ONTARIO

ASBESTOS IN ONTARIO

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ASBESTOS IN ONTARIO

by

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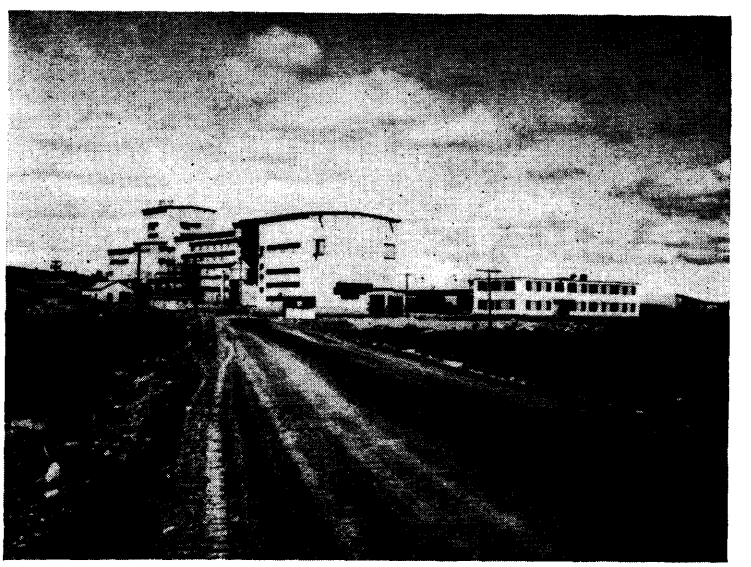
(Reference numbers in brackets refer to the bibliography at the back of the report)

INTRODUCTION

The term "asbestos" is applied to a number of fibrous minerals belonging to the serpentine and amphibole groups. The most important asbestos mineral is the hydrous magnesium silicate, chrysotile, mined chiefly in Quebec. Amosite, an iron-rich variety of anthophyllite and crocidolite, the blue amphibole asbestos, are mined commercially in Africa. Fibrous tremolite and actinolite, brittle, acid-resistant amphiboles, are used to a limited extent.



Mill and crusher building of the Munro mine, Canadian Johns-Manville Company, Limited, July 30, 1950.

Few mineral industries have expanded so rapidly in recent years as the asbestos industry. New uses for asbestos and increased demands for asbestos products have resulted in a shortage of fibre of the higher grades. This shortage has led to a period of very active prospecting and exploration in Canada ever since 1946, and several important new deposits have been found. Until 1950 nearly all the chrysotile produced in Canada came from the eastern townships of Quebec. In 1949 a large deposit of good-grade chrysotile was found in Munro township, district of Cochrane, Ontario, and the Munro mine has been a substantial producer of chrysotile since 1950. The successful development of this ore body led to intensive prospecting in the peridotite belts of northeastern Ontario; two other potential ore bodies have been outlined by diamond-drilling and may be developed in the near future.

ASBESTOS MINERALS

Chrysotile, $H_4Mg_3Si_2O_9$, is yellow to green in colour and fibrous in habit. It occurs in cross-fibre veins in which the silky fibres of the mineral are perpendicular, or nearly perpendicular, to the vein walls, and as slip-fibre veins, in which the fibres lie parallel to the vein walls. The cross-fibre type is most common, and the width of the veinlet limits the fibre length, which ranges from 1/32 inch to 3 inches or longer.

The most important properties of chrysotile asbestos are its fibrous structure, flexibility, and high tensile strength, which allow it to be spun, woven, or felted into sheets, and its non-inflammability and low heat-conductivity in porous packings, which make it a fireproof insulator. The fibre filaments are of extreme fineness, and the chrysotile fibre bundles can be broken down or "willowed" into very fine silky filaments. When exposed to high temperature, the water of crystallization is driven off and the mineral becomes brittle.

Chrysotile has poor resistance to acids and alkalies. Some varieties low in iron content have high electric resistance and make excellent electric insulators.

Amosite, $(Fe,Mg)SiO_3.xH_2O$, is an iron-rich variety of anthophyllite, a member of the amphibole group. It is yellowish-gray to white in colour and may have longer fibre length than chrysotile. The tensile strength is good, but the harsh fibres have poor spinnability. Heat resistance and acid resistance are high.

