8.26	7.52	5.73
K_2O	3.26	4.66	6.77
H_2O+	3.50	0.67	0.30
H_2O-	0.28	0.05	0.10
CO_2	1.62	1.07	0.11
TiO_2	0.07	0.08	0.15
P_2O_5	trace	0.00	trace
Cr_2O_3	<0.01	<0.01	<0.01
MnO	0.04	0.02	0.01
NiO	.....	.....	trace
V_2O_5	0.01	0.01	0.02
Total	99.86	99.93	99.24

The main chemical and mineralogical features of the alteration are an increase in silica, a decrease in alumina, and a decrease in soda (representing the replacement of nepheline by feldspar), and an increase in potash (representing the formation of potash feldspar). In some cases the excess alumina goes to form corundum.

At Craigmont there are no nepheline rocks exposed in the surface workings, but one band of leucocratic nepheline-rich corundum gneiss is exposed in the adit. The origin of the corundum-bearing rocks at Craigmont has been discussed in a recent paper by Carlson.[1]



REPLACEMENT OF NEPHELINE GNEISS BY PINK LEUCOSYENITE

The photo shows a section on the west wall of cut No. 6, the main upper cut at the west Klondike workings. Here the intrusive character of the pink leucosyenite into the nepheline-albite-corundum gneiss is particularly well shown. The tongue of pink leucosyenite (1) appears to intrude the nepheline-albite-corundum gneiss (3). Grey and buff corundum syenite gneiss (2) are apparently intermediate or hybrid facies. The stages of alteration appear to be: (a) the appearance of corundum, gieseckite, and muscovite; (b) an increase in buff coloration in the rock and the development of abundant biotite and muscovite; (c) more buff coloration, some pink coloration probably due to introduction of microcline perthite, and a less gneissic structure in the rock; (d) alteration of the rock to a mottled, pink and buff syenite gneiss; the mottling still gives the rock a foliated appearance; (e) complete alteration to a massive, pink leucosyenite. There is a distinct segregation of biotite into mafic bands in the buff and grey hybrid gneisses, and a granoblastic flaser structure is apparent. Samples KC-1, KC-2, and KC-3 were taken from this section for chemical analysis to show the transition from KC-1, pink leucosyenite to KC-2, nepheline-albite-corundum gneiss.

[1]H. D. Carlson, "Origin of the Corundum Deposits of Renfrew County, Ontario," *Bulletin*, Geol. Soc. Amer., Vol. 68, 1957, No. 12, pt. 1, pp. 1605–36.

WASMUND NEPHELINE SYENITE

Lots 12 to 14, Concession XV, Raglan Township
(See Map No. 1953-2)

The Wasmund nepheline syenite is exposed irregularly in a band, ¼ mile wide and ½ mile long, striking in an east-west direction along the crest of a ridge east of the Wasmund farmhouse, in lots 12–14, concession XV, Raglan township. The nepheline rock is a white nepheline-plagioclase gneiss, which is interbanded with white and pink alkaline syenite and amphibolite. The nepheline content ranges from 0 to about 50 percent, but the average nepheline content is estimated to be low. Interbanded with the nepheline-plagioclase gneiss, the following other facies are found: nepheline-biotite-plagioclase gneiss; nepheline-hornblende gneiss with no feldspar; nepheline-hornblende-garnet gneiss with no



KLONDIKE CUT NO. 3

The photo is taken at cut No. 3, at the foot of the main western Klondike cuts, looking north up the hill. This section is one of the best places to see typical, pink and buff, mottled leucosyenite. Here, as shown on the right-hand side of the photo, there are good exposures of medium-grained equigranular pink leucosyenite with small, 2- to 10-inch, blotches of buff leucosyenite scattered throughout the outcrop in gneissic alignment. Bronze corundum occurs in many of the buff patches. The relations suggest that the pink leucosyenite is replacing the buff syenite. In the upper left-hand part of the photograph, leucocratic nepheline-rich albite gneiss outcrops on the hillside. This band is continuous down to the foot of the cut, as shown. Between this nepheline gneiss and the pink mottled leucosyenite, there is a narrow zone of hybrid gieseckite syenite gneiss, with corundum.

feldspar; and plagioclase-scapolite-garnet-titanite gneiss. Small patches of nepheline pegmatite of the xenoblastic patch replacement type, up to 8 inches across, were noted.

The strike of the gneisses is varied with some minor folding, but in general is east-west; dips are 20°–60°S. The footwall of the nepheline gneiss band is marble, while the hanging wall is pink syenite gneiss, paragneiss, and marble.

To the west of the Wasmund farmhouse, a second ridge extends westward across lot 10 towards the Conroy marsh. This ridge consists mostly of pink syenite gneiss and amphibolite. However, along the crest of the ridge a band of garnet-scapolite-pyroxene rock, up to 200 feet wide, is exposed. This rock consists of orange-brown, fine-grained, granular garnet, white scapolite, bright

green diopside, and titanite. In places, the garnet makes up 60–80 percent of the rock. Some alkaline hornblende may also be present. These garnet-pyroxene-scapolite skarns are sometimes associated with the nepheline rocks, and this occurrence is probably related in age and origin to the Wasmund nepheline syenite.

JEWELLVILLE NEPHELINE SYENITE

Lots 25 and 26, Concession XIX, Raglan Township
(See Map No. 1953-2)

A range of hills, predominantly pink hornblende syenite gneiss, rises on the east side of the Madawaska River valley at the Palmer Rapids bridge and extends northeastward towards the highland peneplane in the vicinity of Rosenthal. The gneisses strike northeast and dip 30°–70°SE. These ridges are composed of pink leucosyenite gneiss, pink hornblende syenite gneiss, hybrid syenite gneiss, and amphibolite, with some narrow bands of pink corundum syenite gneiss, pink corundum pegmatite, and a few narrow relict bands of grey nepheline-plagioclase-corundum gneiss.

On the first ridge, ¼ mile northeast of the river, in lot 25, concession XIX, nepheline-albite-corundum gneiss occurs with pink and grey corundum-muscovite syenite gneiss in a band 100 feet wide. The discontinuous bands and lenses of nepheline-bearing rock rarely exceed 3 feet in width; the nepheline-bearing zone is exposed in shallow pits and strippings and can be traced for 300–400 feet along strike.

A second occurrence of narrow bands of nepheline-albite-corundum gneiss was observed on the crest of a ridge in lot 26, concession XIX, Raglan township, about ½ mile northeast of the Madawaska River. Here the narrow bands of nepheline-albite gneiss contain corundum, muscovite, and occasional biotite. They are surrounded and enveloped by younger pink and grey syenite gneiss.

ROSENTHAL NEPHELINE SYENITE (GUTZ FARM)

Lot 34, Concession V, Brudenell Township
(See Map No. 1953-2)

On the farm of Richard Gutz, lot 34, concession V, Brudenell township, there is a 15-foot-wide band of nepheline-muscovite-albite-biotite gneiss exposed for a length of 150 feet just south of the farmhouse. The nepheline syenite gneiss is intruded and replaced along strike by pink corundum leucosyenite; the transition from nepheline-albite gneiss, through white alkaline gneiss, in which the nepheline is completely altered, to pink corundum syenite gneiss can be well seen on the outcrop.

One hundred feet to the southeast there is an outcrop of nepheline-albite-corundum pegmatite with long, tapered crystals of grey corundum.

The nepheline band strikes north-south and dips 20°E. One-quarter mile to the north, on the north half of this same lot, a band of nepheline-albite gneiss again is exposed, interbanded with pink leucosyenite gneiss and pink corundum-muscovite syenite gneiss. This band strikes N.40°W. and dips 20°SW. It may represent the northeast arm of a flatly south-pitching syncline. The nepheline band south of the Gutz farmhouse would form the northwest arm of this syncline.

The nepheline content of these bands is varied and rarely exceeds 20–25 percent; the bands are narrow and discontinuous, being replaced along strike by pink syenite; they are, therefore, of no commercial interest as a source of nepheline.

A second set of three samples was taken for chemical analyses, to show the character of the alteration of nepheline syenite to pink syenite here in a well-exposed band on the Gutz farm. The exposure sampled is shown in the accompanying photo.

Potash Metasomatism of Nepheline Rocks

The samples are taken along strike, over a length of 20 feet, and represent: (1) nepheline-rich gneiss (GU-4); (2) an altered nepheline gneiss in which the nepheline has been hydrated to form a fibrous zeolite alteration matte (GU-2); and (3) an albite syenite produced by alteration of GU-2 with the disappearance of the hydrated zeolitic phase and further silication (GU-1). As will be noted in the following analyses, this first stage of alteration consists of silication with a noticeable increase in SiO_2, hydration, and an increase in lime when the zeolitic aggregate is formed, followed by dehydration and a decrease in lime when the altered nepheline is replaced by sodic feldspar.

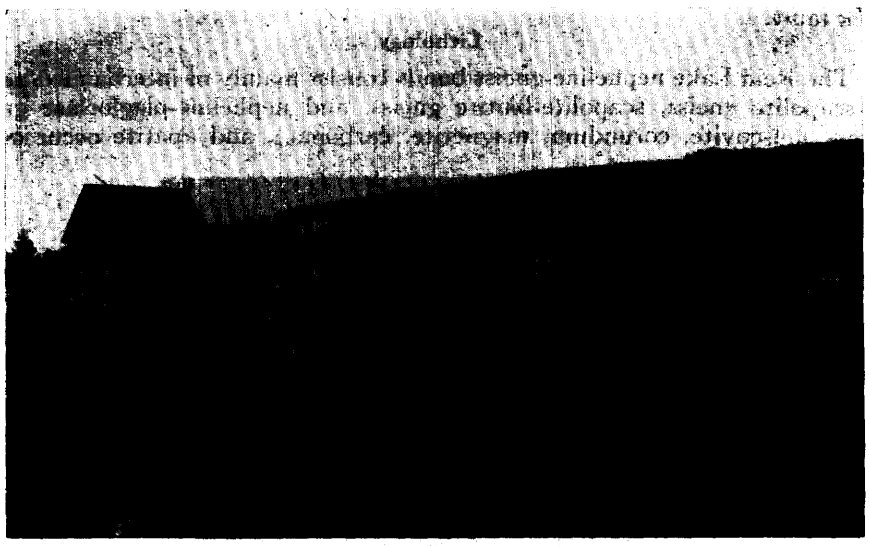
POTASH METASOMATISM OF NEPHELINE ROCKS
(Analyses by Provincial Assay Office, Ontario Department of Mines, 1952)

	From the Gutz Farm		
	Sample GU-4	Sample GU-2	Sample GU-1
SiO_2	52.29	54.18	57.00
Al_2O_3	25.67	24.21	24.91
Fe_2O_3	2.35	3.59	3.47
FeO	1.87	2.00	1.26
MgO	trace	trace	trace
CaO	1.28	2.65	0.50
Na_2O	11.26	7.97	7.90
K_2O	3.49	3.57	3.00
H_2O+	0.74	1.83	1.12
H_2O-	0.09	0.22	0.09
CO_2	0.69	0.52	0.00
TiO_2	0.21	0.13	0.14
P_2O_5	trace	trace	trace
Cr_2O_3	<0.01	<0.01	<0.01
MnO	0.03	0.03	0.02
NiO	.....	.....	.....
V_2O_5	<0.01	<0.01	<0.01
Total	99.97	100.91	99.41

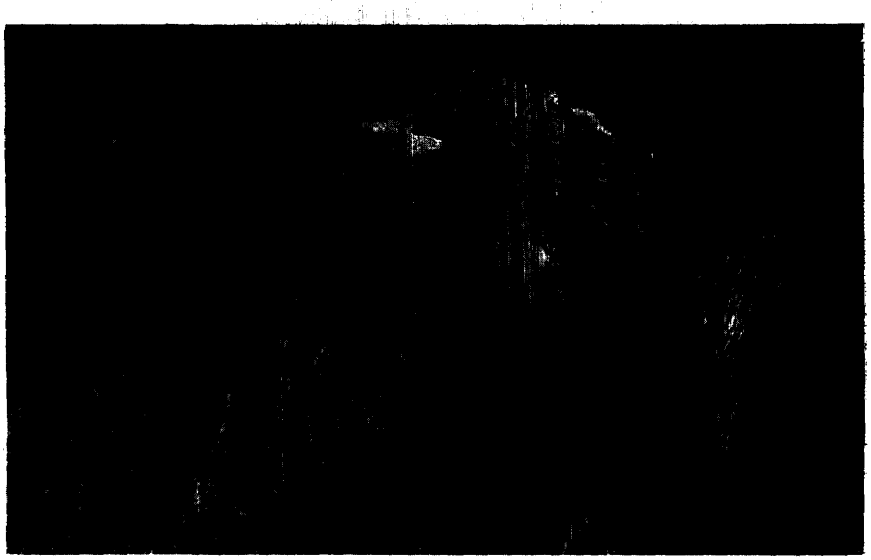
REID LAKE NEPHELINE SYENITE

Lot 34, Concession VII, Brudenell Township; Lot 32, Concession V, Radcliffe Township
(See Map No. 1953-2)

Two miles north of Rosenthal postoffice, nepheline gneisses again are exposed in lot 34, concession VII, Brudenell township, and in lot 32, concession V, Radcliffe township, to the north and south of Reid (Rockingham) Lake. South of Reid Lake the nepheline gneisses form two north-south-striking, east-dipping, bands from 100 to 200 feet wide, separated by a band of pink syenite gneiss. Tracing these bands to the south they are syenitized and pass into pink syenite gneiss. To the north these two bands are exposed up to the shore of Reid Lake. The east band is sharply dragfolded near the shore of Reid Lake. On the northwest side of the lake the nepheline gneiss is exposed as a single band, which may be the more western of the two bands, or may represent the merging of the two



An exposure of gneiss on the farm of Richard Gutz, Rosenthal, from which samples GU-1, GU-2, and GU-4 were taken for chemical analysis.



Reid Lake nepheline-scapolite gneiss showing the differential weathering of alternate scapolite gneiss and syenite gneiss bands.

bands. This nepheline band strikes north-south and dips steeply east. It is apparently cut off by the Reid Lake fault and displaced 1,000 feet to the northwest, where it is again exposed for a short distance before it is cut off by the Rockingham Creek fault.

Lithology

The Reid Lake nepheline-gneiss bands consist mainly of interbanded nepheline-scapolite gneiss, scapolite-biotite gneiss, and nepheline-plagioclase gneiss. Zircon, muscovite, corundum, magnetite, carbonate, and apatite occur as accessories. A little microcline is present in bands adjacent to pink microcline leucosyenite. These medium-grained, equigranular, foliated rocks are of particular interest because of the predominance of scapolite gneiss and nepheline-scapolite gneiss. The scapolite, on a fresh surface, has a greasy, yellowish grey colour. After the freshly broken surface has been exposed to sunlight for a few days, the scapolite turns deep blue. On weathered surfaces, the scapolite ranges from grey to pale blue-grey in colour, and since it weathers very much like nepheline, it is often difficult to distinguish blue-grey scapolite from dove-grey nepheline. The differential weathering of the scapolite gneisses is well shown where the bands cross the Rosenthal-Rockingham road at Reid Lake. Here the alternate scapolite bands and syenitic bands weather differentially, giving the rock a ribbed appearance.



Corundum crystals standing up above nepheline and albite in the nepheline-plagioclase-corundum gneiss at Reid Lake.

Many of the scapolite-rich gneisses contain no plagioclase, and the scapolite may take the place of plagioclase. The nepheline-plagioclase gneisses generally have a hypidiomorphic interlocking, somewhat serrate, granitoid texture. The nepheline-scapolite gneisses generally have an equigranular, granoblastic, metamorphic texture and may represent a metamorphic facies, stable under high-grade metamorphism. Thin-section examinations show strong shearing in some of the scapolite of the scapolite-bearing gneisses. On outcrop surfaces the scapolite-rich bands may show fracture cleavage that is not apparent in adjacent syenitic bands.

In the more eastern of the two bands of nepheline-scapolite gneiss, there is a small occurrence of corundum about 100 feet north of the road. This occurrence of corundum was first noted by Miller.[1]

Corundum grains, intimately intergrown with magnetite, occur in masses ½–2 inches in diameter in a nepheline-plagioclase gneiss. The corundum-magnetite aggregates are mantled by nepheline. The corundum crystals make up 10 percent of a small outcrop of 6 by 10 feet. A small amount of corundum occurs in grey nepheline-albite gneiss on the road, 100 feet to the south of the outcrop described above. A third small occurrence was found south of the road, 300 feet west of the latter exposure.

OTHER BRUDENELL NEPHELINE SYENITE OCCURRENCES

(See Map No. 1953-2)

White alkaline plagioclase gneisses west of Gorman Lake, and west of Brudenell postoffice, in Brudenell township, contain corundum but no nepheline. They were considered to belong to the nepheline syenite group and were therefore mapped in yellow on map No. 1953-2, accompanying the Brudenell-Raglan report.

A small outcrop of nepheline syenite gneiss occurs on the Letterkenny road, in lot 26, concession V, Brudenell township, south of Beardwood Lake. The small 3-foot band of nepheline gneiss is interbanded with amphibolite, marble, and syenitic gneiss, on the west side of the road.

WOLFE NEPHELINE BELT

Lot 14, Concession XIV to Lot 1, Concession XII, Lyndoch Township
(See Map No. 1953-2)

The Wolfe nepheline belt forms a prominent ridge extending eastward from the Wesley Kargus farm, lot 14, concession XIV, through the Welk and Remus farms to Heiderman Lake, lot 5, concession XIII, Lyndoch township. In this 2½-mile section, the nepheline and associated alkaline hornblende gneisses form a well-defined band 300–1,000 feet wide, dipping 30°–70°S. East of Heiderman Lake, outcrops are scarce, but the band is believed to extend to the east boundary of the map area. From the few outcrops available in this section, it appears that the belt narrows in width to 50 feet or less at the east end.

Throughout the length of the belt the nepheline gneiss–syenite gneiss complex has a footwall of crystalline limestone and a hanging wall of interbedded limestone and paragneiss. A narrow bed of glassy, coarsely recrystallized quartzite lies between the nepheline gneiss and the crystalline limestone footwall on the Kargus, Welk, and Remus farms.

[1]Willet G. Miller, "Economic Geology of Eastern Ontario: Corundum and Other Minerals," *Annual Report*, Ont. Bur. Mines, Vol. VII, 1898, pt. 3, pp. 221, 222.

At the west end of the belt the foliation of the nepheline gneiss swings from east-west to north-south; dips are 30°–50°S. and E., respectively. The nepheline gneiss ridge terminates in a swamp. No nepheline gneiss outcrops west of lot 14, and the band either pinches out, as suggested by the convergence of the footwall and hanging-wall limestones, or is faulted off by a northwesterly strike fault, which may occupy the pronounced valley south of the nepheline belt. If the latter is the case, the swing in structure may be a drag on the fault.

Throughout the nepheline gneiss belt there is a pronounced, strong lineation trending about S.60°E. and pitching 20°–25°SE. It is possible that the nepheline band may occupy the north arm and trough of an eastward-pitching drag fold on the north arm of a major syncline.

Lithology

The nepheline gneisses consist of nepheline, plagioclase, microcline, and hastingsite as the major constituents, with biotite, magnetite, garnet, fluorite, vesuvianite, carbonate, titanite, apatite, and zircon present in minor amounts. In places, garnet makes up as much as 10 percent of the rock. Scapolite was present as an important constituent in 4 out of 15 thin sections examined, and in one case, makes up as much as 32 percent of the rock. Where scapolite is abundant, microcline is generally absent, and the percentage of plagioclase may be low. In 15 samples examined, nepheline ranged from 5 to 40 percent, plagioclase (from albite to andesine) from 0 to 58, microcline and microcline microperthite from 0 to 38, green amphibole from 0 to 48, and biotite from 0 to 10 percent.

Overlying, and occasionally interbanded with, the nepheline gneisses, are a series of garnet-hornblende-plagioclase-scapolite gneisses with poor foliation but pronounced lineation. In 10 samples examined, garnet ranged from 0 to 15, averaging about 10 percent, green amphibole ranged from 6 to 38, pyroxene from 0 to 40, scapolite from 3 to 65, and plagioclase from 0 to 63 percent. Microcline is absent in this rock. Plagioclase varies from oligoclase to andesine. Carbonate, titanite, apatite, and zircon are accessories. This coarse-grained hornblende-garnet-plagioclase gneiss appears to cut the nepheline gneiss and is in sharp contact with it in several places. It may be genetically related to the nepheline rocks and represent a slightly later phase of a composite intrusion.

Both these rocks are intruded by pink and white syenites and syenite gneisses and pegmatites.

Patches of nepheline pegmatite, consisting of large crystals of nepheline and albite, up to 4 feet in diameter, cut the nepheline gneisses at the west end of the Wolfe belt on the Wesley Kargus farm. Fluorite, apatite, biotite, and zircon occur as accessories in these pegmatites. Contacts of the pegmatite with the gneisses are graditional through a 1-foot transition zone.

A restudy of the Wolfe nepheline belt has recently been made by E. C. Appleyard.[1]

The three areas where the nepheline rocks of the Wolfe belt are best exposed are: (1) the Heiderman Lake ridge, lot 6, concession XIII; (2) the Welk-Remus ridge, lots 10–12, concession XIV; and (3) the Wesley Kargus ridge, lots 13 and 14, concession XIV.

[1]E. C. Appleyard, *A Metasomatic or Magmatic Origin for Nepheline-bearing Gneisses at Wolfe, Lyndoch Township, Ontario*, M.A. thesis, Queen's Univ., 1959.

Heiderman Lake Ridge, Lot 6, Concession XIII, Lyndoch Township (See Map No. 1953-2)

Just west of Heiderman Lake, in open fields in lot 6, concession XIII, Lyndoch township, a 500-foot band of nepheline-bearing gneisses is exposed in scattered outcrops over a length of ⅜ mile. The gneisses strike east-west and dip 40°–80°S. The gneisses in the Heiderman Lake section of the Wolfe nepheline belt are intimately interbanded, and all of the following lithological types are present: nepheline-plagioclase gneiss; nepheline-hornblende-plagioclase gneiss; nepheline-hornblende gneiss; nepheline-scapolite-hornblende gneiss; scapolite-hornblende gneiss; white alkaline syenite gneiss; pink alkaline syenite gneiss; pink and white syenite-pegmatite; yellow-brown biotite-scapolite syenite gneiss. Nepheline content is low and erratic, and the occurrence is of no commercial interest at present.

Welk-Remus Ridge, Lots 10–12, Concession XIV, Lyndoch Township (See Map No. 1953-2)

The accompanying map shows the general geology and structure of the rocks on an east-west-trending ridge, which crosses the Welk and Remus farms in lots 10, 11, and 12, concession XIV, Lyndoch township. The ridge has a length of ½ mile and for the most part is sheep pasture with good rock exposures. The rocks strike in a general east-west direction and dip 40°–70°S. As shown on the map, the nepheline-bearing gneisses occupy the north side of the ridge and form a distinct unit at the west end of the ridge, with an overlying unit of hornblende-garnet-plagioclase-scapolite gneiss to the south. To the east the nepheline gneisses are intruded by white alkaline, pink, and yellow-brown, syenite and syenite pegmatites; the nepheline content is low and erratic.

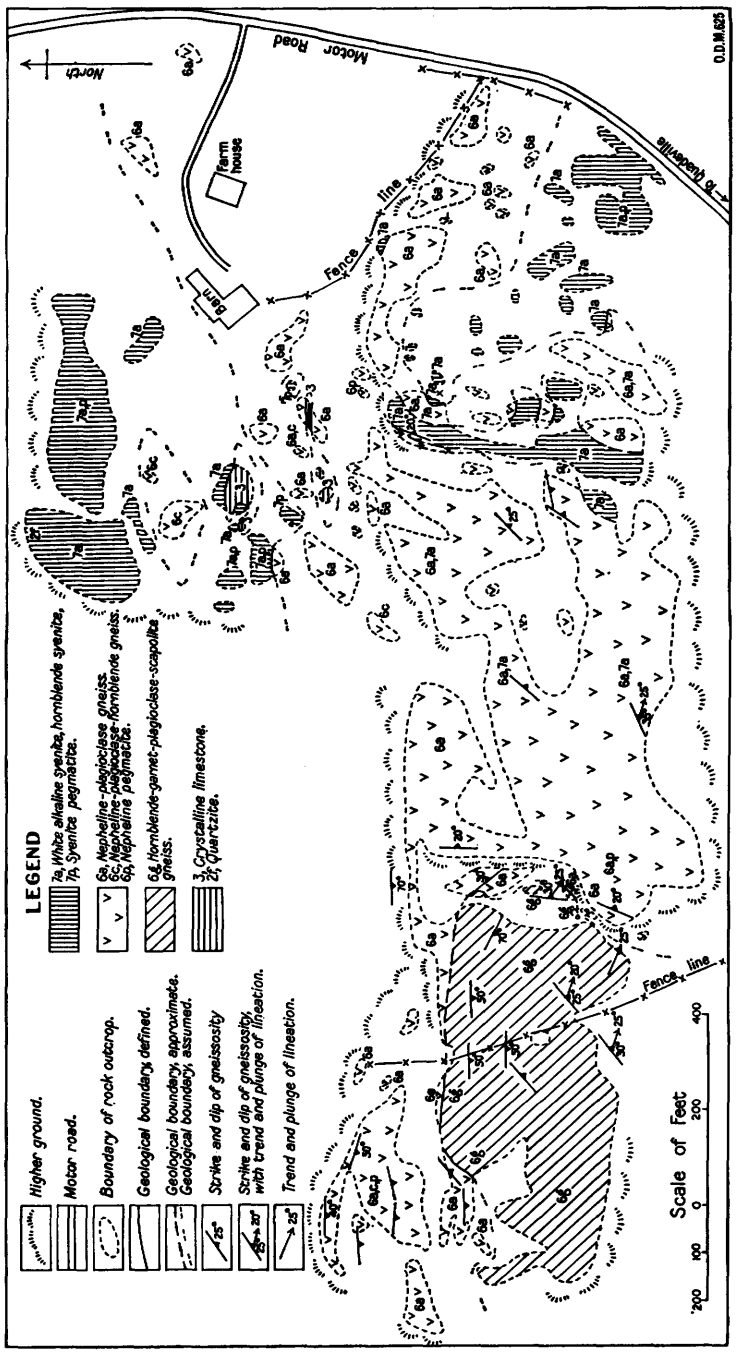
On the north or footwall side of the band, there is a narrow band of coarsely crystalline glassy quartzite again present. The hornblende-plagioclase-garnet-scapolite rock is coarse-grained and shows a very strong lineation trending southeast and pitching 20°–25°SW. A mafic hornblende-nepheline-garnet rock occurs in one or two small outcrops at the base of the ridge on the south side, near the fence line between lots 11 and 12.

The nepheline content of the gneisses exposed on this ridge is too low and erratic to be of commercial interest.

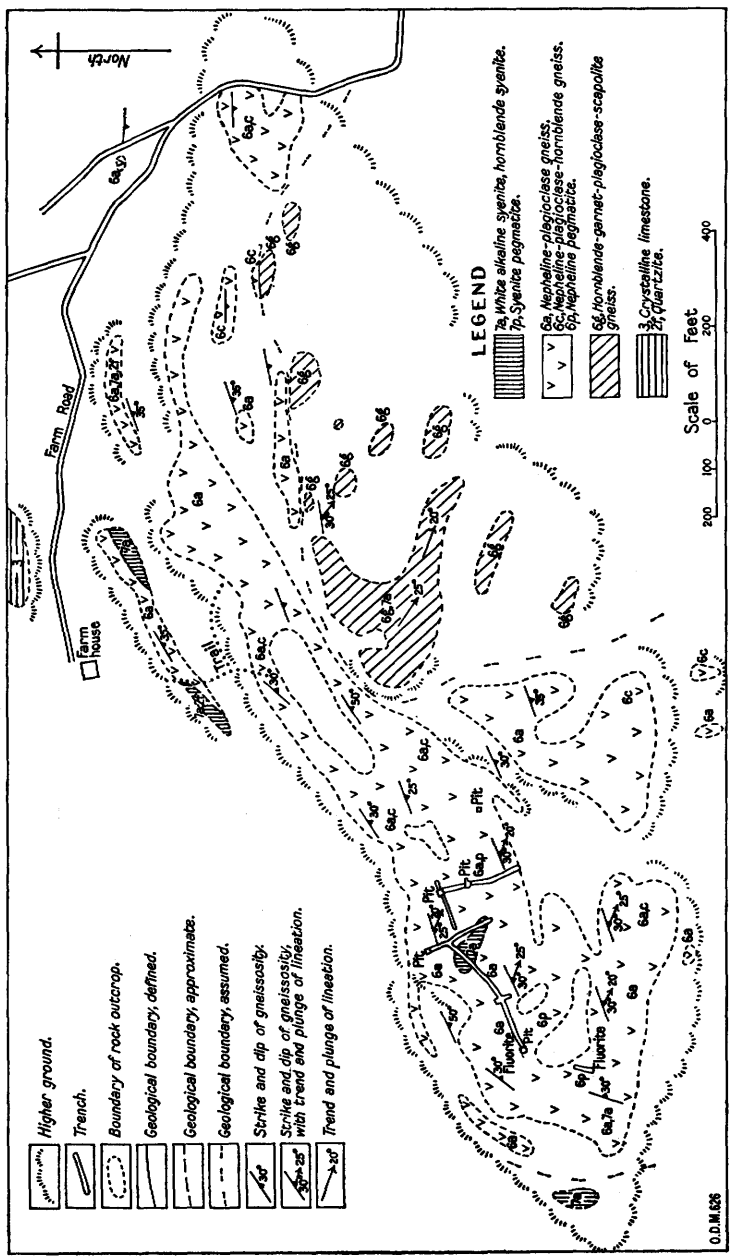
Wesley Kargus Farm, Lots 13 and 14, Concession XIV, Lyndoch Township (See Map No. 1953-2)

The accompanying map shows the general geology and structure of the nepheline-plagioclase and associated white alkaline syenite gneisses, which form an 80-foot ridge, trending in an east-west direction, just south of the farmhouse in lots 13 and 14, concession XIV, Lyndoch township. The ridge is ½ mile long; throughout its length, the gneisses strike in a general east-west direction and dip 30°–50°S. At the west end of the ridge, the structure of the nepheline gneisses swings from east-west to northeast-southwest, and the ridge falls off into low ground. No outcrops of nepheline gneiss occur to the west, and the band either pinches out, possibly in the trough of an east-plunging synclinal drag fold, or is faulted off by a northwest-trending strike fault, which may occupy the valley south of the ridge.

On the north side of the ridge, the footwall rocks of the nepheline gneiss consist of a series of coarsely crystalline white limestone and siliceous paragneisses. At the base of the ridge there is a narrow band of glassy quartzite. In



Geological map of Welk-Remus ridge, Wolfe nepheline belt.



Geological map of Wesley Kargus ridge, Wolfe nepheline belt.

some places pink alkaline syenite forms the footwall of the nepheline gneiss band. The nepheline gneiss band consists of interbanded white nepheline-plagioclase gneiss, white plagioclase gneiss, hornblende-nepheline-plagioclase gneiss, hornblende-garnet-plagioclase gneiss, and nepheline pegmatite. The nepheline content is extremely variable and erratic. As shown on the accompanying map, the nepheline-bearing gneisses occupy the west end and the north side of the ridge. To the south and east, the hanging wall gneisses consist of hornblende-plagioclase gneiss, hornblende-garnet-scapolite plagioclase gneiss, and mafic garnet-hornblende-scapolite gneiss. Garnet porphyroblasts up to 1¼ inches in diameter occur in the nepheline-free gneiss on the southeast side of the ridge.

At the west end of the ridge some shallow trenches and pits have been excavated in the nepheline-bearing gneisses. Small patches of nepheline pegmatite of the replacement type are common on this part of the ridge. Good evidence of the progressive replacement of medium-grained hypidiomorphic granitoid nepheline-albite syenite by large 4- to 12-inch pegmatitic patches of pure grey nepheline can be seen in the trenches at the west end of the ridge. The patches of grey nepheline grade into medium-grained nepheline albite gneiss, often with a border zone of nepheline, with relict inclusions of unabsorbed medium-grained albite scattered throughout.

Pale-violet fluorite up to ⅛ inch in grain size is a common accessory in the nepheline gneiss. On the south side of the ridge at the west end, there is a small pit, which exposes nepheline-albite pegmatite over a length of 25 feet. Coarse-grained green apatite and purple fluorite are present with biotite and nepheline crystals in the pegmatite.

The nepheline content at the west end of this ridge ranges from 0 to 40 percent and probably does not average over 15 percent over an average 100-foot width of the banded gneiss. Hornblende is the chief mafic mineral present and ranges from 0 to 25 percent. This part of the Wolfe nepheline belt is the best from the viewpoint of nepheline content, low percentage of mafic impurities, and constancy of composition, but even this part of the belt is of questionable economic interest.

The strong gneissosity of the nepheline rocks, and their great variability across their strike, with interbanding of nepheline-rich, albite-rich, and hornblende-rich facies, is interpreted as a result of metamorphic differentiation. The Wolfe nepheline belt, for example, consists of two or possibly three distinct lithological units that are variable within themselves, but in sharp contact and distinct from one another. A careful study was made to determine whether these units could possibly represent the original disposition of stratigraphic units in a replaced sedimentary sequence. At the east end of the Wolfe belt the nepheline gneisses narrow from 1,000 feet to less than 200 feet, with convergence of the footwall and hanging-wall limestones. As the nepheline gneiss bands converge, various ones disappear, a feature difficult to explain if the rock is a replaced sediment. The bands do not grade into nepheline-poor paragneiss but disappear by convergence of adjacent gneiss bands within the intrusive, and finally the nepheline band disappears as though it were the end of a sill. The Wolfe belt is interpreted as a composite intrusive, consisting of two or three distinct units intruded as a conformable sill into a sedimentary sequence.

E. Eastern Extension of Haliburton-Bancroft Nepheline Belt

Small occurrences of nepheline syenite have been reported in Denbigh, South Algona, Sebastopol, Brougham, and Admaston townships on the eastern extension of the Haliburton-Bancroft nepheline belt.

DENBIGH TOWNSHIP

Concession IX, Lot 33

A small band of nepheline syenite about 20 feet wide is exposed for a few hundred feet on the hillside of the east side of the creek flowing from Ashden Lake to Little Birch Lake, in lot 33, concession IX, Denbigh township, county of Lennox and Addington. The nepheline syenite outcrops just north of Little Birch Lake and is interbanded with marble.[1]

SEBASTOPOL TOWNSHIP

Concession XIV, Lot 16

SOUTH ALGONA TOWNSHIP

Concession I, Lot 18

Three occurrences of nepheline syenite are described as follows by J. Satterly:[2]

Occurrences of nepheline rocks adjacent to the boundary between Sebastopol and South Algona townships were first reported by Miller.[3]

Moyd[4] reports that the occurrences are limited to the northern part of concession XIV, Sebastopol township, no farther west than lot 12 nor farther east than lot 20, and in South Algona township to the southern part of concession I, from about lot 15 on the east to lot 23 on the west. North and south of these limits, no nepheline was seen by Moyd in the outcrops. Possible extensions to the east and west are obscured by heavy drift.

Some lots were staked for nepheline about ten years ago and again in 1943. The writer examined parts of the lots staked in 1943. The country rock is mainly a pink hornblende syenite or syenite-pegmatite containing a few inclusions of coarsely crystalline limestone and small areas of medium (one-quarter inch) to coarse (2-inch) nepheline pegmatite containing some dark mica. In lot 18, concession I, South Algona township, a mass of nepheline pegmatite, from 100 to 150 feet wide and about 350 feet long, was observed. Another mass in lot 16, concession XIV, Sebastopol township, is about 100 feet wide. No nepheline was seen in the syenite.

No development on these occurrences has been carried out, and the claims staked in 1943 have been allowed to lapse. The nearest station, Eganville, is 12 miles by road. Owing to the small size of the nepheline bodies, they are of doubtful commercial interest at present.

BROUGHAM TOWNSHIP

A nepheline syenite band in Brougham township is described by H. A. Quinn as follows:[5]

A band of nepheline-albite gneiss up to 400 feet wide and about 1 mile long lies about ¾ mile northwest of Guiney Lake on Mount St. Patrick in the southwestern part of the map-area. The band trends northeasterly and dips 50 to 85 degrees southeast. For most of its length the band has crystalline limestone on its hanging-wall and rusty paragneiss on its foot-wall. Toward its southern end, it grades into limestone. Toward its northeastern end it is cut by dykes and irregular masses of granite-pegmatite and of syenite-pegmatite.

The gneiss is a grey, fine- to medium-grained, indistinctly banded rock with a pitted surface. It is composed mainly of albite, biotite, and nepheline. The last mineral locally comprises up to 30 percent of the rock, but averages only 10 to 15 percent of the band as a whole. The grains of nepheline have weathered down more rapidly than the other minerals, producing numerous tiny pits as much as ¼ inch deep on the surface of the rock. Short veinlets of nepheline up to ¾ inch wide occur in the gneiss at a few places. A few grains of a pale blue mineral, possibly sodalite, were noted in one locality. Scattered crystals of brown corundum as much as 1 inch wide and 3½ inches long occur in the gneiss near its contacts with the pegmatites.

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[1] E. C. Appleyard, personal communication.

[2] J. Satterly, *Mineral Occurrences in the Renfrew Area*, Ont. Dept. Mines, Vol. LIII, 1944, pt. 3, p. 92.

[3] Willet G. Miller, "Corundum and Other Minerals," *Annual Report*, Ont. Bur. Mines, Vol. VIII, 1899, pt. 2, p. 224.

[4] Louis Moyd, private report on nepheline and corundum occurrences in eastern Ontario for Frobisher Exploration Co. Ltd.

[5] H. A. Quinn, *Renfrew Map Area*, Geol. Surv. Can., Paper 51-27, 1951, p. 9.

Two localities where this nepheline band is exposed are described as follows by J. Satterly:[1]

Concession XIV, Lot 11

A band of nepheline-albite gneiss crosses the farm of J. J. Maloney, lot 11, concession XIV, Brougham township.

The band can be traced from a point north of the barn in a northeast direction. The exposed width is about 250 feet. It is flanked on either side by bands of rusty paragneiss. The gneiss consists of albite, nepheline and biotite. The rock is of medium grain with the nepheline occurring in linear chains of grains, so that the nepheline content is extremely variable from band to band.

No sampling or test-pitting has been carried out. The occurrence contains too much biotite to be of any ceramic value, and the nepheline content appears to be too low for the deposit to be of any interest because of its alumina content.

Concession XV, Lot 8

A narrow band of nepheline-poor albite gneiss is exposed by moss-covered outcrops on a wooded hill in lot 8, concession XV, Brougham township. The gneiss is fine- to medium-grained and is composed of albite, nepheline (10–25 percent), and biotite. The gneissic structure trends N.55°–60°E. and dips 45°–55°SE. The band is cut by a number of masses or dikes of pink graphic granite pegmatite or hornblende syenite pegmatite. Adjacent to these pegmatites the gneiss contains an abundance of pink feldspar in streaks parallel to the foliation, the nepheline content being very low. Scattered crystals of brown corundum occur in this feldspathized gneiss. Most of the crystals are less than half an inch across, but occasionally large ones occur, the biggest seen being 1 inch across and 3½ inches long. Several small areas of gneiss containing corundum were found, but the percentage of corundum present is negligible and of no commercial interest.

Although the nepheline-poor gneiss can be traced down the slope of the hill to the northeast for a distance of 1,000 feet, the occurrence cannot be considered of any economic significance, owing to the low nepheline content, the abundance of biotite, and the frequent occurrence of masses of pink pegmatite. This band is probably a continuation of that found on lot 11, concession XIV, where its width is about 250 feet.

ADMASTON TOWNSHIP

Concession X, Lot 15

H. A. Quinn[2] reports that "some nepheline occurs in a syenitic body in lot 15, concession X, Admaston township, about 1 mile southwest of Colton Lake."

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[1] J. Satterly, *op. cit.*, pp. 89, 90.
[2] H. A. Quinn, *op. cit.*, p. 65.

CHAPTER III

Geology of Methuen Township

INTRODUCTION

Methuen township, in the eastern part of the county of Peterborough, eastern Ontario, has an area of about 110 square miles. The Bannockburn, Coehill, and Burleigh Falls map sheets of the National Topographic Series[1] cover the township.

The settlements and postoffices of Nephton (at the mine site of American Nepheline Limited), Blue Mountain (at the mine site of International Minerals and Chemical Corporation (Canada) Limited), Jack Lake, Oak Lake, and Vansickle lie within the area.



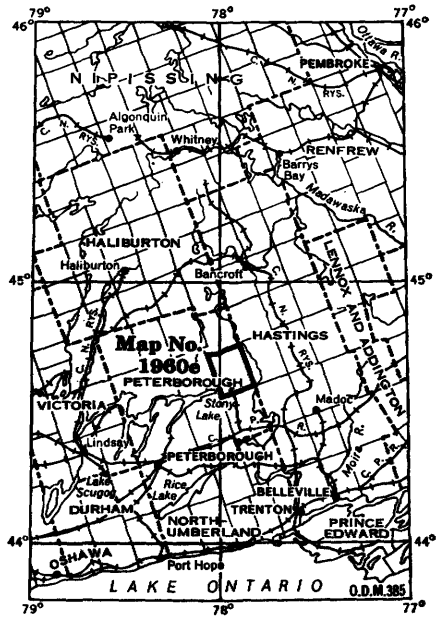
American Nepheline Mill, Blue Mountain.

Most of the township is easily accessible by road. The motor road from Havelock, north through Oak Lake to Lasswade on highway No. 504, in Chandos township, passes through the entire east-central part of Methuen township from south to north. Vansickle in the southeast corner of the township, may be reached by road from Cordova Mines. The road from Vansickle to Oak Lake is no longer passable. Nephton, in the west-central part of the township, is connected by 25 miles of paved road with the town of Lakefield on highway No. 28. A road from Nephton to join the Havelock–Oak Lake road passes through the southwest

[1]Published on a scale of 1:50,000 by the Canadian Department of National Defence, and available from the Canadian Department of Mines and Technical Surveys, Ottawa.

corner of the township. Both Jack and Kasshabog lakes are popular summer resorts and have many cottages on their shores; they are accessible by motor roads.

In 1955 a spur line of the Canadian Pacific Railway was built from Havelock to Nephton, and thence to the Blue Mountain mine of International Minerals and Chemical Corporation (Canada) Limited at Barrette Lake in central Methuen township. Although the two nepheline syenite mines are only 4½ miles apart by rail, there is no direct motor road connecting them, the distance around, by Oak Lake, being about 30 miles by car.



Key map showing the location of Methuen township, Peterborough county. Scale, 1 inch to 50 miles.

The mines are served by power lines of the Hydro-Electric Power Commission of Ontario. Rural power lines were extended to serve farms in the Oak Lake area, and cottages on Jack and Kasshabog lakes, in 1956 and 1957.

Prospecting and Mining Activity

The Blue Mountain nepheline syenite deposit in Methuen township is the centre of a flourishing mining industry producing nepheline syenite for the glass and ceramic trade. Production began in 1936, and American Nepheline Limited and its predecessors have produced continuously ever since. In 1956 a second producer, the Canadian Flint and Spar Division of International Minerals and Chemical Corporation (Canada) Limited, began operations at the northeast end of Blue Mountain.

Several small mica mines operated in Methuen township in the 1890's and again from 1940 to 1942, but production was small. Corundum, copper, ilmenite, iron, lead, and uranium prospects have been examined in the township, but little or no development work has resulted.

Present Geological Survey

The present geological survey of Methuen township was carried out during parts of the 1956 and 1957 field seasons. From July to September, 1956, the party consisted of the author and R. Laakso, who mapped in southern Methuen township. Mapping of the township was completed in June and July 1957 by D. F. Hewitt, R. Laakso, K. D. Card, and J. Mathieson.

Plotting of geological data was done on Perfatrace fitted over air photographs on the scale of 1 inch to 1,320 feet. Pace-and-compass traverses were run between points easily recognizable on the air photos. Owing to the abundance of topographic control such as rivers, lakes, roads, and swamps, no picketed base lines for traverse control were cut. Traverses were usually spaced at ¼ mile intervals. However, the frequency of long, narrow beaver swamps made traversing in a straight line across structure quite difficult. Where bush cover was not too heavy, the outcrop areas and geology between traverse lines was generalized by stereoscopic examination of air photos.

Geological data were transferred by sketchmaster from Perfatrace transparencies to a base map, on a scale of 1 inch to 1,320 feet, prepared by the cartography section of the Ontario Department of Mines from maps of the Forest Resources Inventory, Ontario Department of Lands and Forests. The original geological outcrop map compiled on ¼-mile scale was reduced to ½-mile scale and redrawn, with geology simplified and generalized. The final map is reproduced on a scale of 1 inch to ½ mile. (See map case.)

On this geological map, an area of many small outcrops may appear as a single outcrop area. In this township, as in other parts of the Grenville province, the rocks often show rapid variations over short distances, and in a single small outcrop several different rock types may occur; consequently on this scale of mapping, the colours and symbols pertaining to an outcrop area often represent only the rock types most prominently exposed, and the map gives only a generalized picture of the geology. In using the map the prospector should realize that the generalization is based on a traverse interval of ¼ mile, and that the percentage of outcrop seen by the geologist may be small, particularly in areas of heavy bush and heavy drift. In these areas the geologists' traverse line is often indicated on the map by a string of small outcrops, so that the map reader can determine where the rock has been examined.

Acknowledgments

The author was ably assisted in 1956 by R. Laakso, and in 1957 by R. Laakso, K. D. Card, and J. Mathieson. The author is pleased to acknowledge their efficient and wholehearted co-operation. Independent mapping was carried out by R. Laakso in 1957.

The party received assistance from many residents of the area. The author wishes to express his thanks especially to the officials of the two mining companies in the area for their many favours, assistance, and co-operation, in particular to E. Craig, E. B. Wright, and G. R. Guillet of American Nepheline Limited, and N. B. Davis, W. H. Hood, and Leo McDonnell of International Minerals and Chemical Corporation (Canada) Limited. W. Scott, chief ranger of the Ontario Department of Lands and Forests at Apsley, also gave much assistance to the party.

C. V. G. Phipp's map of Blue Mountain, kindly supplied to the author by American Nepheline Limited, was of considerable assistance.

Previous Geological Work

Willet G. Miller's reports, on corundum deposits, contain the earliest geological descriptions of parts of Methuen township.

Willet G. Miller, "Economic Geology of Eastern Ontario: Corundum and Other Minerals," *Annual Report*, Ont. Bur. Mines, Vol. VII, 1898, pt. 3, pp. 207–38.
Willet G. Miller, "Corundum and Other Minerals: Corundum Areas of Ontario," *Annual Report*, Ont. Bur. Mines, Vol. VIII, 1899, pt. 2, pp. 206–17.

The first geological map and report covering Methuen township was by Adams and Barlow. The mineral deposits and general geology of the area are described by J. Satterly. Part of southern Methuen township is covered by M. E. Wilson's Marmora map sheet.

F. D. Adams and A. E. Barlow, *Geology of the Haliburton and Bancroft Areas, Province of Ontario*, Geol. Surv. Can., Memoir No. 6, 1910 (with maps Nos. 708 and 770).
J. Satterly, *Mineral Occurrences in the Haliburton Area*, Ont. Dept. Mines, Vol. LII, 1943, pt. 2.
Map No. 560A, *Marmora, Hastings, Peterborough and Northumberland Counties*, Scale, 1 inch to 1 mile. Geol. Surv. Can., 1940. (M. E. Wilson.)

The Blue Mountain nepheline syenite has been the subject of several geological papers:

M. L. Keith, "Petrology of the Alkaline Intrusive at Blue Mountain," *Bulletin*, Geol. Soc. Amer., Vol. 50, 1939, pp. 1795–1826.
D. R. Derry, "The Lakefield Nepheline Syenite; Evidence of a Non-Intrusive Origin," *Transactions*, Royal Soc. Can., Section IV, Third series, Vol. XLV, 1951, pp.31–40.
C. Friedlaender, "Alkaligesteine von Blue Mountains, Ontario," Schweig. Min. Petr. Mitt, Vol. 32, 1952, pp. 213–42.
C. V. G. Phipps, *The Petrology and Structure of the Alkaline Rocks of the Blue Mountain Area*, unpublished Ph.D. thesis, Univ. of Toronto, 1955.
D. R. Derry and C. V. G. Phipps, "Nepheline Syenite Deposit, Blue Mountain, Ontario," *Geology of Canadian Industrial Minerals*, Volume, Sixth Commonwealth Mining and Metallurgical Congress, 1957, pp. 190–95.

Physiography

Methuen township forms part of a remarkably flat peneplane sloping gently south at about 20 feet to the mile. The average elevation in the northeastern part of the township is 1,050 feet, whereas the average elevation along the south boundary of the township is 800-850 feet. Except for Blue Mountain, the nepheline syenite ridge that stands up 250 feet above the surrounding peneplane, the relief is small and rarely exceeds 50–100 feet. The highest point in the area is Blue Mountain, with an elevation of 1,150 feet.

The area was glaciated, but in general there is little glacial drift. The township therefore has a great deal of rock exposed, outcropping as low hummocks. The proportion of outcrop exceeds 60–70 percent in many areas. The country is poorly drained and of low relief, so that frequently the inter-hummock areas are filled with muskeg. Numerous beaver dams make the area difficult to traverse.

The Methuen granite, which occupies the central third of the township, is often deeply weathered to a coarse feldspathic yellow-brown gravel. The author believes that this deep-weathering is largely pre-Paleozoic, and that the present peneplane surface is close to the pre-Paleozoic erosion surface. Ancient regoliths are sometimes present.

Drainage

There are two large lakes in Methuen township, Jack Lake and Kasshabog Lake, both having irregular indented shorelines over 20 miles long. There are over thirty smaller lakes and ponds, as well as many beaver ponds and swamps.

Jack Lake drains via Jack Creek into Stony Lake, thence into the Trent River system and Lake Ontario. Grassy Creek, which drains the Sugarbush lakes, joins Jack Creek a mile south of Jack Lake. Half a mile southwest of this junction, Jack Creek disappears into a sink hole in crystalline limestone, flows underground, and reappears ¼ mile downstream to the southwest. Kasshabog Lake drains southward via the North River into Round Lake, thence via the Crowe River into the Trent River and Lake Ontario.

Natural Resources and Development

The area was opened for settlement in the early 1800's. The township was originally surveyed by J. Huston in 1822 and 1823. The north boundary was re-surveyed by T. Bolger in 1876; the west boundary was re-surveyed by Pierce in 1937. A re-survey of Jack Lake was carried out in 1948, and the boundaries of the Peterborough Crown Game Reserve were surveyed and cut out in 1951.

Some farming is carried out at Oak Lake and Vansickle on, and near, the Paleozoic outliers in the southeastern part of the township. There are a few farms in northern Methuen on the road south from Lasswade. Most of the township is unsuited to agriculture as soil cover is insufficient.

Some lumbering is carried on in the township. In the summer of 1957, Purdy's sawmill, in lot 24, concession V, was the only mill operating in the area. Much of the east-central part of the township was burnt over in the late 1930's.

GENERAL GEOLOGY

The bedrock formations in Methuen township are of Precambrian and Paleozoic age. The oldest Precambrian rocks are metasediments and metavolcanics. The metasediments include marble, paragneiss, para-amphibolite, quartzite, arkose, schist, and conglomerate. The metavolcanic rocks are largely epidotized amphibolite and amphibolite schists.

In the southeastern part of Methuen township a stratigraphic section of about 12,000 feet of sediments, including some volcanic schists, has been measured. The Kosh Lake and Big Island beds, making up the lower 2,000 feet of this section, consist of: (1) epidotized amphibolite, paragneiss, and feldspathic gneiss; and (2) interbedded marble and schist, respectively. Above these beds is the Oak Lake formation, 5,000 feet thick, consisting primarily of pink arkose and quartzite, with some interbeds of amphibolite schist and greenstone schist. The percentage of volcanic (tuffaceous) material in this formation increases to the northeast. Above the Oak Lake formation is the Vansickle formation, consisting of over 4,500 feet of interbedded marble and schist, with some conglomerate. The upper limits of this formation were not determined, since it extends upward into Lake and Belmont townships. The base of this formation is marked by the first appearance of conglomerate in the section, below the Lower Marble member of the formation. The Middle (Vansickle) conglomerate, lying 2,300 feet above the base of the formation, is lens-like and has a thickness of 500 feet. On M. E. Wilson's Marmora map sheet,[1] this Middle conglomerate marks the so-called Grenville-Hastings contact.

In the northwestern part of the township, top determinations in the sediments are lacking, and the stratigraphic succession is not clear.

[1]Map No. 560A, Geol. Surv. Can.

TABLE OF FORMATIONS

CENOZOIC

Pleistocene and Recent

Sand, gravel, clay, silt, till.

Great Unconformity

PALEOZOIC

Ordovician

Limestone, dolomitic limestone.
Red argillaceous limestone and shale.
Basal grit and arkose.

Great Unconformity

PRECAMBRIAN

Plutonic Rocks

Granitic Rocks: granite, granite gneiss, granite pegmatite.

Intrusive Contact

Syenitic Rocks: syenite, syenite gneiss, hybrid syenite gneiss, syenite pegmatite.

Intrusive Contact

Nepheline Syenite.

Intrusive Contact

Basic Intrusives: diorite, gabbro, norite, pyroxenite, amphibolite.

Intrusive Contact

Sedimentary and Volcanic Rocks

Southeast Methuen (stratigraphic succession)	Northwest Methuen
Vansickle Formation (approximate thickness, 4,500 ft. +):	Blue Mountain sedimentary band. Lasswade marble. Apsley formation
Upper schist.	
Upper marble.	
Middle schist.	
Vansickle conglomerate	
Middle marble.	
Lower schist.	
Lower marble.	
Lower conglomerate.	

Oak Lake Formation (approximate thickness, 5,000 ft.):

Pink arkose, quartzite, amphibolite schist, feldspathic schist, some volcanic amphibolite.

Big Island Beds:

Interbedded marble and schist.

Kosh Lake Beds:

Epidotized amphibolite, paragneiss.

Troutling Bay Volcanics.

} approximate thickness, 2,000 ft. +.

The oldest intrusives cutting the metasedimentary complex are a series of basic intrusives, predominantly diorite and gabbro, but ranging from peridotite to quartz diorite. The two largest basic intrusive bodies are the Horse Lake and Twin Lake diorites, which occupy two basin structures in southern Methuen township. Many of the smaller basic intrusive bodies and dikes are altered to amphibolite.

The Blue Mountain nepheline syenite body is also one of the oldest intrusive rocks in the area. It cuts and replaces para-amphibolite, paragneiss, and marble. However, its age relation to the basic intrusives is not clear, since these two rock types do not cut one another. In the Haliburton-Bancroft area to the north, nepheline syenite cuts the older gabbro, and this relationship may apply in Methuen township. Several narrow bands of mafic rock in the nepheline syenite have been interpreted, by various geologists, as metadiabase dikes, relict bands of paragneiss, or mafic segregations along shear zones, and these occurrences shed little light on this age relationship.

The nepheline syenite is intruded and replaced by pink and buff syenite. Syenite occurs as dikes cutting the nepheline syenite, and the relationships are well shown in quarries at both the mines. Pink alteration of the nepheline syenite is apparently a hydrothermal alteration related to the intrusion of the pink syenite. Syenite pegmatites carrying mica and corundum appear to be offshoots of the pink syenite magma.

The latest intrusive rocks in the township belong to the granite group. These rocks intrude metasediments, basic intrusives, nepheline syenite, and syenite. The largest granitic intrusive is the Methuen granite, which consists mainly of medium- to coarse-grained pink gneissic biotite granite. Some facies are pink biotite granite porphyry with large feldspar phenocrysts (up to 1 inch). A grey, fine- to medium-grained biotite granodiorite occurs as large inclusions in the Methuen granite. Granite intrudes both the Twin Lake and Horse Lake diorites in southern Methuen township. A large pink biotite granite body occurs in northern Methuen township, at the south end of Jack Lake. Many granite and granite pegmatite dikes occur in the area.

The intrusion of the granite may have marked the culmination of the Grenville orogeny. Most of the rocks in the area show a regional B-lineation, attributed by the author to folding during this orogeny. Argon age determinations, on muscovite from a granite pegmatite from Big Mountain Lake, indicate an age of $1{,}000 \pm 70$ million years,[1] an age common in the area for rocks formed during the Grenville orogeny.

After this period of mountain building, the area was eroded to a peneplane of low relief. In Paleozoic times the seas covered Methuen township, and outliers of Black River limestone laid down in Ordovician times occur at Vansickle and Oak Lake in southern Methuen township. The Black River limestone also extends into southwestern Methuen township, south of Long Lake.

During Pleistocene time the area was glaciated; the township lies partly within the area described by Chapman and Putnam[2] as the Dummer till moraine, an area of scoured rock plains and thin recessional moraines, characterized by large angular blocks of Paleozoic limestone and Precambrian crystallines.

[1] C. V. G. Phipps, *The Petrology and Structure of the Alkaline Rocks of the Blue Mountain Area*, unpublished Ph.D. thesis, Univ. of Toronto, 1955.

[2] L. F. Chapman and D. F. Putnam, *The Physiography of Southern Ontario*, Univ. of Toronto Press, 1951, pp. 227–29.

Sedimentary and Volcanic Rocks

The sedimentary rocks of the township occur in two main areas, the northwestern and the southeastern; these are separated from one another by the Methuen granite batholith, which extends across the township in a broad northeast-trending band, 2–4 miles wide.

NORTHWESTERN METHUEN

The sedimentary rocks in northwestern Methuen can be divided into three northeasterly-trending units: (1) paragneiss and amphibolite north of Jack Lake in northwestern Methuen, called the Apsley formation by D. M. Shaw; (2) a broad band of marble 2–3 miles wide[1] extending northeast through Jack Lake; (3) a 1- to 2-mile-wide band of paragneiss, amphibolite, and marble,[2] much intruded and replaced by granite, syenite, and nepheline syenite, extending northeastward between the Methuen granite and the Lasswade marble band referred to in (2) above.

Apsley Formation

The paragneiss and amphibolite north of Jack Lake strikes in an east-northeasterly direction and usually dips gently 10°–30°SE. The metasediments are intruded by pink leucogranite, and granite pegmatite dikes and sills. Lithologically, the rocks are medium-grained, well-banded crystalline gneisses, and schists, composed of the following mineral assemblages:

Assemblage	Rock Name
Plagioclase–amphibole	Amphibolite
Plagioclase–biotite–amphibole	Biotite amphibolite
Plagioclase–garnet–amphibole	Garnet amphibolite
Plagioclase–quartz–biotite	Biotite paragneiss
Plagioclase–quartz–biotite–garnet	Garnet paragneiss
Plagioclase–quartz–diopside–pyrite	Rusty paragneiss or schist

Narrow marble bands and minor amounts of feather amphibolite occur in this band of sediments.

Lasswade Marble

The broad marble band 2–3 miles wide strikes northeast through Jack Lake and dips 20°–50°SE. Structurally, this band overlies the paragneiss and amphibolite to the north, but no top determinations are available, so the stratigraphic relations are not clear. The possibility of overturning, or isoclinal folding, precludes solution of the structure at this time. The marble band is composed of medium- to fine-grained, well-bedded, white to grey crystalline limestone. Silicated impurities are uncommon, but fine-grained argillaceous material may be present. The marble band is intruded by much granite, granite pegmatite, and ortho-amphibolite. These intrusive rocks all frequently occur as narrow dikes or branching dikes and sills, 10–20 feet wide and several hundred feet long. One such pink granite dike extends for 3½ miles. Since the marble band occupies an area of low relief, the dikes stand up as marked ridges conspicuous on the air photographs.

Blue Mountain Sedimentary Band

The paragneiss, amphibolite, and marble occupy a band 1–2 miles wide between the Lasswade marble and the Methuen granite; the band strikes northeast and has a variable dip. In the zone adjacent to the Lasswade marble the amphibolite dips southeast and appears to be structurally above the marble.

[1]Herein referred to as the Lasswade marble.
[2]Herein referred to as the Blue Mountain sedimentary band.

However, adjacent to the Methuen granite, the rocks may dip steeply northwest, or vertically. It is possible that this Blue Mountain metasedimentary band occupies a synclinal structure between the Lasswade marble and the Methuen granite, with the south limit of the syncline partly cut off against the granite. As mentioned previously, no top determinations have been made in these sediments, and the structural interpretation is made solely on strike and dip of bedding foliation, which is not reliable in this type of metamorphic terrane in the absence of top determinations. No repetition of lithology can be recognized to suggest that the synclinal structure is correct. However, at the north end of this Blue Mountain band of metasediments, on the west flank of the Methuen Lake granite dome, sediments dip 25°–50°W., also suggesting that the Blue Mountain band may form a syncline.

The Blue Mountain nepheline syenite intrudes this metasedimentary band and divides it into two parts, one on each side of the main nepheline syenite ridge quarried by American Nepheline Limited. On the northwest side of the nepheline syenite ridge, the metasediments have variable lithology and consist predominantly of amphibolite, biotite amphibolite, garnet amphibolite, biotite paragneiss, and feldspathic paragneiss, with narrow bands of marble, silicated marble, lime silicate rock, diopsidic quartzite, quartzite, rusty-weathering paragneiss, and feather amphibolite.

Between the Blue Mountain nepheline syenite ridge and the Methuen granite in the vicinity of Big Mountain Lake, the metasedimentary band has a width of ½ mile. These rocks consist mainly of amphibolite, biotite amphibolite, biotite paragneiss, and rusty paragneiss, with minor bands of sillimanite paragneiss, garnet paragneiss, garnet amphibolite, and marble. These rocks strike northeast and generally dip vertically or steeply southeast. There is a pronounced metamorphic lineation in these metasediments, trending southwesterly and plunging 20°–40°SW., conforming to the trend and plunge of lineation in the adjacent nepheline syenite and granite. This is interpreted by the author as a B-lineation paralleling the axes of Grenville orogenic folding.

At Grassy Lake the attitude of foliation in the surrounding nepheline syenite gneiss indicates that Grassy Lake lies in the trough of a syncline plunging southwest. Strikes and dips in the metasediments at Grassy Lake conform to this synclinal structure, but the author was unable to make any confirmatory top determinations or trace any recognizable lithology on either limb of the fold. A narrow marble bed flanks the southeast side of the nepheline syenite ridge southwest of Grassy Lake. This marble band appears to be dragged on what may be a fault lineament running south from St. Charles Lake to Kasshabog Lake. A small outcrop of marble occurs adjacent to the nepheline syenite ridge on the east side of the Grassy Lake syncline, but there is no certain way of connecting it stratigraphically with the marble noted on the northwest side.

A distinctive lithological unit occurs in the sedimentary sequence near the west township boundary, south of the nepheline syenite, and also on the northwest side of the nepheline syenite. This is described by Phipps[1] as "leucocratic gneiss" and was referred to by the present author on field sheets as the BM gneiss. The rock is a grey, fine- to medium-grained, biotite-quartz-oligoclase-microcline gneiss. It is poorly bedded and usually rather massive, with very little structure to indicate whether it is sedimentary or intrusive in origin. The BM gneiss extends northeastward in a 200-foot-wide band from the west boundary of the township about 200 feet north of the Nephton road. It is well exposed on the power line.

[1]C. V. G. Phipps, *op. cit.*, pp. 15–17, 97–99.

Near the power line the grey, massive BM gneiss carries ghostly angular fragments of the same composition as the gneiss, but slightly darker in colour. These fragments range from 2 inches to 1 foot or more long, and suggest to the author that the rock may be a welded tuff with volcanic fragments. This band of BM gneiss borders the nepheline syenite on the southeast, and is intruded and replaced by pink syenite, which also replaces the nepheline syenite.

Bands of gneiss, very similar in appearance to the BM gneiss, occur on the northwest side of the nepheline syenite ridge, where it is interbedded with rusty paragneiss and amphibolite. The BM gneiss also occurs immediately adjacent



Blue Mountain gneiss, showing cognate inclusions.

to the nepheline syenite ridge on its northwest flank at St. Charles Lake, and again along strike ¾ mile southwest of St. Charles Lake along the nepheline syenite contact. In both these places there appears to have been some replacement of the BM gneiss by nepheline syenite. Phipps[1] suggests that the Blue Mountain nepheline syenite may replace a favourable sedimentary horizon in the metasediments and suggests that this favourable horizon was the leucocratic gneiss (or BM gneiss). The present author has found evidence of some nephelinization of the BM gneiss in two locations along the northwest contact of the nepheline syenite intrusive in the vicinity of St. Charles Lake.

On the northwest side of the Blue Mountain nepheline syenite from St. Charles Lake to the west boundary of Methuen township, the Blue Mountain sedimentary band is intruded and replaced by pink granite, granite pegmatite, and syenite. A great deal of feldspathization and granitization has taken place and has resulted in extensive development of hybrid granite and hybrid syenite gneiss from paragneiss and amphibolite. The geological map of this section of the township indicates the large area of hybrid granitic and syenitic gneisses de-

[1]C. V. G. Phipps, *op. cit.*, pp. 97–99.

veloped by metasomatism of the sediments. In the syenitized zone north of St. Charles Lake, a good deal of relict feather amphibolite was noted in the syenitized amphibolite facies.

To the north of the Blue Mountain nepheline syenite, the Blue Mountain sedimentary band has an uninterrupted width of 1½ miles between the Lasswade marble and the Methuen granite. The metasediments strike north-northeast and dip 30°–60°SE. over most of the width of the band, but the dips become vertical near the granite contact. The area underlain by these metasediments is low-lying and partly covered by black spruce swamp. Outcrops are not numerous, but the following is the lithological succession from Lasswade marble to Methuen granite: the Lasswade marble structurally underlies a ½-mile width of dark-coloured amphibolite and biotite amphibolite, containing some dark-coloured bands of biotite paragneiss; occasional bands of feather amphibolite were noted. Above this there is 1,000 feet of white coarse-grained marble containing narrow bands of amphibolite; this marble band appears to be truncated against the Blue Mountain nepheline syenite. Above this marble there is a width of ¾ mile of amphibolite and feather amphibolite, containing narrow bands of marble, silicated marble, lime silicate rock, minor quartzite, paragneiss, garnet paragneiss, rusty paragneiss, and feldspathic schist. As previously indicated, no top determinations are available, but this band may be an isoclinally folded syncline; to the northeast, the dips on the Methuen granite side of the band are definitely at 25°–70°NW. However, interpretation of structure, especially interpretation of a complexly folded synclinorium as given by Phipps,[1] based on attitude of foliation and dispositions of metasedimentary bands and nepheline syenite tongues, is questionable in a terrane where much of the foliation and lineation is that of a metamorphic tectonite, resulting from deformation accompanying intrusion and replacement during the Grenville orogeny. The tectonic style of the whole area indicates a rather deep zone of metamorphism. Phipps has recognized the important fact that much of the foliation and lineation, seen both in the metasedimentary rocks and the nepheline syenite, is axial-plane foliation.[2] Appreciation of this fact makes acceptance of a single unique solution of the structure impossible in the absence of either top determination or traceable marker horizons within the structure.

On examining the interpretation given by Derry and Phipps[3] that the main nepheline syenite replaces a complex folded series of at least five anticlines and synclines in the sediments, evidence, for the presence of this series of folds in the metasediments to the north of Blue Mountain on strike, is lacking. In the section dealing with the Blue Mountain nepheline syenite the author suggests the alternative possibilities of a simple V fold, a Z drag fold, or a W fold all pitching southwest. The complex nepheline syenite metasediments intertonguing, on the south limb of the structure north of the railway line, may be interpreted as normal intrusive relationships.

SOUTHEAST METHUEN

As described earlier, in southeastern Methuen township south of the Methuen granite batholith, a thick section of almost 12,000 feet of sediments has been measured. The three major elements of structure affecting the succession in this

[1] C. V. G. Phipps, *op. cit.*, pp. 68–79.
[2] *Ibid.*, pp. 14, 75–77.
[3] D. R. Derry and C. V. G. Phipps, "Nepheline Syenite Deposit, Blue Mountain, Ontario," *Geology of Canadian Industrial Minerals*, Volume, Sixth Commonwealth Mining and Metallurgical Congress, 1957, pp. 190–95.

area are: the Horse Lake basin, the Twin Lake basin, and the Oak Lake dome The centres of the basins are occupied by gabbro and diorite, the rims are sedimentary. The Oak Lake dome is entirely sedimentary.

The stratigraphic succession recognized by the author is given in a series of three sections taken: (A) southward from the centre of the Oak Lake dome; (B) southeast from the northeast end of the Oak Lake dome, through Vansickle; and (C) southeast across the structure, from the Methuen granite to the east township boundary north of the Vansickle Paleozoic outlier. (Sedimentary Formations S.E. Methuen, in map case.)

A general description of the 12,000-foot stratigraphic section was given previously. It consists of 2,000 feet of Kosh Lake and Big Island beds, mainly epidotized amphibolite and paragneiss, overlain by interbedded marble and schist; 5,000 feet of Oak Lake arkose, and 4,500 feet plus, of Vansickle formation, which is interbedded marble, schist, and conglomerate.

Kosh Lake Beds

The Kosh Lake beds consist of epidotized amphibolite, paragneiss, feldspathic schist, and pink arkose. The thickness of these beds is unknown, since they are cut off against the Methuen granite, but at least 500 feet of them have been observed at Portage Bay, on Kasshabog Lake. They are exposed in the centre of the Oak Lake dome and along the south and east margins of the Methuen granite batholith, from Portage Bay on Kasshabog Lake, northeastward through Sams, Blue, and Twin lakes, northward to Troutling Bay on Tangamong Lake on the east boundary of the township. Some facies of the Kosh Lake beds are very similar to the pink arkose of the Oak Lake formation.

The Methuen granite intrudes and replaces the Kosh Lake beds along their mutual contact, and there is some granitization of the sediments, but no recognizable migmatites are formed. In many places the contact is sharp; in places it is marked by a narrow swamp-filled draw.

As these beds are traced to the north along the east margin of the Methuen granite, where they outcrop along the edge of the Big Swamp of eastern Methuen, more amphibolite and amphibolite schist appear in the section. There is a facies change representing an increasing amount of amphibolite of volcanic (tuffaceous) origin. At Troutling Bay the Kosh Lake beds interfinger with basic volcanics. These basic volcanics are named the Troutling Bay volcanics, and consist of epidotized amphibolite, amphibolite schist with epidote bombs, volcanic fragmentals, and epidotized pillow lava. One exposure of pillow lava on the Tangamong Lake road, just west of the Methuen township boundary, has pillows that indicate tops to the east. Epidotized clots and vesicular epidote bombs are common in this volcanic amphibolite. The original composition of the lava is uncertain but would be tentatively placed by the author as dacite or andesite. The volcanics are exposed over a width of 1,500 feet from the Methuen granite contact, and were observed by the author over a length of about a mile south of Troutling Bay.

Big Island Beds

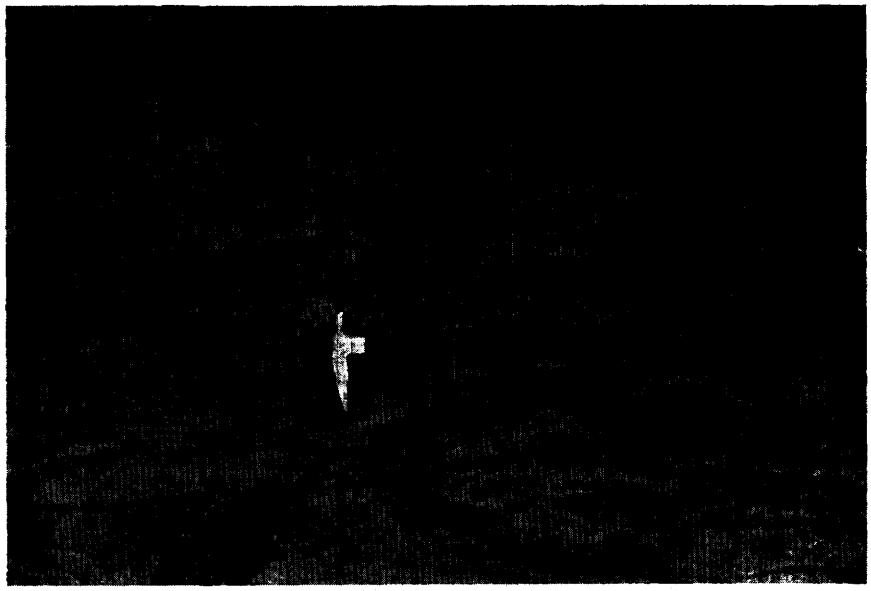
The Big Island beds exposed on Big Island in Oak Lake lie above the Kosh Lake beds and below the pink arkose of the Oak Lake formation. These beds consist of schist interbedded with grey, well-bedded limestone. The schists are reddish or greenish, fine- to medium-grained, micaceous, feldspathic rocks, usually thinly bedded or flaggy. They are often either iron stained (brown to red) or chloritic (green).

The thickness of these beds is unknown, but at least 300 feet are exposed on Big Island. The limestones resemble the thin-bedded Hastings limestones described by Adams and Barlow. The grade of metamorphism is low.

Oak Lake Formation

The Oak Lake formation, named for the excellent exposures around the shores of Oak Lake in southern Methuen township, consists of 5,000 feet of pink arkose, and pink and grey quartzite, with some interbeds of amphibolite schist and greenstone schist. Oak Lake occupies an anticlinal dome, with the resistant ridges of Oak Lake arkose forming the south and west shores of the lake.

On the south shore of Oak Lake the formation strikes N.70°E. and dips 40°–50°S. It has a thickness of 5,000 feet, and is overlain by the amphibolite, greenstone schist, marble, and conglomerate of the Vansickle formation. The base of the Oak Lake formation is not exposed, but is assumed to lie close to the shore, between the pink arkose on the shoreline and the small limestone islands a few hundred feet off shore. As noted in section A, 2,000 feet above the base of



Pillow lava, Troutling Bay volcanics, Tangamong Lake Road.

the formation there is a 350-foot band of dark-coloured amphibolite and paragneiss. This member can be traced from South Lake, eastward and northward to the Lake township boundary. The darker amphibolite bands stand out on air photographs in contrast to the light-coloured arkose ridges. Narrow bands of mica schist and micaceous feldspathic schist occur frequently in the formation, but normally they rarely exceed 30–50 feet wide. To the northeast, along strike in the vicinity of section C (map case), more tuffaceous amphibolitic material appears mixed with the arkosic sediments, indicating an increasing contribution from volcanism in the sedimentary section. Narrow bands of amphibolite and greenstone schist may represent tuffs or thin flows. There is a good exposure of greenstone amphibolite showing volcanic structures, vesicles, and ropy flow, in lot 2, concession IV, on a farm road ¼ mile east of the Oak Lake road. Other narrow bands of volcanic greenstone occur along strike to the northeast in the upper part of the formation. Thin amphibolite sills also occur in places in the Oak Lake formation near the Lake township boundary.

The pink quartzite and arkose are medium- to fine-grained with well-developed massive bedding. Cross-bedding and grain gradation are usually lacking. In thin section these rocks are seen to consist of a fine-grained (0.2–0.5

millimetres), equigranular to interlocking mosaic of quartz, plagioclase, and microcline. Mafic minerals are uncommon. Occasionally the rock contains porphyroblasts of muscovite or microcline, particularly in areas where it has been granitized.

South of Long and South lakes the Oak Lake formation is intruded and replaced by pink leucogranite and biotite granite. Large inclusions of Oak Lake quartzite and arkose occur in the granite. These relationships are well shown in the railway cuts south of Long Lake in southern Methuen township. In places, the borders of the Oak Lake inclusions are sharp and well defined with little or no granitization. In other places, as for example along the south shore of Kasshabog Lake, there is extensive granitization of the Oak Lake formation, generally by potash metasomatism rather than injection.

The Oak Lake arkose, at Oak Lake in Methuen township, was first described by Adams and Barlow[1] as follows:

> This [arkose] overlies the limestone of Oak Lake, and belongs to the same series as that which furnishes the paragneiss described . . . ., resembling in appearance that [paragneiss] from the line between lots 3 and 4 of concession III of Methuen, being, however, practically free from iron-magnesia constituents. It is well exposed on the shore of the lake, about the middle of lot 3, concession V. Here, the rock, although on first examination resembling a fine-grained granite, on closer examination seems to be a sedimentary rock composed largely of granitic material, a sort of fine-grained arkose. It possesses a well-marked bedded appearance, unlike the granite or gneissic granite found elsewhere in this region, and when carefully examined on the weathered surface, these bands are seen in some cases to be more quartzose than in other cases, some bands being, in fact, composed of nearly pure quartz. Most of the rock is, however, evidently highly feldspathic. A silica determination, made on a hand specimen of the rock, yielded 74.62 percent of silica, which is the percentage present in an acid granite. Under the microscope it is seen to be composed essentially of quartz, orthoclase, microcline, and plagioclase, the first mentioned constituent being the most abundant, and the orthoclase preponderating among the feldspars. The only other constituent present is a little magnetite, in irregularly scattered grains; and a few flakes of muscovite are also seen.
>
> The banded character above referred to is distinctly seen, the bands presenting a variation in size of grain, as well as in relative proportion of the constituent minerals.

The paragneiss referred to above, in lot 3, concession III, is described by Adams and Barlow, in the reference already given, as follows:

> . . . a fine-grained grey rock showing a rather distinct foliation. Under the microscope it is seen to be composed of an aggregate of clear colourless grains, which are for the most part quartz, although there is probably some orthoclase associated with them. These form an aggregate, giving to the rock a pavement, or mosaic structure. This varies somewhat in size of grain in different bands. Through this are sparingly distributed—emphasizing the foliation—larger skeleton crystals of muscovite, biotite, and calcite, with small irregularly rounded grains of black iron ore, and a few crystals of deep bluish-black tourmaline. This is a highly siliceous paragneiss, being undoubtedly an altered sediment. It is typical of the lighter coloured bands found in this series of rocks which strike across concessions II and III on lot 3 of this township. It is interstratified with very dark coloured bands, which resemble it in microscopic character, but which are rich in biotite and hornblende, forming transitions into amphibolite.

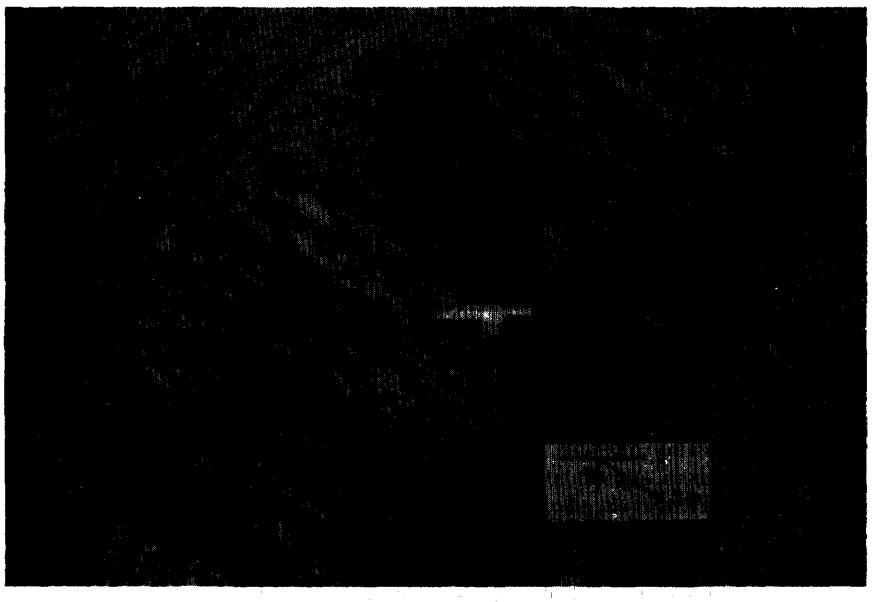
Vansickle Formation

The Vansickle formation lies above the Oak Lake formation, in the vicinity of Vansickle in southeastern Methuen. The typical lithology of the underlying Oak Lake formation is arkose and quartzite, the typical lithology of the Vansickle formation is schist and limestone or marble, with some conglomerate. The upper part of the Oak Lake formation is marked by a series of passage beds containing much more feldspathic and amphibolite schist than the main part of the formation. The base of the Vansickle formation is placed below the Lower marble member, at the first appearance of conglomerate, 200–300 feet below the base of the Lower marble.

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[1] F. D. Adams and A. E. Barlow, *Geology of the Haliburton and Bancroft Areas, Province of Ontario*, Geol. Surv. Can., Memoir No. 6, 1910, pp. 177, 180.

In the Vansickle area the formation strikes northeast and dips 40°–50°SE. The formation here consists of the following members in ascending order (see section B, map case): the Lower conglomerate member, represented here by 200–300 feet of feldspathic and amphibolitic schist and conglomerate; the Lower marble, 300–600 feet thick; the Lower schist, 1,200 feet of feldspathic schist, greenstone schist, slate argillite, and minor conglomerate; the Middle marble, 600 feet of argillaceous marble interbedded with some quartzite; the Middle conglomerate, 500 feet of conglomerate, at the Vansickle schoolhouse; the Middle schist, 350 feet of feldspathic and amphibolitic schist; the Upper marble, consisting of 900 feet of marble, and some interbedded schist. This Upper marble is overlain by schist.



Vansickle conglomerate, showing stretched pebbles; Vansickle schoolhouse.

The 500-foot thick Middle conglomerate member exposed at Vansickle schoolhouse is of great interest since it was considered by M. E. Wilson[1] to be a "Hastings conglomerate," marking the Grenville-Hastings contact. The conglomerate is exposed in fields west of the schoolhouse over a width of 12 chains. It consists of a heterogeneous assemblage of pebbles, ½–5 inches in size. The pebbles are stretched and elongated along the plane of fracture cleavage. The conglomerate is strongly sheared, and the fracture cleavage strikes N.75°E. and dips 60°S. The trend of stretched pebbles on cleavage surfaces measures 110 degrees, with a plunge of 30°SE. Many of the pebbles are stretched to a length of 5 inches, with a width of only ½–1 inch. The pebbles consist of grey and black schist, slate, amphibolite, greenstone, and pink arkose and quartzite of the Oak Lake formation. The conglomerate is lens-like, and from the place where it disappears under the Vansickle Paleozoic outlier it can be traced southwest for only 1,500 feet. This conglomerate, and the underlying Lower conglomerate, were first described by Adams and Barlow.[2]

[1]Map No. 560A, Geol. Surv. Can., 1940.
[2]F. D. Adams and A. E. Barlow, *op. cit.*, pp. 47, 48.

The upper part of the Lower schist member consists of grey, finely laminated mica schist and slaty greywacke, occasionally showing grain gradation indicating tops to the southeast.

West of the Vansickle Paleozoic outlier the Lower conglomerate member is mainly feldspathic amphibolite schist, but it carries two narrow conglomerate horizons a few feet thick. On strike ¾ mile to the north on the Lake township boundary, two other narrow conglomerate horizons were noted. One of these is exposed on the lumber road running up the township boundary, and the 4-foot exposure consists of grey pebble-conglomerate made up of rounded to angular pebbles of greenstone, amphibolite, Oak Lake arkose, and pink and grey felsite. The pebbles are mostly ½–1 inch in size, occasionally up to 3 inches. The matrix is micaceous.

Conglomerate also is exposed in a small monadnock piercing the Vansickle Paleozoic outlier.

Plutonic Rocks

BASIC INTRUSIVES

The basic intrusives are thought to be of two or possibly three ages. Some narrow amphibolite dikes and sills occurring in the Oak Lake formation may be related in age and origin to the basic volcanics in this sedimentary section. Other amphibolite dikes in the area may also be of this early age. Some dikes and smaller intrusives are undoubtedly related in age to the Horse Lake, Twin Lake, and related gabbro intrusives, which cut the folded metasedimentary rocks. These rocks form the bulk of the basic intrusives in the area. Some narrow dikelets of amphibolite and hornblendite are found in the Methuen granite and in the Blue Mountain nepheline syenite. Whether these dikelets represent lamprophyre dikes associated in age with the Methuen granite, or represent relict earlier intrusive dikelets, as suggested by Derry,[1] is unknown. If they are lamprophyre dikelets associated with the granite they represent a third age of basic intrusives. However, the difference in age between the intrusives, as represented by the Horse Lake diorite, and the Methuen granite may not be very great, and they may belong to the same orogenic period.

The basic intrusives in the township include quartz diorite, diorite, gabbro, norite, peridotite, and hornblendite. The meta-intrusives are mainly amphibolite, with minor metagabbro. The diorites and gabbros commonly have an interlocking, serrate, hypidiomorphic, granular texture; the more basic facies generally have a xenomorphic granular texture. Two stages of dynamic metamorphic alteration are recognized. In the first stage, incipient crushing and granulation of the larger hypidiomorphic plagioclase or ferromagnesian minerals results in fine-grained allotriomorphic aggregates of recrystallized plagioclase and hornblende surrounding the larger relict mineral grains. The second, or completely recrystallized, stage is an amphibolite composed of a fine- to medium-grained, xenomorphic, granular-granoblastic mosaic of secondary plagioclase and hornblende.

Horse Lake Basic Intrusive

The Horse Lake basic intrusive in southwestern Methuen occupies the centre of a basin structure between Stony Lake Bay on Kasshabog Lake and Long Lake. The body is oval-shaped in outcrop area, with a length of 3½ miles and a width of 1¾ miles. The relief in this basin is low, with much swamp and muskeg. There is a great deal of magnetic attraction, and a sundial compass

[1] D. R. Derry, "The Lakefield Nepheline Syenite: Evidence of a Non-Intrusive Origin," *Transactions*, Royal Soc. Can. Section IV, Third series, Vol. XLV, 1951, pp. 31–40.

must be used for running lines. The diorite-gabbro basin is rimmed by granite hills. The diorite is rarely foliated, but where it is foliated, dips appear to be towards the centre of the basin. Strikes and dips, in the granite gneiss and quartzite of the Oak Lake formation around the rim, indicate a basin structure.

The granite rim surrounding the basic intrusive, and separating it from the surrounding Oak Lake formation, intrudes the basic intrusive; dikes and small bodies of pink leucogranite occur in the diorite at several places within the basin. Sedimentary inclusions are sometimes found in the diorite.

In composition the Horse Lake body grades from quartz diorite to norite. Thin sections of quartz diorite indicate an interlocking serrate, hypautomorphic granular texture, composed of hornblende and plagioclase (oligoclase, An_{28}, to andesine, An_{40}) with minor quartz and biotite, and accessory magnetite, carbonate, apatite, zircon, and titanite. The gabbro differs from the diorite in that it contains pyroxene; the plagioclase is generally andesine, An_{30-40}. The norite facies contain hypersthene, and plagioclase as calcic as labradorite, An_{52}. Minor quartz, sometimes in myrmekitic intergrowth, occurs in several slides.

The diorite is well-exposed along the railway line north of Long Lake, and a good cross-section can be seen in the railway cuts. One interesting facies observed in railway cuts, in lot 6, concession XI, is a diorite breccia. The fragments consist of fine-grained amphibolite (quartz-plagioclase-hornblende-pyroxene) in a matrix of medium-grained quartz diorite (quartz-plagioclase-hornblende). The plagioclase of the fragments is andesine, An_{40}; the plagioclase of the quartz diorite matrix is oligoclase, An_{28}. No sulphide mineralization was observed in the diorite-gabbro body, but rusty gossan zones were observed near the North River, in lots 4–7, concession IX.

Twin Lake Diorite

The Twin Lake diorite occupies a second basin structure in southern Methuen township, east of the Horse Lake basin, on the road between Oak Lake and Twin Lakes. The diorite occupies an oval-shaped basin, 2½ miles long and 1¼ miles wide. It is surrounded by a rim of quartzite and arkose, dipping in towards the centre of the basin. The diorite is intruded by pink biotite granite and granite porphyry. Inclusions of arkose, quartzite, and para-amphibolite occur in the diorite near its margins. Hybrid biotite diorite border facies are common where the rock intrudes quartzite and arkose.

In thin section the diorite shows an interlocking, serrate, hypautomorphic granular texture, the common mineral assemblage being biotite-hornblende-plagioclase, with accessory opaque minerals, carbonate, apatite, and chlorite. The plagioclase ranges from oligoclase (An_{20}) to andesine (An_{40}), in slides examined. Quartz is common, and much of the body is quartz diorite. Gabbroic facies carrying pyroxene also occur, but dioritic facies predominate. Some small deposits of magnetite and ilmenite occur in the Twin Lake diorite near the Oak Lake road.

A small offshoot from the main Twin Lake diorite intrudes sediments at the east end of Portage Bay. This is a biotite-quartz-hornblende-plagioclase (andesine, An_{32-38}) rock with hypautomorphic granular texture.

Another small offshoot from the diorite is exposed on the north end of Big Island in Oak Lake. This is a diorite porphyry, composed of oligoclase phenocrysts up to 1½ inches in size in a matrix of biotite, hornblende, plagioclase, and minor quartz; the hornblende is poikilitic. Carbonate, titanite, apatite, and opaques are minor accessories.

Jack Creek Amphibolite

The Jack Creek amphibolite is in west-central Methuen township, on the east side of Jack Creek, lots 15–17, concessions X and XI. The amphibolite body has a length of 1 mile and a width of ¼ mile. It intrudes para-amphibolite, marble, and quartzite of the Blue Mountain metasedimentary band.

The rock is a rather uniform, foliated, dark-coloured biotite amphibolite, with a pronounced metamorphic lineation or foliation striking northeast, parallel to the foliation in the metasediments. Under the microscope the amphibolite consists of a xenomorphic granular-granoblastic mosaic of hornblende and plagioclase. Quartz, garnet, and biotite are characterizing accessories, with titanite, apatite, and opaques as minor accessories. Plagioclase ranges from andesine (An_{42}) to labradorite (An_{52}). The body is probably a metamorphosed gabbro.

Grassy Creek Ultrabasic Intrusive

To the north of the Jack Lake amphibolite there is a second basic intrusive body, the Grassy Creek ultrabasic intrusive, which lies on the southeast side of Jack and Grassy creeks, in lots 18–20, concessions VIII and IX, Methuen township. This body has a length of 1½ miles, and a width of about 1,000 feet; its strike parallels that of the para-amphibolite and marble, which it intrudes.

The body is mainly altered to amphibolite, but there are some relicts of the original ultrabasic intrusive. One sample from lot 20, concession VIII, was peridotite consisting of sheared and shattered olivine and pyroxene, with green spinel, rutile, opaques, and secondary hornblende as accessories. A sample from lot 19, concession IX, was garnet hornblendite consisting mainly of garnet and hornblende, with accessory green spinel and opaque minerals.

Other Basic Intrusives

A peridotite dike occurs in lot 13, concession XII, on the west boundary of the township, north of the Nephton road. This dike is well exposed on the power line, 1,000 feet north of the road. The dike strikes northeast, and two outcrops, 400 feet apart, occur on strike. The dike intrudes sandy paragneiss. Thin-section examination indicates that the rock consists of altered olivine and pyroxene, with accessory green spinel and magnetite.

One-quarter mile northeast along strike, in the low ground adjoining the east side of the Blue Mountain nepheline syenite, another outcrop of what may be a continuation of this peridotite dike was observed. This second dike also strikes northeast and is exposed again on the mine road below the southwesternmost nepheline syenite quarry. This dike is also peridotite, composed of serpentinized olivine and pyroxene. It appears to cut the paragneiss and amphibolite that flanks the nepheline syenite at this point, but contacts are not exposed.

A narrow basic dike occurring in Methuen granite on the east shore of Kasshabog Lake, in lot 13, concession VII, proved on microscopic examination to be a fine-grained, xenomorphic granular biotite-hornblende rock with accessory magnetite and apatite. No feldspar is present.

Several narrow amphibolite dikes and sills intruded the Lasswade marble in northwest Methuen township. Some of these narrow, 15- to 20-foot, dikes are traceable for over a mile in length. Microscopic examination of two specimens from different dikes, in lot 27 and lot 30, concession VIII, indicates that the amphibolite dikes are composed of xenomorphic granular-granoblastic mosaics of hornblende and plagioclase, with accessory titanite, magnetite, carbonate, chlorite, apatite, and biotite. The plagioclase of one dike was oligoclase (An_{20}), and that of the other, andesine (An_{35}).

A large basic intrusive body now largely altered to amphibolite occurs intruding marble and para-amphibolite, south of Sugarbush Lake, in north-central Methuen township, lots 26 and 27, concessions IV and V. Although most of the body, which measures ¾ mile in diameter, is amphibolite composed of a granoblastic mosaic of medium-grained hornblende and plagioclase, some gabbroic and coarse hornblendite facies occur. A coarse hornblendite from lot 27, concession V, consists of hornblende and pyroxene, with accessory epidote, plagioclase, and titanite. Plagioclase, in one thin section of amphibolite examined, is andesine (An_{45}). The rock is massive in appearance and dark in colour.

BLUE MOUNTAIN NEPHELINE SYENITE

The nepheline syenite occurs in one single body in west-central Methuen township. The intrusive consists of an elongate, irregular-shaped stock lying east of Grassy Lake, having a length of 2½ miles in a north-south direction, and a width of 1¼ miles in an east-west direction. A long sill-like arm, up to ¼ mile wide, extends southwest from the main mass to the west of Grassy Lake, for a distance of 4 miles. The nepheline syenite intrudes and partially replaces para-amphibolite, paragneiss, and marble of the Blue Mountain metasedimentary band. The nepheline syenite itself is intruded and replaced by pink syenite and syenite pegmatite.

The southwest arm of the nepheline syenite forms a prominent ridge standing up 150–200 feet above the surrounding country. This ridge lies northwest of Little Mountain and Big Mountain lakes, and the quarry operations of American Nepheline Limited are located on Cabin Ridge west of Big Mountain Lake. The nepheline syenite of Cabin Ridge is foliated; the foliation strikes northeast, parallel to the trend of the ridge, and dips steeply southeast.

The main body of nepheline syenite lying between St. Charles Lake and Devils Lake stands up in a series of high ridges, 200 feet in relief above the surrounding peneplane. The quarry operation of International Minerals and Chemical Corporation (Canada) Limited is located at the northeast corner of the nepheline syenite body, just west of Barrette Lake.

The nepheline syenite shows a marked foliation along the west contact to the north of Grassy Lake. The foliation strikes northeast and dips southeast at 40–50 degrees. The nepheline syenite is strongly foliated along the east contact of the intrusive, just west of the railway line. Here the foliation again strikes northeast, paralleling the contacts, and dips vertically or steeply northwest or southeast.

The nepheline syenite body appears to occupy the trough of a syncline plunging gently (20°) southwest. The southwest arm occupies the west arm of the syncline. The trough of the syncline passes northeast through Grassy Lake, and the main body of the nepheline syenite is emplaced in the trough and intrudes the east arm of the syncline east of Grassy Lake. The foliation of the nepheline syenite indicates a synclinal structure pitching southwest, with Grassy Lake lying in the trough of the syncline. A strong lineation of mafic minerals in the nepheline syenite indicates a trend and plunge of 20°SW.

Although the nepheline syenite is well foliated near the contacts in a zone at least ¼ mile wide, in the central part of the main mass the rock is poorly foliated, and strike and dip of foliation was either absent or measured with difficulty. In places the foliation, where it can be found, appears to be horizontal. However, throughout the whole mass there is a well-developed metamorphic lineation, and the trend of lineation can everywhere be measured on horizontal surfaces. On vertical surfaces parallel to the trend of lineation, the plunge of

lineation, usually 10°–30°SW., can be measured. However, although careful attempts were made, it was frequently impossible to find any dip of foliation on vertical surfaces normal to the strike of lineation. In some places, as around the ridges making up the Grassy Lake syncline, both foliation and lineation could be measured. The presence of two lineations in some places, together with textural evidence, which will be detailed in a later section, indicates a complex metamorphic history for the nepheline syenite body. The author believes that a major part of the foliation and lineation observed is secondary and was imposed during the folding accompanying the Grenville orogeny.

Contact and Intrusive Relationships

In early descriptions of the Blue Mountain nepheline syenite, W. G. Miller,[1] and Adams and Barlow[2] regarded the body as an intrusive rock. The first detailed work was done by M. L. Keith,[3] who mapped the deposit; he described the zoned mineral distribution, and interpreted the body as an intrusive stock. Subsequently D. R. Derry, consulting geologist for American Nepheline Limited, published a paper[4] postulating a non-intrusive origin for the Blue Mountain nepheline syenite. He thus supported the views expressed by Gummer and Burr[5] of the origin of the Bancroft nepheline syenites by a

> . . . process of "nephelinization," in which certain impure calcareous sedimentary horizons were attacked and replaced by solutions from some unknown but probably granitic source, resulting in the deposition of nepheline and sodic plagioclase *without the formation of an actual nepheline-syenite magma*, which has been postulated by proponents of the syntexis theory.[6]

A later paper by C. Friedlaender upheld this view that Blue Mountain nepheline syenite was of non-intrusive origin:

> It is believed by the present author that the alkaline rocks of Blue Mountains were formed at low temperature, without liquid mixing, by action of hydrothermal solutions and/or gases on sediments including paragneisses and, to some extent, limestone.[7]

Recently C. V. G. Phipps[8] remapped the Blue Mountain nepheline syenite, under the direction of Dr. Derry, for American Nepheline Limited, paying particular attention to the structure of the body. A summary of the conclusions reached by Derry and Phipps as the result of this study is given in a later paper.[9] They re-affirm Derry's views that the Blue Mountain body was produced by a process of nephelinization of a pre-existing sedimentary structure.

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[1] Willet G. Miller, "Economic Geology of Eastern Ontario; Corundum and Other Minerals," *Annual Report*, Ont. Bur. Mines, Vol. VII, 1898, pt. 3.
Willet G. Miller, "Corundum and Other Minerals: Corundum Areas of Ontario," *Annual Report*, Ont. Bur. Mines, Vol. VIII, 1899, pt. 2.

[2] F. D. Adams and A. E. Barlow, *Geology of the Haliburton and Bancroft Areas, Province of Ontario*, Geol. Surv. Can., Memoir No. 6, 1910.

[3] M. L. Keith, "Petrology of the Alkaline Intrusive at Blue Mountain, Ontario," *Bulletin*, Geol. Soc. Amer., Vol. 50, 1939, No. 12, pt. 1, pp. 1795–1826.

[4] D. R. Derry, *op. cit.*

[5] W. K. Gummer and S. V. Burr, "Nephelinized Paragneisses in the Bancroft Region, Ontario," *Journal of Geology*, Vol. LIV, No. 3, 1946, pp. 137–68.

[6] *Idem.*, p. 137 (italics in quotation are by D. F. Hewitt).

[7] C. Friedlaender, "Alkaligesteine von Blue Mountains, Ontario," Schweig. Min. Petr. Mitt., Vol. 32, 1952, pp. 213–42.

[8] C. V. G. Phipps, *The Petrology and Structure of the Alkaline Rocks of the Blue Mountain Area*," unpublished Ph.D. thesis, Univ. of Toronto, 1955.

[9] D. R. Derry and C. V. G. Phipps, "Nepheline Syenite Deposit, Blue Mountain, Ontario," *Geology of Canadian Industrial Minerals*, Volume, Sixth Commonwealth Mining and Metallurgical Congress, 1957, pp. 190–95.

Two of the reasons for this conclusion for the origin of the Blue Mountain nepheline syenite concern contact and intrusive relationships. These are stated as follows in Derry's earlier paper:[1]

1) The nepheline syenite has never been seen to show intrusive relationships towards the paragneiss, nor to any other rock. On the other hand the nepheline syenite is intruded by "biotite dikes," and by the red syenite.

. . . . . .

3) Contacts with paragneiss, where exposed, are gradational and their attitude is conformable to the strike and dip of the layer as a whole.

In the later papers no further detailed descriptions of the contact relationships of the body are given, and the author considered that a closer examination of the contacts of the nepheline syenite with the enclosing rocks would be warranted.

Significant contact or intrusive relationships are described by the author at twelve different localities on the Blue Mountain. Numbers in text correspond to those on the overprint of the aerial photograph in the map case.

1. *Southwest End of Blue Mountain; Lots 12 and 13, Concessions XI and XII.*—The southwest end of the Blue Mountain ridge was examined to find out what happened to the nepheline syenite at that end of the body. At the southwest end of the ridge the grey nepheline syenite is engulfed and replaced by pink alkaline syenite. However, in lot 13, concession XI, the width of the pink syenite band, which carries interbanded relicts of grey nepheline-poor albite gneiss, narrows down to less than 100 feet, and is flanked on both sides by biotite paragneiss. Farther southwest, on the township boundary of Methuen, the nepheline rock disappears, and only a narrow (100-foot) band of pink leucosyenite gneiss persists.

One thousand feet south, on the Nephton road near the township boundary, a second narrow band of white biotite nepheline syenite in pink syenite gneiss begins. It is separated from the end of the Blue Mountain body by a wide band of biotite paragneiss (BM gneiss described earlier). This parallel band extends southwest into Burleigh township. The nepheline gneiss was not traced along strike through Burleigh township to the shore of Stony Lake, but G. R. Guillet, geologist of American Nepheline Limited, showed the author an outcrop of grey nepheline-albite-corundum gneiss with accessory biotite and muscovite, on the north shore of Stony Lake, in concession X, Burleigh township, opposite Craig Island, which appears to be the extension of this band along strike. A chemical analysis of this rock is given in the table on page 140. (Analysis No. 6).

This nepheline band is bordered by pink syenite gneiss. It extends southwest, and is seen outcropping on Craig Island in Stony Lake. Here the nepheline-albite gneiss, with accessory biotite and muscovite, occurs in a band 10–20 feet wide, striking southwest and dipping vertically, flanked on both sides by pink alkaline syenite gneiss. Chemical analyses of both these rock types are given in the table on page 140. (Analyses Nos. 7 and 8).

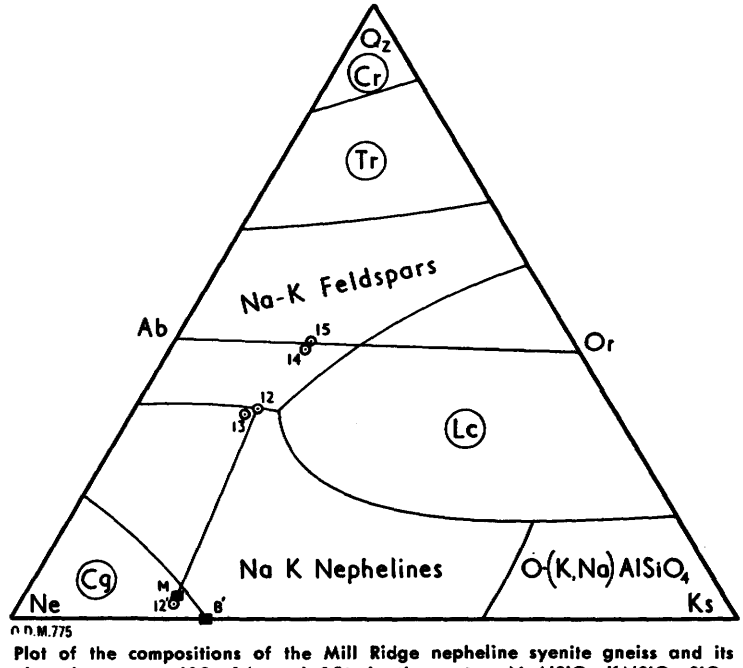
This nepheline band may sweep around in a gentle arc to the west, since a similar narrow band of grey nepheline gneiss, interbanded with pink alkaline syenite gneiss, outcrops on Casement Island in Stony Lake, about 2 miles west of Craig Island.[2] Mr. Guillet and the author were unable to locate any westward extension of this band along the shore of the mainland.

[1]D. R. Derry, "The Lakefield Nepheline Syenite; Evidence of a Non-Intrusive Origin," *Transactions*, Royal. Soc. Can. Section IV, Third series, Vol. XLV, 1951, p. 39.

[2]See Map No. 1957b, *Haliburton-Bancroft Area.* Scale, 1 inch to 2 miles. Ont. Dept. Mines, 1957.

2. *Old Quarries in Nepheline Syenite Ridge; Lot 13, Concession X.*—In the old quarries on the southeast side of the nepheline syenite ridge, lot 13, concession X, Methuen township, the intrusive relations between the pink alkaline leucosyenite and the grey nepheline syenite are well displayed. The pink alkaline syenite intrudes and replaces grey nepheline syenite. Near the pink syenite contact, microcline is developed in the nepheline syenite, and the nepheline is altered to a white opaque fibrous aggregate of micaceous or zeolitic minerals. Along joints in the nepheline syenite, solutions from the pink alkaline leucosyenite have caused bands of alteration to penetrate the nepheline rocks. Usually there are three bands: a green chlorite or "gieseckite" alteration adjacent to the joint; then a pink "hydronephelite" type alteration penetrating 2–6 inches into the rock; and finally a further zone of alteration in the rock, where, although no colour change has taken place, microcline is introduced, and the nepheline shows the hydrous alteration described above.

PETROGRAPHIC NOTES BY C. E. TILLEY
(ALTERATION ALONG JOINT PLANES IN THE NEPHELINE SYENITE GNEISS)



Plot of the compositions of the Mill Ridge nepheline syenite gneiss and its alteration zones (13, 14, and 15) in the system $NaAlSiO_4$–$KAlSiO_4$–SiO_4. 12—12' represent the compositions of a nepheline syenite gneiss (12) from Cabin Ridge Quarry and its contained nepheline (12'). M and B' nepheline compositions: M, Morozewicz formula; B', Buerger formula.

The type of alteration developed along the joint planes of the Blue Mountain alkali mass is illustrated in the photograph on page 128, a specimen from Mill Ridge Quarry. The white nepheline syenite gneiss passes out to the joint face into a pink zone (2–3 inches wide) followed by a grey zone of comparable thickness. Studied in thin section the white unaltered nepheline rock is seen to be built of albite, microcline, and nepheline with subordinate magnetite fringed around which are plates of muscovite with rarer biotite. Muscovite appears also as scattered plates in the body of the rock. The rock contains 27 weight percent

nepheline, 18 percent microcline, and 52 percent albite, with magnetite and muscovite 3 percent. In the pink zone the texture is unchanged, but the nepheline is replaced pseudomorphously by a fine felted sericite (gieseckite) stained in part with ferric oxide, which gives the assemblage its pink tint. This zone is followed by the grey zone with a similar texture, the nepheline being replaced as before by sericite, but the replacement product is here more turbid, and in hand specimens the pseudomorphs themselves are light green in colour.

CHEMICAL ANALYSES
(Analyses by J. H. Scoon)

	No. 13	No. 14	No. 15
SiO_2	58.4	58.4	58.2
Al_2O_3	24.8	25.2	24.7
Fe_2O_3	0.75	0.85	0.83
FeO	0.46	0.47	1.04
MnO	0.01	0.03	0.03
MgO	0.14	0.58	1.46
CaO	0.59	0.88	0.60
Na_2O	10.48	6.89	6.35
K_2O	4.34	4.66	4.51
H_2O+	0.40	2.24	2.65
H_2O-	0.02	0.05	0.17
TiO_2	nil	nil	0.01
P_2O_5	0.01	0.01	0.02
CO_2	0.10	0.13	0.15
Total	100.50	100.39	100.72

NORM

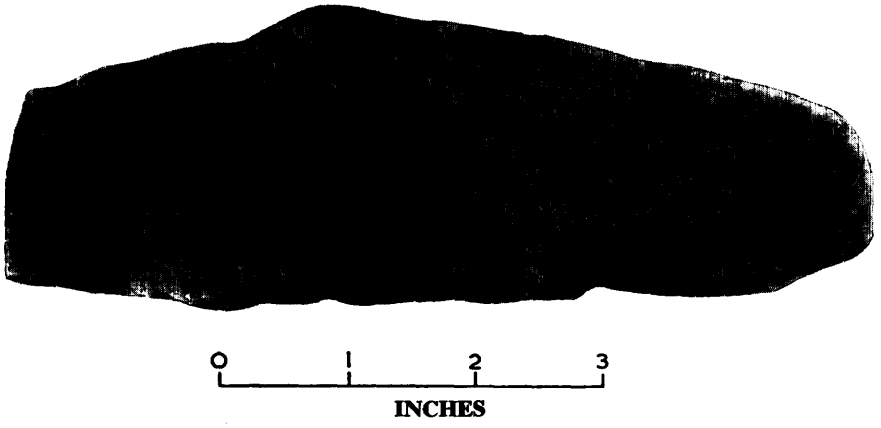
	No. 13	No. 14	No. 15
Qz	.....	.....	0.60
Or	25.58	27.80	26.69
Ab	44.27	54.62	53.45
Ne	24.00	1.91	.....
Cor	1.94	7.45	8.62
An	2.50	3.61	2.08
Ol	0.51	1.18	.....
Hyp	.....	.....	4.79
Mt	0.93	1.16	1.16
Ct	0.23	0.30	0.34
Rest	0.44	2.33	2.88
Total	100.40	100.36	100.61

CO-ORDINATES IN SYSTEM NE-KS-QZ

Ne	51.2	37.3	35.9
Ks	15.5	18.8	18.8
Qz	33.3	43.9	45.3

No. 13—White nepheline syenite gneiss, Mill Ridge Quarry, Blue Mt., Ontario (1177/64717).
No. 14—Pink alteration zone along joint in No. 13 (Zone 1).
No. 15—Grey alteration zone along joint in No. 13 (Zone 2).

Analyses of the nepheline syenite gneiss and of the two altered zones are set out in the accompanying table, analyses Nos. 13, 14, and 15. The chemical changes noted can be interpreted in terms of replacement of nepheline only by the sericite product. The silica percentage remains effectively unchanged, while there is a notable reduction of the soda content, a smaller increment in potash, and a large



Nepheline syenite gneiss of Mill Ridge Quarry, Methuen township, Peterborough county, with two alteration zones developed at joint surfaces. On the right is unaltered gneiss with magnetite. To the left this passes sharply into a pink zone, which is succeeded by the grey zone at the joint face. The unaltered rock and the two zones are described in the text, and analyses by J. H. Scoon are shown in the accompanying table (Nos. 13–15).

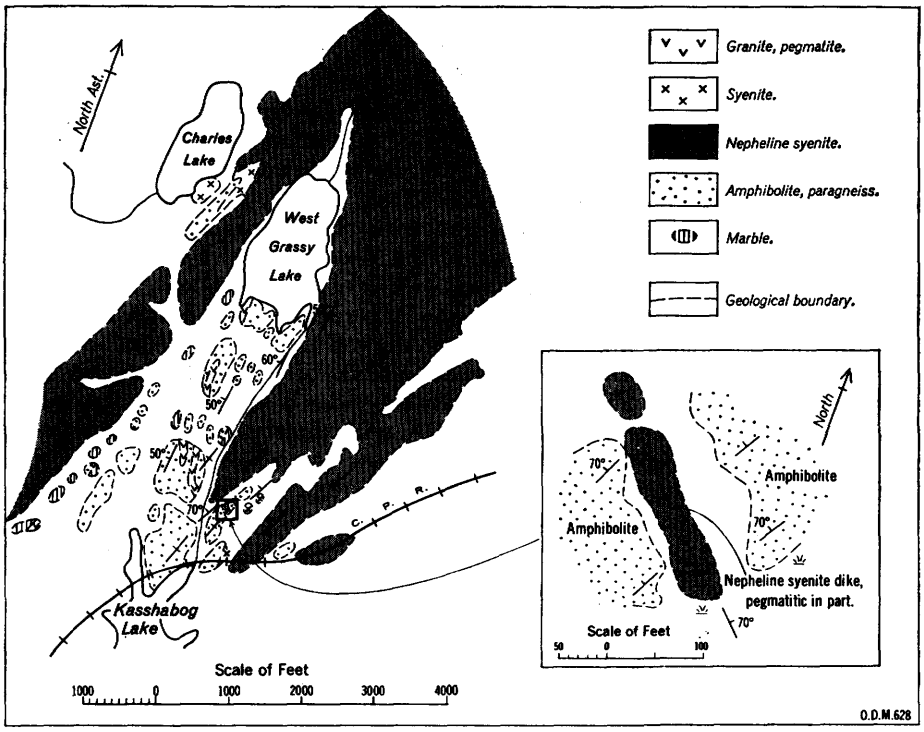
increase in water. Nepheline disappears from the norm, and with the incoming of the sericite, corundum becomes a significant normative mineral (analyses Nos. 14 and 15). The small amount of normative corundum in the unaltered nepheline syenite gneiss is accounted for by its content of muscovite as a primary phase. The three analyses are plotted in the system $NaAlSiO_4$–$KAlSiO_4$–SiO_2 where it is seen (figure, p. 126) that the unaltered rock plots in the normal position of the Blue Mountain nepheline syenite gneisses, whereas the two altered zones are represented in the plot on or close to the feldspar join near the "syenite" minimum.

C.E.T.

3. *East Contact of Mill Ridge; Lot 14, Concession IX.*—Along the northwest shore of Big Mountain Lake a tongue of leucocratic nepheline syenite intrudes like a prong extending southwest into the para-amphibolite of the Blue Mountain sedimentary band. Between this nepheline syenite along the lakeshore and the main mass of nepheline syenite making up Mill Ridge to the west, there is a band of amphibolite about 100 feet wide. This amphibolite band is exposed in outcrops along the road between the primary crusher building and Cabin Ridge quarries. On the north side of the road, in lot 14, the contact between the amphibolite and the white leucocratic nepheline syenite is exposed. The nepheline syenite cuts across the foliation of the para-amphibolite at an angle of about 15 degrees and appears to be a normal sharp knife-edge intrusive contact, with no nephelinization of the black biotite amphibolite adjacent to the contact. The white alkaline syenite adjacent to the contact is poor in nepheline and consists predominantly of albite. There is no hybrid or mixed gneiss zone at the contact.

4. *Cabin Ridge Quarries; Lot 15, Concession VIII.*—At the foot of Cabin Ridge along the eastern contact of the nepheline syenite, quarrying operations have stripped the intrusive close to the amphibolite-paragneiss contact. Although the contact itself is in a draw, the stripping has indicated that, although the general trend of the contact is conformable with the foliation of the metasediments, in detail there are irregular tongues of nepheline syenite in the amphibolite, and horses of amphibolite in the margins of the nepheline syenite.

5. *West Contact of Blue Mountain Ridge; Lot 16, Concession VIII.*—At this locality along the west contact of Blue Mountain, in lot 16, concession VIII, the light-coloured biotite paragneiss described in an earlier section as the BM gneiss occurs in contact with nepheline syenite. The BM gneiss is a paragneiss of distinctive lithology and was recognized in several places along the west contact of the Blue Mountain nepheline syenite. At this locality the BM gneiss appears to have been albitized and nephelinized; both albite and nepheline appear to have been introduced into the rock. The contact might here be truly described as gradational. The author interprets this as a bona fide case of nephelinization of



Nepheline syenite dike cutting sediments, lot 17, concessions VII and VIII, Methuen township.

a permeable sedimentary bed by action of the adjacent nepheline syenite intrusive. The presence of this hybrid mixed gneiss along the contact zone at this locality indicates the type of relationship to be expected where nephelinization has taken place.

Most of the contact examined by the author, as detailed here, shows a normal sharp transgressive intrusive contact, lacking nephelinization of adjacent metasediments. The fact that most of the contacts do not show a nephelinized hybrid zone, indicates that, although nephelinization does accompany intrusion of the Blue Mountain nepheline syenite, it is of limited extent occurring only under favourable conditions. Just as granitization may accompany the intrusion of granites under certain conditions, so too nephelinization may accompany intrusion of nepheline syenite.

6. *South End of Grassy Lake Ridge; Lot 17, Concessions VII and VIII.*—At this locality, in lot 17, concessions VII and VIII, about ½ mile south of Grassy Lake, on the east side of the nose of the Grassy Lake nepheline syenite ridge, there is a nepheline syenite dike, pegmatitic in part, cutting across well-banded

sedimentary amphibolite. The outcrop is easily accessible as it is only 10 chains north of the railway embankment at Kasshabog Lake, The dike is exposed over a length of 150 feet, is 20–25 feet wide, and strikes N.30°W. and dips northeast at 70 degrees. The country rock (sedimentary amphibolite) strikes N.30°E. and dips northwest at 70 degrees. These relations are indicated on the accompanying sketch map. The dike appears to be an offshoot from the main Grassy Lake nepheline syenite ridge. This is a new occurrence, not previously mapped.

The dike rock consists mainly of nepheline and plagioclase, with accessory muscovite, aegirine, and hastingsite; some parts are pegmatitic.

Petrographic Notes By C. E. Tilley

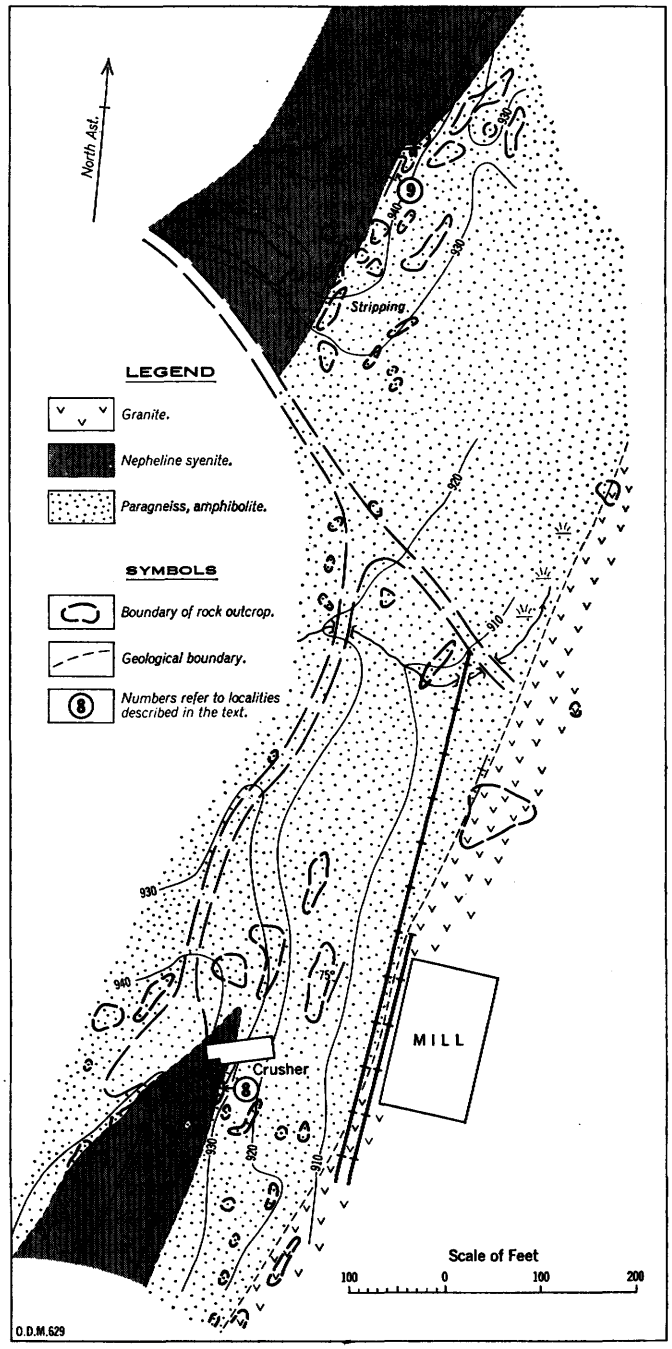
Three specimens of the nepheline syenite gneiss dike cutting the sediments north of Kasshabog Lake were supplied for study by Dr. Hewitt. Of these one collected from the middle portion of the dike was analyzed by Mr. Scoon; the two remaining specimens were collected from the northwest and southeast ends of the dike. The specimen analysed (1728/65268) is a typical nepheline syenite gneiss, closely comparable in composition with the assemblages recorded from Cabin Ridge Quarry at the south end of the Blue Mountain mass. (Analysis, accompanying table). It is coarse grained with conspicuous though not abundant dark minerals, principally hastingsite with a layered distribution giving rise to a faint banding. The felsic minerals are albite, microcline, and nepheline; cancrinite is also present associated chiefly at the boundaries of the nepheline grains, and there is a trace of fluorite. The mafic minerals besides hastingsite are subordinate aegirine, some green biotite, and magnetite, with andradite recorded as a rare accessory. The modal composition of the analysed specimen is (weight percent) albite, 47; nepheline, 29, including a little cancrinite; microcline, 21; and mafics 3, dominantly hastingsite, with biotite, aegirine, and magnetite subordinate.

Analysis of Nepheline Syenite Gneiss (Hastingsite, Biotite, Aegirine), Lot 17, Concessions VII and VIII, Methuen Township

Chemical Analysis		Norm	
SiO_2	58.72	Or	30.86
Al_2O_3	23.07	Ab	39.30
Fe_2O_3	0.93	Ne	25.56
FeO	0.91	An	1.25
MnO	0.04	Di	0.62
MgO	0.03	Ol	0.46
CaO	0.53	Mt	1.39
Na_2O	10.20	Ct	0.32
K_2O	5.23	Rest	0.49
H_2O+	0.36		
H_2O-	0.06		100.25
TiO_2	<0.01		
P_2O_5	0.01	Co-ordinates in System Ne–Ks–Qz	
CO_2	0.14	Ne	49.0
SO_3	nil	Ks	18.3
	100.23	Qz	32.7

The specimens from the ends of the dike are distinguished by their albitic character and the presence of coarse muscovite and biotite. Nepheline has been replaced by fine sericite and secondary coarser grained muscovite. Prehnite is also present. A conspicuous feature is the almost total absence of potash feldspar. These assemblages would appear to represent later modified derivatives of the central part of the dike illustrated by the analysed specimen.

C.E.T.



Geological map showing nepheline syenite – paragneiss contact at the Canadian Flint and Spar property of International Minerals and Chemical Corporation (Canada) Limited, Blue Mountain.

7. *Kasshabog Sedimentary Embayment; Lot 18, Concessions VI and VII.*—Interesting and significant relationships between the sediments and the nepheline syenite are disclosed in the Kasshabog sedimentary embayment, in lot 18, concessions VI and VII. A band of marble and para-amphibolite, 300–400 feet wide, extends northeast from Kasshabog Lake for a distance of 1½ miles into the nepheline syenite body. The sediments strike N.40°E. and dip 70°SE. The main Grassy Lake nepheline syenite ridge flanks the metasediments to the northwest; a 600-foot-wide tongue of nepheline syenite and pink syenite, intruding southwest from the main nepheline syenite, flanks the metasediments along the railway line to the southeast.

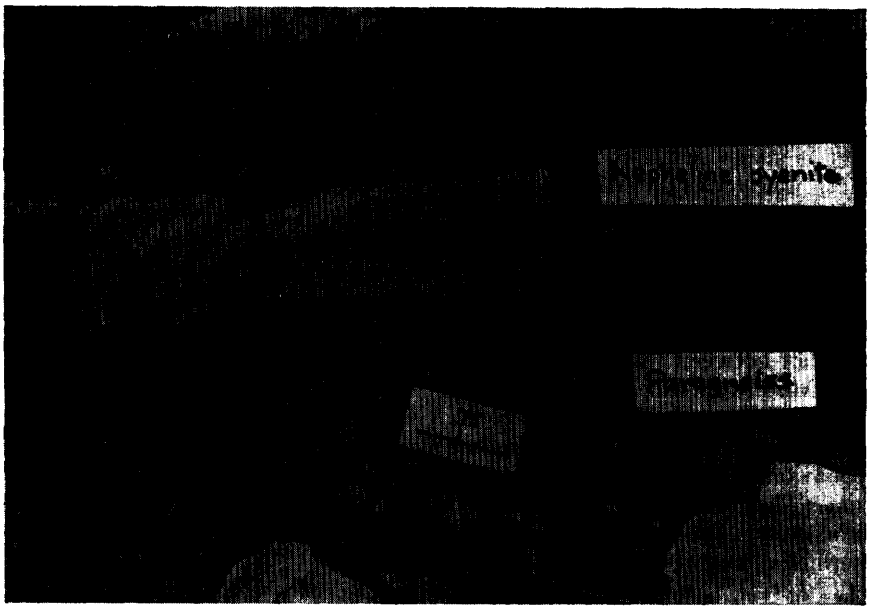
In lot 18, concessions VI and VII, the metasedimentary band occupies a wide embayment in the nepheline syenite. The metasedimentary rocks in this embayment strike N.40°E. and dip 50–70°SE., in conformity with the regional structure. A section of 1,400 feet of sediments is indicated; this consists of marble, lime silicate rock, amphibolite, biotite amphibolite, feather amphibolite, quartzite, diopsidic quartzite, and minor biotite paragneiss. Tongues of nepheline syenite intrude the embayment from northeast and southwest. No indication of isoclinal folding in the attitude of the metasedimentary rock, nor in the attitude of foliation or lineation in the nepheline syenite was observed. However, no top determinations could be made in the metasediments.

The contacts of the nepheline syenite with the metasediments are not exposed, but along the northwest side of the embayment, lineation in the nepheline syenite strikes N.60°E. and pitches southwest, although the bedding of the metasediments along this contact strikes N.37°E. and dips 50°SE. This indicates a discrepancy of 23 degrees between the bedding of the sediments and the lineation of the nepheline syenite.

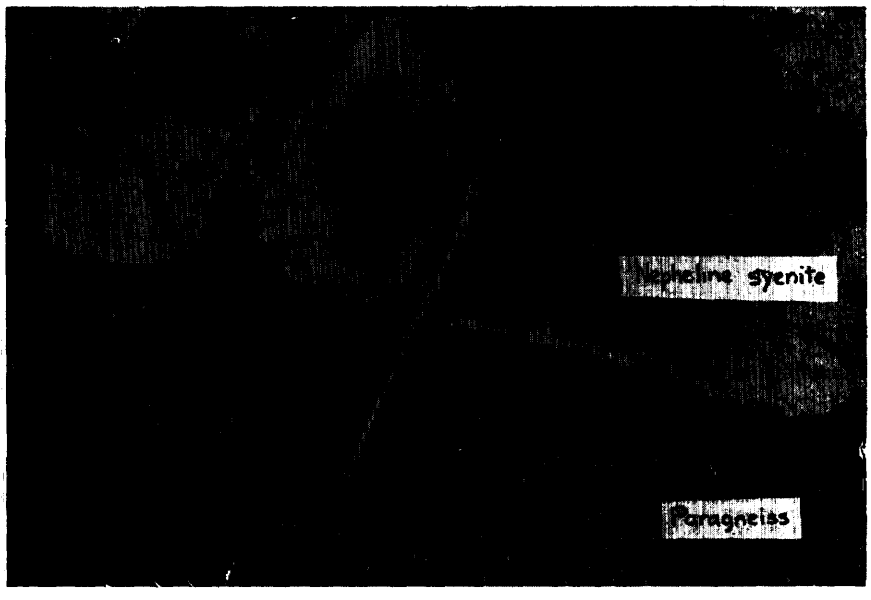
8. *International Minerals and Chemical Corporation (Canada) Limited; Lot 19 or 20, Concession VI.*—The best place in the township to see contact relationships between the nepheline syenite and the metasediments is along the east contact of the nepheline syenite, near the mill of International Minerals and Chemical Corporation (Canada) Limited. Between Devils and Barrette lakes a band of metasedimentary rock, 500 feet wide, lies between the Methuen granite and the nepheline syenite ridge. A narrow tongue of nepheline syenite, 100–200 feet wide, intrudes this amphibolite band from the southwest. The tongue has a length of about ½ mile, and is separated from the main nepheline syenite ridge, except at its south end, by a narrow band of amphibolite.

The intrusive contacts of the tongue of nepheline syenite with the limy amphibolite and paragneiss is well shown at the north end of the tongue, in lot 19 or 20, concession VI, near the primary crusher installation. The transgressive contact was well exposed in the rock excavation for the crusher footings. At present the contact is exposed 20 feet south of the crusher on the hillside. The nepheline syenite cuts across the bedding of the sediments at an angle of about 20 degrees, as indicated in the accompanying photos. On the west side of the tongue, the contact is exposed in three places, as shown on the accompanying plane-table map. The contact was planetabled by the author on a scale of 50 feet to 1 inch, and the plane-table map is reproduced in the accompanying figure.

9. *Lot 20, Concession VI (900 feet north of Locality 8).*—On the accompanying plane-table map it will be seen that the contact of the main nepheline syenite ridge and the metasedimentary rocks is again exposed, 900 feet north of the crusher, in bulldozed strippings. Here the contact was exposed in three places,



Nepheline syenite – paragneiss contact, International Minerals and Chemical Corporation (Canada) Limited (Canadian Flint and Spar property), Blue Mountain.



Sharp contact of nepheline syenite and paragneiss — no nephelinization.

and although the contact may be termed conformable when mapped on a scale of 1 inch to ¼ mile, when mapped at 1 inch to 50 or 20 feet it is seen to be irregular and crosscutting in minor detail.

On the east shore of Devils Lake the metasedimentary band narrows to a width of 6 chains between the nepheline syenite and Methuen granite. It is mainly amphibolite with some feather amphibolite. The contact is again exposed, and narrow fingers of nepheline syenite run out into the amphibolite.

Wherever the contact is exposed as described at Localities 8 and 9, the contact is sharp, with no indication of hybridization or nephelinization at the contact. The rocks on either side of the contact are widely different rock types. There is no evidence of chilling of the borders of the nepheline syenite, since both nepheline syenite and metasediments have been recrystallized by metamorphism, which produced the secondary lineation in the nepheline syenite and in the metasediments.

10. *Lot 21, Concession VI.*—Near the powder house in lot 21, concession VI, the contact between feather amphibolite and nepheline syenite at the north end of Blue Mountain can be seen.

11. *Lots 21 and 22, Concession VI.*—A narrow tongue of nepheline syenite extends northeastward into the metasediments. All along this north contact, the foliation of the metasediments is at right angles to the nepheline syenite contact. The foliation or lineation of the nepheline syenite is also at right angles to the contact; the strikes of both rock types are north-northeast. Lineation in the nepheline syenite pitches southwest.

12. *Lot 22, Concessions VI and VII.*—At Locality 12, at the northwest end of Blue Mountain, a marble band, 1,000 feet wide, is truncated against the north contact of the Blue Mountain nepheline syenite.

Mineralogy and Chemical Composition

Detailed descriptions of the mineralogy and mineral variations in the Blue Mountain nepheline syenite are given by M. L. Keith[1] and C. V. G. Phipps.[2] The reader is referred to their papers for a more comprehensive description. The following is only a summary and commentary.

MINERAL COMPOSITION—BLUE MOUNTAIN NEPHELINE SYENITE

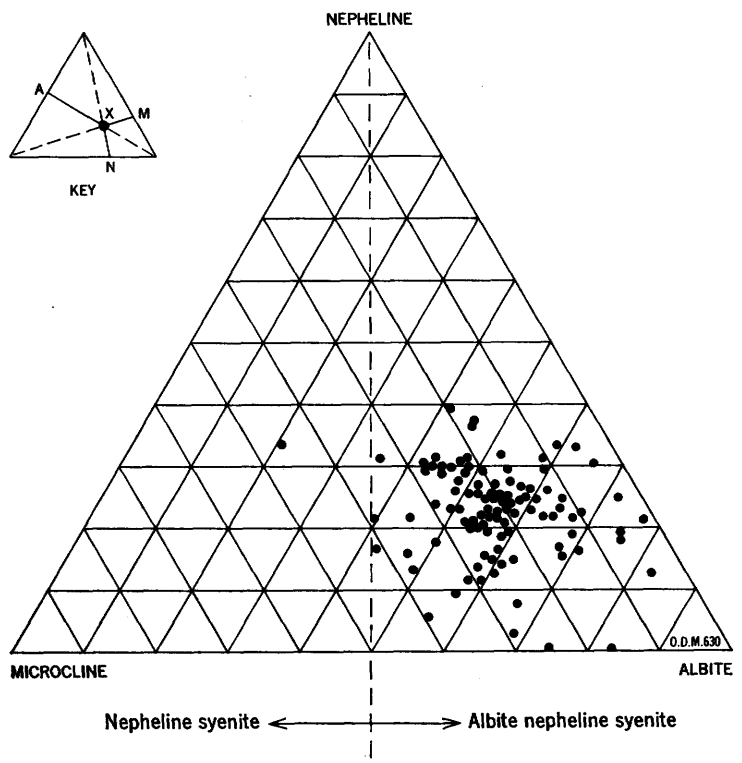
Essential Minerals (90–95 percent)		Characterizing Accessories (3–6 percent)	Minor Accessories	Secondary Hydrothermal and Pegmatitic Minerals
	Average Range[1] percent	Magnetite and ilmenite	Muscovite	Epidote
Nepheline	10–35	Biotite	Garnet	Riebeckite
Microcline	10–37	Hastingsite	Corundum	Zeolites:
Plagioclase (usually albite An_5, sometimes oligoclase to An_{26})	40–73	Aegirine	Zircon	Natrolite
Perthite or antiperthite			Calcite	Prehnite
			Apatite	Analcite
			Titanite	Hydronephelite
			Allanite[2]	Cancrinite
				Sodalite
				Tourmaline
				Lavenite (?)

[1]See M. L. Keith, "Petrology of the Alkaline Intrusive at Blue Mountain, Ontario," *Bulletin*, Geol. Soc. Amer., Vol. 50, 1939, No. 12, pt. 1, Figure 3. The figure from Keith's report is also reproduced on page 135 of this report.
[2]Reported by G. R. Guillet.

[1]M. L. Keith, "Petrology of the Alkaline Intrusive at Blue Mountain, Ontario," *Bulletin*, Geol. Soc. Amer., Vol. 50, 1939, No. 12, pt. 1, pp. 1795–1826.
[2]C. V. G. Phipps, *The Petrology and Structure of the Alkaline Rocks of the Blue Mountain Area*, unpublished Ph.D. thesis, Univ. of Toronto, 1955.

The Blue Mountain nepheline syenite is a rather uniform, foliated or lineated, fine- to medium-grained (0.5–1.0 mm.) leucocratic rock, composed essentially of nepheline, albite, and microcline. Characterizing accessories are magnetite, biotite, hastingsite, and aegirine. Minor accessories are muscovite, garnet, corundum, zircon, calcite, apatite, and titanite. Secondary hydrothermal and pegmatitic minerals include epidote, riebeckite, natrolite, prehnite, analcite, hydronephelite, cancrinite, sodalite, and tourmaline. C. Friedlaender[1] tentatively identified lavenite.

An average of 112 Rosiwal modal analyses of thin sections of the Blue Mountain nepheline syenite is given by Keith[2] as follows:



Ternary diagram showing composition of Blue Mountain alkaline intrusive, based on over 100 Rosiwal analyses. (M. L. Keith.)

	Modal Analysis Percent
Albite	54
Microcline	20
Nepheline	22
Muscovite	2
Mafic minerals	2
	100

[1]C. Friedlaender, "Alkaligesteine von Blue Mountains, Ontario," Schweig. Min. Petr. Mitt., Vol. 32, 1952, pp. 220, 221.

[2]M. L. Keith, *op. cit.*, p. 1806.

ROSIWAL MODAL ANALYSES OF FIVE SAMPLES OF THE BLUE MOUNTAIN NEPHELINE SYENITE

Mineral	Sample No. and Location				
	H5731, Lot 21, Con. VI	H5733, Lot 20, Con. VI	H5734, Lot 20, Con. VII	H5737, Lot 19, Con. VI	H5736, Lot 19, Con. VII
Nepheline	31.8	32.1	18.4	30.4	16.0
Plagioclase	49.5 (albite)	41.3 (albite)	56.0 (albite)	47.2 (oligoclase, An_{26})	51.7 (albite)
Microcline	7.5	24.5	19.2	12.4	29.2
Muscovite	9.2	.....	.....	.....	.....
Biotite	1.0	0.2	4.4	6.7	.....
Carbonate	0.1	0.9	0.4	3.3	.....
Opaques	0.9	1.0	1.5	.....	0.2
Hastingsite	.....	.....	0.1	.....	0.5
Aegirine	.....	.....	.....	.....	1.8
Zeolite	.....	.....	.....	.....	0.6
Accessory Minerals	.....	Muscovite	Epidote	.....	.....
	.....	.....	Tourmaline	.....	.....

Textures range from xenomorphic interlocking to even-grained granitoid or granoblastic.

The accompanying table gives Rosiwal analyses made by the author on five samples of nepheline syenite from the central part of the intrusive, between Barrette and Grassy lakes.

Chemical analyses of the crude rock and refined products produced by American Nepheline Limited, and by International Minerals and Chemical Corporation (Canada) Limited, are given in a previous section on economic development of nepheline syenite, pages 7 and 8.

Comments on Mineralogy and Mineral Distribution.—In bulk composition the Blue Mountain nepheline syenite is rather uniform; it falls within the Johannsen classification (leucolitchfieldite, 1119P). It is a leucocratic rock throughout the entire intrusive body; mafic minerals rarely exceed 8 percent, usually averaging 3–6 percent. Keith's ternary diagram showing the composition plot of 112 Rosiwal analyses on a ternary nepheline-microcline-albite diagram is reproduced in the accompanying figure. It can be seen that the relative nepheline to microcline to albite ratios lie in a rather restricted range. This homogeneity suggests magmatic origin.

It has been the author's experience, in the Bancroft area, that when dealing with a hybrid nepheline gneiss (produced by nephelinization or replacement of a para-amphibolite similar to that of the Blue Mountain sedimentary band), the resulting hybrid rock shows an extremely variable nepheline and mafic content, often with a migmatitic type of banding. The absence of this mixed rock structure, and the low mafic content of the leucolitchfieldite, suggest to the author that the leucolitchfieldite definitely did not result from replacement of amphibolite. Similarly, where the nepheline hybrids resulted from the replacement of marble, the plagioclase normally shows a tendency to increase in anorthite content from albite to oligoclase, or even andesine (viz., the York River nepheline band, Monteagle Minerals Limited). The plagioclase of the leucolitchfieldite is normally a very sodic albite, An_1 to An_5;[1] this narrow compositional range for the albite

[1] M. L. Keith, *op. cit.*
C. V. G. Phipps, *op. cit.*

suggests a magmatic origin rather than the replacement of marbles. Friedlaender[1] reports oligoclase as basic as An_{25-30} in some thin sections. This plagioclase has the same extinction angle as albite and might not be noted unless index or sign were checked. The author confirms that oligoclase does occur in some slides. Sample No. H5737 from lot 19, concession VI (see above table), has oligoclase An_{26}. This rock also contains 3.3 percent calcite, and the swing of the anorthite content towards the calcic end may be due to assimilation or reaction of the magma in this vicinity with inclusions of marble (i.e. the plagioclase effect[2]).

In many places the nepheline syenite is distinctly foliated, and throughout the intrusion there is a layering due to minor but distinct mineral variation between adjacent bands or layers. As pointed out previously, the mineral variations occur in a restricted range, but although the variations may be minor, they mark out readily discernable zones or layers of considerable economic interest for commercial exploitation of the deposit.

Zones or layers containing biotite and magnetite, or both, as the chief mafic accessory are quarried, and these ferromagnesian minerals are readily removed by magnetic separation. In zones containing aegirine and hastingsite, these ferromagnesian minerals occur as irregular, xenoblastic grains, intimately intergrown with albite and nepheline in such a fashion that they cannot be entirely removed from the sand-sized product by the dry-magnetic separation process. Even in cases where the hastingsite is entirely removed, the iron content may still remain too high. These zones are not favourable for quarrying for this reason, although some of the rock may be used by careful blending with other facies.

The mineral variations in the Blue Mountain body were plotted by Keith.[3] However, as Phipps[4] points out, although the mineral distribution in general is correct (except that the hastingsite zone nearly always contains aegirine), the layered character of the rock, due to the mineral variations, which may occur rather rapidly from layer to layer, makes general mapping of mineral variations on a broad scale very difficult.

The nepheline is generally clear and unaltered. Near joints or contacts with pink syenite it alters to hydronephelite, or a fibrous aggregate of micaceous and zeolites minerals. It generally occurs interstitial to albite and microcline. Variations in nepheline content of up to 20 percent, in adjacent layers in the rock, accentuate banding. Nepheline also occurs in pegmatitic patches and stringers in the rock. An analysis of the Blue Mountain nepheline reported by Keith[5] indicates a potash content of 6.15 percent and a Na_2O:K_2O ratio of about 4: 1.

Biotite and magnetite are the mafic constituents throughout much of the intrusive. Hastingsite and aegirine are also common in certain zones. Biotite may occur in small amounts in the hastingsite-aegirite zone, as noted by Phipps. The author also confirms Phipps' observation that there seems to be an inverse relationship between the magnetite content and the content of other mafic minerals. Leucolitchfieldite containing much magnetite (up to say 5 percent) may contain no other mafic. Leucolitchfieldite with abundant biotite may contain little

[1] C. Friedlaender, *op. cit.*

[2] D. F. Hewitt, *Geology of the Brudenell-Raglan Area*, Ont. Dept. Mines, Vol. LXII, 1953 pt. 5, p. 96.

[3] M. L. Keith, *op. cit.*, Plate 1, *facing* p. 1814.

[4] C. V. G. Phipps, *op. cit.*, p. 30.

[5] M. L. Keith, *op. cit.*, p. 1811.

magnetite. The author also observed that magnetite may replace biotite when the rock is recrystallized to a granoblastic gneiss. In general, biotite is commonly found in the marginal facies of the intrusive, but hastingsite tends to predominate in the central parts.

Phipps[1] has reported the presence of riebeckite in the nepheline syenite as a secondary mineral replacing aegirine or hornblende, or as vein fillings.

Corundum in fine-grained, bronze-coloured crystals occurs in the nepheline syenite of Mill Ridge on the American Nepheline property. Corundum crystals have also been reported by Phipps in two or three other localities.[2] Corundum also occurs with muscovite, in syenite pegmatites cutting syenite and nepheline syenite in other places in the area.[3] Small reddish garnet, zircon, calcite, titanite, and apatite also occur as minor accessories in places. Excellent prehnite and analcite crystals have been collected from vugs at the Cabin Ridge quarries. Cancrinite, sodalite, hydronephelite, and tourmaline sometimes occur in pegmatitic facies.

The following data and illustrations are supplied by C. E. Tilley:

CHEMICAL ANALYSES

	No. 1	No. 2	No. 1′	No. 2′	No. 2″
SiO_2	58.57	59.69	42.89	43.60	64.40
Al_2O_3	23.68	22.70	33.99	34.27	19.09
Fe_2O_3	0.66	1.31	0.36	0.25	0.31
FeO	0.90	0.67			
MnO	0.02	0.04	.....	nil	0.01
MgO	nil	0.07	nil	nil	0.04
CaO	0.35	0.56	0.23	0.40	0.05
Na_2O	9.57	10.51	16.27	15.57	1.09
K_2O	5.82	4.61	6.57	6.29	15.26
H_2O+	0.23	0.17	.....	.....	.....
H_2O-	0.08	0.02	.....	nil	nil
TiO_2	0.05	0.01	nil	nil	nil
P_2O_5	0.07	0.01	.....	.....	.....
CO_2	nil	.....	.....	.....	.....
Total	100.00	100.37	100.31	100.38	100.25

NORMS

	No. 1	No. 2
Or	34.47	27.24
Ab	36.61	45.19
Ne	23.90	23.49
Cor	1.02	.....
An	1.67	1.39
Fa	0.92	.....
Mt	0.93	1.86
Di	.....	0.68
Wo	.....	0.23
Rest	0.45	0.25
Total	99.97	100.33

[1]C. V. G. Phipps, *op. cit.*, p. 36.

[2]*Ibid.*, pp. 39, 40.

[3]See page 159.

CO-ORDINATES IN SYSTEM NE-KS-QZ

Ne	46.0	50.0
Ks	20.6	16.1
Qz	33.4	33.9

No. 1—Biotite nepheline syenite gneiss, North Quarry, Blue Mt., Ontario.
No. 2—Nepheline syenite gneiss with some andradite, Cabin Ridge Quarry, No. 2, Blue Mt.
No. 1′—Nepheline from rock, analysis 1, ($Ne_{75.1}$ $Ks_{22.2}$ $Qz_{2.7}$).
No. 2′—Nepheline from rock, analysis 2, ($Ne_{73.4}$ $Ks_{21.8}$ $Qz_{4.8}$).
No. 2″—Microcline, analysis 2, The analyzed sample estimated optically and by X rays to contain 2 percent of albite; corrected composition of potash phase is $Or_{92.5}$ $Ab_{7.2}$ $An_{0.3}$ (W. S. Mackenzie *Mineralogical Magazine*, Vol. 30, 1954, pp. 3, 5, 7,).
(*All analyses by J. H. Scoon.*)

CHEMICAL ANALYSES

	No. 4	No. 5	No. 6	No. 7	No. 8
SiO_2	59.68	59.80	59.56	58.79	63.32
Al_2O_3	23.48	22.12	24.69	23.77	18.97
Fe_2O_3	0.59	1.03	0.44	1.06	2.21
FeO	0.37	1.61	1.28	0.81	0.88
MnO	nil	0.10	0.04	0.04	0.03
MgO	0.21	0.01	0.03	0.04	0.01
CaO	0.26	4.48	0.43	0.41	1.18
Na_2O	9.52	8.72	8.80	10.69	7.28
K_2O	4.68	1.44	3.89	4.42	5.35
H_2O+	0.66	0.46	0.56	0.27	0.33
H_2O-		nil	0.04	0.01	0.02
TiO_2	nil	0.08	0.13	0.03	0.08
P_2O_5	nil	0.01	0.02	0.02	0.03
CO_2	0.04	0.26	0.19	0.05	0.63
Total	99.49	100.12	100.10	100.41	100.32

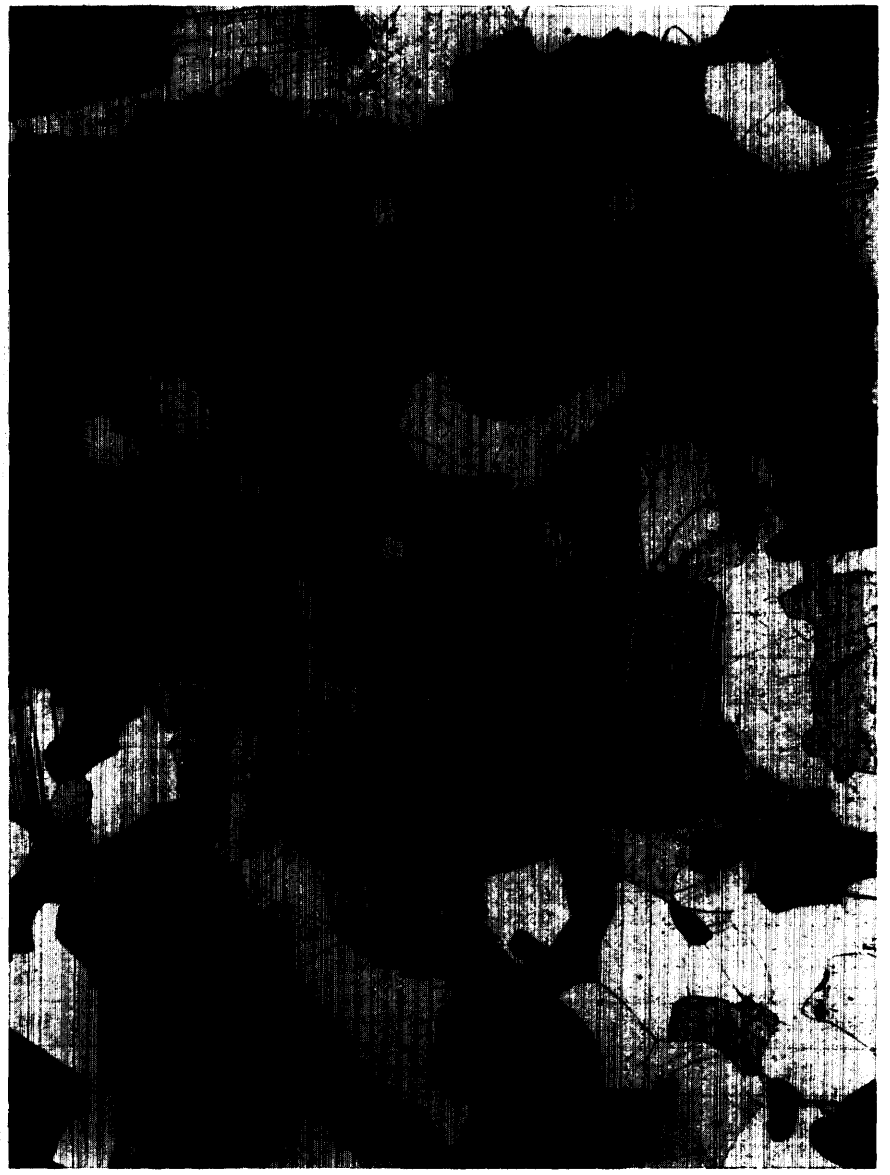
NORMS

	No. 4	No. 5	No. 6	No. 7	No. 8
Or	27.80	8.34	22.80	26.13	31.14
Ab	49.25	62.48	59.73	44.14	61.44
Ne	16.76	5.87	7.95	25.20	0.21
Cor	2.24	.....	5.81	0.71	0.51
An	1.25	17.24	0.56	1.67	1.95
Di	.....	2.97	.....	.....	.....
Ol	0.45	0.41	1.32	0.58	.....
Mt	0.93	1.39	0.70	1.39	2.78
Il	.....	0.15	0.30	.....	0.15
Ct	.....	0.54	0.43	0.11	1.43
Rest	0.70	0.48	0.69	0.37	0.74
Total	99.38	99.87	100.29	100.30	100.35

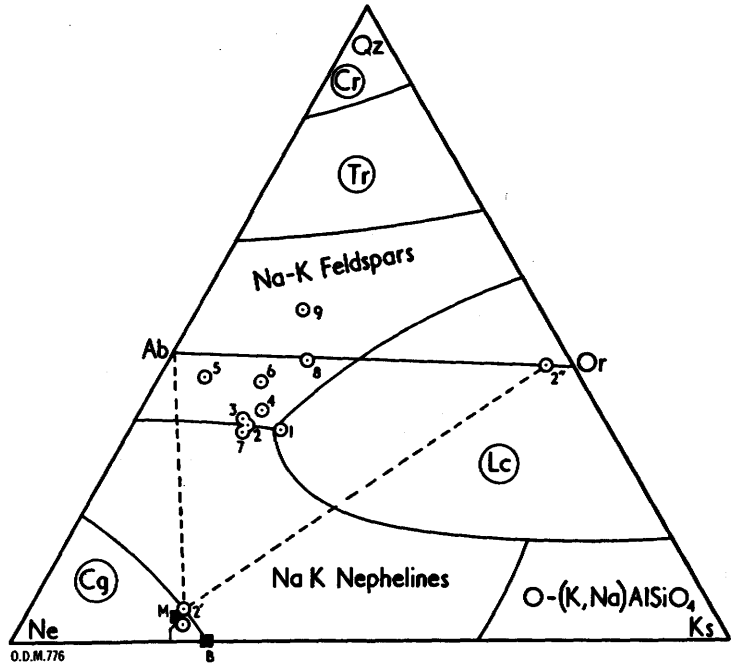
CO-ORDINATES IN SYSTEM NE-KS-QZ

Ne	46.4	51.8	44.6	51.4	36.1
Ks	16.8	6.2	14.3	15.6	19.1
Qz	36.8	42.0	41.1	33.0	44.8

No. 4—Nepheline syenite gneiss (muscovite, biotite), concession X, lots 13-14, Methuen Tp., Blue Mt., Ontario (Adams and Barlow 1910, p. 295).
No. 5—Garnet hastingsite nepheline oligoclase gneiss, N.E. end of Swamp Ridge, N.E. of Grassy Lake, Blue Mt., Ontario.
No. 6—Nepheline corundum albite gneiss (with muscovite and biotite), N. shore of Stony Lake, Concession X, Burleigh Tp., Peterborough Co., Ontario.
No. 7—Nepheline syenite gneiss (biotite, muscovite) Craig Island, Stony Lake, Burleigh Tp., Peterborough Co., Ontario.
No. 8—Syenite gneiss (biotite, muscovite) bounding nepheline syenite gneiss, analysis 7.
(*Analyses of Nos. 5–8 by J. H. Scoon.*)



Nepheline syenite gneiss of Cabin Ridge Quarry No. 2, Blue Mountain (rock of analysis No. 2 of table), showing the typical crystalloblastic texture of the Blue Mountain nepheline gneiss. Visible in the photograph are nepheline, albite and microcline. The mafic accessories include magnetite (near upper right edge) and, not shown in the field of view, some andradite and rare aegirine-augite. (22 diameters, crossed nicols.)



Plot of compositions of nepheline syenite gneisses and syenite gneisses of the Blue Mountain area in the system $NaAlSiO_4$–$KAlSiO_4$–SiO_2. M and B are Morozewicz and Buerger formulae for nepheline. 1 to 9 represent rocks; 1′ and 2′ are the nephelines of rocks 1 and 2; 2″ is the microcline of rock 2. The analyses, numbered to correspond, are given in the accompanying tables except 3, which is given under analysis 11, and 9 (See F. D. Adams and A. E. Barlow, "Geology of the Haliburton and Bancroft Areas, Province of Ontario," Geol. Surv. Can., Memoir No. 6, 1910).

CHEMICAL ANALYSES

	No. 10	No. 11	No. 12	No. 12 (a)
SiO_2	58.93	60.27	58.84	42.74
Al_2O_3	23.10	23.26	23.26	34.21
Fe_2O_3	2.09	0.07	1.43	0.12
FeO			0.53	
MnO	.....	.....	0.05	<0.01
MgO	0.10	0.17	0.03	nil
CaO	0.83	0.71	0.66	0.75
Na_2O	10.33	10.40	10.09	16.11
K_2O	4.12	4.23	4.75	6.13
H_2O+	0.53	0.73	0.19	0.26
H_2O-			nil	nil
TiO_2	0.06	.....	nil	nil
P_2O_5	0.02	.....	0.01	.....
CO_2	.....	.....	0.13	nil
ZrO_2	0.05	0.07	0.05(S)	.....
Total	100.16	99.91	100.02	.....
Less O = S	.....	.....	0.02	100.32
			100.00	

NORMS

	No. 10	No. 11	No. 12
Or	24.46	25.02	27.80
Ab	46.24	48.47	44.14
Ne	22.36	21.44	22.36
An	3.89	3.61	2.50
Cor	0.10	0.20	0.61
Ol	0.44	0.28	.....
Mt	1.86	.....	2.09
Ct	.....	.....	0.29
Rest	0.66	0.87	0.23
Total	100.01	99.89	100.02

CO-ORDINATES IN SYSTEM NE-KS-QZ

Ne	50.9	50.1	49.1
Ks	14.9	15.0	16.8
Qz	34.2	34.9	34.1

No. 10—Average of five analyses of "crude nepheline syenite ore"
No. 11—Average of five analyses of "refined nepheline syenite ore"
} Cabin Ridge Quarries, Blue Mt., Ontario. Analysis 11 plotted as 3 in figure.

No. 12—Nepheline syenite gneiss with buff coloured nepheline, Cabin Ridge Quarries, Blue Mt. Ontario.

No. 12(a)—Buff coloured nepheline of rock 12 ($Ne_{73.8}$ $Ks_{20.5}$ $An_{3.6}$ $Qz_{2.1}$ or $Ne_{76.5}$ $Ks_{21.3}$ $Qz_{2.2}$).

(*Analyses of Nos. 12 and 12 (a) are by J. H. Scoon.*)

C.E.T.

Structure and Metamorphism

The regional structure is described in a later section. In summary, the regional fold axis in the vicinity of Blue Mountain trends northeast, and there is a strong B-lineation developed by metamorphism accompanying the folding. This B-lineation trends northeast, parallel to the fold axes. An axial plane foliation may also be developed. The B-lineation and axial plane foliation is a regional structure, being developed in nepheline syenite, metasedimentary rocks, granite, and syenite.

There are axes of crossfolding running in a northwesterly direction across Methuen township, and reversal of pitch along axes of northeast folding is common. This results in a series of domes and basins.

As described earlier, if the Lasswade marble, which dips 30°–70°SE., underlies the Blue Mountain sedimentary belt stratigraphically as well as structurally, and if the southeast part of this sedimentary belt lies on the west limb of the Methuen Lake dome, the Blue Mountain sedimentary band may be an isoclinally folded syncline. The marble band, truncated at the north end of Blue Mountain, may represent the keel of the syncline, which may extend on, or through, Grassy Lake.

The Blue Mountain nepheline syenite body appears to have intruded the trough of a syncline; the long arm to the southwest is interpreted as a sill intruding and partially replacing the metasediments. The main stock of the intrusive intrudes the trough of the southwest-pitching syncline, a tongue penetrates the sediments on the northwest limb, north of St. Charles Lake. Foliation in this tongue dips 40°–50°SE. The main body of the stock lies on the southeast arm of the synclinal structure, and this may have been a favourable zone of intrusion owing to drag-folding of the sediments east of Grassy Lake.

Along the north contact of Blue Mountain the nepheline syenite contact crosses the general structure of the metasediments nearly at right angles, and there is no suggestion that the nepheline syenite here replaces a particular favourable sedimentary horizon that is stratigraphically a part of the Blue Mountain sedimentary band. The structure here seems to indicate a normal intrusive relationship, with tongues of nepheline syenite extending northward, as at Devil Lake, and re-entrants of sediments extending southward, as seen north of the fire tower.

Along the east contact, the long nepheline syenite tongue in the vicinity of the primary crusher, at International Minerals and Chemical Corporation property, has already been described. Similarly the Kasshabog sedimentary embayment appears to be a case of intrusion of tongues of nepheline rock into a monoclinal sequence of sediments.

Phipps,[1] and Derry and Phipps,[2] postulated that the nepheline syenite replaced a folded stratigraphic horizon in the sedimentary sequence; therefore, to account for intertonguing, it would be necessary to regard the structure in the Kasshabog sedimentary embayment as a series of isoclinally folded anticlines and synclines having marked reversals of pitch. In the absence of any confirmatory structural data in the nepheline syenite and sediments, the author favours the alternative hypothesis of normal intrusive relationships. The picture, of course, is complicated by the later metamorphic lineation and foliation imposed on both sediments and intrusives.

Evidence from the attitude of foliation in the nepheline syenite indicates that the body was emplaced in a folded structure; the foliation around the north side of Grassy Lake indicates a major southwest-pitching syncline, and possibly a minor drag fold to the east of Grassy Lake. The author's interpretation is that the nepheline syenite was emplaced, in approximately the size and shape it now occupies, during a period of folding, and that the secondary metamorphic tectonite structure of the whole sequence was imposed during the period of northeast-folding and after emplacement of the Methuen granite. The nepheline syenite intruded the folded structure and partially conformed to the folded structure, but did not replace a single sedimentary band by selective volume-for-volume replacement.

As previously mentioned, the long southwest arm of the Blue Mountain nepheline syenite, which extends past Big Mountain Lake, shows a foliation and slight layering of minerals. The foliation strikes north-northeast and dips 40°–80°SE. In the main body of the intrusive, although there is measurable foliation present in places, especially in a zone about ¼ mile from the contacts, in many places only a lineation is developed. A strike and plunge of mafic minerals or nepheline grains can be measured, but no dip of planar structure.

Derry and Phipps[3] describe the foliation and banding as follows:

> Foliated or banded texture is general throughout the nepheline syenite and is expressed several ways as follows:
>
> 1) By the elongation and orientation of groups of nepheline grains.
>
> 2) By the orientation of the mafic minerals, including the tendency of biotite to be arranged in lines.
>
> 3) By the distribution of variable nepheline percentage into distinct bands.

[1] C. V. G. Phipps, *op. cit.*

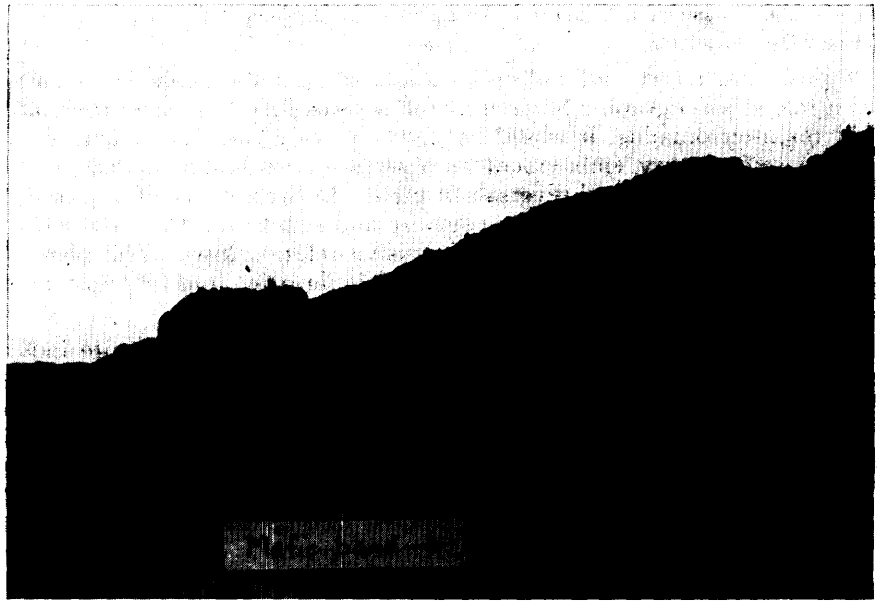
[2] D. R. Derry and C. V. G. Phipps, "Nepheline Syenite Deposit, Blue Mountain, Ontario," *Geology of Canadian Industrial Minerals*, Volume, Sixth Commonwealth Mining and Metallurgical Congress, 1957, pp. 190–95.

[3] D. R. Derry and C. V. G. Phipps, *op. cit.*, pp. 191, 192.

4) By the occurrence of bands of different mineral composition, e.g. with higher-than-average garnet content. This feature occurs mainly in the "impure" portions of the nepheline syenite, unsuitable for commercial exploitation.

The foliation and banding appear to have two quite distinct causes which are not always easy to distinguish in the field. The first cause is due to the original layering or, as we prefer to believe, bedding of the formation. Type (4) above, and probably also type (3) are examples of this cause. The bands are parallel to the main contacts of the nepheline formation, can be followed around the curves of folds and generally behave like the constituents of a bedded and folded formation. It is not claimed that they necessarily represent in detail the actual units of the bedded series, but that they do inherit their attitude from that of the original bedding.

The second cause of foliation is evidently the normal relief from regional compression by recrystallization of nepheline and other minerals with their long axes parallel to the axes of folding. The foliation of types (1) and (2) are at least partly due to this cause. This type of foliation is always oriented in a general northeasterly direction regardless of the local strike of formation



Mafic band in nepheline syenite, Cabin Ridge, American Nepheline property.

contacts. On the apices of folds the two directions and origins of foliation can be easily distinguished where one may see the orientation of nepheline and mafic minerals parallel to fold axes while the trend of the fold is expressed by the banding of mineral variation. It should be stressed, however, that some crystal orientation occurs parallel to the banding or bedding. Where the formation contacts are roughly parallel in strike to the fold axes it is very difficult to distinguish the causes of foliation.

Appreciation of the fact that much of the foliation and lineation observed in the Blue Mountain nepheline syenite is a secondary metamorphic fabric, is a big step towards the interpretation of the metamorphic history and origin of the body. Whether the minor but distinct mineral content variations, which occur in bands, represent original primary layering of an intrusive, or original compositional differences inherited from a bedded sediment (completely replaced), is a matter of controversy. There is suggestive evidence on both sides.

Mafic Bands.—Within the nepheline syenite body there are a number of narrow and discontinuous bands of mafic rock. These mafic bands are often composed mainly of biotite, with minor calcite and albite. Some bands are biotite amphibolite with albite, hornblende, and biotite as the chief constituents; others contain quartz. In the quarries of American Nepheline Limited, these narrow biotite bands are well-exposed and are seen to be of irregular size and

shape. Three theories of origin have been suggested for these bands: (1) they are sedimentary inclusions; (2) they are metamorphosed basic dikes; (3) they represent biotitic shear zones in the intrusive.

The bands differ widely in characteristics, and the author believes that mafic bands of all three types may be present. Some of the narrow mafic bands certainly appear to be sedimentary inclusions. The contacts of the nepheline syenite with these bands are sharp, and the intertonguing of nepheline syenite and metasediments, along the contacts and in the Kasshabog sedimentary embayment, suggests that sedimentary origin is very probable.

Derry[1] has suggested that some of the "biotite dikes" that angle across the foliation of the nepheline syenite may be old basic dikes or sills, which intruded the sedimentary series prior to nephelinization.

Other mafic bands, composed mainly of biotite, appear to mark rolling shear zones, which cut the nepheline syenite. There appears to have been some migration of mafic material to these shear zones, which may have been zones of dilatency during final consolidation of the intrusive. In some places the nepheline syenite adjacent to the mafic biotite-filled shears is leached or notably lower in mafic content than the normal nepheline syenite. This suggests a limited migration of mafics to these shear zones.

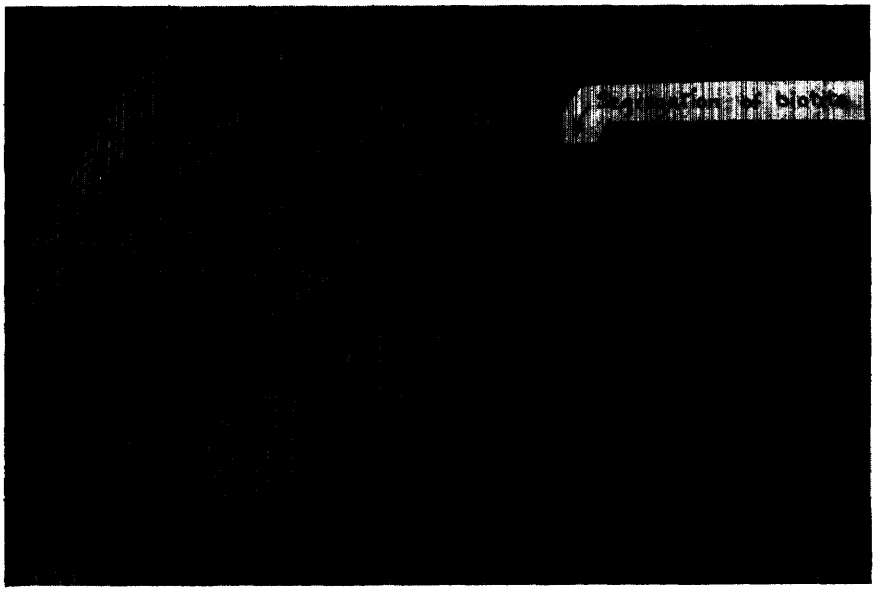
Within the main body of the intrusive, east of Grassy Lake, several narrow amphibolite, or biotite amphibolite, bands occur as inclusions in the nepheline syenite. These appear to follow no particular pattern but are short and discontinuous. The author was unable to trace any of these bands around folded structures.

Metamorphic Effects.—The period of metamorphism accompanying the Grenville orogeny affected the Blue Mountain nepheline syenite and its enclosing sediments, and the Methuen granite. The complex metamorphic history of the Blue Mountain intrusive is indicated by the two metamorphic lineations that can be observed in places. At Mill Ridge quarry, a lineation or leucocratic banding in the rock cuts across the lineation produced by alignment of small corundum and garnet grains at an angle of about 20 degrees.

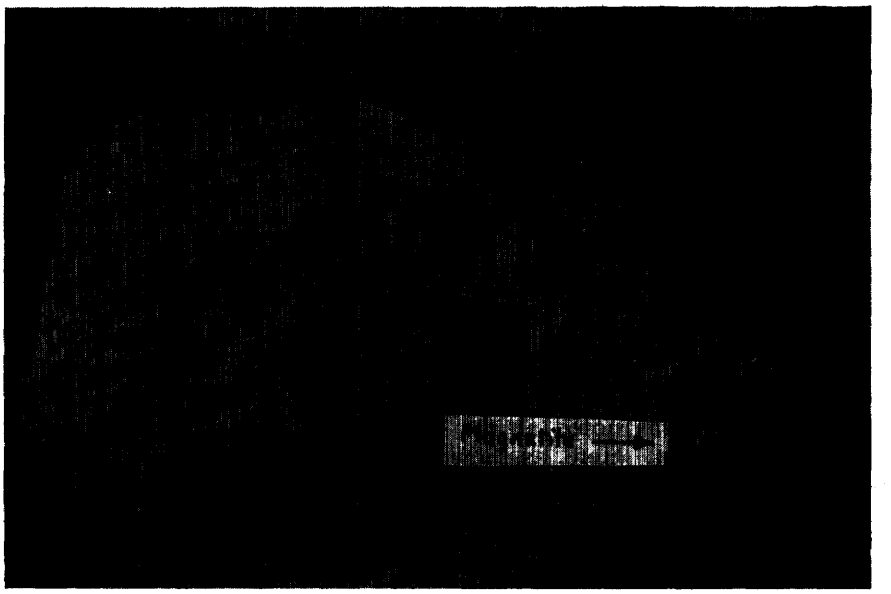
In most places foliation conforms with minor compositional banding in the intrusive, but frequently the regional lineation, trending southwest and plunging 10°–40°SW., can be measured on foliation planes. In much of the central part of the intrusive, foliation is absent, but the regional metamorphic lineation can be measured. Cross-folding does not seem to have affected the nepheline syenite to any degree, since the plunge of lineation, although ranging 10°–40°, is always to the southwest.

The recrystallization of the intrusive has destroyed any evidence of chilled border zones. However, in places nepheline content is lower adjacent to the margins of the intrusive. A noteworthy change in texture and mineralogy, due to metamorphism, was noted at the quarries of International Minerals and Chemical Corporation. Here, as shown in the accompanying photos, the rock consists of a biotite nepheline syenite showing a marked lineation of biotite. In places there has been a segregation of biotite into clots of 1 inch or so in diameter, with a zone of impoverishment of biotite extending 2–3 inches around the mafic clot. The second step in this metamorphic reconstitution is the replacement of biotite clots by magnetite rimmed with biotite, until finally only magnetite

[1]D. R. Derry, "The Lakefield Nepheline Syenite: Evidence of a Non-Intrusive Origin," *Transactions*, Royal Soc. Can., Section IV, Third series, Vol. XLV, 1951, p. 38.



Segregation of biotite in nepheline syenite.



Segregation of biotite gone to completion, with formation of magnetite crystals in a leucocratic facies of the nepheline syenite; a type of metamorphic differentiation.

remains. There is a change from a biotite nepheline syenite to a leuconepheline syenite carrying small rounded magnetite grains or clots. The stages in the process of migration of biotite to these centres where porphyroblasts of magnetite grow are shown in the accompanying photos.

SYENITIC ROCKS

The syenitic rocks consist of pink and biotite leucosyenite, biotite syenite, and hybrid syenitic gneiss formed by potash metasomatism of paragneiss and amphibolite. Pink syenite pegmatites, often carrying muscovite and corundum, are also present. The syenitic rocks occur within and flanking the Blue Mountain nepheline syenite body and are apparently closely associated in age and genesis with the nepheline syenite. Wherever the nepheline syenite and syenite occur together, the pink syenite is seen to intrude the nepheline syenite. The alteration of the nepheline syenite near the pink syenite contacts was described earlier.

Mineralogically the syenitic rocks are of four main types:

1) White alkaline syenite or albitite, composed mainly of white albite; probably a facies of the nepheline syenite;
2) Pink or buff syenite, composed mainly of plagioclase (albite to oligoclase) and microcline or microcline microperthite;
3) Pink syenite, composed predominantly of microcline and microcline microperthite;
4) Hybrid syenitic gneisses, containing microcline and microcline microperthite with mafic bands rich in biotite and amphibole; clearly produced by potash metasomatism of para-amphibolite and paragneiss.

These facies grade one into another.

Texturally, the syenitic rocks range from allotriomorphic interlocking to hypidiomorphic granitoid and equigranular granoblastic.

Syenite pegmatites, containing muscovite and corundum, are described in Economic Geology (page 159) under muscovite and corundum.

The main outcrop area of syenitic gneisses occupies an area, ¾ mile wide and 2½ miles long, west of Blue Mountain. As noted on the geological map of Methuen township, this area is composed largely of hybrid syenitic gneisses. All gradations, from bedded amphibolite and paragneiss to banded hornblende and biotite syenitic gneisses, occur. Some of the feather amphibolite is syenitized, and poikiloblastic amphibole feathers occur in the hybrid syenitized rock. There is preservation of original sedimentary bedding and features of texture, such as the feathering typical of the feather amphibolite bands, in the transformed metasomatic syenitic gneisses. Contacts between the sedimentary rocks and the hybrid syenite gneisses are truly gradational.

The criteria used by the author to interpret these rocks as hybrid syenite gneisses, produced by potash metasomatism of sedimentary rocks, are the following:

1) Non-uniformity across and along strike; mafic-rich and microcline-rich bands, and all gradations between these, occur intimately intermingled. Differences are not merely due to minor variations of accessory mineral content.
2) Wide variation of mafic content, from 0 to 50 percent or more. Relict schlieren of amphibolite, paragneiss, or other metasedimentary rocks may be present.
3) Variable bulk composition, with a wide range of potash feldspar to plagioclase content. To be considered significant, variations in range of feldspar content will generally be over 30 percent.

4) Bands of sediment, traceable along strike into hybrid syenitic gneiss with increase of feldspar content; preservation of structure of sedimentary rocks.

5) Preservation of textures, such as that of the feather amphibolite in the syenitized rocks. Although feather amphibolite is in contact with nepheline syenite in many places, if the nepheline rock represents nephelinized feather amphibolite this textural feature is never preserved. This seems unusual since such preservation is common in the hybrid syenitic gneiss zone.

The author uses the above criteria for distinguishing hybrid granitic, syenitic, and nepheline-bearing gneisses from granitic, syenitic, and nepheline syenite ortho-gneisses throughout the area. Hybrid nepheline syenite gneiss facies are common in the Bancroft area, and there, where paragneiss or amphibolite has been replaced, the above criteria hold good. There is generally a wide range in mafic content and in bulk composition. In the case where marbles are nephelinized, the criteria watched for, in addition to the above, are the presence of calcite or scapolite in the rock and the change of plagioclase composition towards the anorthite end, i.e. oligoclase or andesine is found instead of albite. The presence of calcite, scapolite, or more calcic plagioclase is regarded as a possible indication of the metasomatic replacement of marble.

These criteria apply to the hybrid syenite zone west of Blue Mountain but do not apply to the Blue Mountain body itself. In attempting to interpret the origin of the Blue Mountain body, the author would suggest that observers examine a typical hybrid or migmatitic type of assemblage as exposed west of St. Charles Lake and compare it with the Blue Mountain intrusive.

GRANITIC ROCKS

Granitic rocks occur widely throughout Methuen township. The central third of the township forming a diagonal band, 3–4 miles wide, extending from the southwest corner to the northeast corner of the township, is largely granite or granite gneiss. The Methuen granite, which occupies most of this area, is a pink gneissic leucocratic granite containing 2–10 percent mafic minerals, mainly biotite. Coarse-grained, pink porphyritic biotite granite and fine-grained, grey granodiorite occur in minor amounts in the Methuen granite. A coarse-grained, pink porphyritic biotite granite rims the basic intrusives in the Horse Lake basin. Pink granitic rocks invade and replace sediments south of Long and South lakes in southwest Methuen. Pink porphyritic biotite granite also intrudes the Twin Lake diorite.

West of Blue Mountain, near the west boundary of the township, the hybrid syenite gneiss grades into pink hybrid granitic gneisses, which occur intimately interbanded with, and replacing, metasediments. Leucogranite pegmatite dikes and sills occur in the area between Blue Mountain and Jack Creek. A large body of medium- to fine-grained pink biotite granite invades the Lasswade marble at the south end of Jack Lake. Numerous long, narrow granite and granite pegmatite dikes cut the Lasswade marble, as shown on the geological map of the township. Other smaller granitic stocks and dikes cut the paragneiss and amphibolite north of Jack Lake.

Methuen Granite

The Methuen granite body has a length of over 12 miles, measured from its western extremity at the railway line west of Stony Lake Bay, Kasshabog Lake, in lot 11, concession XI, through Kasshabog and Methuen lakes, to the northeast corner of the township. It has a maximum width of 4 miles, measured from

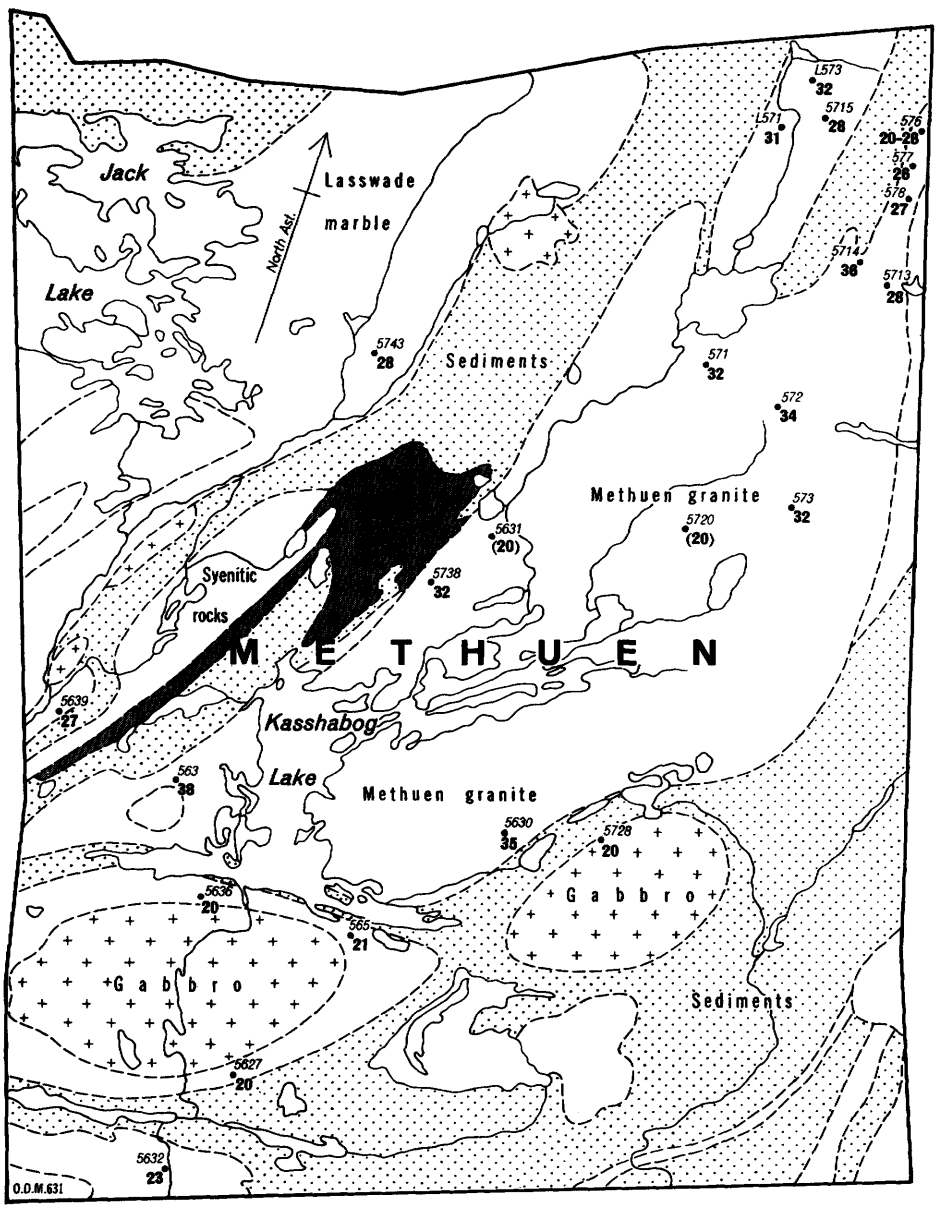
Barrette Lake to Twin lakes. The main body of Methuen granite is separated from the Methuen Lake granite dome, which is considered to be part of it, by a narrow band of metasedimentary rocks, which flank the dome.

The Methuen granite occupies an area of very low relief. Outcrops are abundant, as soil cover is absent over most of the area. Low rock hummocks are frequently surrounded by muskeg. The Methuen granite is a medium-grained, granular to granoblastic rock, and is characterized in many places by a peculiar weathering feature. It weathers deeply to a yellow-brown feldspathic gravel. The deep mechanical weathering of the granite is rather puzzling in view of the lack of soil cover, and the presence of unweathered glaciated surfaces of Methuen granite in much of the area. It is possible that the deep mechanical weathering is a pre-Paleozoic feature. Outliers of Paleozoic limestone indicate that the present erosion surface may be close to the pre-Paleozoic surface underlying the Paleozoic limestone cover.

Contacts.—The Methuen granite is bounded on the northwest by the Blue Mountain metasedimentary band. The contact is generally sharp, and little or no hybrid granite occurs along this contact. South of Barrette Lake the Methuen granite is in contact for a short distance with the nepheline syenite and associated pink alkaline syenite. The granite is later than these rocks, and there is some syenitization of the nepheline syenite, which may be attributed to the intrusion of the granite. The granite intrusive may cut off the southwest arm of the syenite-nepheline syenite complex in the vicinity of Kasshabog Lake. As mentioned above, the Methuen granite of the main intrusive is separated from the granite of the Methuen Lake dome by a band of metasediments consisting mainly of amphibolite, biotite amphibolite, quartzo-feldspathic sediments, and marble. The contacts between the granite and metasediments are sharp, and granitization is of minor extent. Disoriented inclusions of para-amphibolite occur with the pink leucogranite in places, as in lot 28, concession I. A narrow band of fine-grained, leucocratic pink granite extends north from the Methuen granite body into Wollaston township, and may form a connection with the Coe Hill granite of that township.

On the east and south, the Methuen granite body is bordered by the Kosh Lake beds, consisting mainly of amphibolite, paragneiss, feldspathic gneiss, and arkose. South of Troutling Bay on Tangamong Lake, the Troutling Bay volcanics, which occur within the Kosh Lake sequence, are in contact with, and cut off by, the Methuen granite. Inclusions of metasediments and volcanic amphibolite are found in places along the margins of the Methuen granite. Along the contact of the Methuen granite north of Sams and Blue lakes, within a zone about 2,000 feet wide, there appears to have been some granitization of pink arkose or quartzite similar to the Oak Lake formation. This is one place within the Methuen granite where some hybrid granite appears to have been formed by a process of granitization.

Inclusions.—Narrow bands of amphibolite and biotite schist, similar in size, shape, and lithology to those found within the Blue Mountain nepheline syenite, occur in places within the Methuen granite. These bands, up to 50 feet wide, may occasionally be traced for over 1,000 feet in length. Their origin is not known, but, as in the case of those in the Blue Mountain body, they are thought to be either relict sedimentary inclusions, metamorphosed basic dikes, or biotite schists formed along shear zones. It is possible, as noted previously, that some of these represent biotitic or hornblendic lamprophyres associated in age with the Methuen granite. Since the granite itself has been metamorphosed and now shows a marked lineation or foliation, so these dikes also may have been considerably altered by metamorphism.



Location of Methuen granite samples, showing variation of anorthite content in plagioclase of the granite samples examined.

Lithology.—The Methuen granite is composed of three main facies: a pink biotite leucogranite usually medium- to coarse-grained and foliated or lineated; a fine-grained grey biotite granodiorite, which occurs as inclusions in the pink granite; and a pink porphyritic facies of the biotite granite, often somewhat richer in biotite than the normal Methuen granite. Texturally, the granite grades from hypidiomorphic granitoid to porphyritic or porphyroblastic.

Rosiwal modal analyses of 14 samples of Methuen granite (pink facies), and 2 samples of the grey fine-grained granodiorite, are given in the accompanying tables. The locations of these granite samples are indicated on the accompanying figure. Samples Nos. L.571, L.573, and 5715 are from the granite within the Methuen dome north of Methuen Lake. Samples Nos. 5713, 5714, 578, 577, and 576 are from the north end of the body, near its connection with the Coe Hill granite. Samples Nos. 5631 and 5720 are the fine-grained, grey biotite granodiorite.

As noted in the accompanying table, the plagioclase content ranges from 23.3 to 45.3 in the normal pink facies of the granite. Anorthite content ranges from An_{26} (oligoclase) to An_{38} (andesine), andesine being the common plagioclase. As shown on the accompanying figure, the oligoclase occurs mainly in the narrow neck joining the Coe Hill granite. Quartz content ranges from 19.8 to 41.0 percent. Microcline content ranges from 15.3 to 38.2 percent. Perthite is uncommon, never making up over 5 percent. From a comparison of the potash feldspar to plagioclase ratio it will be seen that the Methuen granite ranges in composition from quartz monzonite to granodiorite.

Both biotite and hornblende may be present; however, biotite is the more common. The total mafic content ranges from 2.2 to 9.6 percent. Muscovite, pyroxene, titanite, magnetite, apatite, carbonate, fluorite, allanite, and zoisite are minor accessories. Some myrmekitic intergrowths were noted.

The fine-grained grey facies, as represented by samples 5631 and 5720, are granodiorites rather richer in biotite than the normal pink facies. The plagioclase is more sodic, being oligoclase, An_{20}.

Structure.—The Methuen granite, although rather uniform in composition, shows a marked foliation or lineation. In some places the rock is foliated, in other places only a trend and plunge of lineation, evidenced by alignment of quartz and biotite, can be measured. The foliation and lineation strike northeast-southwest, in agreement with that of the metasediments and intrusives to the northwest. Along the west contact of the Methuen granite south of Methuen Lake, the foliation parallels the contact and dips steeply northwest. Along the east and south contacts, the foliation dips steeply east or south towards the metasediments that flank the granite.

Plunge of lineation can be measured throughout most of the granite body, and these observations are recorded on the township geological map. The plunges are generally to the southwest and range from 0° to 60°. A few plunges to the northeast may mark the northwest axes of crossfolding evident farther south in the Oak Lake dome and Twin Lake basin. There is a strongly marked S-shaped drag-fold in the gneissic granite on the west shore of Kasshabog Lake. This fold plunges 60°W.

The granite body north of Methuen Lake is dome-shaped, with the structure of the metasediments dipping away from the granite on all sides. Lineations within the granite indicate a gentle plunge southwest at Methuen Lake, and northeast at the north end of the dome.

Rosiwal Modal Analyses of Samples of the Methuen Granite

Mineral	Sample No. and Location							
	No. 563 Lot 12 Con. IX	No. 5630 Lot 10 Con. V	No. 5738 Lot 18 Con. VI	No. 573 Lot 18 Con. III	No. 572 Lot 22 Con. II	No. 571 Lot 23 Con. III	No. L571 Lot 30 Con. II	No. L573 Lot 31 Con. II
Plagioclase	23.3	21.3	33.4	30.4	32.6	35.9	45.3	33.9
(Anorthite content)	(An_{38})	(An_{35})	(An_{32})	(An_{32})	(An_{34})	(An_{32})	(An_{31})	(An_{32})
Quartz	34.1	40.9	31.5	30.2	22.7	19.8	29.8	25.2
Microcline	36.8	34.9	31.4	30.4	33.0	29.8	15.3	36.5
Perthite	0.8	0.4	.....	.....	4.5	3.8	.....	.....
Biotite	0.9	2.3	1.5	7.4	1.4	3.6	8.8	1.2
Hornblende	4.1	.....	1.8	1.6	5.5	5.8	0.8	1.4
Pyroxene	.....	.....	.....	.....	.....	.....	.....	0.5
Muscovite	.....	.....	.....	.....	.....	.....	.....	.....
Titanite	.....	.....	.....	.....	0.3	1.3	.....	0.5
Opaques	.....	0.1	0.3	.....	.....	.....	.....	0.8
Apatite	.....	0.1	.....	.....	.....	.....	.....	.....
Carbonate	.....	.....	.....	.....	.....	.....	.....	.....
Fluorite	.....	.....	0.1	.....	.....	.....	.....	.....
Myrmekite	.....	.....	.....	.....	.....	.....	.....	.....
Allanite	.....	.....	.....	.....	.....	.....	.....	.....
Zoisite	.....	.....	.....	.....	.....	.....	.....	.....

Mineral	No. 5715 Lot 29 Con. II	No. 5713 Lot 25 Con. I	No. 5714 Lot 26 Con. I	No. 578 Lot 29 Con. I	No. 577 Lot 29 Con. I	No. 576 Lot 30 Con. I	No. 5631 Lot 18 Con. V	No. 5720 Lot 19 Con. III
Plagioclase	34.4	33.5	23.2	32.6	37.5	30.1	49.5	31.0
(Anorthite content)	(An_{28})	(An_{28})	(An_{36})	(An_{27})	(An_{26})	(An_{20}-An_{28})	(An_{20})	(An_{20})
Quartz	40.6	31.0	41.0	29.1	27.0	26.3	28.4	45.2
Microcline	17.1	31.7	32.6	33.3	30.4	38.2	9.2	16.5
Perthite	.....	.....	.....	.....	0.8	.....	.....	.....
Biotite	7.9	2.2	2.3	3.7	2.5	4.4	11.1	6.6
Hornblende	.....	.....	.....	.....	.....	.....	.....	.....
Pyroxene	.....	.....	.....	.....	.....	.....	.....	.....
Muscovite	.....	1.3	.....	1.2	1.3	0.5	.....	.....
Titanite	.....	.....	.....	.....	.....	.....	0.2	0.3
Opaques	.....	.....	0.9	0.1	0.4	0.3	.....	.....
Apatite	.....	.....	.....	.....	0.1	0.2	0.2	.....
Carbonate	.....	0.1	.....	.....	.....	.....	1.2	.....
Fluorite	.....	.....	.....	.....	.....	.....	.....	.....
Myrmekite	.....	0.2	.....	.....	.....	.....	.....	.....
Allanite	.....	.....	.....	.....	.....	.....	0.2	.....
Zoisite	.....	.....	.....	.....	.....	.....	.....	0.4

ROSIWAL MODAL ANALYSES OF GRANITIC ROCKS, METHUEN TOWNSHIP

Mineral	Sample No. and Location						
	No. 5636 Horse Lake Basin Lot 9 Con. IX	No. 565 Horse Lake Basin Lot 8 Con. VII	No. 5627 Horse Lake Basin Lot 4 Con. VIII	No. 5632 Southwest Corner Lot 1 Con. IX	No. 5728 Twin Lakes Lot 10 Con. IV	No. 5639 Blue Mountain Lot 14 Con. XI	No. 5743 Granite Dike Lot 25 Con. VII
Plagioclase	24.4	40.8	33.7	38.1	36.1	75.0	29.3
(Anorthite content)	(An_{20})	(An_{21})	(An_{20})	(An_{23})	(An_{20})	(An_{27})	(An_{28})
Quartz	17.7	25.5	19.6	25.9	25.2	5.3	28.2
Microcline	10.0	12.6	12.6	24.9	7.4	2.3	36.9
Perthite	22.1	.....	0.3	4.9	22.7	.....	.....
Biotite	11.4	17.4	17.7	4.2	6.7	.....	4.0
Hornblende	9.5	0.5	11.9	.....	.....	17.4	0.8
Pyroxene	.....	0.3	.....	.....	.....	.....	.....
Muscovite	.....	.....	.....	1.1	.....	.....	.....
Titanite	.....	1.6	2.2	.....	0.8	.....	0.2
Opaques	1.6	0.4	1.3	0.1	0.7	.....	0.1
Apatite	0.3	0.6	0.3	0.1	0.2	.....	.....
Carbonate	.....	0.1	.....	.....	.....	.....	0.5
Zoisite	.....	0.2	.....	.....	.....	.....	.....
Myrmekite	3.0	.....	0.4	.....	0.2	.....	.....
Allanite	.....	.....	.....	0.7	.....	.....	.....

Horse Lake Basin Granite

A granite rim, ½–1 mile wide, forms a range of hills standing up 50–100 feet above the basic intrusives of the Horse Lake basin. Foliation in the granite dips steeply towards the centre of the basin. The granite intrudes the basic rocks within the basin, and intrudes and replaces the sedimentary rocks around the basin rim. Inclusions of para-amphibolite, paragneiss, and pink and grey banded arkose of the Oak Lake formation occur commonly in the granite rim rock. Much of the sedimentary material shows granitization; there is introduction of pink microcline, microperthite, and quartz into the sedimentary rocks. Metasomatism is more general than injection, and injection gneisses are not common.

The granite of the Horse Lake basin consists of the following facies in order of abundance: coarse-grained pink porphyritic (or porphyroblastic) biotite granite; biotite granite; pink banded leucogranite gneiss; hybrid granitized sediments grading to hybrid granitic gneiss. The porphyritic biotite granite facies may be seen in a small quarry on the shore of Stony Lake, by the side of the road to Nephton, in lot 32, concession XII, Dummer township.

The granitic rocks of the Horse Lake basin are well-exposed in railway cuts north of Long Lake. Three samples of the granitic rocks were sectioned, and Rosiwal modal analyses of these samples are given in the accompanying table. Sample No. 565 is a pink biotite granite from lot 8, concession VII, near Blind Lake. Samples Nos. 5636 and 5627 are pink porphyritic biotite granite from lot 9, concession IX, and lot 4, concession VIII, respectively, on the north and south rims of the basin. These granites range from granodiorite to quartz monzonite in composition. The plagioclases are oligoclase, An_{20-21}. Plagioclase content is 24.4–40.8 percent; quartz, 17.7–25.5 percent; microcline and microcline microperthite, 12.6–32.1 percent. Only one sample, No. 5636, contains an appreciable amount of microperthite. These granitic rocks are much higher in mafic mineral content than the Methuen granite. Total mafics range from 18.3 to 30.9 percent, biotite being most common and ranging from 11.4 to 17.7 percent. Pyroxene, titanite, apatite, magnetite, carbonate, zoisite, and myrmekite are accessories.

Other Granitic Rocks

The granite-sedimentary complex south of Long and South lakes consists of facies similar to those of the Horse Lake basin granite. There is intimate intermingling of granitic and sedimentary material. Granitization is a common feature. A Rosiwal analysis of sample No. 5632, from lot 1, concession IX, is given on the accompanying table. It is a quartz monzonite similar to those described in the Horse Lake basin. However, the mafic content is much lower, being 4.3 percent.

Pink biotite granite, leucogranite, and porphyritic biotite granite, similar to those in the Horse Lake basin, intrude the Twin Lake diorite. A Rosiwal analysis of sample No. 5728 from lot 10, concession IV, near Twin Lakes, indicates that this rock, which intrudes the Twin Lake diorite, is a quartz monzonite. The plagioclase is oligoclase, An_{20}. Microcline microperthite makes up 22.7 percent, plagioclase 36.1 percent, quartz 25.2 percent, and microcline 7.4 percent. (See table.)

Hybrid granite gneiss occurring west of Blue Mountain, near the Methuen boundary has already been described. This grades into the hybrid syenitic gneisses, to the northeast towards St. Charles Lake. A transitional facies from lot 14, concession XI, is represented by sample No. 5639. A Rosiwal analysis of this quartz-bearing monzonite is given in the accompanying table.

The pink biotite granite that intrudes the Lasswade marble at the south end of Jack Lake occupies an area of over 3 square miles. The granite is a fine-grained foliated rock; the foliation strikes northeast and dips gently southeast, in conformity with the regional structure of the marble.

Granite and Granite Pegmatite Dikes

Several large granite pegmatite dikes occur in the area between Blue Mountain and Jack Creek. One large dike, outcropping on the Methuen township boundary just south of Jack Creek, has a width of 25–30 feet and can be traced for over a mile. It stands up as a prominent 30-foot ridge, and is composed of pink leucogranite pegmatite, showing graphic granite intergrowths. Other granite pegmatites occur at the southwest end of the Blue Mountain ridge, near the township boundary.

Numerous pegmatitic granite, and granite pegmatite dikes and sills cut the Lasswade marble. Perhaps the most noteworthy of these is the long dike shown on the map extending in a northwest direction for over 3 miles through the narrows of Jack Lake. This dike has a width of 10–20 feet and ranges in texture from a fine-grained leucogranite to a granite pegmatite. Sample No. 5743 was taken from this dike, in lot 25, concession VII, and a Rosiwal analysis is given in the accompanying table. This rock is a fine-grained, pinkish-grey biotite granite consisting of 29.3 percent oligoclase (An_{28}), 28.2 percent quartz, 36.9 percent microcline, 4.0 percent biotite, 0.8 percent hornblende, plus accessory titanite, magnetite, and carbonates. Contacts with the marble are sharp, and there are no appreciable contact metamorphic effects.

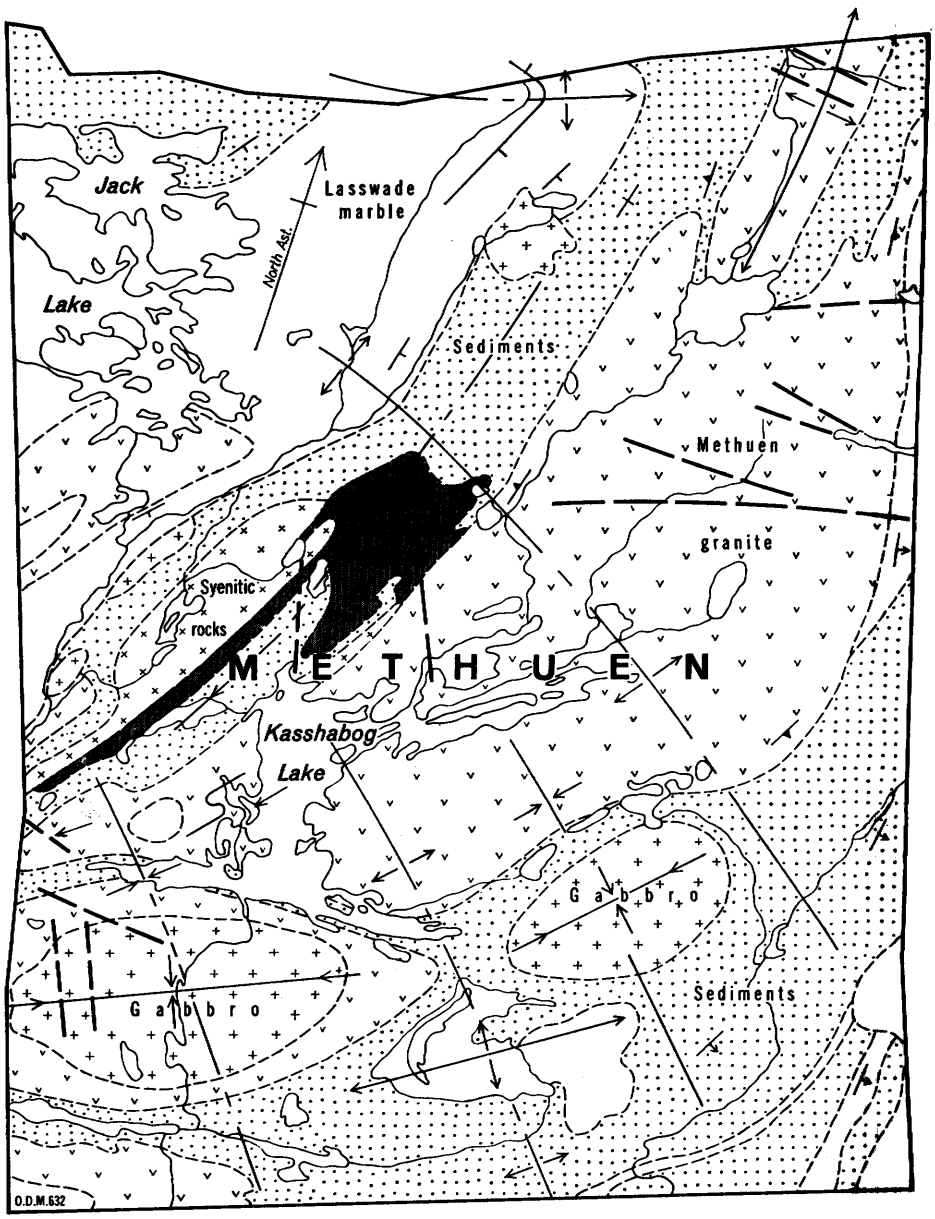
Pleistocene and Recent Deposits

The area was glaciated in Pleistocene time, but the glacial drift is thin over most of the area, and outcrop is plentiful. Glacial striae on islands in Portage Bay, on Kasshabog Lake, indicate that the direction of ice movement was S.–S.10°W. Some gravel deposits lie in the low ground north of Blue Mountain, south of Purdy's sawmill.

STRUCTURAL GEOLOGY

The main folds and faults, or lineaments, are indicated on the accompanying figure which shows the structure of the area. In that part of the township northwest of the Methuen granite, the grade of metamorphism is high; top determinations can rarely be made in the metasedimentary rocks, and information on folding is based solely on strikes and dips of strata and foliation. Marker horizons are likewise lacking. In the area south and east of the Methuen granite the sedimentary rocks are less metamorphosed, and some top determinations can be made. Fracture cleavage and drag-folding as well as recognizable marker horizons in the sediments also assist structural interpretation.

The area was strongly folded during the Grenville orogeny. Age determinations on granitic rocks and pegmatites in this part of the Grenville province give ages of about 1,000 million years, and it is postulated that the Grenville orogeny, with which the last period of folding was associated, is of this age. Emplacement of many of the intrusives, including the Blue Mountain nepheline syenite and the Methuen granite, probably took place at this time, because their foliated or lineated structure indicates a syntectonic or pre-tectonic origin.



Scale of Miles

1 0 1 2 3 4

Lineaments.

Fold axis, plunge indicated.

Structural map of Methuen township.

Folding

The major fold axes in Methuen township trend northeast, in sympathy with the generally northeast trend of folding in the Haliburton-Bancroft area. There also appears to be crossfolding trending at right angles to the main northeasterly-trending folds, as evidenced by the dome and basin structures in the vicinity of Oak Lake.

LASSWADE-APSLEY CROSSFOLD

On the north boundary of Methuen township the Lasswade marble is crossfolded along an east-west anticlinal axis. The anticline plunges to the east. This crossfold continues through, towards Apsley village in Anstruther township, and the Apsley paragneiss and amphibolite below the Lasswade marble is also involved.

METHUEN LAKE DOME

The Methuen Lake dome is a domed structure in granite gneiss, flanked by metasediments. The long axis of the Methuen Lake dome extends 4 miles north of Methuen Lake. The shorter dimension of the dome in an east-west direction is 1 mile.

GRASSY LAKE SYNCLINE

Between the anticline in Jack Lake marble and the Methuen Lake dome there is thought to be an isoclinally folded syncline, the axis of which trends northeast. This syncline involves the Blue Mountain band of metasediments. At the north end of the syncline, west of Methuen Lake, the synclinal structure is indicated by inward dips of foliation on each side of the metasedimentary band. Farther to the south the dips are all southeast or nearly vertical. This syncline passes through Grassy Lake and is called the Grassy Lake syncline. The Blue Mountain nepheline syenite has been intruded along the trough and east arm of the syncline. It has been suggested by Phipps[1] and Derry and Phipps[2] that there are a series of northeast-trending anticlines and synclines in the area occupied by the main part of the Blue Mountain nepheline syenite. Top determinations are lacking in the sediments of this area, and this structural interpretation is based on the hypothesis that the nepheline syenite replaces a stratigraphic horizon in the folded sediments. On this premise the disposition of nepheline syenite and metasediments would necessitate close isoclinal folding. The author believes that, although there may have been some dragfolding on the east limb of the Grassy Lake syncline, the intertonguing between the nepheline syenite and metasediments is better explained by normal intrusive relationships, in view of the character of the sharp transgressive contacts.

HORSE LAKE BASIN, TWIN LAKE BASIN, AND OAK LAKE DOME

South of the Methuen granite, the structure is dominated by two basins and a dome. The Horse Lake basin and Twin Lake basin are on the same northeasterly-trending synclinal axis, and are the result of crossfolding on a northwest-trending axis through Oak Lake. The Horse Lake basin has a length of 5 miles and a width of 2½ miles, whereas the Twin Lake basin has a length of 3 miles and a width of 1¾ miles. The Oak Lake dome, lying on a parallel fold axis 1¼ miles south, has a length of 5 miles and a width of 1½ miles.

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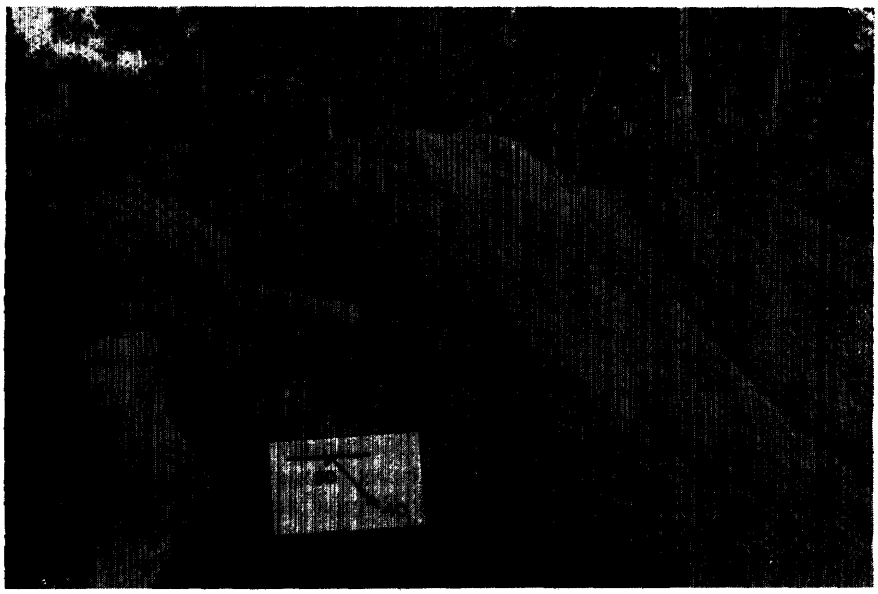
[1] C. V. G. Phipps, *The Petrology and Structure of the Alkaline Rocks of the Blue Mountain Area*, unpublished Ph.D. thesis, Univ. of Toronto, 1955.

[2] D. R. Derry and C. V. G. Phipps, "Nepheline Syenite Deposit, Blue Mountain, Ontario," *Geology of Canadian Industrial Minerals*, Volume, Sixth Commonwealth Mining and Metallurgical Congress, 1957, pp. 190–195.

The central parts of the basin structures are occupied by basic intrusives and granite, only the rims being sediments.

Foliation and Lineation

During the strong folding along northeast axes accompanying the Grenville orogeny, foliation and lineation have been developed in the metasedimentary and intrusive rocks. Bedding foliation, axial-plane foliation, and a strong B-lineation parallel to the fold axes and normal to the direction of applied stress may be found throughout the area. The regional character of the metamorphic



Lineation on bedding surface of paragneiss, in railway cut, Methuen township.

lineation is evident as it occurs in the Blue Mountain metasedimentary band, in the nepheline syenite, and in the Methuen granite. The trend of this lineation is southwest, and the plunge is generally southwest, although some variation in the plunge is noted probably due to the effects of crossfolding.

Faulting

The accompanying sketch map of the structure of the township indicates a number of the major lineaments apparent on air photographs. These represent joints and faults crossing the structure. Two prominent lineaments cut the Blue Mountain nepheline syenite body, but the contacts do not seem to be appreciably displaced. Pegmatites are frequently intruded on these lineaments. Some strong lineaments show up in the Methuen granite and may represent jointing.

ECONOMIC GEOLOGY

The only mineral industry in Methuen township is the mining of nepheline syenite, carried out at Blue Mountain by American Nepheline Limited, and International Minerals and Chemical Corporation (Canada) Limited.

Several small muscovite mica and corundum pits have been opened up in the vicinity of Blue Mountain. Prospecting for copper, lead, zinc, iron, titanium, and radioactive minerals has been carried out in the township, and a few small showings have been opened up. The large basic intrusive bodies in the southern part of the township offer prospecting possibilities for base metals and iron deposits.

Copper

Small amounts of chalcopyrite and pyrite are reported in rusty gneiss in pits in lot 26, concession IV. Some prospecting for copper was carried out in concession I, north of Troutling Bay on Tangamong Lake.

Corundum

Corundum occurs in syenite pegmatite dikes, with muscovite mica. Several small pits were opened up in these pegmatites, mainly for muscovite mica, and no commercial production of corundum has been reported. Most of this work was done during the "corundum rush" of 1898–1901.

These workings are located mainly in three areas: on the northwest side of Blue Mountain, in lot 14, concessions IX and X (Bennett's mine); along the railway near Kasshabog Lake, in lots 14 and 15, concession VIII; and on the shore of Kasshabog Lake, in lot 16, concession VIII.

The following descriptions of corundum occurrences are taken from V. L. Eardley-Wilmot's report.[1]

Concession VIII, Lots 14 and 15

What is known as the Croft property was worked during 1901 by the Imperial Corundum Company. Dykes of pegmatite from 2 to 5 feet wide occur close to the contact of the dark gneiss and nepheline syenite in which several pits, up to 20 feet in depth, have been sunk close to the northwest end of Kasshabog Lake. The corundum occurs with the muscovite mica, for which most of the mining was done, and although the company set aside about 10 tons of hand-picked corundum ore, apparently no shipments were made.

Concession IX, Lot 13

On the Miller property, concession IX, lot 13, on the south side of Little Mountain Lake, most of the work was done for mica near the contact of a fine-grained syenite and the granite, but the percentage of corundum is small.

Concessions IX and X, Lot 14

During 1901 the Crown Corundum and Mica Company did some work in the northwest corner of the above lot near the boundary between concessions IX and X. Nine or ten pits for white mica had previously been opened up in the coarse-grained syenite, and on the northeastern slope of the mountain several pits were sunk and three or four level entry cuts, each about 100 feet in length, had been driven, following coarse, pink syenite dikes of 1 to 4 feet in width. Nearly all these northerly workings particularly the most westerly cut, show the presence of a bluish corundum embedded in the muscovite. In many cases the corundum is not revealed until the mica books are broken open. The surface of the corundum crystals are frequently rounded due to their alteration into the mica. In other cases the corundum is splashed through the pink rock and is invariably completely fringed with a coating of pearly mica. In some instances also the presence of the corundum is somewhat deceptive as it occurs in small mica-like flakes of a bronze lustre on the weathered surfaces.

In places some of the syenite dikes contain probably up to 10 per cent corundum, but the average mining ore is decidedly less.

It was stated by local inhabitants that 150 tons of mica and corundum ore were shipped to the United States, but there is no official record of this.

Further work on this deposit, known as Bennett's mine, is reported in the section on mica.

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[1] V. L. Eardley-Wilmot, *Abrasives: Part II, Corundum and Diamond*, Mines Branch, Can. Dept. Mines, No. 675, 1927, pp. 18–19.

Concession IX, Lot 15

On the Madill property, concession IX, lot 15, a little work has been done, where corundum, of a somewhat radiated structure, occurs surrounded by tough nodules containing masses of granular white feldspar and species of black mica.

Ilmenite and Magnetite

Small showings of ilmenite, magnetite, and hematite occur in the Twin Lake diorite, in lot 8, concession III. A few small prospect pits were put down east and west of the Oak Lake road. In 1956 the east half of lot 8, concession IV, and lot 8, concession III, were staked, and some prospecting and 118 feet of diamond-drilling were carried out.

Lead

In lot 2, concession I, Methuen township, there is a 12-inch calcite vein containing galena. The vein strikes N.65°W. and dips vertically. It shows a colloform vuggy structure. The vein cuts grey "Hastings type" limestone, which strikes N.20°E. and dips southeast. A pit, 70 feet long and 6 feet wide and reported to be 50 feet deep, has been sunk in the vein.

Mica

On the southeast side of the C.P.R. railway line, in lot 14, concession VIII, Methuen township, there are three small pits on three narrow syenite pegmatite dikes striking northwest and dipping vertically. These dikes cut across the strike of the amphibolite country rock almost at right angles. A small amount of muscovite in books up to 3 inches in diameter was noted. The dikes are narrow and rarely exceed 3 feet in width.

On the shore of Kasshabog Lake, just northeast of the outlet of Big Mountain Lake, in lot 15, concession VIII, a small pit measuring 8 by 10 feet has been sunk on a muscovite-corundum syenite pegmatite. The pegmatite cuts amphibolite. Muscovite books of poor quality up to 6 inches in diameter were noted. Grey-green corundum crystals up to 1 inch in size, mantled with muscovite, occur in the dike.

At the north end of Kasshabog Lake, on the east shore across from the railway embankment in lot 16, concession VIII, there is a small trench, 10 by 5 feet by 6 feet deep, in pink aplitic syenite. Muscovite books up to 5 inches in size occur in the syenite, with biotite.

Along the northwest shore of Big Mountain Lake, just below the Cabin Ridge quarries of American Nepheline Limited, in lot 14 or 15, concession VIII, there are three mica pits in pink syenite pegmatite. These deposits were worked in 1941, and are described by J. Satterly as follows:[1]

In 1941 J. E. Ayrhart opened up a pit on the shore of Mountain lake 2 chains east of a cabin. The pit, which is 40 feet long and 25 feet wide and has a maximum depth of 15 feet, was put down on a 25-foot muscovite pegmatite dike. The books of muscovite range in width from less than 1 inch to a maximum of 4 inches.

Two chains north of the cabin and 4 chains north of Mountain lake a pit, 20 feet long, from 4 to 6 feet wide, and from 6 to 20 feet deep, exposes a 25-foot sill of pink muscovite syenite-pegmatite, which trends N.30°–35°E. and dips vertically. It is bounded on the north and south by hornblende gneiss. The muscovite occurs in fractured books as much as 3 inches in width. Muscovite pegmatite is also exposed in a second pit 1 chain west of the first and in a third at the lake shore, 4 chains to the south.

From what can be seen in these occurrences there appears to be little hope of recovering any quantity of commercial mica.

[1] J. Satterly, *Mineral Occurrences in the Haliburton Area*, Ont. Dept. Mines, Vol. LII, 1943, pt. 2, p. 60.

On the northwest side of Blue Mountain, 200 feet northwest of the mine road along the ridge in lot 14, concession IX, there are several corundum-muscovite syenite pegmatite dikes trending N.63°W. and dipping 80°SW. These dikes cut syenitized gneiss and para-amphibolite. Three open cuts were driven southeast into the hillside on three of these dikes for mica and corundum. This location was known as Bennett's mine and was originally opened about 1899. The property was leased in 1940 from American Nepheline Limited by J. E. Ayrhart, and in 1941-2 by White Mica Mining Syndicate.

Two open cuts trending S.65°E. measuring 60 by 10 feet by 12 feet deep and 65 by 10 feet by 12 feet deep are located 80 feet apart. A third cut, 200 feet to the northeast, measures 90 by 6 feet by 20 feet deep. The two northeastern cuts are described by J. Satterly as follows:[1]

> Two open cuts, probably those first opened up as Bennett's mine, are located in the northwestern part of the lot on the north slope of the Blue Mountains. The first open cut is 100 feet long in a direction S.70°E. and from 5 to 10 feet wide. There is a pit in the bottom of the open cut 15 feet long and 4 feet deep. The rocks exposed are pink syenite gneiss and grey granite gneiss showing a pegmatitic development along two vertical fractures, 3½ feet apart, in the face of the trench. The pegmatitic phases have gradational contacts with the gneiss and are 1 and 1½ feet in width. In places books of muscovite form as much as 25 per cent of the pegmatite. They range in width from 1 to 5 inches and are as much as 6 inches in length.
>
> The second open cut, which is 2½ chains southeast of the first, is 7 feet wide and from 10 to 15 feet deep. It trends S.65°E. and extends for 70 feet into the slope of the hill. It exposes pink syenite gneiss and a pegmatitized phase containing mica and cutting irregularly across the face of the open cut. The structure of the gneiss trends N.30°–35°E. The pegmatite zone ranges from 1 to 2 feet in width. Books of muscovite average 2 inches across, the maximum seen being 5 inches across and 6 inches in thickness. Parallel fracturing is common, and if the mica were trimmed most of it would be not larger than 1 by 1 or 1 by 2 inches. The deposit is not considered of any economic importance owing to the small size of the zones of muscovite-bearing pegmatites.

The pegmatites show a porphyroblastic development of feldspar.

Nepheline Syenite

The nepheline syenite deposits worked by American Nepheline Limited, and International Minerals and Chemical Corporation (Canada) Limited, are described in Part I of this report entitled "Economic Development of Nepheline Syenite Deposits."

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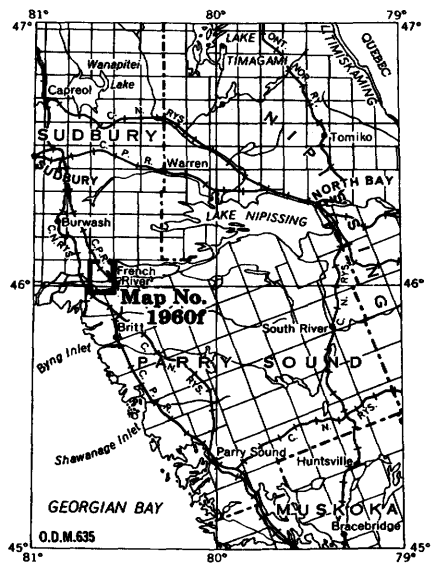
[1] J. Satterly, *op. cit.*, pp. 59, 60.

CHAPTER IV

French River Nepheline Syenite Deposits, Bigwood Township District of Sudbury

INTRODUCTION

Two lens-shaped nepheline syenite bodies form part of an elongate alkaline syenite intrusive in Bigwood township, District of Sudbury. The alkaline syenite intrusive has a length of 7 miles in a north-south direction and a maximum width of 1 mile. As shown on the accompanying map (No. 1960f, in map case) the nepheline syenite bodies form a northern lens, the Rutter nepheline syenite, and



Key map showing the location of Bigwood township, District of Sudbury. Scale, 1 inch to 50 miles.

a southern lens, the French River nepheline syenite, within the alkaline syenite complex. The Rutter nepheline syenite has a length of 3 miles in a north-south direction and a maximum width of ⅜ mile. It lies ⅝ mile west of Rutter on highway No. 69. The French River nepheline syenite has a length of 2½ miles and a width of ½ mile. The south tip of the French River nepheline syenite extends south of the French River for ½ mile into Fifteen Mile Island, District of Parry Sound. The French River nepheline syenite is 2½ miles west of Bigwood on highway No. 69, or 3¼ miles down the French River from the highway bridge.

Bigwood township is easily accessible; the new highway No. 69 from Parry Sound to Sudbury crosses it. It is bounded on the south by the French River, and on the east by Dry Pine Bay and Eighteen Mile Bay on the French River. The area is settled, and all parts of the township are easily accessible by motor road. The concession road running west from Bigwood village passes across the French River nepheline syenite. Roads running west and south from Rutter both cross the Rutter nepheline syenite.

The villages and postoffices of Rutter, Alban, Jamot, Bigwood, and French River Station lie within the township of Bigwood. It is a flourishing tourist resort area, and many cottages and lodges line the shores of the lakes, rivers, and bays.

The Canadian Pacific Railway's main line from Toronto to Sudbury passes through French River Station, Bigwood, and Rutter. The Canadian National Railways' Muskoka line crosses the French River 2 miles west of the west township boundary of Bigwood.

Connecting highways, No. 607 from Bigwood to Jamot and No. 64 from Rutter to Noelville, serve the northern and eastern parts of the township.

The French River was traversed by early explorers, and formed part of the historic canoe route from Quebec to Huronia and the west.

Bigwood township, and the alkaline syenite area to the south, was mapped by the author and his assistants in August and early September, 1957. The author was ably assisted by R. Laakso, K. D. Card, and John Mathieson. Independent mapping was carried out by R. Laakso.

Previous Work in the Area

Robert Bell made the first geological survey of the French River in 1891 and 1892, and his map published by the Geological Survey of Canada in their 1896 annual report represents the area as Laurentian gneiss. Bigwood township is included in the Delamere sheet, Map No. 238A of the Geological Survey of Canada, published in 1930. Geological field work for this map sheet was carried out by T. T. Quirke in 1924 and 1925, and by R. H. Pegrum in 1926. The nepheline syenite deposit, discovered in 1924 by T. T. Quirke, was examined by T. L. Walker and A. L. Parsons in 1925. The following bibliography lists the papers and reports resulting from previous geological work in the area.

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T. L. Walker and A. L. Parsons, "Minerals from the New Nepheline Syenite Area, French River, Ontario," *Contributions to Canadian Mineralogy*, Univ. of Toronto Studies No. 22, 1926, pp. 5–14.

Physiography

Bigwood township is a peneplane of low relief almost swept bare by glaciation, and there is a high proportion of outcrop. Relief rarely exceeds 100 feet. The bare white quartzite ridges of the Delamere Hills to the northeast form a prominent landmark standing up above the level peneplane surface.

DRAINAGE

Two structures control the drainage pattern:

1) A prominent east-west joint system cutting across the foliation of the gneisses;
2) The north or northwest strike of foliation in the gneisses.

The French River occupies a prominent east-west joint, and is incised in a 100-foot-deep gorge trending across the gneissic structure of the area. Patches of late Keweenawan diabase are occasionally seen along the gorge walls, and diabase occupies parts of this joint system. There appears to be little or no displacement of the nepheline syenite band at the French River.

Rae Lake and associated ponds lie along a second east-west joint 2½ miles north of the French River, and Emma Lake occupies a third of these east-west joints 2½ miles north of Rae Lake.

The Pickerel River, to the south, follows two more of the east-west joints.

Daoust Creek flows along a north-south strike valley for part of its course, and along a north-south linear, marking the west contact of the alkaline syenite body, for the lower 3 miles of its course. The outlet of Ham Lake, the creek flowing southward into Bigwood Bay, and the Murdock River, all occupy north-trending strike valleys controlled by the foliation in the gneisses.

Rapids and waterfalls along the French River indicate a youthful stage of drainage. The main falls in the area is Recollet Falls with a drop of about 8 feet.

GENERAL GEOLOGY

The bedrock formations of Bigwood township are all of Precambrian age. The oldest rocks are a series of sandy and pelitic sediments now metamorphosed to quartzite, biotite paragneiss, and amphibolite. During the Grenville orogeny, about 1,000 million years ago, these rocks were highly folded, and intruded and replaced by nepheline syenite, pink alkaline syenite, and granite. Most of the rocks of the area are now altered to stratiform, well-banded granitic gneisses. However, recognizable sediments exist along the Murdock River valley, in a mile-wide band along the west side of the river for the length of Bigwood township, and in the Delamere Hills, a relict area of white quartzite near Jamot.

The main plutonic rocks of the area are diorite, nepheline syenite, pink alkaline syenite, and granitic gneiss, probably emplaced in that order during the plutonic epoch accompanying the Grenville orogeny. These rocks are cut by late diabase, probably Keweenawan in age. All the plutonic rocks, with the exception of the late Keweenawan diabase, have been metamorphosed and have a gneissic structure.

TABLE OF FORMATIONS

CENOZOIC			
RECENT AND PLEISTOCENE:	Sand, gravel, and clay.		
	Great Unconformity		
PRECAMBRIAN	Diabase and gabbro (Keweenawan).		
	Intrusive Contact		
	Granitic rocks. Syenite. Nepheline syenite.	Granitization Intrusion	Grenville orogeny
	Intrusive Contact		
	Diorite	Folding	
	Intrusive Contact		
	Sedimentary Rocks: Jamot quartzite; Bigwood paragneiss, garnet paragneiss, para-amphibolite, biotite amphibolite; Murdock River quartzite and paragneiss.		

The accompanying sketch map indicates the main rock units and structure in Bigwood township. In the northeast corner of the township, and occupying an area of approximately 6 square miles in the adjacent townships of Delamere, Cosby, and Mason, the Jamot quartzite and greywacke forms a high range of hills, the Delamere Hills. These sediments are mainly pure white quartzite, and form an ungranitized sedimentary relict in the younger Grenville granitization gneiss terrane. Probably owing to the similarity between this white quartzite and the white quartzite of the La Cloche Hills to the west, T. T. Quirke correlated these rocks with the Lorrain quartzite of the Cobalt Series.[1]

Southwest of the Jamot quartzite there is a 2-mile-wide band of granitic gneisses striking northwest and dipping 60°–70°SW. These form a highland area between the Murdock River and Jamot. The glacial drift on this flat highland plane is thicker than in other parts of the township, where soil cover is sparse, and the main farming community of Bigwood township is situated here around Alban village. This band of rock is called the Alban granitic gneisses.

Along the Murdock River there is a prominent band of metasediments characterized by white quartzite. The band is not over 1,000 feet wide, and strikes northwest and dips 60°–70°SW. This band, called the Murdock River quartzite and paragneiss, consists of white quartzite, grey biotite paragneiss, garnet-biotite paragneiss, biotite amphibolite, and garnet amphibolite. It is granitized in places. The white quartzite was correlated by T. T. Quirke[2] with the Serpent quartzite of the Bruce Series, and the underlying garnet paragneiss with the Espanola limestone.

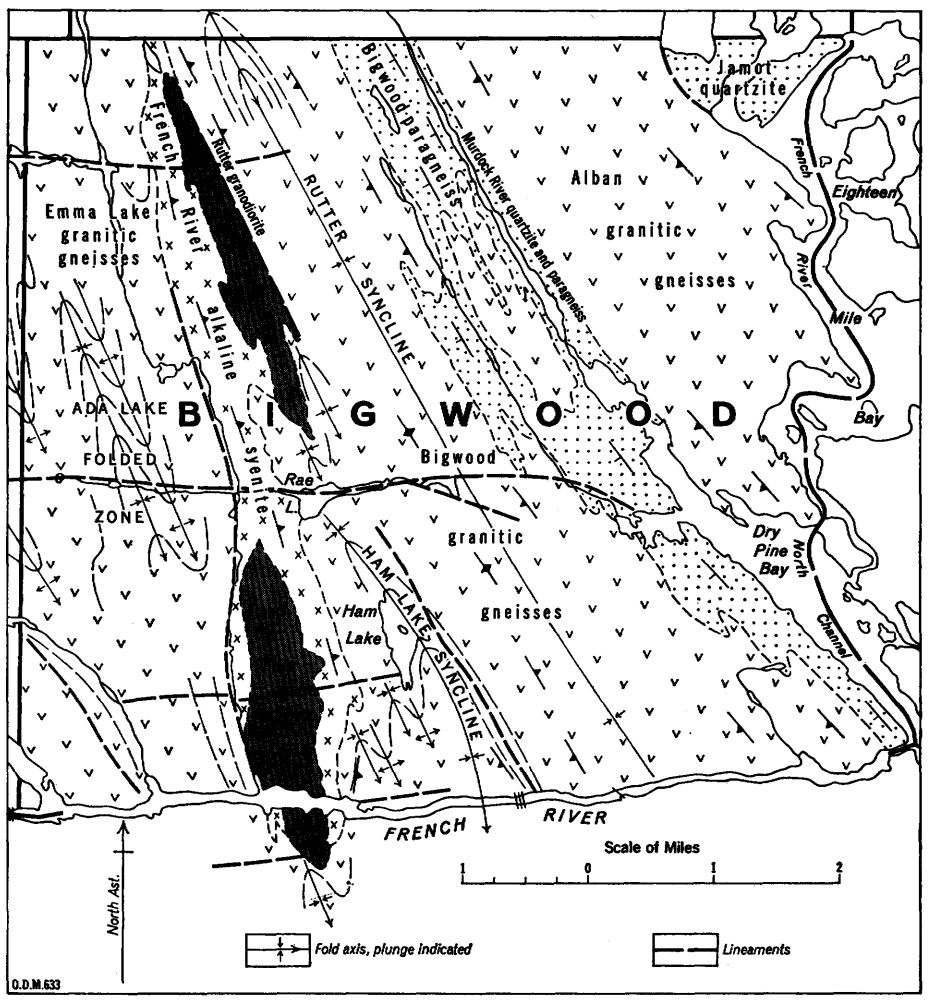
West of the Murdock River there is a band of metasediments, mainly grey biotite paragneiss, called by the author the Bigwood paragneiss. The band strikes northwest, parallel to the Murdock River, and dips 60°–80°SW. This band is granitized extensively in places by the introduction of pink potash feldspar

[1] Map No. 238A, *Delamere Sheet, Sudbury and Parry Sound Districts.* Scale, 1 inch to 1 mile. Geol. Surv. Can., 1930.

[2] T. T. Quirke, "Mineral Deposits of the Rutter Map-Area, Sudbury District, Ontario," *Summary Report,* Geol. Surv. Can., 1924, Part C, pp. 89–95.

and quartz, and grades westerly into stratified pink granitic and hybrid granite gneisses. The recognizable paragneiss band ranges from ½ to over ¾ mile wide, depending on the extent of granitization.

Between the Bigwood paragneiss and the alkaline syenite intrusive there is an area of stratiform granitic and hybrid granitic gneisses, ranging from 1¼ miles



Geological sketch map of Bigwood township showing main structural features.

wide at Rutter to 3 miles wide at the French River. These well-banded hybrid granitic gneisses occupy a well-defined south-pitching syncline, the Rutter syncline, whose axis more or less parallels highway No. 69 throughout the township. The trough of this syncline is excellently exposed west of Rutter, on the north township boundary.

In south-central Bigwood township, a second major syncline in granitic gneisses west of the Rutter syncline can be seen extending southeast through Ham Lake. This syncline also pitches southward, and is called the Ham Lake syncline. There is pronounced drag folding in the granitic gneisses along the east side of the alkaline syenite intrusive north of Rae Lake, and also southwest of Ham Lake.

The hybrid granitic gneisses between the Bigwood paragneiss band and the alkaline syenite are mainly well banded, but there is a massive lens of pink granodiorite, ¼ mile wide and 3 miles long, extending southeast from the north township boundary along the west limb of the Rutter syncline next to the Rutter nepheline syenite. This dark-red granodiorite is characterized by pencil lineation of hornblende and pyroxene.

West of the alkaline syenite the township is underlain by pink biotite leucogranite gneisses, called by the author the Emma Lake granitic gneisses. This granitic gneiss is somewhat more massive than the Ham Lake and Rutter granitic gneisses to the east. It is not pronouncedly stratified, but has a distinct foliation and lineation. It may represent a more extreme phase of granitization granite than that to the east. Occasional narrow relict bands of biotite and garnet amphibolite can be found in the granitic gneiss.

Sedimentary Rocks

JAMOT QUARTZITE AND GREYWACKE

The Jamot quartzite is composed mainly of a distinctive pure white coarse-grained glassy quartzite. The quartzite is well bedded. It ranges in colour from pure white to pinkish, due to hematite (specularite) inclusions. Muscovite occasionally occurs as an accessory, and in thin section small muscovite flakes are aligned parallel to one another and can be observed transecting quartz-grain boundaries. The quartzite is somewhat sheared in outcrops on the sawmill property, just east of the bridge on highway No. 64 near Jamot. Sericite and sillimanite are developed along shears. In this area, fine-grained well-bedded, highly folded siliceous greywacke occurs interbedded with the quartzite.

Owing to its high purity the Jamot quartzite is of interest as a source of silica for flux. In 1949 the author sampled some of the quartzite in Cosby township near Jamot:

A small quarry was opened half a mile north of the Noelville road on the east side of the quartzite range, but only test shipments were made.

Three analyses of quartzite from Cosby township gave the following results:

Sample	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O
42.....	98.07	1.00	0.40	0.05	0.06	0.06	0.06	<0.50
44.....	96.98	1.76	0.75	0.05	0.03	0.09	0.04	<0.50
45.....	98.09	0.37	1.09	0.01	0.02	0.08	0.04	<0.50

Sample 42 is a composite chip sample taken over a 350-foot width across the strike of the quartzite just north of the Noelville road in the southern part of Cosby township.

Sample 44 is a composite chip sample taken over a 700-foot width across structure on a quartzite ridge immediately north of the schoolhouse in Cosby township on the Noelville road.

Sample 45 is a composite grab sample from the small quartzite quarry half a mile north of the main road, Cosby township.[1]

MURDOCK RIVER QUARTZITE AND PARAGNEISS

This formation, occurring in a 1,000-foot-wide band along the valley of the Murdock River, consists mainly of white quartzite and interbedded grey biotite and garnet paragneiss. On the east side of the Murdock River the band is mainly dark-grey, medium- to coarse-grained, garnet-biotite paragneiss. This grades eastward into the Alban granitic gneisses. Patches and bands of white quartzite occur on the west side of the river and sparingly on the east side. The quartzite beds cannot be traced continuously along strike to the southeast, but grade into granitized quartzite and paragneiss. All stages in the metasomatic alteration of

[1]D. F. Hewitt, *Silica in Ontario*, Ont. Dept. Mines, Indus. Min. Circ. No. 2, 1951, p. 10.

pure white quartzite to a granitic-looking pink gneiss, by addition of pink potash feldspar, can be followed in outcrop. Garnet and biotite para-amphibolite are also present in this band, but in minor amounts.

Relict patches of the Murdock River quartzite band occur along strike 4 miles south of the mouth of the Murdock River, on the west shore of Dry Pine Bay at the southeast corner of Bigwood township.

BIGWOOD PARAGNEISS

The Bigwood paragneiss forms a band ½–¾ mile wide, striking north-northwest and dipping 60°–80° SW., extending throughout the entire length of the township, from the north boundary east of Rutter Station to the French River.

It consists mainly of light-grey, dark-grey, and pink-banded biotite paragneisses in various stages of granitization. Dark-grey, biotite-rich bands, only an inch or two in width, persist along strike for great distances giving the rock a distinctive banded structure. The paragneiss is well bedded, medium-grained, and consists mainly of the following mineral assemblages:

Biotite-quartz-plagioclase
Biotite-quartz-plagioclase-garnet
Biotite-hornblende-quartz-plagioclase
Hornblende-quartz-plagioclase
Hornblende-garnet-plagioclase

Microcline is present in varying amounts, depending on the degree of potash metasomatism to which the gneiss has been subjected. The replacement character of the microcline is evident in thin sections, since it embays and replaces other minerals and often occurs in much larger crystals than the average uniform grains of the paragneiss. Fresh rock cuts exposing this band may be seen along highway No. 64, west of the Murdock River. Dark bands high in biotite and hornblende occur thinly interbedded with pink and grey leucocratic bands.

T. T. Quirke in his paper of 1929 on the structures and batholiths of the French River area gives analyses of five samples of "country gneisses" taken in order from west to east, from east of Rutter to the Murdock River. These analyses are as follows:

CHEMICAL COMPOSITION OF COUNTRY GNEISSES
(T. T. Quirke, "The Structures and Batholiths of the French River Area," *Journal of Geology*, Vol. XXXVII, 1929, No. 7, p. 688.)

	Sample				
	b	c	d	e	f
SiO_2	54.00	69.00	71.06	71.70	76.80
Al_2O_3	20.65	14.95	13.60	13.22	11.58
Fe_2O_3	4.33	3.41	1.28	1.34	0.50
FeO	5.05	2.34	2.08	1.87	0.86
CaO	7.20	1.60	1.70	1.48	0.84
MgO	3.11	0.73	1.62	1.13	0.47
K_2O	1.74	3.86	3.98	4.44	6.04
Na_2O	3.52	4.07	3.80	4.40	2.41
H_2O+	0.42	0.19	0.38	0.13	0.19
H_2O-	0.05	0.10	.....	.....	.....
TiO_2	n.d.	n.d.	0.34	0.17	0.05
MnO	.....	.....	0.04	0.02	trace
P_2O_5	n.d.	n.d.	0.05	0.01	.....
BaO	.....	.....	.....	.....	.....
S	.....	.....	.....	.....	.....
Cl	.....	.....	.....	.....	.....
CO_2	0.27	0.16	0.20	0.10	0.49
Total	100.34	100.41	100.15	100.01	100.23

Sample b—Banded gneiss, east of Rutter. A dark-coloured layer in the Gowganda formation, probably originally a fine-grained silt rock. (M. F. Connor, analyst.)

c—Banded gneiss, east of Rutter. A pale-pink sillimanite gneiss, which is an altered conglomerate of Gowganda age, probably originally a typical "slate conglomerate." (M. F. Connor, analyst.)

d—Banded gneiss, east of Rutter, similar to sample c but lacking the evidence of a conglomeratic origin. Several hundred feet stratigraphically below sample c, but also part of the Gowganda formation. (William Gerrie, analyst.)

e—Banded gneiss, near west bank of Murdock River, east of Rutter. A highly-altered conglomerate member of the Serpent formation. (William Gerrie, analyst.)

f—Banded gneiss, near same locality as sample e, but stratigraphically lower, and separated from it by a band of quartzite. It is an altered member of the Serpent formation. (William Gerrie, analyst.)

Quirke points out that "these gneisses look like igneous rocks in hand specimens, and chemical analyses show that they are essentially the same in composition as many alkaline plutonic rocks." Their banding and structure however, as well as their intercalation with undoubted quartzites, indicate their sedimentary origin.

On the Delamere map sheet, T. T. Quirke correlates the Bigwood paragneiss with the Gowanda formation of the Cobalt Series. This paragneiss formation contains no recognizable conglomerate in Bigwood township, and Quirke's correlation may be based on the fact that it lies above the Murdock River quartzite, which he correlated with the Serpent quartzite of the Bruce Series.

While no true conglomerates were seen by the author within the map area, tectonic breccias or "pseudo-conglomerates," consisting of fragments of amphibolite and paragneiss in a granitized gneiss matrix, were observed in places along the Murdock River valley. The accompanying photos illustrate this type of occurrence.

Narrow relict bands of grey paragneiss and biotite amphibolite occur in places in the granitic gneisses to the west. A small relict patch of white quartzite, 150 feet wide and a few hundred feet long, is exposed on the north shore of the French River, in lot 13, concession I.

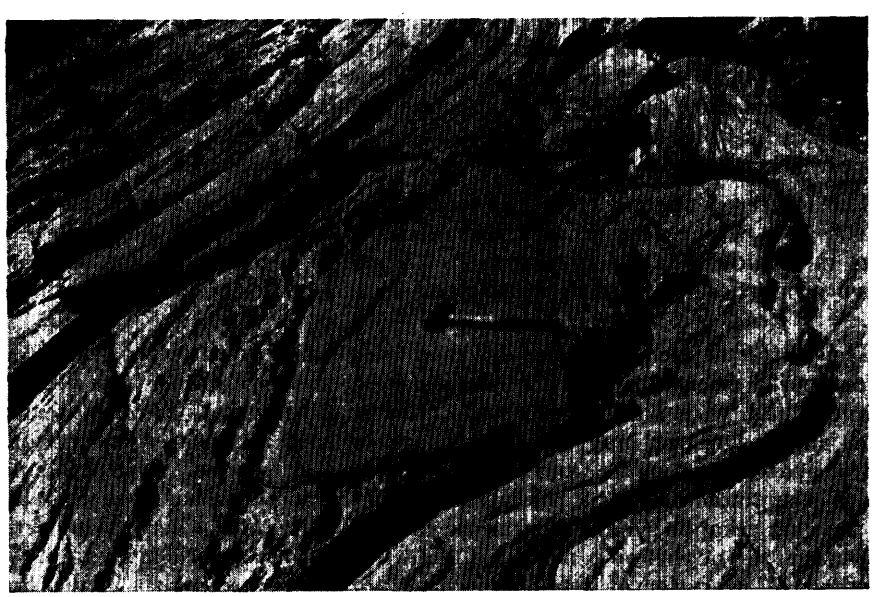
Undoubtedly all the sediments of the area were highly metamorphosed, and often granitized, during the Grenville orogeny, which affected this whole area south of the Grenville Front. It seems likely that T. T. Quirke's postulation is correct that the rocks of the Grenville province south of the Grenville Front may represent highly metamorphosed and granitized equivalents of the rocks of the Timiskaming sub-province north of the Grenville Front. However, correlation of formations from one area to the other is very doubtful in view of lack of valid criteria for correlating across wide areas of granitic gneiss. The concept of the "Disappearance of the Huronian" described in Memoir No. 160 of the Geological Survey of Canada appears to be well-founded, although correlation of the rocks involved with those of the Huronian system may be questioned.

Diorite

The oldest plutonic rocks in the area are the metamorphosed garnetiferous diorites, which form small dikes and irregular bodies in the granitized gneisses. These rocks are of minor size and extent. One such garnetiferous diorite occurs on the Pickerel River, just east of the Atlin-Ruffner allanite showing. Others occur in places along the Murdock and French rivers. These diorites are metamorphosed and are cut by syenite and granite.



Tectonic breccia showing boudins of amphibolite in a matrix of granitized Bigwood paragneiss; Murdock River, Bigwood township.



Tectonic breccia showing a large block of amphibolite in a matrix of granitized paragneiss; Murdock River, Bigwood township.

French River Alkaline Syenite

The French River alkaline syenite intrusive consists of two lenses of nepheline syenite within a sheath of pink alkaline syenite. The alkaline syenite mass has a total length of 7 miles and extends from lot 12 on the north boundary of the township, to lot 10 on the French River, and thence for ½ mile south of the French River, on Fifteen Mile Island. There is another small outcrop on the Pickerel River, ½ mile south of the south end of the French River nepheline syenite and separated from it by granitic gneiss. The alkaline syenite body has a maximum width of one mile, and is constricted to a width of less than ½ mile at Rae Lake near the middle of the body.

The nepheline and pink alkaline syenites are foliated; the foliation and lineation strikes N.20°–30°W. and dips 20°–50°E. The alkaline syenite body lies on the west limbs of the south-pitching Rutter and Ham Lake synclines. The Rutter nepheline syenite lens to the north lies on the west limb of the Rutter syncline, and terminates in south-pitching drag folding in the granitic gneisses north of Rae Lake. The French River nepheline syenite lens to the south lies on the west limb of the Ham Lake syncline, and is terminated by south-pitching drag folding in the granitic gneisses between the French and Pickerel rivers.

The two nepheline syenite lenses, the Rutter nepheline syenite to the north, and the French River nepheline syenite to the south, are similar in colour, structure, grain size, texture, and leucocratic mineral content, but differ in that the chief mafic mineral of the Rutter nepheline syenite is hastingsite, while the chief mafic mineral of the French River nepheline syenite is biotite.

RUTTER NEPHELINE SYENITE

The Rutter nepheline syenite extends from the south end of Rutter Pond, in lot 12, concession VI, Bigwood township, for a distance of 3 miles to the south-southeast to lot 10, concession III. It is flanked on the east by red alkaline granodiorite, on the south by pink granitic gneiss, and on the west and north by pink alkaline syenite gneiss. The nepheline syenite makes up about 50 percent of the north half of the French River alkaline syenite mass. Several bands and lenses of pink alkaline syenite intrude and replace the nepheline syenite.

The Rutter nepheline syenite is foliated; the foliation strikes N.30°W. and dips 40°–70°E. The gneissic structure is due to alignment of hornblende and biotite in a rude foliation or lineation. There is a considerable variation in relative proportions of nepheline, plagioclase, and mafic minerals from band to band.

The Rutter nepheline syenite is a medium-grained granitoid to granoblastic rock composed essentially of white plagioclase (generally albite), pink nepheline and microcline, with hastingsite as the chief mafic mineral. Biotite, aegirine-augite, and magnetite may occur as characterizing accessories, and titanite, allanite, apatite, carbonate and zircon as minor accessories. Microcline antiperthite is common in parts of the intrusive where microcline has been introduced from the pink alkaline syenite or granitic rocks. In the cases where microperthite is abundant, the nepheline is usually altered to a fibrous zeolitic aggregate. This hydrothermal alteration of nepheline during potash metasomatism is also found in the Haliburton-Bancroft and Blue Mountain nepheline syenite deposits.

The accompanying table gives Rosiwal modal analyses of seven samples from the Rutter nepheline syenite:

ROSIWAL ANALYSES OF RUTTER NEPHELINE SYENITE

	Sample No. and Location						
	49–12, Lot 12, Con. VI	B577, Lot 12, Con. VI	49–14, Lot 11, Con. V	49–18, Lot 11, Con. V	49–20, Lot 11, Con. V	B573, Lot 11, Con. IV	B574, Lot 10, Con. IV
Nepheline	28.4	21.8	0.8	48.9	32.8	12.2	34.4
Plagioclase	42.6	41.9	16.4	30.6	20.2	39.7	39.0
Microcline	20.6	21.8	10.8	7.5	6.2	16.1	17.2
Perthite	.....	7.0	56.5	11.8	37.1	6.3	3.5
Biotite	.....	.....	2.4	.....	.....	0.6	.....
Hastingsite	8.2	2.4	11.1	0.6	3.7	23.9	3.7
Aegirine-augite	.....	1.3	.....	.....	.....	0.6	0.8
Opaques	.....	3.8	0.3	.....	.....	.....	1.4
Titanite	.....	.....	1.7	0.4	.....	.....	.....
Allanite	.....	.....	.....	0.2	.....	.....	.....
Apatite	.....	.....	.....	.....	.....	0.6	.....

Samples Nos. 49-12 and B577 are representative of the north end of the Rutter nepheline syenite in concession VI. Samples Nos. 49-14, 49-18, and 49-20 are members of a suite taken across the nepheline syenite body along the east-west farm road, 2 miles south of Rutter. Sample No. 49-18 represents the central part of the body, 800 feet west of the east contact. Sample No. 49-14 is taken from a band of nepheline-poor white alkaline syenite, about 20 feet from the east contact of the Rutter body, and the large content of microcline antiperthite (56.5 percent) is characteristic of the border zones of nepheline syenite, which have suffered potash metasomatism. Sample No. 49-20 was taken from the west contact zone of the nepheline syenite, about 200 feet from the west contact. It also shows a substantial potash introduction, with 37.1 percent microcline antiperthite. Samples Nos. B573 and B574 are representative of the southern part of the nepheline syenite lens.

R. H. Pegrum[1] in his study of the French River alkaline rocks gives the following complete chemical analysis of the Rutter nepheline syenite:

	PERCENT	NORM		MODE	
SiO_2	58.27	Or	22.24	Microperthite	45.39
Al_2O_3	20.35	Ab	44.54	Microcline	7.07
Fe_2O_3	1.33	Ne	21.30	Albite	20.69
FeO	2.92	Ac	3.70	Nepheline	22.74
MnO	0.22	Na_2SiO_3	2.56	Amphibole	4.11
TiO_2	0.63	Ol(Fa)	3.47		100.00
MgO	0.08	Ol(Fo)	0.14		
CaO	0.21	Il	1.22		
Na_2O	11.68	Ap	0.16		
K_2O	3.88	Ct	0.30		
P_2O_5	0.07	H_2O	0.30		
CO_2	0.32		99.93		
H_2O	6.31				
	100.27				

[1]R. H. Pegrum, *The Alkaline Syenites and Associated Rocks of the French River Area, Ontario*, unpublished Ph.D. thesis, Princeton Univ., 1927.

In summary, the Rutter nepheline syenite consists essentially of albite, nepheline, microcline, and hastingsite, with accessory biotite, aegirine-augite, and magnetite. It is not uniform in composition, but may vary in mafic content from band to band from less than 5 percent to over 30 percent; normally less than 10 percent mafic minerals are present. Nepheline content ranges from zero to over 50 percent, but may be generally 20–30 percent. The nepheline is frequently pink to salmon pink in colour, even when fresh and unaltered, and analyses of the pink nepheline, made for the author by the Provincial Assayer of the Ontario Department of Mines, indicate an iron content of 0.34 percent Fe and 0.18 percent Fe for two samples from the Rutter nepheline syenite.

FRENCH RIVER NEPHELINE SYENITE

The French River nepheline syenite extends for 2½ miles in a north-south direction, from lot 11, concession II, Bigwood township, 2 miles north of the French River, to the French River, and thence for ½ mile to the south of the French River into Fifteen Mile Island. The intrusive has a maximum width of ½ mile, on the Ham Lake road. The French River nepheline syenite is surrounded by a mantle of pink alkaline syenite. This pink alkaline syenite zone is over ¼ mile wide on the east flank of the nepheline syenite, but only a few hundred feet wide on the west flank.

The French River nepheline syenite is foliated and, like the Rutter nepheline syenite, has the lineation of a metamorphic tectonite. The foliation and lineation strikes N.10°–30°W. and dips 20°–50°E., generally having a shallower dip than the Rutter body. In the French River body the foliation is due to alignment and rude layering of biotite and nepheline-rich bands. There is again considerable variation in proportions of biotite, nepheline, albite, and microcline from band to band across the intrusive.

The French River nepheline syenite is a medium- to coarse-grained granitoid to granoblastic gneiss, composed essentially of nepheline, plagioclase, and microcline, with biotite as the characterizing accessory. Microcline microperthite (antiperthite) may be present in major amounts, especially near the contacts. Hastingsite, aegirine-augite, magnetite, titanite, zircon, apatite, graphite, corundum, carbonates, sodalite, and cancrinite are sometimes present. The nepheline syenite is intruded and replaced by the pink alkaline syenite, which forms the border zone of the composite alkaline intrusive. Where potash metasomatism has been effective, the nepheline is generally highly altered to a fibrous aggregate of zeolitic minerals.

Xenoblastic patch pegmatites, composed of nepheline and albite up to a foot or more in diameter, are occasionally observed, and these patch pegmatites frequently contain blue sodalite and orange and yellow cancrinite. Chemical analyses of nepheline, biotite, cancrinite, hydronephelite, and acmite from the French River nepheline syenite are given by Walker and Parsons.[1]

Corundum and graphite are uncommon and were only observed by the author in one area of lot 10, concession II, just north of the Ham Lake road. Here graphite flakes up to ¼ inch in diameter made up about 5 percent of a white alkaline nepheline-poor syenite. Rare grey corundum crystals to ½ inch in diameter occurred in nearby grey biotite nepheline syenite, but corundum

[1]T. L. Walker and A. L. Parsons, Minerals from the New Nepheline Syenite Area, French River, Ontario," *Contributions to Canadian Mineralogy*, Univ. of Toronto Studies No. 22, 1926, pp. 7–12.

is more common in the adjacent pink alkaline syenites. The occurrence of corundum here is very similar to that already described in Carlow and Raglan townships of the Haliburton-Bancroft area.

The proportion of outcrop within the French River nepheline syenite body is low compared to that of the Rutter body, and the best exposures are along the shores of the French River.

The accompanying table gives Rosiwal modal analyses of six samples from the French River nepheline syenite and one sample from the Pickerel River:

ROSIWAL ANALYSES OF FRENCH RIVER NEPHELINE SYENITE

	Sample No. and Location						
	49-21, Lot 10, Con. II	49-25, Lot 10, Con. II	49-30, Lot 10, Con. I	49-31, Lot 10, Con. I	49-37, Lot 10, Con. I	49-39, Lot 10, Con. I	B5711, Pickerel River
Nepheline	11.7	11.3	13.5	16.6	12.6	20.9	24.9
Plagioclase	66.1	58.4	49.2	47.9	47.5	46.3	43.0
Microcline	10.3	18.8	22.7	20.9	23.2	23.9	20.5
Perthite	0.2	4.9	7.4	1.3	0.5	4.4	.....
Biotite	11.7	6.6	7.3	6.5	13.9	4.4	11.5
Hastingsite	.....	.....	.....	6.5	.....	0.1	.....
Titanite	.....	.....	.....	0.4	.....	.....	.....
Carbonate	.....	.....	.....	.....	2.4	.....	0.1

Samples Nos. 49-21 and 49-25 were taken along the Ham Lake road. Sample No. 49-21 showed minor accessory graphite in hand specimen. Samples Nos. 49-30, 31, 37, and 39 were taken from east to west across the intrusive along the French River: sample No. 30 at the east contact, sample No. 31 at 25 feet to the west, sample No. 37 near the centre of the body, and sample No. 39 near the west contact with pink syenite.

Sample No. B5711 is taken from the small outcrop area of grey biotite nepheline syenite shown on the map on the north shore of the Pickerel River, ½ mile south of the tip of the French River nepheline syenite.

The following chemical analysis of the French River nepheline syenite made by H. C. Rickaby is quoted from Walker and Parson's paper:[1]

CHEMICAL ANALYSIS

	Percent
SiO_2	55.90
Al_2O_3	22.12
Fe_2O_3	0.96
FeO	4.33
MnO	0.14
CaO	0.44
MgO	0.37
Na_2O	8.35
K_2O	6.42
TiO_2	0.05
H_2O	0.57
CO_2	0.67
	100.32

MODE
(average of 3 sections of analyzed rock)[2]

	Percent
Albite	40.34
Microcline	29.17
Nepheline	21.08
Orthoclase	3.24
Microperthite	1.58
Biotite	2.28
Carbonate and Magnetite	0.73
Cancrinite	1.58

[1]T. L. Walker and A. L. Parsons, *op. cit.*, p. 6.
[2]R. H. Pegrum, *The Alkaline Syenites and Associated Rocks of the French River Area, Ontario*, unpublished Ph.D. thesis, Princeton Univ., 1927.

In summary, the French River nepheline syenite consists essentially of nepheline, albite, and microcline, with biotite as the main mafic constituent, in contrast to the Rutter body in which hastingsite predominates. Hastingsite and aegirine-augite are generally minor constituents of the French River body. Zircon, sodalite, and cancrinite are more common in the French River body, and corundum and graphite were observed only in it, not in the Rutter body. The nepheline is commonly white in the French River body, and does not often have the characteristic pink or buff tone of that of the Rutter body. The nepheline content of the French River body is variable, as is that of the Rutter body, but the nepheline content averages perhaps as much as 10 percent less in the French River body, i.e. 10–20 percent. The plagioclase in both bodies is albite ranging from An_4 to An_9. Microperthite is more common in the Rutter body. Mafic minerals are frequently not uniformly distributed in the rock, but occur in linear streaks or bands parallel to the foliation.

Throughout both intrusives, the contacts with the enclosing pink alkaline syenite gneiss are gradational, and the pink alkaline syenite replaces the nepheline syenite in a fashion similar to that described in the Blue Mountain and Haliburton-Bancroft areas. Nepheline syenite inclusions have been observed in pink augen syenite gneiss. Microcline is commonly introduced into the nepheline syenite from the adjacent pink syenite, with production of abundant antiperthite, and concomitant hydration of the nepheline and formation of "hydronephelite."

ANALYSES OF FRENCH RIVER NEPHELINE SYENITE AND ASSOCIATED ROCKS
(Supplied by C. E. Tilley)

CHEMICAL ANALYSES

	1	2	3	4
SiO_2	59.03	56.35	65.52	65.96
Al_2O_3	21.81	20.31	18.61	18.92
Fe_2O_3	2.34	2.66	1.00	0.48
FeO	1.34	4.09	1.17	0.53
MnO	0.03	0.18	0.03	0.03
MgO	0.06	0.11	0.10	0.08
CaO	0.53	1.69	0.45	0.23
Na_2O	10.78	8.31	7.59	7.17
K_2O	4.36	4.86	5.13	5.90
H_2O+	0.12	0.67	0.18	0.15
H_2O-	0.03	0.02	0.06	nil
TiO_2	0.03	0.16	0.04	0.03
P_2O_5	0.02	0.04	0.01	0.04
CO_2	nil	0.67	0.02	0.16
Total	100.48	100.12	99.91	99.68

NORM

	1	2	3	4
Qz	.....	.....	0.30	1.14
Or	26.13	28.91	30.02	35.03
Ab	41.92	40.48	64.45	60.78
Ne	24.71	16.11	.....	.....
Cor	.....	.....	.....	0.61
An	.....	3.61	1.39	.....
Di	2.20	0.49	0.73	.....
Ac	3.23	.....	.....	.....
Hy	.....	.....	1.14	0.73
Ol	0.30	4.09	.....	.....
Mt	1.62	3.94	1.39	0.70
Il	.....	0.30	.....	.....
Ct	.....	1.52	.....	0.36
Rest	0.26	0.73	0.34	0.25
Total	100.37	100.18	99.76	99.60

Co-ordinates in System Ne-Ks-Qz

Ne	51.1	44.5	36.9	34.0
Ks	16.0	19.2	18.0	20.5
Qz	32.9	36.3	45.1	45.5

No. 1—Aegirine nepheline syenite gneiss; Rutter nepheline syenite body, central part of the "nepheline belt", Bigwood tp., French River area. (1560/65100).

No. 2—Hastingsite-biotite nepheline syenite gneiss; south shore of French River, Bigwood tp. (1595/65135).

No. 3—Syenite (biotite, aegirine, hastingsite) interbanded in nepheline syenite gneiss; north shore of French River, Bigwood tp. (1588/65128).

No. 4—Syenite (biotite, aegirine); south shore of French River, Bigwood tp. (1596/65136).

PINK ALKALINE SYENITE

As already described, the pink alkaline syenite forms an integral part of the French River alkaline syenite body. Pink syenite mantles the French River nepheline syenite lens, and flanks the north and west sides of the Rutter nepheline syenite, as well as intruding and replacing each.

The pink syenite is thought to have been intruded during the same period as the nepheline syenite, but as a later phase of a composite intrusion. However, undoubtedly some of the pink alkaline syenite is produced by potash metasomatism of the nepheline syenite in a manner similar to that described at the Klondike workings, Raglan township, Renfrew county. (See page 86.)

The pink syenite is a medium-grained gneissic rock composed predominantly of microcline microperthite, with abundant albite and microcline. Hastingsite, aegirine-augite, biotite, and magnetite are the chief mafic minerals. Zircon, apatite, garnet, pyrite, carbonate, fluorite, and titanite are accessories. The hornblende and magnetite frequently occur as glomeroporphyroblastic lineal stringers in the pink syenite, giving the rock the appearance of a "pencil gneiss."

The foliation and gneissic structure of the pink alkaline syenite conforms with that of the nepheline syenite lenses, striking N.20°–30°W. and dipping 30°–70°E.

Syenite pegmatites intrude and replace the pink alkaline syenites, and grey corundum crystals up to ½ inch in size occur in the pegmatitic phase in lot 10, concession II, Bigwood township. Graphite occasionally occurs in the syenite gneiss, often adjacent to graphitic nepheline syenite, in lot 10, concession II. Just south of the Ham Lake road, at this locality, large red garnets up to 2 inches in size were noted in syenite pegmatite.

The syenite is called "umptekite" by Pegrum,[1] and the special names "bigwoodite", "rutterite", and "fenite" were used by Quirke[2] to describe it. Pegrum[3] gives the mode of a typical specimen of umptekite as: microperthite, 53.28 percent; albite, 27.69 percent; orthoclase, 12.06 percent; microcline, 5.16 percent; biotite 1.81 percent.

The Johannsen classifications for bigwoodite, rutterite, and fenite are 1114P, 2115P, and 2114P respectively. In bigwoodite and fenite the potash feldspar exceeds the albite, while in rutterite the reverse is true.

In general the pink alkaline syenites are characterized by a great abundance of microcline microperthite, often making up as much as 65 percent of the rock. Plagioclase is generally albite An_5 to An_9. The amphibole, if present, is characteristically a bright green sodic hastingsite. Aegirine-augite occasionally occurs.

[1] R. H. Pegrum, *op. cit.*

[2] T. T. Quirke, *New Nepheline Syenites from Bigwood Township*, Illinois Academy of Sciences Transactions, Dec. 1936.

[3] R. H. Pegrum, *op. cit.*

Garnetiferous Syenite

In Bigwood township, outside of the French River alkaline syenite body, there is another type of syenite found along the east limb of the Rutter syncline near the synclinal axis. This is a dark-red to olive-green, garnetiferous hornblende syenite or quartz syenite. It occurs in a band up to 200 feet wide extending from the lot line between lots 10 and 11 in the centre of concession VI, in a south-southeasterly strike direction to the Ham Lake road in lot 6, concession I. The band is not continuous, but is replaced by granitic rocks, and grades into dark-red hornblende garnet granite gneiss. It has been granitized by addition of microcline and quartz.

The garnetiferous rock is composed of orthoclase, oligoclase, hastingsite or hornblende, biotite, some quartz, and red garnet. It usually contains abundant titanite, as well as pyrite, magnetite, carbonate, and apatite as accessories. In appearance the rock is similar to the Deer Lake syenite of Cardiff township, Haliburton county.

Granitic Rocks

The commonest rock types found in the area are the pink granitic and hybrid granitic gneisses. These rocks occur in two main areas: the Alban granitic gneisses form a band, 1½–2 miles wide, striking southeast and dipping to the southwest, between the Murdock River and Jamot; the main area of Bigwood granitic gneisses occupies two-thirds of the township, west and south of the Bigwood paragneiss band, with the exception of the area underlain by the French River alkaline syenite body.

ALBAN GRANITIC GNEISSES

The structure within the wide band of pink granitic gneisses southeast of Alban is a simple monocline dipping 50°–80°SW. Lithologically, the Alban granitic gneiss is a pink to grey, leucocratic granite gneiss composed essentially of microcline, quartz, and plagioclase (oligoclase), with accessory biotite. Lineation and rude foliation exist throughout the body, and narrow bands of paragneiss occasionally occur. However, the mixed granitic and sedimentary banded type of hybrid granite gneiss is lacking, and if these rocks represent the product of granitization, the process has gone nearly to completion. To the east, the Alban granitic gneisses grade into pink arkose.

BIGWOOD GRANITIC GNEISSES

In the area to the west of the Bigwood paragneiss band, the structure is complex. Between the Murdock River and the French River alkaline syenite there are two major synclines, the Rutter syncline and the Ham Lake syncline, both accompanied by minor drag folding on their west flanks. West of the French River alkaline syenite body, the granitic gneisses are strongly and intricately dragfolded as far south as the Ham Lake road.

This whole area of granitic gneisses is regarded as the product of a process of regional granitization. Definite folded sedimentary structures are preserved in the granitized terrane, e.g. the Rutter syncline, and the granitized gneisses grade into unreplaced paragneiss and quartzite. Granitization increases in intensity from east to west. To the east, on the east limb of the Rutter syncline, light- and dark-grey paragneiss and white quartzite are easily recognizable, but grade into granitized gneisses to the west in the stippled zone shown on the geological map (No. 1960f, in map case). The granitized gneisses have the same attitude and

structure as the unreplaced paragneisses, the only difference being in the addition of pink microcline and quartz. Interbanded pink, grey, and black gneisses are a feature of the hybrid granitic gneiss zone. Banded pink and grey hybrid granitic gneisses extend from highway No. 69, west to the French River alkaline syenite south of Rae Lake, and the gneisses of the Ham Lake syncline are largely of this type. However, to the north, on the west limb of the Rutter syncline, conditions are different.

RUTTER GRANODIORITE

On the west limb of the Rutter syncline, to the north of Rae Lake, there is a great deal of outcrop, and in air photographs lenses of more massive rock, usually well jointed, 100–300 feet wide and over a mile in length, appear to be intercalated as sills in the banded gneiss. The banded gneisses in places appear to swing around these sill-like bodies. On field examination these more massive lenses are found to be foliated pink leucogranite gneiss carrying minor biotite. They lack the excellent banding of the adjacent granitic gneisses but are compositionally similar.

Adjacent to the Rutter nepheline syenite on the east there is a band of pink hornblende granodiorite gneiss, up to ¼ mile in width, extending from the north township boundary for 3 miles along strike to the southeast. This long narrow body is distinguished from the other rocks of the area by its lack of banding. However, it shows a pronounced lineation of hornblende, and clotting of feldspar in places, and was termed "pencil gneiss" and "augen gneiss" by the author in the field. This rock unit was recognized by Pegrum and called granodiorite; it was called "sodaclase adamellite" by Quirke.

The rock consists essentially of albite, microcline, and quartz, with green hornblende and biotite as characterizing accessories. Minor accessories include aegirine-augite, magnetite, apatite, titanite, carbonate, and zircon. The hornblende is sodic, and may be related to the hastingsite. R. H. Pegrum[1] gives the following mode and chemical analyses by A. H. Phillips:

	Percent
SiO_2	66.03
Al_2O_3	13.88
Fe_2O_3	2.86
FeO	2.34
MnO	0.45
CaO	1.96
Na_2O	7.49
K_2O	3.29
P_2O_5	0.38
CO_2	0.28
H_2O	0.35
TiO_2	0.45
	100.15

Norm	
Qz	8.61
Or	19.46
Ab	52.92
Ac	9.24
Di	4.32
Hyp	3.09
Il	0.91
Ap	1.01
Ct	0.70
H_2O	0.36
	100.62

Mode (Rosiwal average of three sections)	
Quartz	21.2
Microcline	14.2
Plagioclase (Ab_{92})	47.3
Hornblende	11.2
Biotite	3.5
Magnetite	1.0
Carbonate	0.8
Apatite	0.6
Zircon	0.2
	100.0

EMMA LAKE GRANITIC GNEISSES

To the west of the alkaline syenite body the township is underlain entirely by pink granitic gneisses. These are well banded hybrid granitic gneisses carrying biotite or hornblende as the chief mafic accessories. They are entirely granitized, but the banded structure is retained. There are a few narrow bands of biotite and garnet amphibolite, and one small relict of white quartzite on the north shore of the French River.

[1] R. H. Pegrum, *The Alkaline Syenites and Associated Rocks of the French River Area, Ontario*, unpublished Ph.D. thesis, Princeton Univ., 1927.

The granitic gneisses consist essentially of quartz, microcline, and plagioclase (albite to oligoclase), with accessory biotite, hornblende, zircon, apatite, titanite, garnet, and carbonate.

In the vicinity of the French River the foliation and banding strikes northwest and dips 40°–80°E. In the area to the north of concession I, the Emma Lake granitic gneisses are strongly dragfolded, as the structures shown in the accompanying map indicate.

PEGMATITES

Pods, lenses, and stringers of pink pegmatitic granite form a part of the hybrid granitic gneiss complex. Allanite and zircon are prominent accessories of many of the pegmatitic stringers.

Diabase

The basic intrusives in the area are of two types: metamorphosed garnetiferous diorite; and relatively fresh Keweenawan-type quartz and olivine diabase. The diabase occurs: along the south shore of the French River, ½ mile east of Flowerpot Bay; along the north shore of the French River, between Recollet Falls and highway No. 69; and along the west shore of the Murdock River, in lot 8, concession VI.

STRUCTURAL GEOLOGY

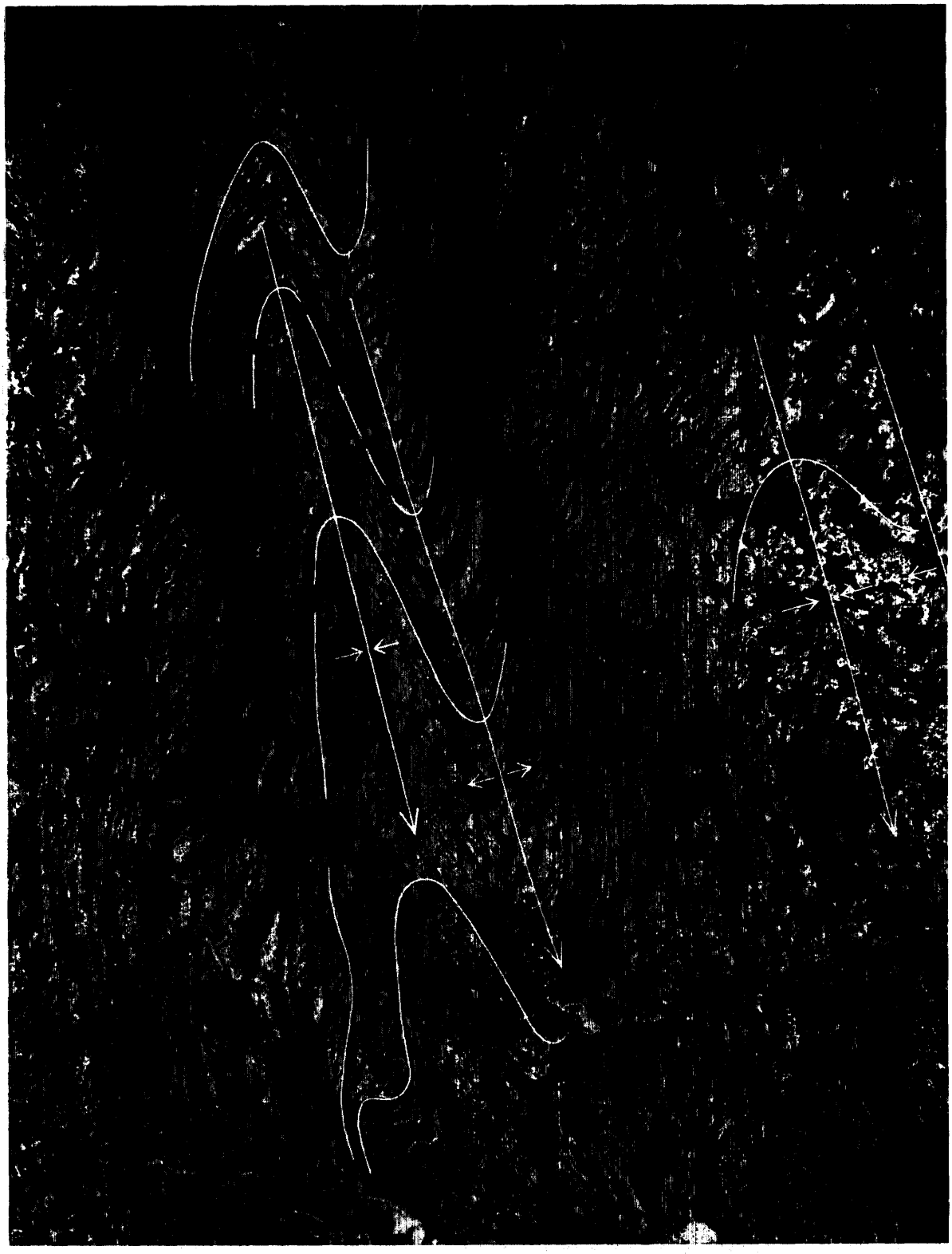
Bigwood township is an area of complex isoclinal folding and intense granitization. There has been some failure by faulting, especially along the limbs of major folds, and mylonitic and cataclastic structures have been developed. A prominent east-west set of late joints, which cuts across the structure of the country rock gneisses, controls the drainage pattern. Emplacement of the alkaline syenite intrusive has been structurally controlled, since it occurs along a zone of weakness and dragfolding on the west limbs of the Rutter and Ham Lake synclines. The Rutter nepheline syenite occurs on the west limb of the Rutter syncline, and the French River nepheline syenite on the west limb of the Ham Lake syncline.

Folding

RUTTER SYNCLINE

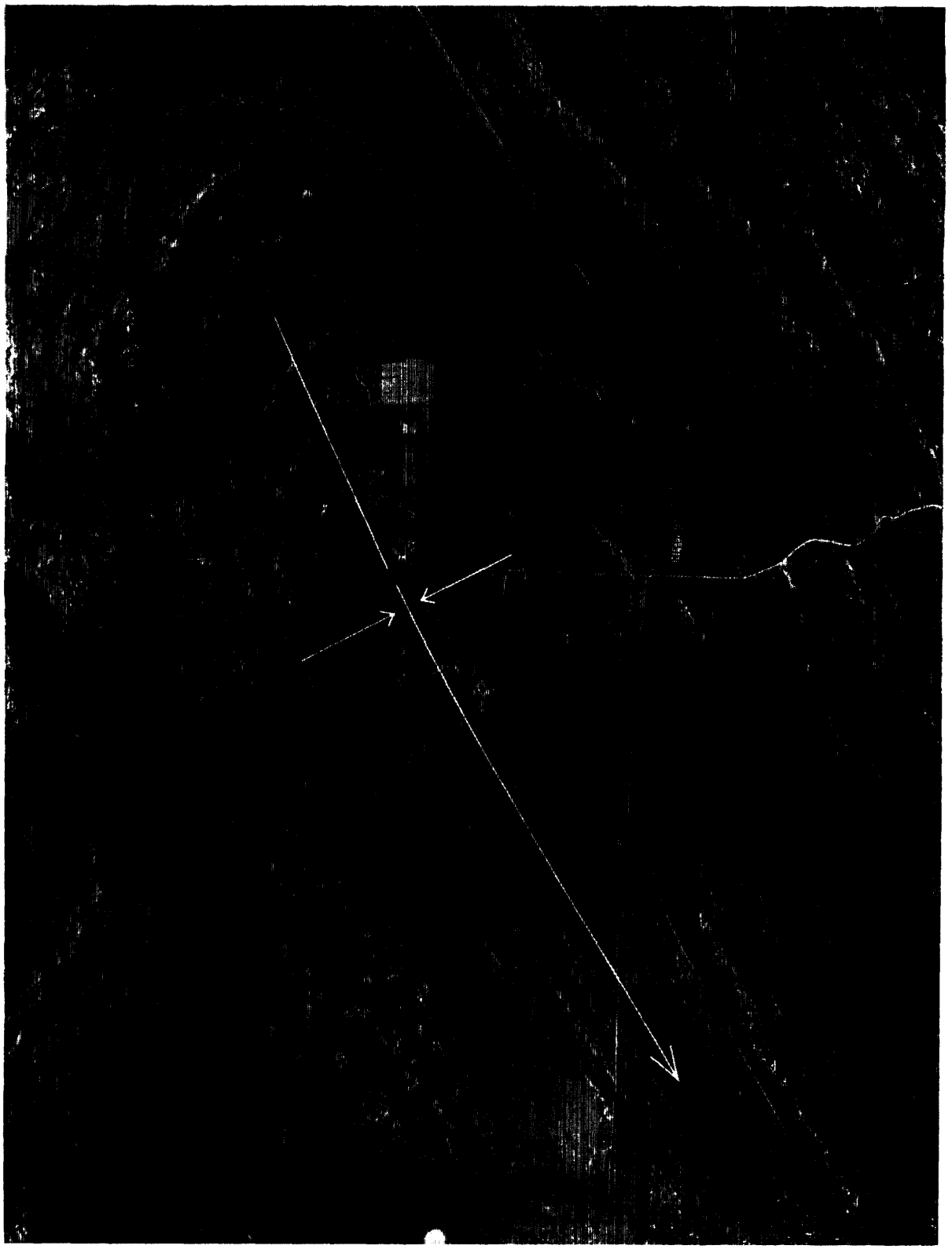
The two main folds in the area are the Rutter and Ham Lake synclines. The Rutter syncline is an isoclinal fold whose axis extends from the north township boundary just west of Rutter, in a southeasterly direction parallel to highway No. 69, to the French River in the vicinity of the highway bridge. At the north end the syncline pitches southeast, as evidenced by the closure of the fold in the Rutter area. The rocks of the syncline are well-banded gneisses, whose structure is emphasized on air photos by narrow lineal strike ridges. The Bigwood paragneiss forms the east limb of the syncline west of the Murdock River, and the formation is progressively granitized to the west; in the vicinity of the synclinal axis, granitic gneisses replace paragneiss. To the west of the synclinal axis, lies the ¼-mile-wide band of red granodiorite pencil gneiss, and west of this the Rutter nepheline syenite. There is a pronounced linear valley between the Rutter nepheline syenite and the granodiorite pencil gneiss, throughout part of the contact length. On the east limit of the Rutter syncline, the Bigwood paragneiss extends down the west shores of the Murdock River and Dry Pine Bay, throughout the entire length of Bigwood township. The formation is not repeated on the west limb of the syncline, as can be seen on the geological map. Its place is taken by complexly folded granitic gneisses, and by the French River alkaline syenite body.

Courtesy Ont. Dept. Lands and Forests



Ada Lake Folded Zone, showing Complex Folding in Stratified Granite Gneisses, Bigwood and Allen Townships.

Courtesy Ont. Dept. Lands and Forests



South-pitching Rutter Syncline in the Vicinity of Rutter Station, Bigwood Township.

HAM LAKE SYNCLINE

The axis of the south-pitching Ham Lake syncline trends southeast from Rae Lake, through Ham Lake, and across the French and Pickerel rivers. North of Rae Lake a tongue of granitic gneiss extending into the alkaline syenite body may mark the northward extension of the synclinal axis, but there is no synclinal structure in the alkaline syenite. Between Rae Lake and the French River the syncline is asymmetrical, with the east limb being poorly developed and possibly sheared along a narrow linear valley marking the course of the outlet of Ham Lake into the French River. To the northeast of Rae Lake, between the Ham Lake synclinal axis and the red granodiorite, which here forms the west limb of the Rutter syncline, there are minor folds that are drags on the major structures. Between the Ham Lake and Rutter synclines the anticlinal structure, if present, is poorly developed, and may be cut out by the shearing along the linear already mentioned, east of Ham Lake.

The west limb of the Ham Lake syncline shows a series of Z-shaped south-pitching drag folds from Ham Lake southwest to the Pickerel River. These drag folds apparently partly controlled the emplacement of the French River part of the alkaline syenite, and this body noses out to the south on the axis of one of these drag folds.

Although the Ham Lake syncline is asymmetric to the north of the French River, and the west limb is strongly dragfolded, on the south side of the French River the syncline is a broad and gentle south-pitching structure. Along the Pickerel River the Ham Lake synclinorium is occupied by two small V-shaped synclines with an intervening anticline, as indicated on the geological map.

ADA LAKE FOLDED ZONE

Ada Lake lies just south of Emma Lake in Allen township on the west boundary of Bigwood township, in the centre of a large area of complexly folded, banded granitic and hybrid granitic gneisses. This complexly folded zone of granitic gneisses is called by the author the Ada Lake Folded Zone, and occupies the whole of Bigwood township west of the French River alkaline syenite body. As shown on the accompanying geological map, the banded granitic gneisses of this area are folded into a complex series of southeast-pitching, anticlinal and synclinal folds, which are compatible in tectonic style with the minor folding on the west side of the Ham Lake syncline.

Faulting

There is shearing in the Jamot quartzite south of Jamot, on the point, and the Jamot quartzite may be separated from the granitized area to the west by a fault. As already mentioned, marked north-trending linears, which may mark faults, occur on the east side of the Rutter nepheline syenite, on the west side of the French River alkaline syenite, and along the east flank of the Ham Lake syncline.

Jointing

A feature of the area is a very strong series of east-west joints, which control much of the drainage of the area. Emma Lake, the Rae Lake chain, the French River, and the Pickerel River all lie along this east-west set of joints. There appears to be no displacement along these joints, as the alkaline syenite body shows no displacement across them. Some Keweenawan diabase apparently came in along the joint that was later occupied by the French River.

THEORETICAL CONSIDERATIONS

In interpreting the geological history and origin of the varied rocks of Bigwood township, the following main features are apparent:

1) The area is highly folded along northwest-trending, south-pitching fold axes.

2) The intensity of folding increases to the west.

3) There is close dragfolding in the granitic gneisses along the east flank of the French River alkaline syenite body, which harmonizes in tectonic style with the close folding in the Ada Lake folded zone to the west of the alkaline syenite.

4) The alkaline syenite body itself is not folded, but shows a consistent north-south, east-dipping foliation with the dip flattening at the south end.

5) The sedimentary rocks that formed the country rocks of the area have suffered a progressive granitization within the area, some being completely granitized, and others being metamorphosed but not granitized.

6) The intensity of granitization decreases from west to east towards the Bigwood paragneiss band.

7) Granitization took place after folding, as indicated by the patchy progressive granitization proceeding to the east across the axis of the Rutter syncline.

Granitization

Undoubted sedimentary quartzite and paragneiss occur along the Murdock River, and form part of the major structure of the area, the Rutter syncline. In places, both along and across strike, the sedimentary rocks can be traced, first into pink and grey banded gneisses in which certain bands are rich in pink microcline, thence into well-banded pink gneisses of granitic composition with accessory biotite and hornblende. Proceeding across the outcrops there is no change of structure in the well-banded or layered gneisses, but there is a change in composition, evidenced by an increase in pink feldspar and in quartz grains and lentils. Many of the sediments are already siliceous, and perhaps the introduction of silica was minor. In thin section the replacement of other minerals by grains of microcline and microperthite is easily discernible. The progressive granitization appears to mainly involve potash metasomatism of the metasediments without disturbance of the structure.

All the sedimentary rocks within the area appear to have suffered granitization. Although the paragneisses may have been granitized more easily than the quartzites, these latter were not impervious to granitization. Progressive introduction of pink microcline into a pure white quartzite band is well shown along the west shore of the Murdock River, south of the No. 64 highway bridge. The change from pure white quartzite to quartzite with pink microcline, and then in progressive stages to pink leucocratic granitic gneiss, can be followed in outcrop. The progressive potash metasomatism of this quartzite is very similar to that described by Quirke[1] in the Killarney area.

The folding and granitization of the rocks of the area apparently took place at the time of the Grenville orogeny, which affected this area south of the Grenville Front. The tectonic style and degree of potash metasomatism is characteristic of other areas near the Grenville Front. Relict patches of folded but ungranitized sediments, such as the Jamot quartzite of the Delamere Hills, form islands in the granitized terrane of this part of the Grenville Province—islands out of harmony with the tectonic style and degree of alteration in the surrounding area.

[1]T. T. Quirke and W. H. Collins, *Disappearance of the Huronian, Ontario*, Geol. Surv. Can., Memoir No. 160, 1930.

ORIGIN OF THE NEPHELINE SYENITE BODIES

The contrast between the tectonic style of the well-banded closely folded granitic gneiss terrane to the west and southeast of the alkaline syenite body, and that of the alkaline syenite body itself, is marked, and indicates that the alkaline syenite body must have been emplaced after the main period of close-folding of the country rock gneisses. The contrast in tectonic style between the granitized country rock gneisses and the alkaline syenite mass, i.e. lack of folded, lineal, banded ridges of gneiss within the alkaline syenite mass, and their presence in the adjacent granitized terrane (see air photographs of the township), emphasizes that the alkaline syenite mass could not have been emplaced by a process of nephelinization or quiescent replacement of the country rock gneisses; there is no preservation of country rock structure in the alkaline syenite as there is in the neighbouring country rock gneisses, which were later granitized.

The presence of close folding in the granitized country rock to the west and southeast, and the absence of any such relict structure in the alkaline mass, also precludes the possibility that the body was emplaced by replacement processes without disturbance of the country rock structure.

This evidence indicates that the nepheline and associated pink alkaline syenite were intruded in a sill-like body, more or less in its present form and shape, into the already folded country rock gneisses. The emplacement took place along a zone of north-south weakness and shearing, marking the change from broad to close folding, which developed along the west limbs of the Rutter and Ham Lake synclines. The shape of the composite intrusive was in part guided and controlled by the drag folding in the country rock gneisses to the east.

Reaction between the silica-deficient nepheline syenite magma and the siliceous country rock sediments may be partly responsible for the mantle of pink alkaline syenite surrounding the two nepheline syenite lenses.

The mineral zoning within the two nepheline syenite lenses, with the northern lens carrying hastingsite as the main mafic mineral, and the southern lens carrying biotite as the main mafic mineral, together with the difference in character and amount of the nepheline itself, suggests composite intrusion from the same source.

The pink syenite probably formed in part as a reaction rim around the nepheline rocks and in part as a slightly later, more siliceous, phase of the composite intrusion.

While the emplacement of the alkaline syenite mass clearly took place after the complex folding of the country rocks, it is more difficult to determine whether the main period of regional granitization or potash metasomatism took place before or after the alkaline syenite intrusion. The author believes that the period of potash metasomatism that granitized the country rock gneisses took place after the emplacement of the alkaline syenite mass, because there is good evidence of potash metasomatism of the alkaline syenite body itself. Contacts between the granitic gneisses and the alkaline syenite are gradational, and microcline and microcline antiperthite are widely introduced into the pink syenite phase of the alkaline intrusive. In some cases, as along the east contact of the Rutter nepheline syenite, microcline and microcline antiperthite occur in the nepheline syenite itself in a zone along the granitic contact. Accompanying this potash metasomatism there is hydration and zeolitization of the nepheline. Both these features are characteristic of granitization of nepheline rocks in the Bancroft area (see Chapter I, part II), and the geological history of this part of the Grenville Province may be analogous.

Metamorphism has produced a pronounced north-south foliation within the alkaline syenite body, dipping to the east. Some clotting and lineal parallelism of hornblende, biotite, and nepheline took place during this period of metamorphism, and the alkaline syenite, together with the enclosing gneisses, show the fabric of metamorphic tectonites.

Age of the Nepheline Syenite

An age determination by the Pb/α method was carried out by Larsen, Gottfried, and Jaffe at Washington, on zircon collected from the Rutter nepheline syenite by C. E. Tilley. This determination indicated an age for the zircon of 975 million years,[1] an age corresponding to that of the Grenville orogeny.

MINERAL OCCURRENCES

Although the area has been widely prospected, there has been no mineral production. The nepheline syenite deposit is somewhat similar in character to that being developed at Blue Mountain, Peterborough county, and the accessibility and proximity to railways are factors favourable to economic development. However, the low nepheline content, together with the high iron content of the pink nepheline of the Rutter body, are undesirable features, and it seems doubtful whether this body could compete economically with the Blue Mountain deposit.

Corundum and graphite occur in nepheline and associated alkaline syenite in lot 10, concession II, Bigwood township, and small test pits were sunk at this locality. A small occurrence of red garnet was observed in a pit just south of the Ham Lake road, in lot 10, concession I. Zircon occurs as an accessory mineral in nepheline syenite and pink syenite, especially in lot 10, concession IV, but these occurrences appear to have poor commercial potentialities due to their small size.

Considerable prospecting for uranium has been carried out in the area since 1950, and pits were sunk near Rae Lake, in lots 8 and 9, concession III. The author noted small veinlets of allanite, and scattered allanite crystals in pink syenite and granite at these localities. Pyrochlore was reported to occur but was not found by the author.

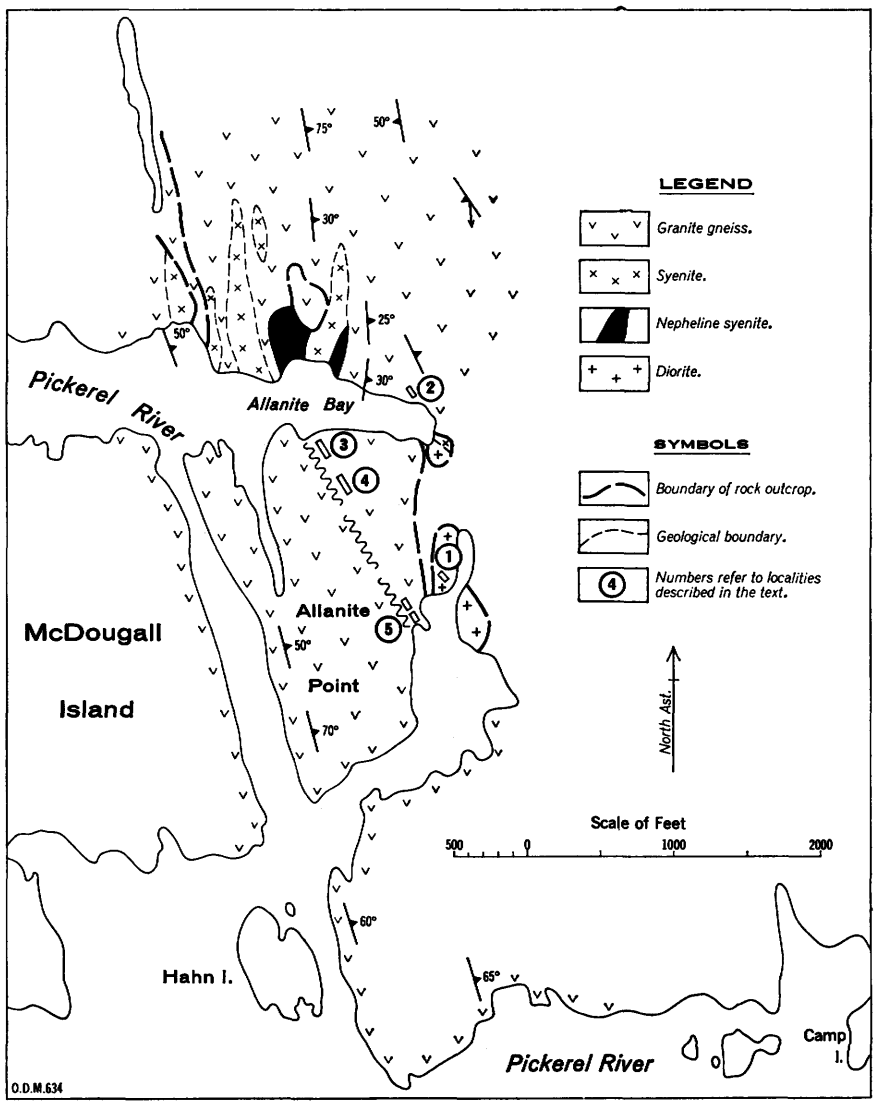
The Atlin-Ruffner allanite property is located on the shores of the Pickerel River, on Fifteen Mile Island, just south of the south end of the French River nepheline syenite body. The country rock of the area is granitized paragneiss and para-amphibolite, and associated hybrid pink granitic gneiss. The oldest intrusive rock is a garnetiferous diorite occurring on the east side of Allanite Point (see accompanying sketch map). Biotite nepheline syenite occurs on the north shore of Allanite Bay, intruded and replaced by pink alkaline syenite. Granitization and intrusion of allanite-bearing granite and pyroxene syenite pegmatite were the latest plutonic activity.

Five allanite showings, numbered (1) to (5) on the accompanying sketch, were examined by the author. At Locality (1) garnetiferous diorite is cut by a pegmatitic syenite dikelet 8–12 inches wide. Allanite occurs in a band 6–8 inches wide in the red syenite along the contact of the garnetiferous diorite with pink biotite syenite and biotite granite gneiss.

At Locality (2) on the north shore of Allanite Bay, an allanite-rich seam 6 inches wide is exposed along a shear, striking N.25°W., in hybrid biotite granite gneiss. A band of para-amphibolite occurs to the east of the showing.

[1] C. E. Tilley, personal communication.

Localities (3), (4), and (5) are along a linear valley striking N.30°W., which cuts across Allanite Point on the south shore of Allanite Bay. At (3) an allanite-rich seam 12–15 inches wide, associated with red granite pegmatite cutting amphibolite, occurs along the linear shear zone, which trikes N.45°W. and dips



Atlin-Ruffner Allanite property.

70°–80°E. The allanite-bearing zone can be traced over 90 feet, but narrows to a crack at the northwest end. At Locality (4) allanite occurs in pyroxene syenite and pegmatite cutting biotite granite gneiss. Allanite-bearing zones, up to a maximum of 3 feet wide, are exposed over a length of 150 feet. At Locality (5) allanite occurs in a red, fine-grained, allanite granite pegmatite cutting pink biotite granite gneiss. Here allanite-bearing pegmatite occurs in a zone 8–15

inches wide and 20 feet long, on a fracture system running off the main linear at N.70°E.

The property was prospected and diamond-drilled by Atlin-Ruffner Mines (B.C.) Limited, in 1955. A report in the *Northern Miner* of June 23, 1955, states that "a 5-ton bulk sample gave returns ranging from 2.13 to 4.16 percent cerium oxide combined with 2.71 to 5.2 percent rare earths."

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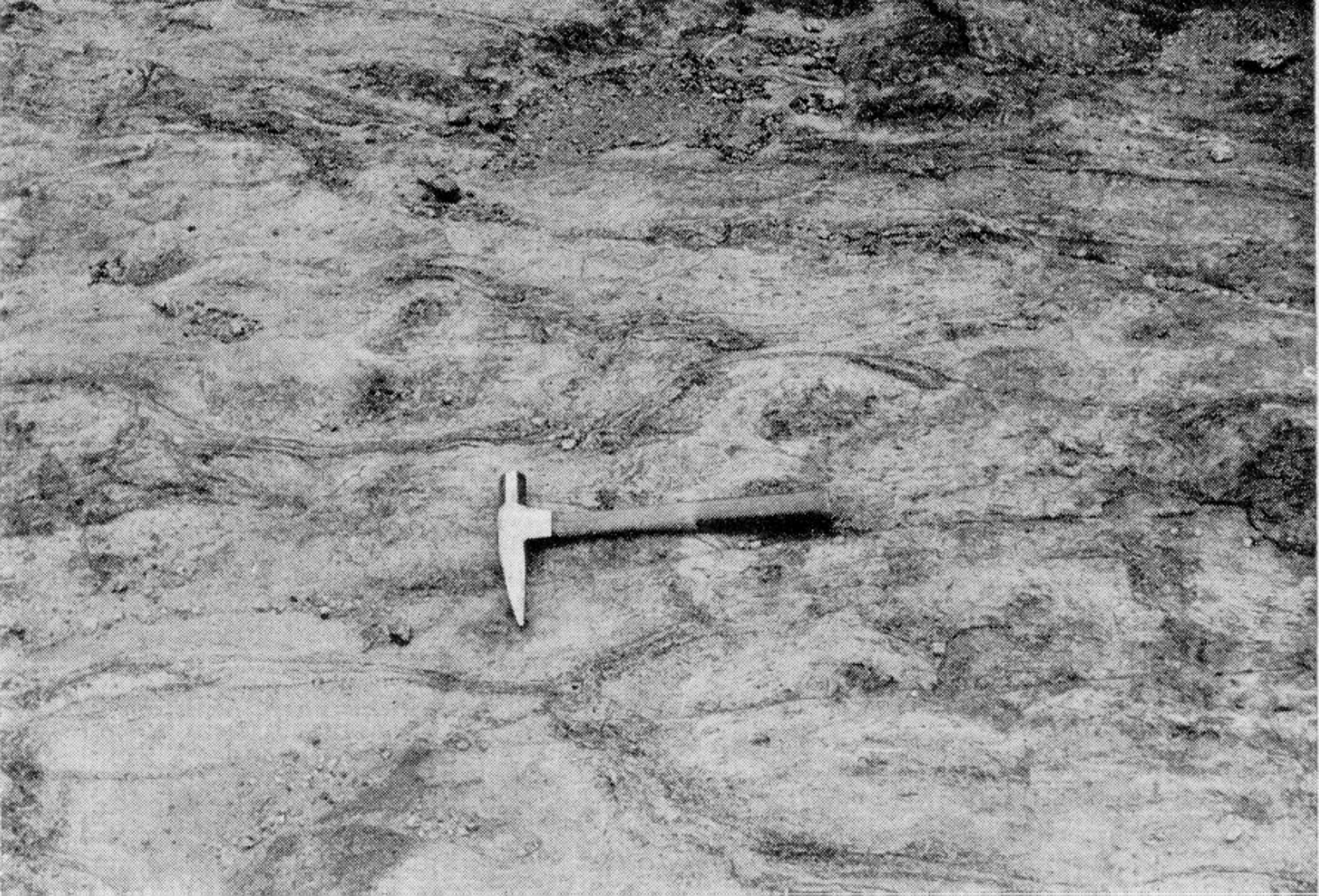
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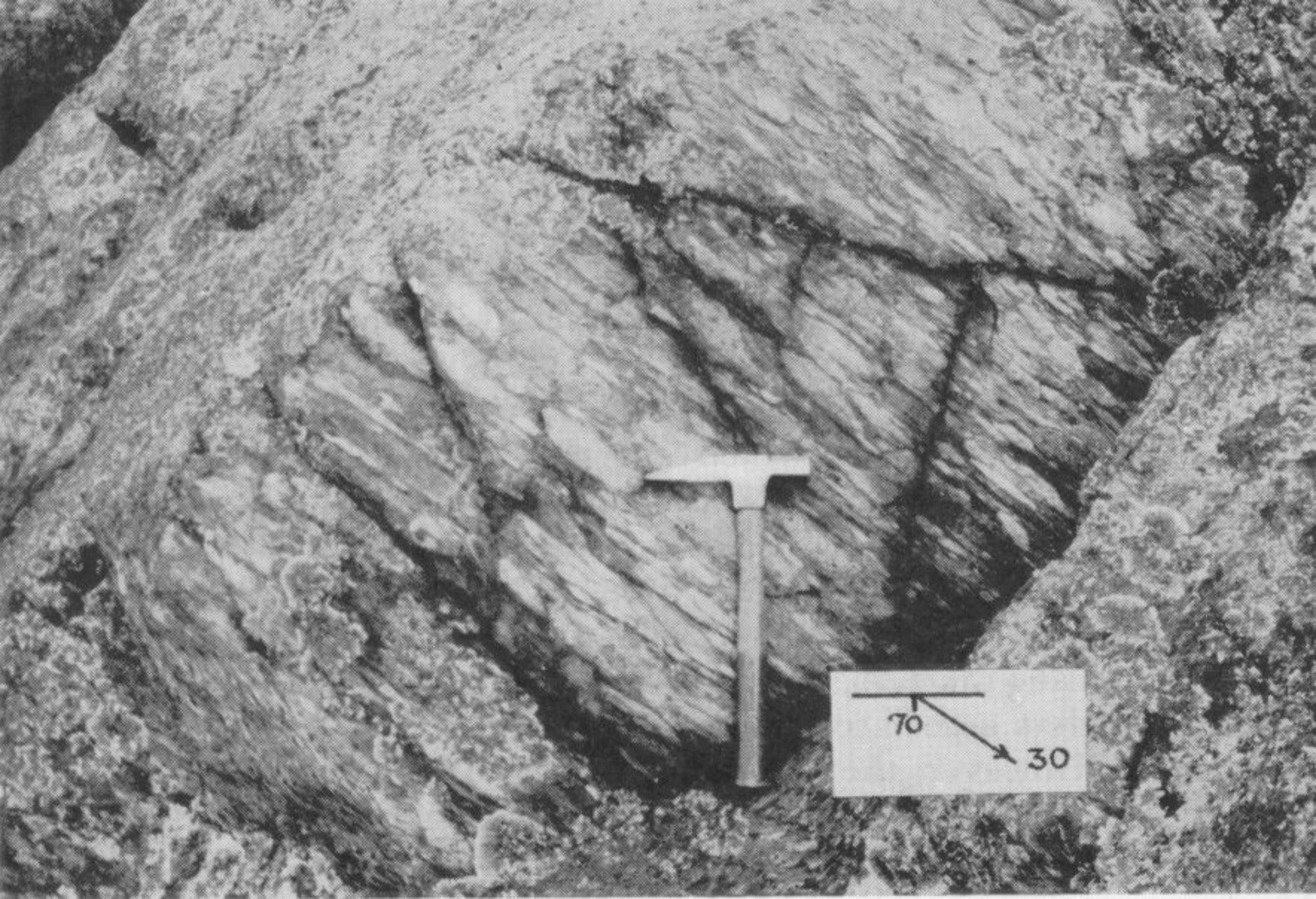
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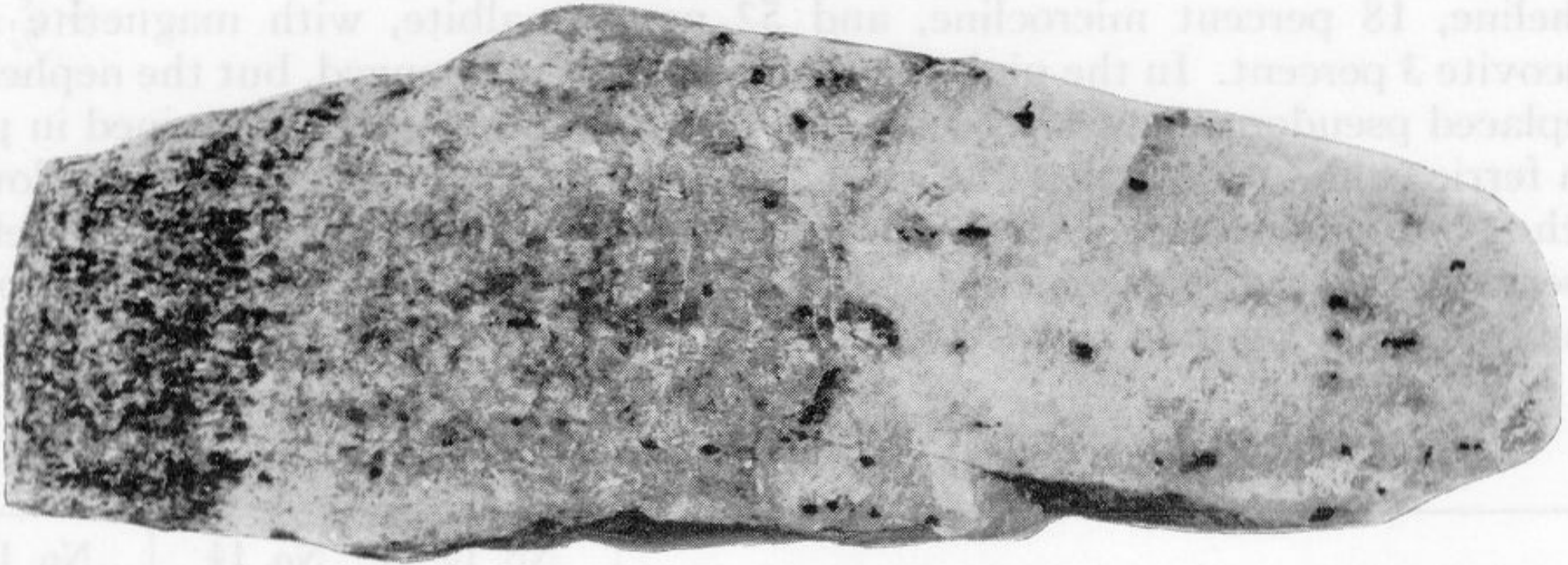
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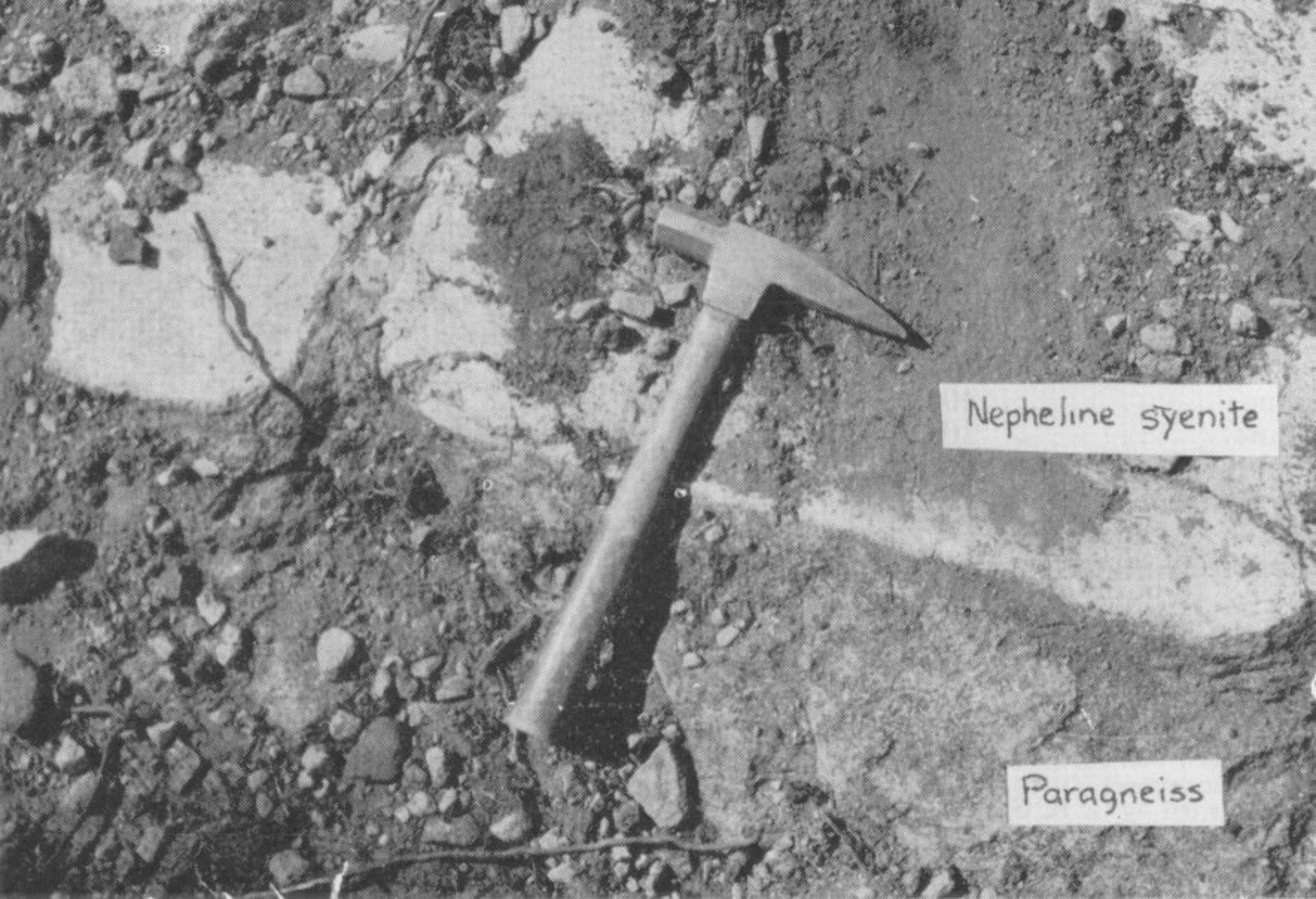




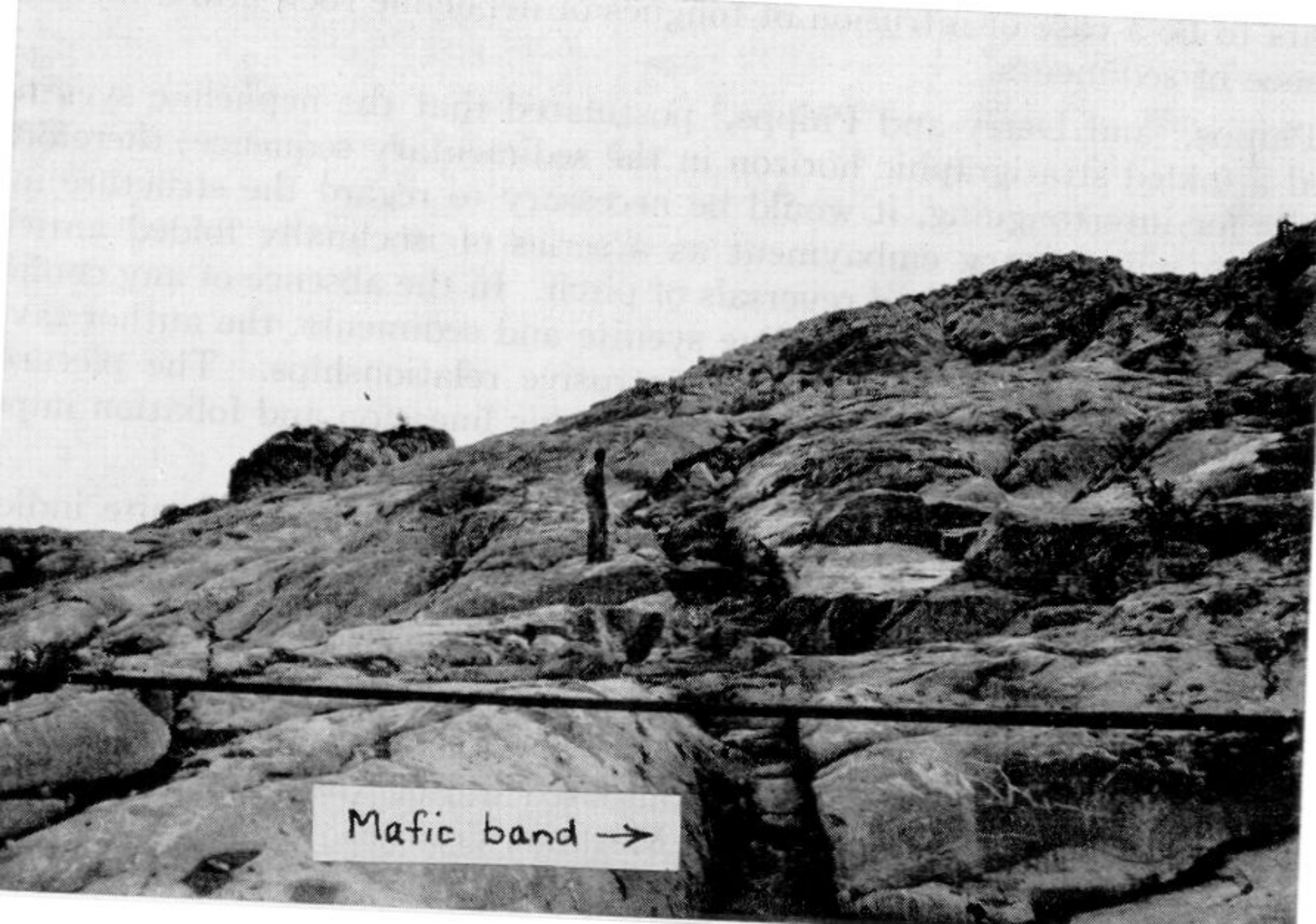

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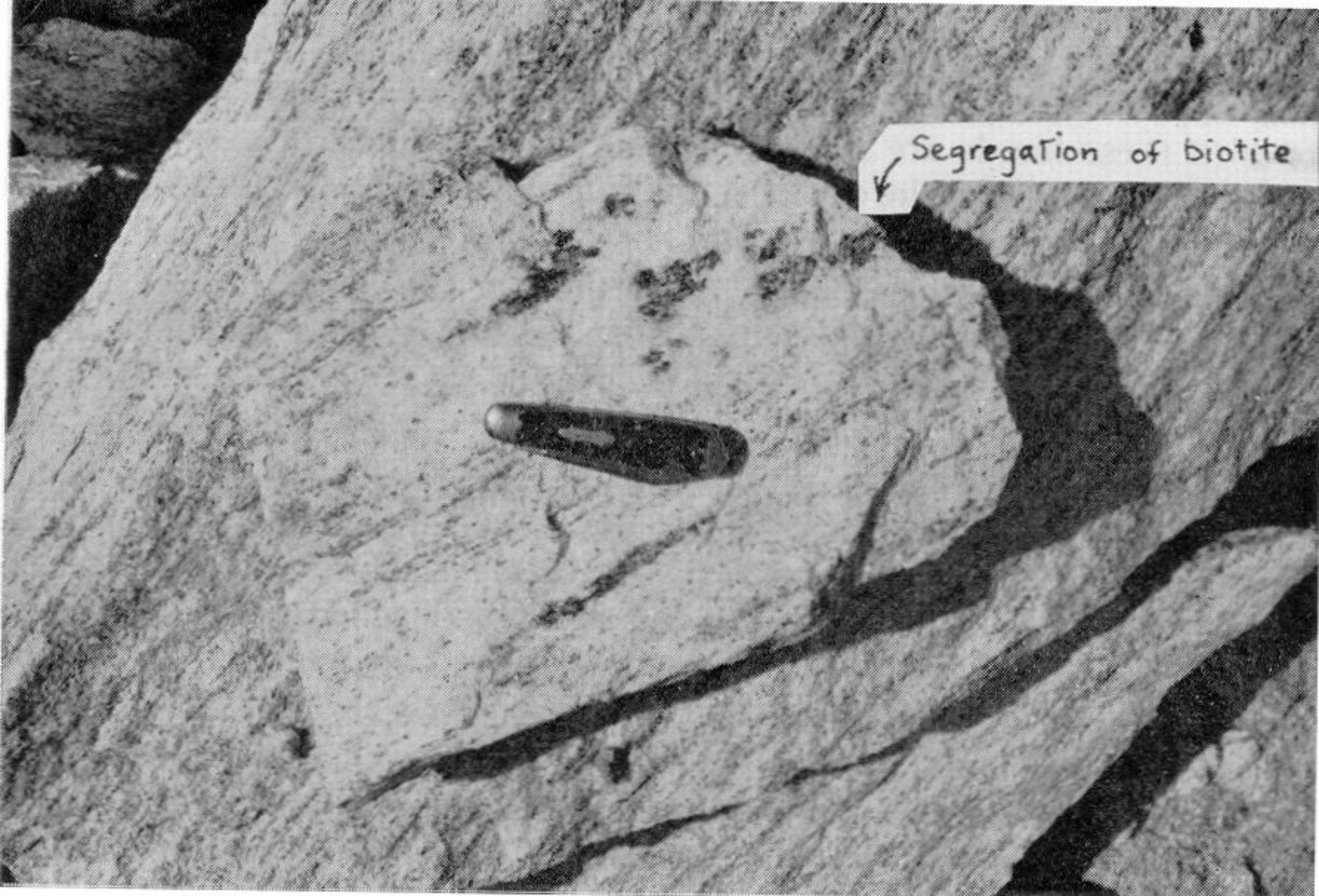

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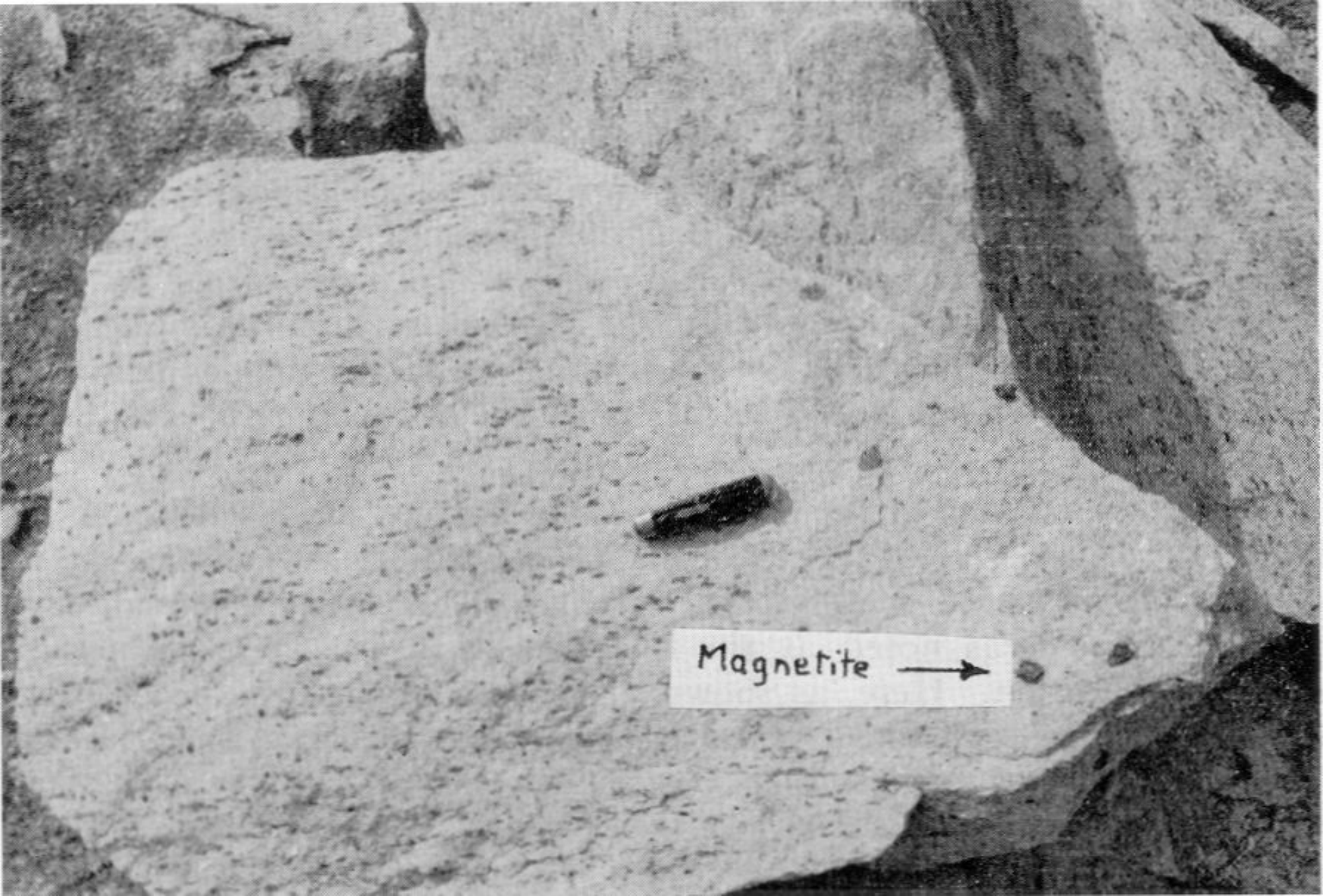

Nepheline syenite
Paragneiss
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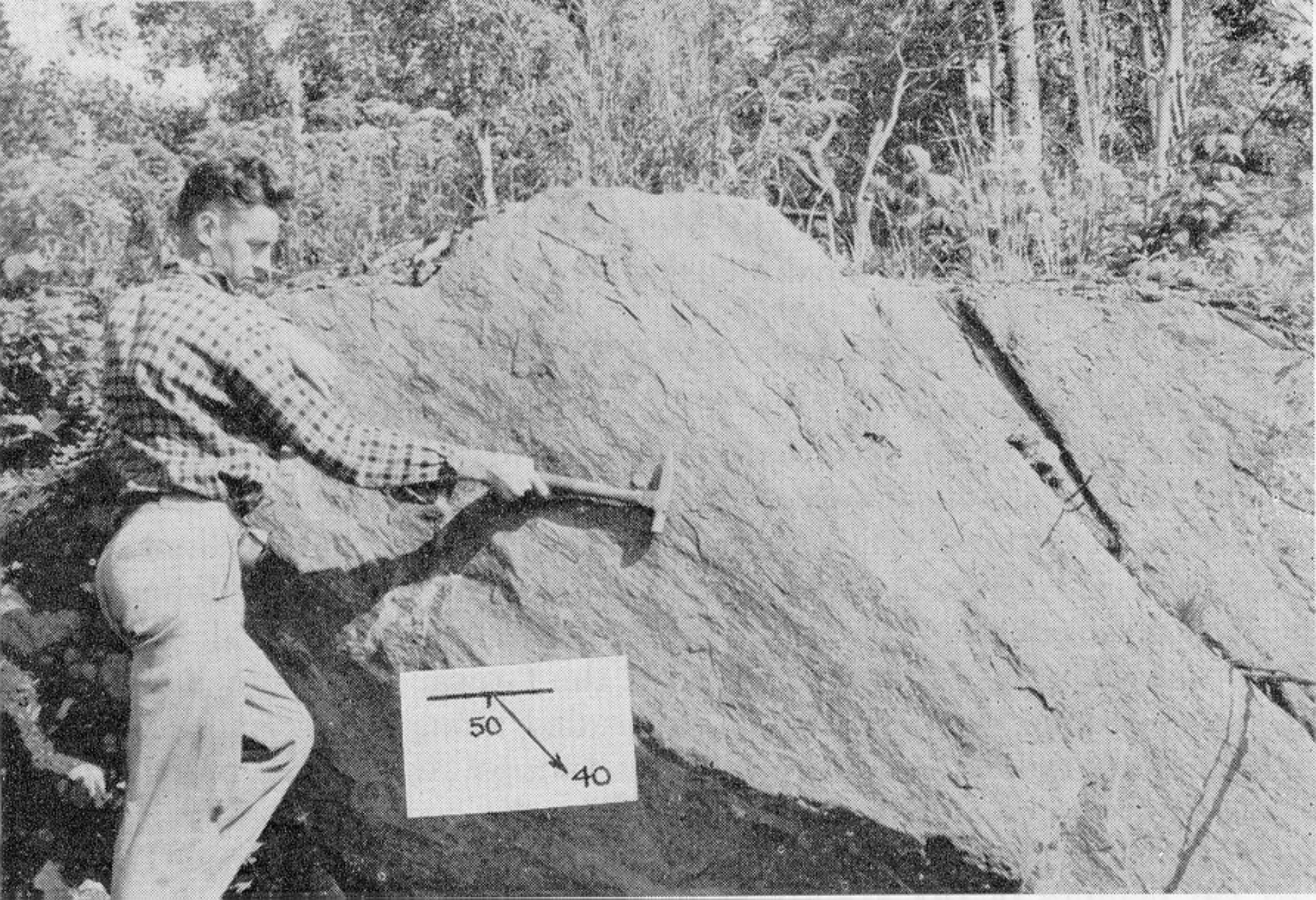

Nepheline syenite
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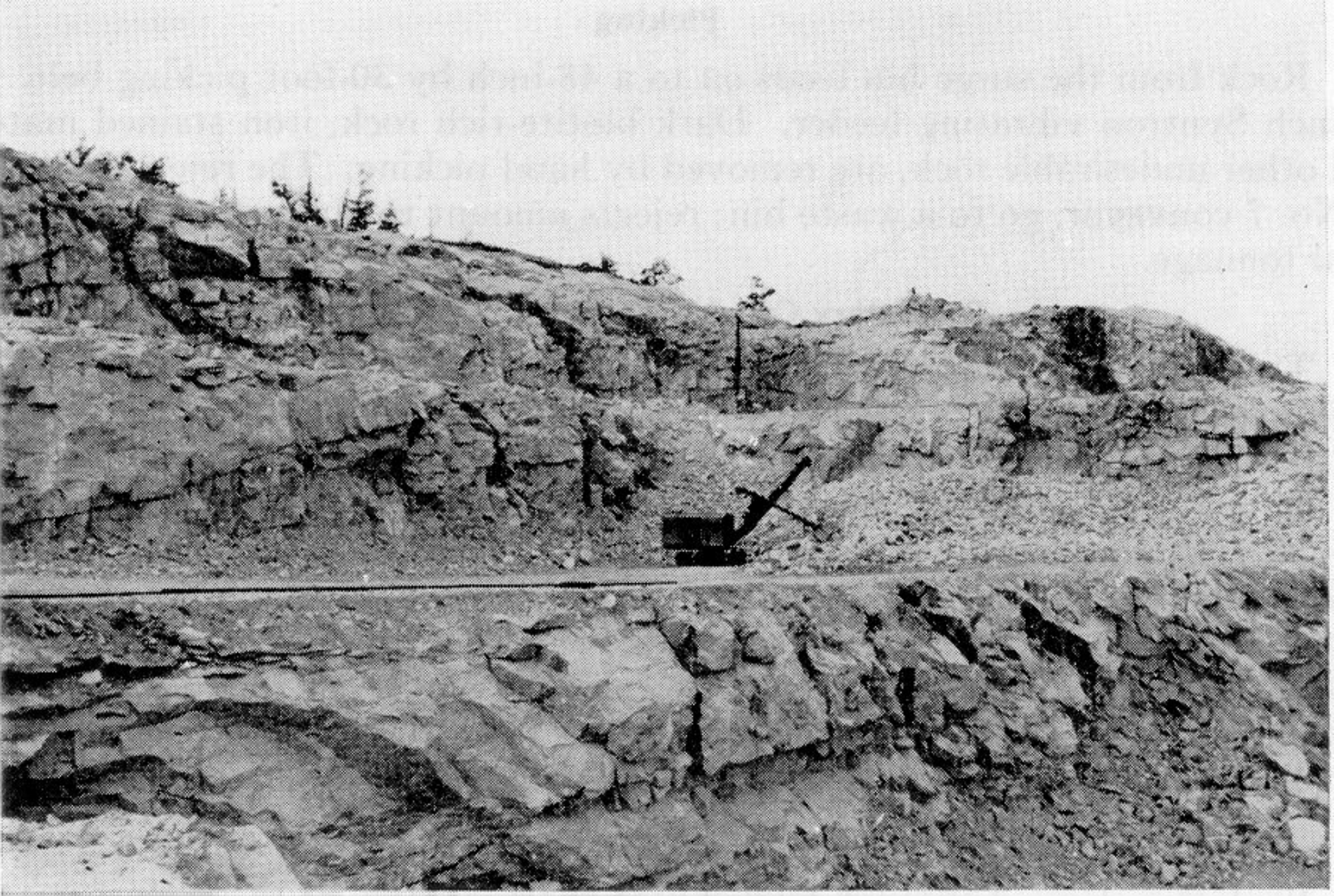


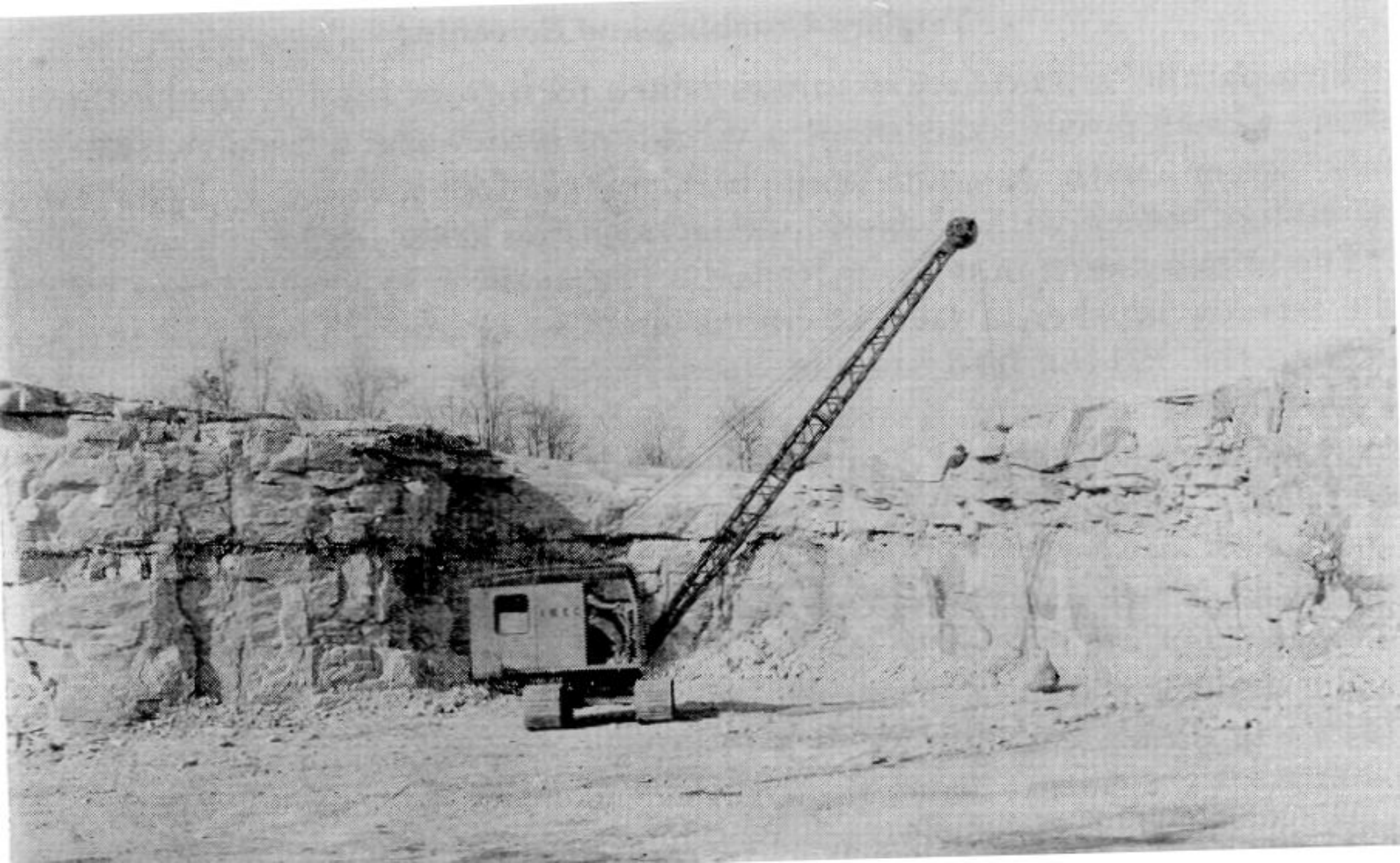

Mafic band →


Segregation of biotite

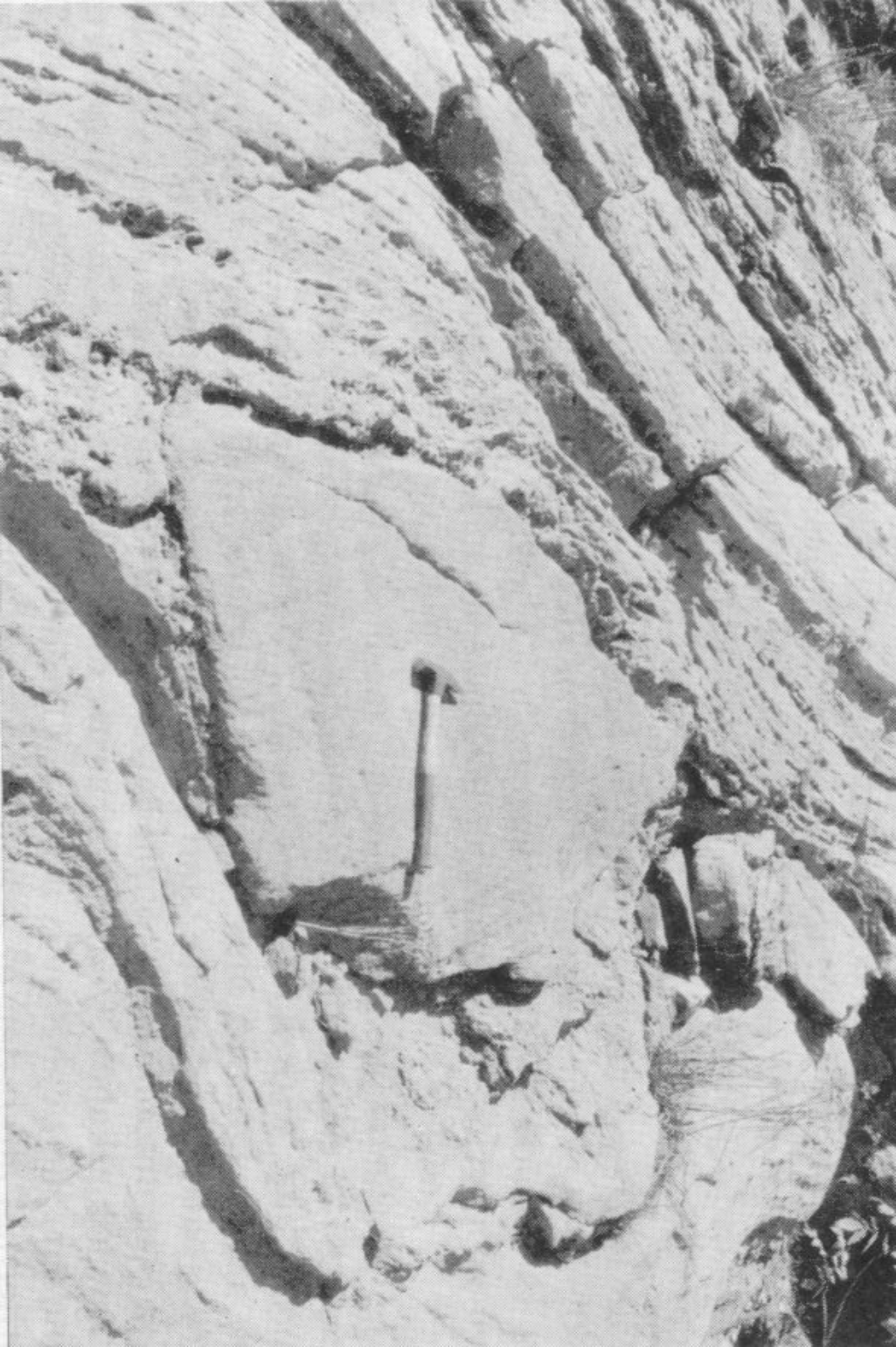

Magnetite


50
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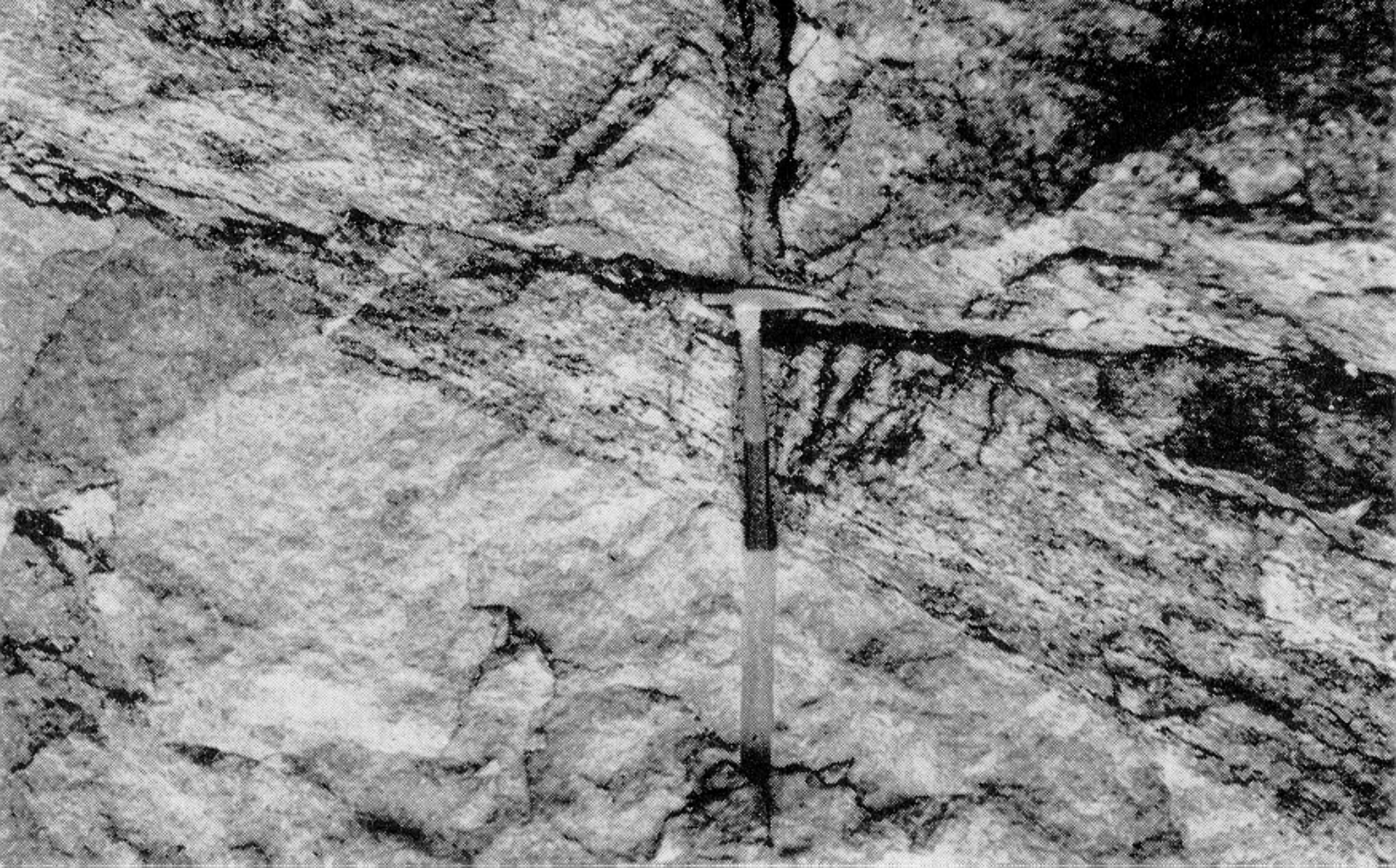

MILL RIDGE QUARRY
CABIN RIDGE QUARRY





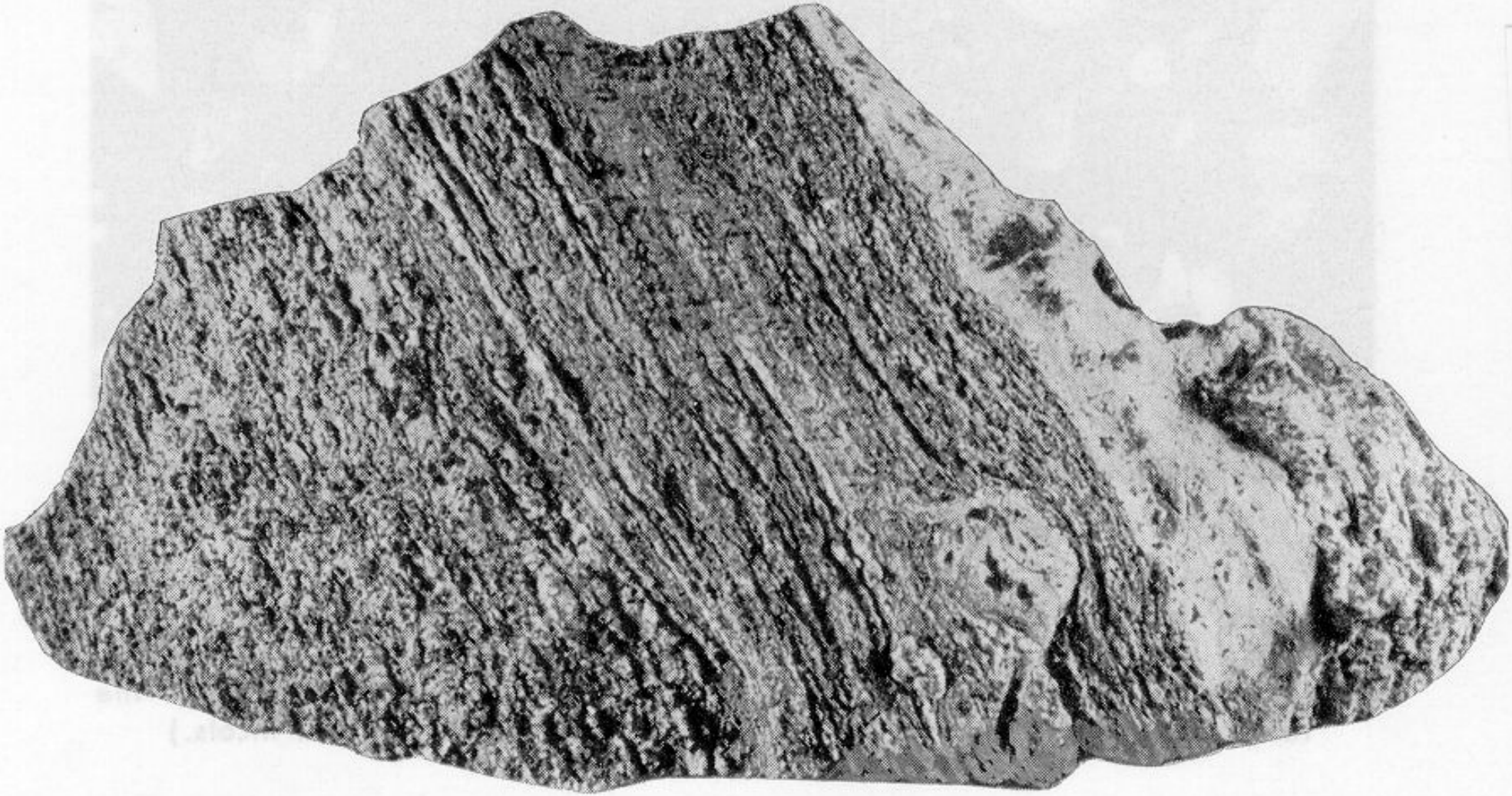


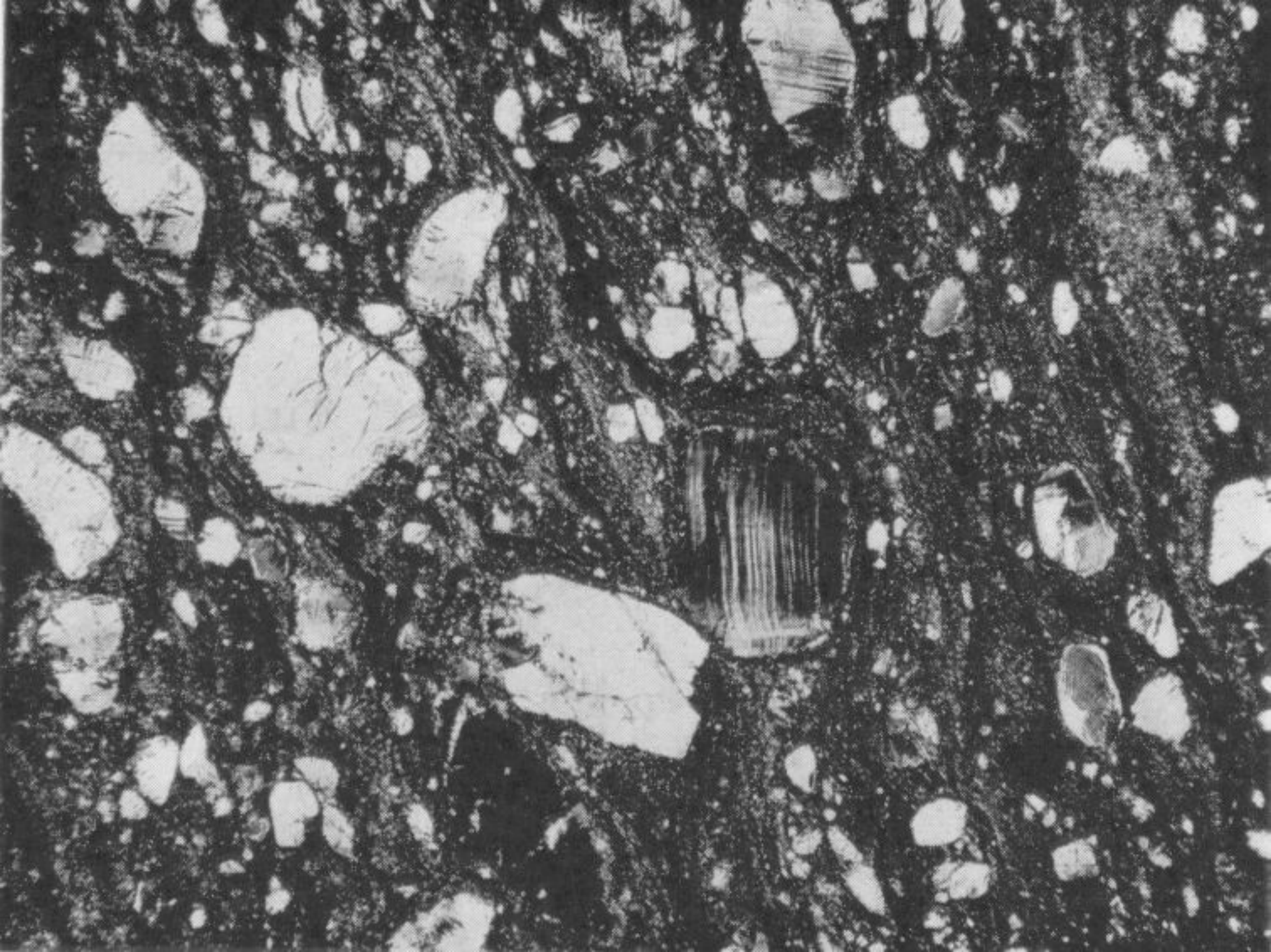


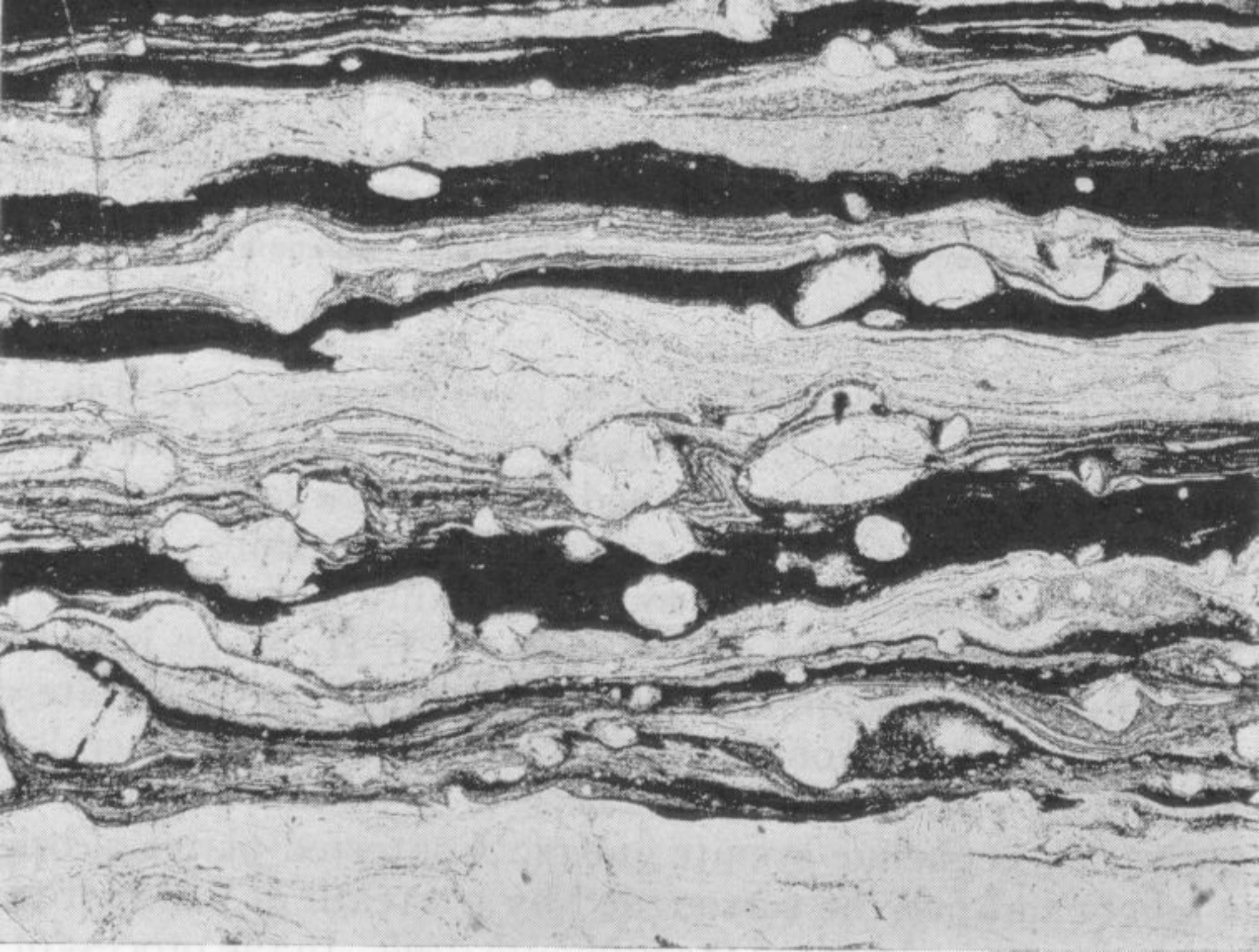


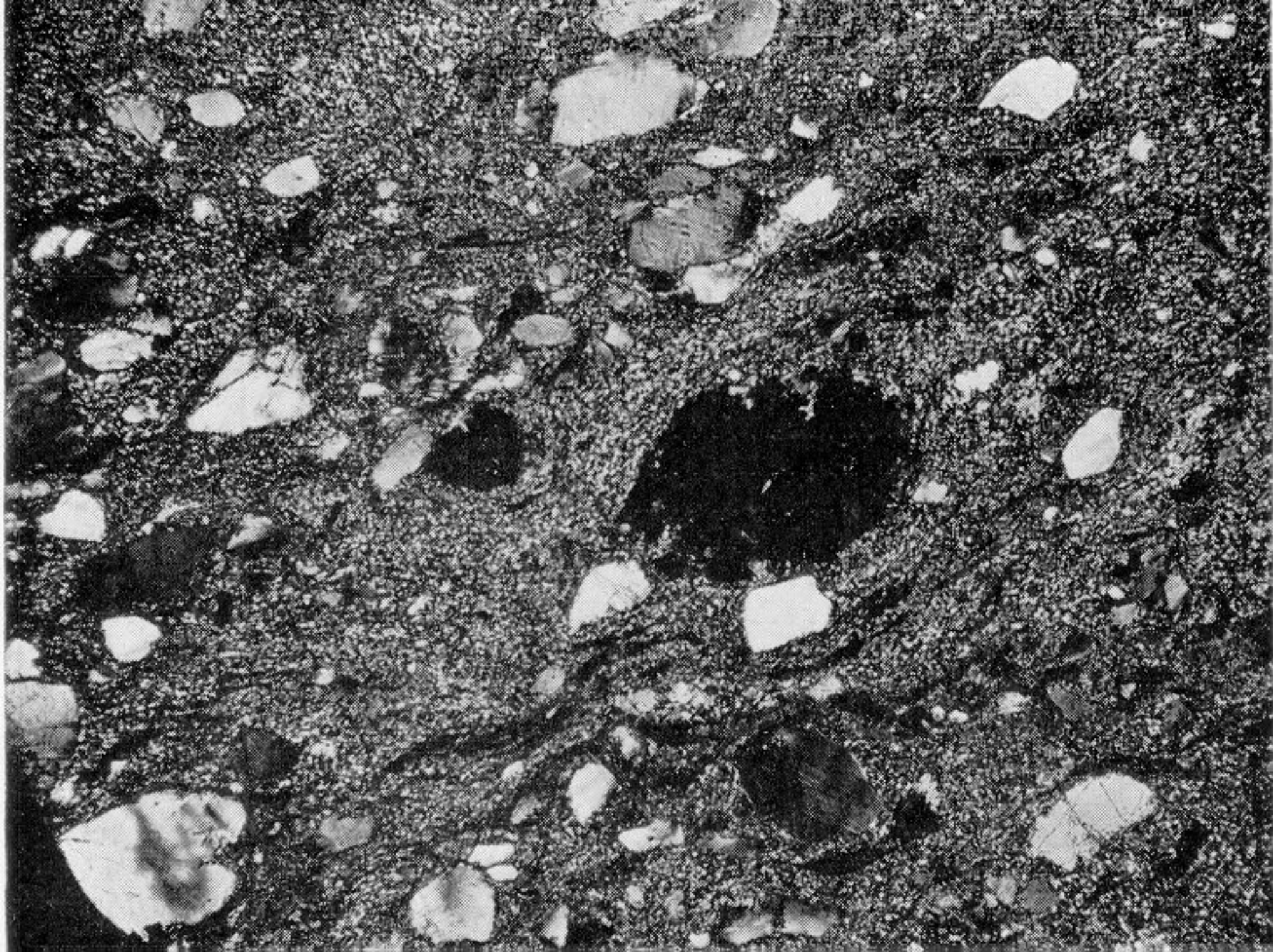


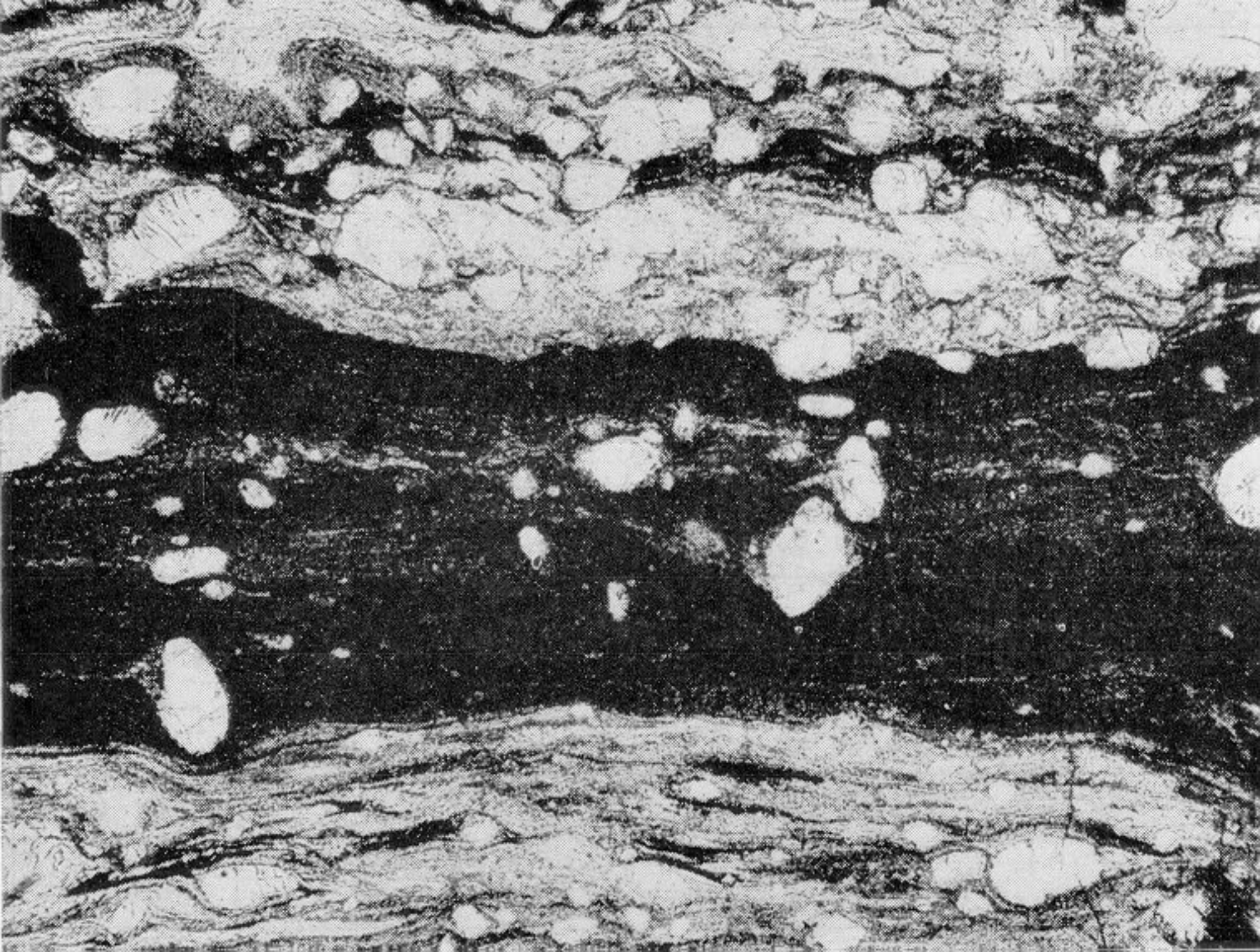



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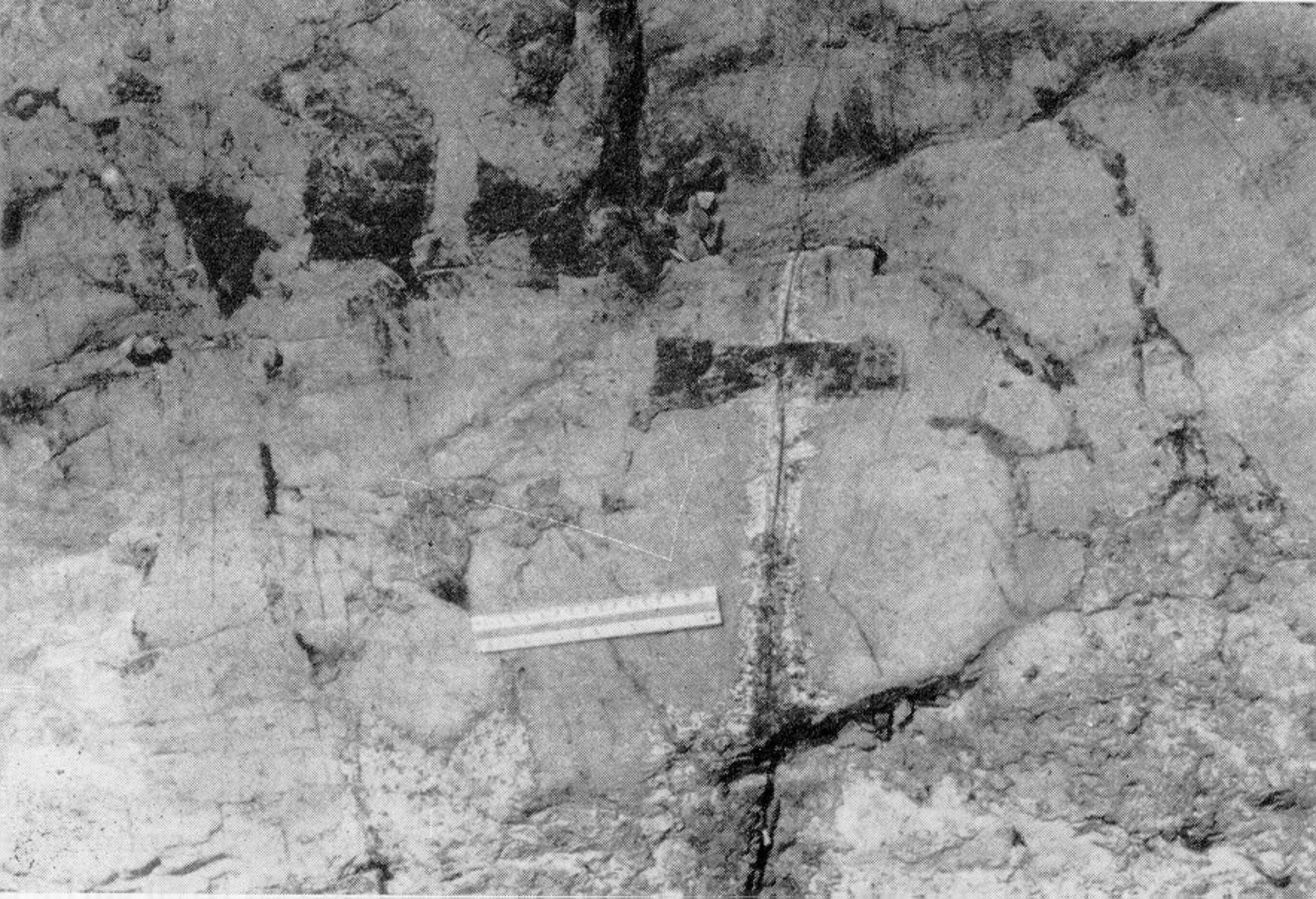


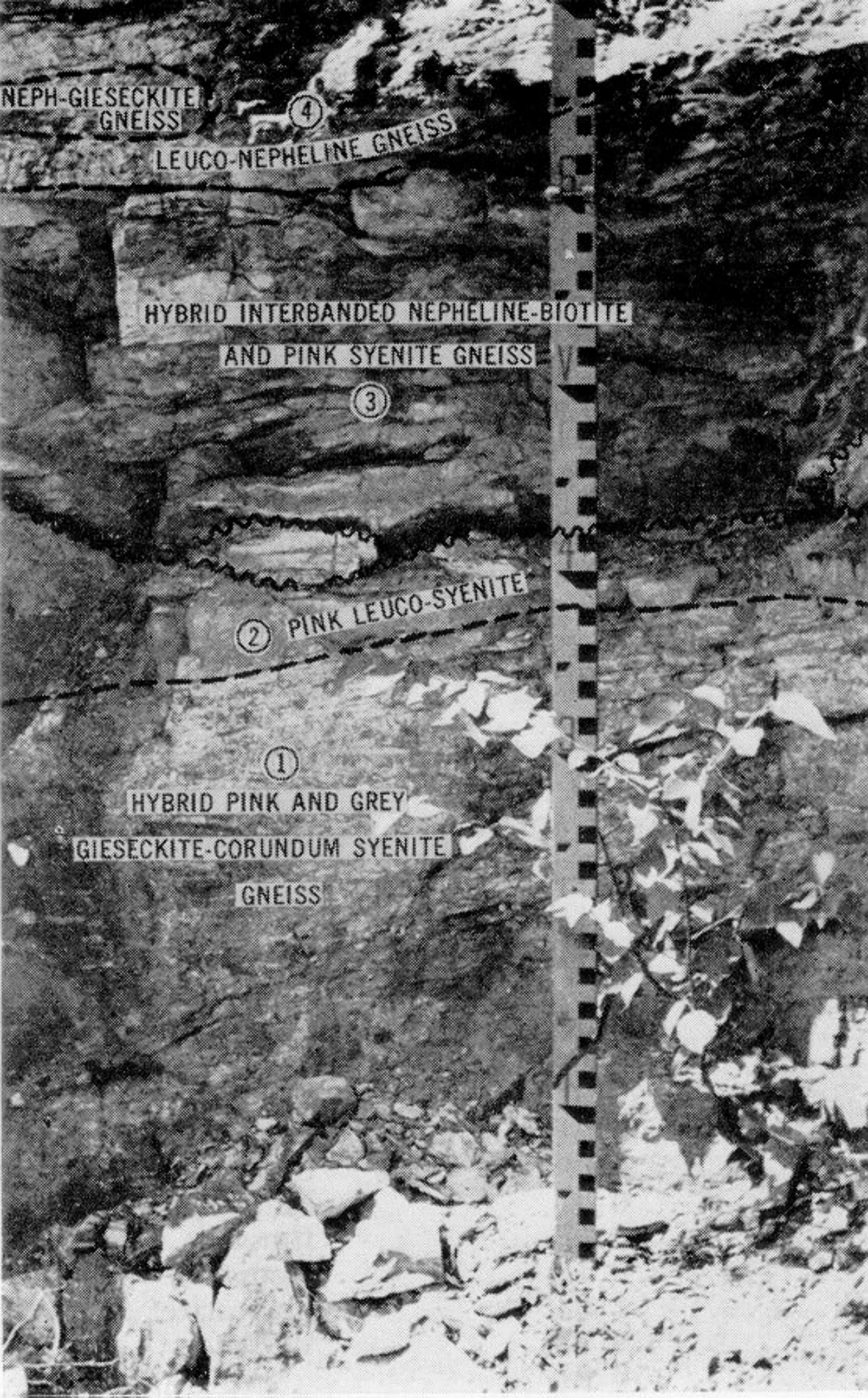


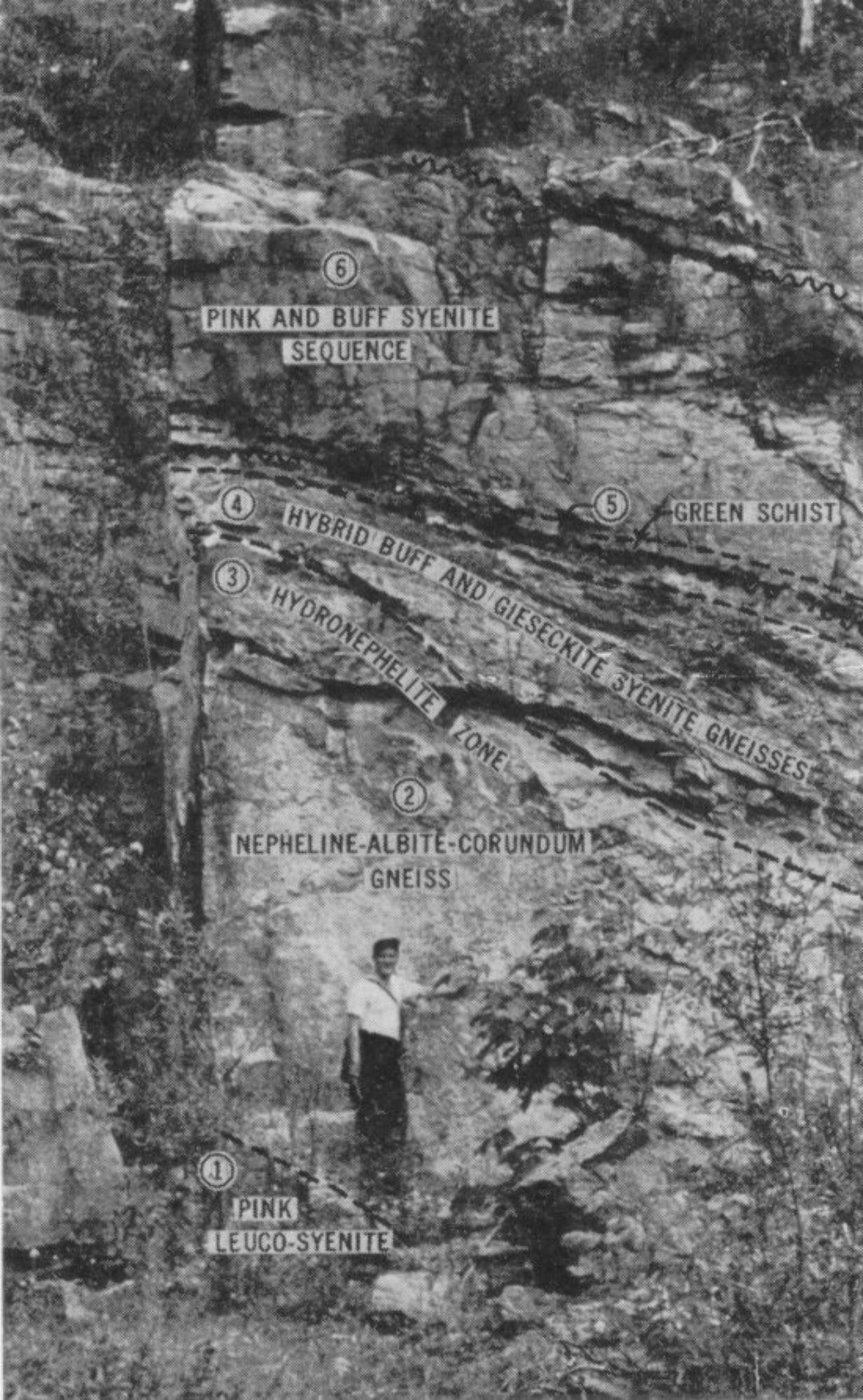


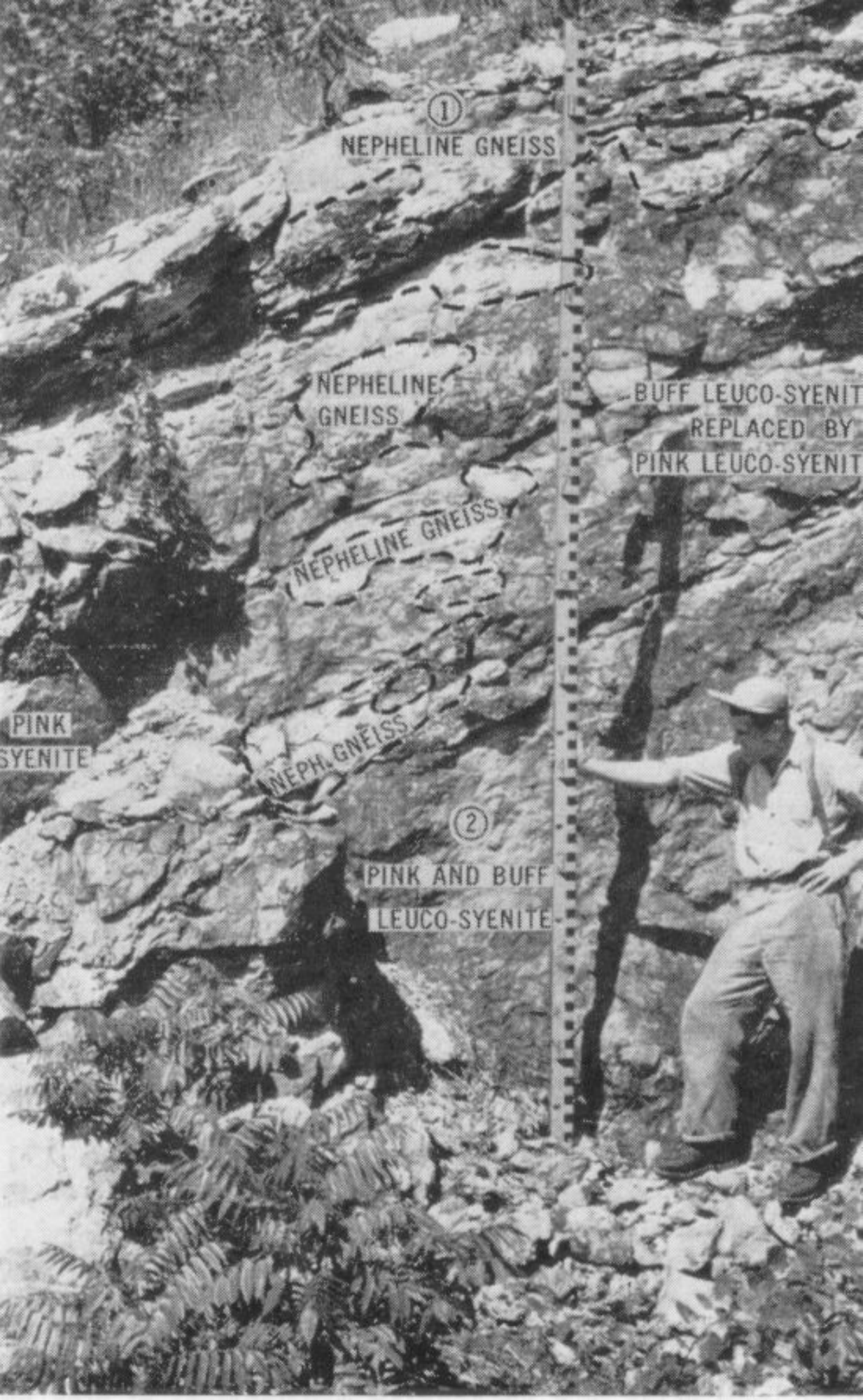


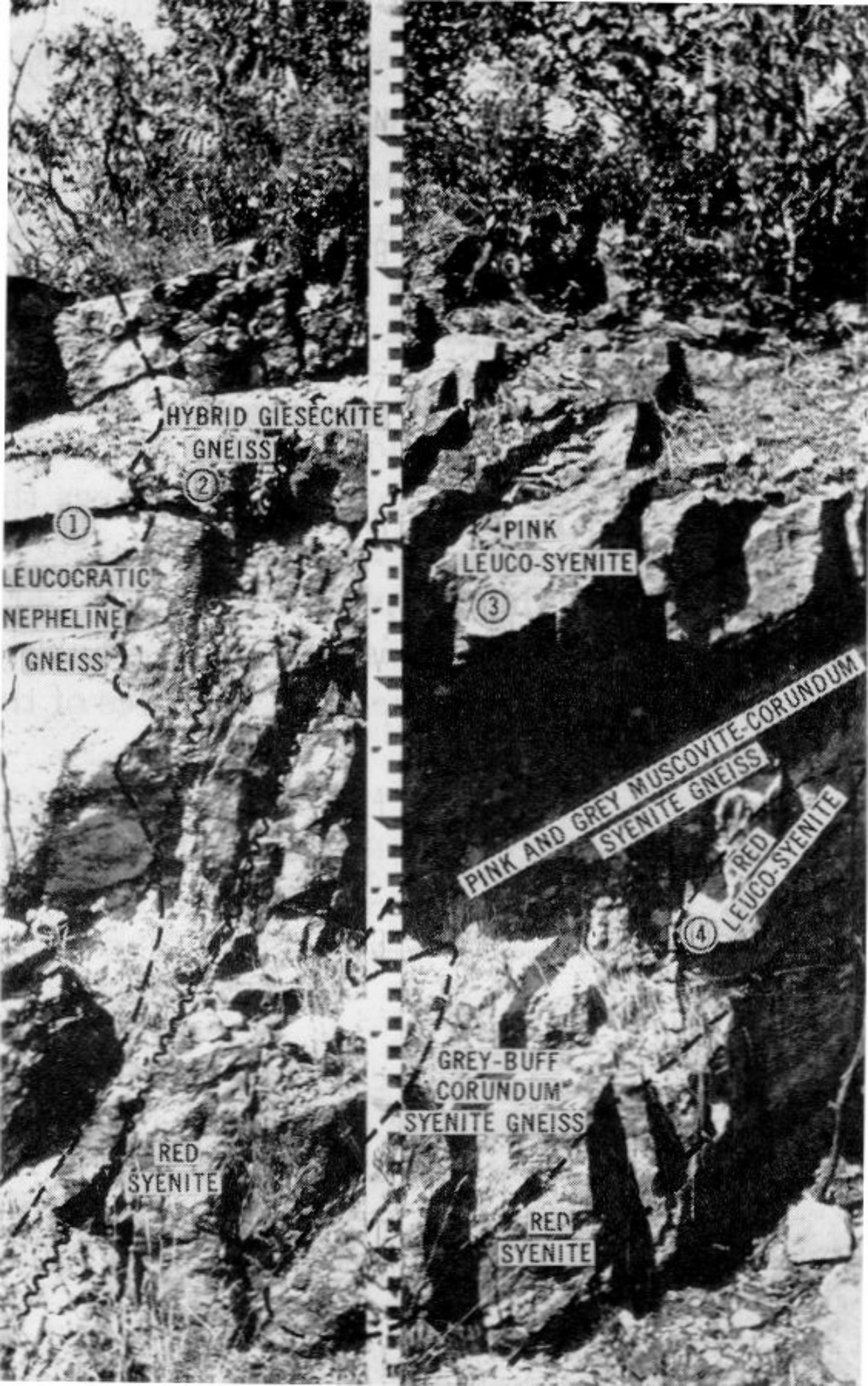


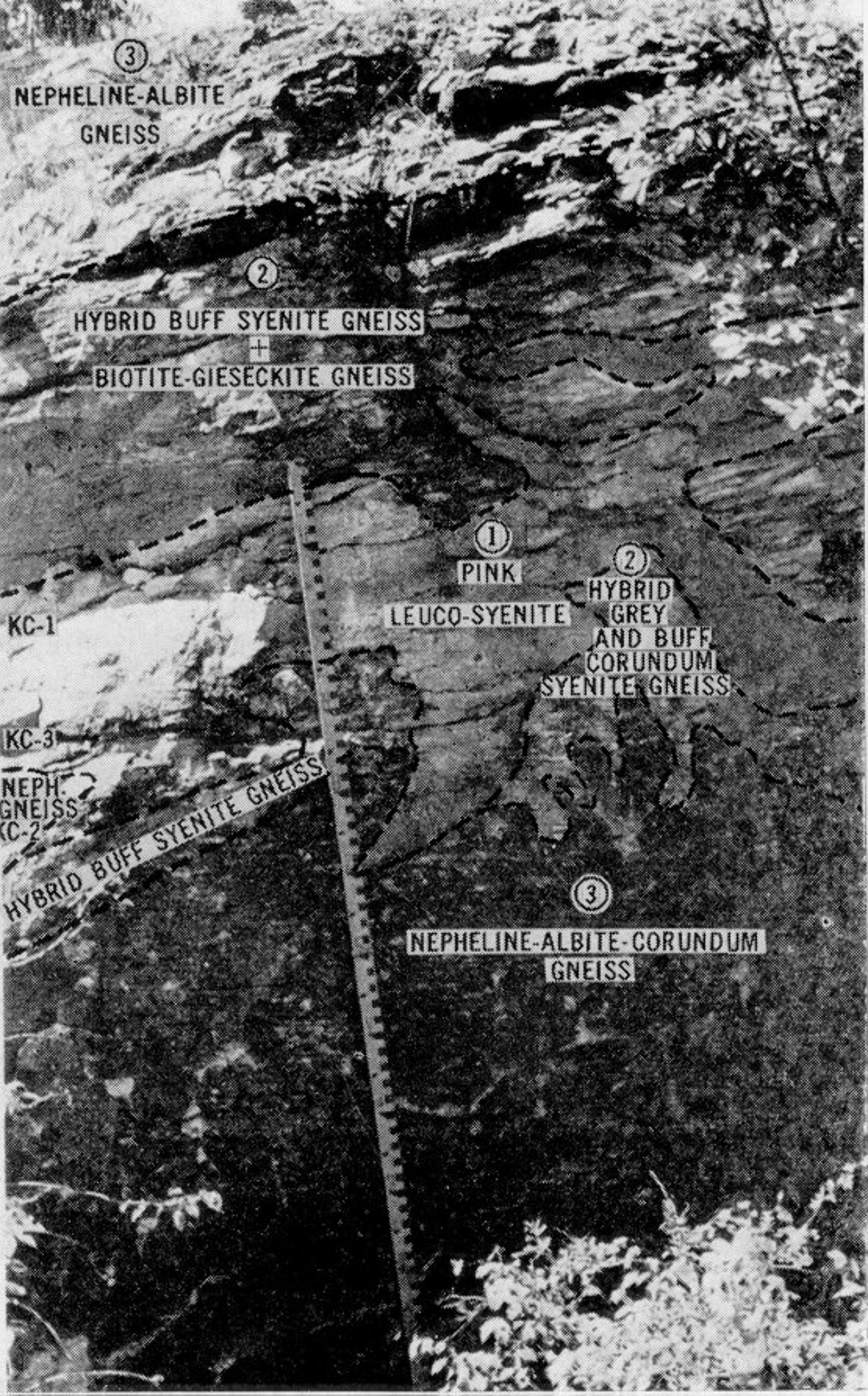



NEPH-GIESECKITE GNEISS
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LEUCO-NEPHELINE GNEISS
HYBRID INTERBANDED NEPHELINE-BIOTITE AND PINK SYENITE GNEISS
3
2 PINK LEUCO-SYENITE
1
HYBRID PINK AND GREY GIESECKITE-CORUNDUM SYENITE GNEISS


6
PINK AND BUFF SYENITE
SEQUENCE
4
HYBRID BUFF AND GIESECKITE SYENITE GNEISSES
5
GREEN SCHIST
3
HYDRONEPHELITE ZONE
2
NEPHELINE-ALBITE-CORUNDUM
GNEISS
1
PINK
LEUCO-SYENITE


①
NEPHELINE GNEISS
NEPHELINE GNEISS
BUFF LEUCO-SYENIT
REPLACED BY
PINK LEUCO-SYENIT
NEPHELINE GNEISS
PINK
SYENITE
NEPH. GNEISS
②
PINK AND BUFF
LEUCO-SYENITE


HYBRID GIESECKITE GNEISS
2
1
LEUCOCRATIC NEPHELINE GNEISS
PINK LEUCO-SYENITE
3
PINK AND GREY MUSCOVITE-CORUNDUM SYENITE GNEISS
RED LEUCO-SYENITE
4
GREY-BUFF CORUNDUM SYENITE GNEISS
RED SYENITE
RED SYENITE


③
NEPHELINE-ALBITE
GNEISS
②
HYBRID BUFF SYENITE GNEISS
+
BIOTITE-GIESECKITE GNEISS
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PINK
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SYENITE GNEISS
KC-1
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KC-2
HYBRID BUFF SYENITE GNEISS
③
NEPHELINE-ALBITE-CORUNDUM
GNEISS


NEPHELINE
GNEISS
PINK AND BUFF MOTTLED
LEUCO-SYENITE WITH CORUNDUM
PINK
LEUCO-SYENITE
NEPHELINE GNEISS
HYBRID
GIESECKITE
GNEISS
PINK AND BUFF MOTTLED
LEUCO-SYENITE