Crocidolite, $Na,Fe(SiO_3)_2.FeSiO_3.xH_2O$, or blue asbestos, is stronger but has poor spinnability in comparison to chrysotile. It has high resistance to acids and alkalies but fuses easily on heating and is therefore unsuitable for heat insulation purposes.

Tremolite, $CaMg_3(SiO_3)_4.xH_2O$, and actinolite, $Ca(Mg,Fe)_3(SiO_3)_4.xH_2O$, are white or green amphiboles with low tensile strength and poor spinnability. Their high resistance to acids make them suitable for acid filtration. Their heat resistance is high.

TABLE I—PHYSICAL PROPERTIES OF ASBESTOS (after Badollet (4))

	CHRYSOTILE	AMOSITE	ANTHOPHYLLITE	CROCIDOLITE	TREMOLITE	ACTINOLITE
Specific heat B.t.u. per lb. per °F.	0.266	0.193	0.210	0.201	0.212	0.217
Tensile strength, lb. per sq. in.	80,000–100,000	16,000–90,000	4,000 or less	100,000–300,000	1,000 – 8,000	1,000 or less
Temperature at maximum ignition, loss °F.	1,800	1,600 – 1,800	1,800	1,200	1,800	....
Filtration properties	Slow	Fast	Medium	Fast	Medium	Medium
Electric charge	Positive	Negative	Negative	Negative	Negative	Negative
Fusion point, °F.	2,770	2,550	2,675	2,180	2,400	2,540
Spinnability	Very good	Fair	Poor	Fair	Poor	Poor
Resistance to acids and alkalies	Poor	Good	Very good	Good	Good	Fair
Magnetite content	0-5.2	0	0	3.0–5.9	0	....
Mineral impurities present	Iron, chrome, nickel, lime	Iron	Iron	Iron	Lime	Lime, iron
Flexibility	High	Good	Poor	Good	Poor	Poor
Resistance to heat	Good, brittle at high temperature	Good, brittle at high temperature	Very good	Poor, fuses	Fair to good	....
Ionizable salts, micro-mhos (relative elec. conductance)	1.82	1.34	0.58	0.84	....	....
Colour	Green, grey to white	Yellowish-brown	Yellowish-brown; sometimes almost white	Blue	White	Greenish
Crystal system	Monoclinic	Orthorhombic	Orthorhombic	Monoclinic	Monoclinic	Monoclinic
Hardness	2.5–4.0	5.5–6.0	5.5–6.0	4.0–6.0	5.5	6.0
Specific gravity	2.4–2.6	2.9–3.4	2.9–3.4	3.0–3.5	2.9–3.2	3.0–3.2
Cleavage	010, good	110, perfect	110, perfect	110, perfect	110, perfect	110, perfect
Optic sign	Biaxial (+)	Biaxial (+)	Biaxial (+)	Biaxial (±)	Biaxial (−)	Biaxial (−)
Extinction	Parallel	Parallel	Parallel	Inclined	Inclined	Inclined
Refractive index	Nx = 1.542 Nz = 1.555	Nx = 1.65 Nz = 1.687	Nx = 1.61 Nz = 1.645	Nx = 1.688 Nz = 1.691	Nx = 1.599 Nz = 1.625	Nx = 1.618 Nz = 1.641
Birefringence	0.013	0.037	0.035	0.003	0.026	0.023

MODE OF OCCURRENCE

In Serpentinized Ultrabasic Rocks

The most important host rocks for chrysotile asbestos are the olivine-bearing ultrabasic intrusives: dunite, composed almost entirely of olivine; peridotite, composed of olivine and pyroxene; and olivine pyroxenite, composed predominantly of pyroxene with some olivine. These intrusives occur as elongated stocks, often grouped in linear bands, and as sills, which may pinch and swell in an irregular manner. These ultrabasic intrusives appear to be spatially related to zones of major faulting and mountain-building movement. Hess (44) has pointed out that belts of peridotites often occur near the central axis of deformation of major mountain systems, such as the Appalachian system in the eastern townships of Quebec and the ancient Archean systems in northeastern Ontario.

These ultrabasic rocks are often altered through metamorphism to serpentine, $H_4Mg_3Si_2O_9$. The common serpentine material formed is antigorite. Chrysotile and antigorite have the same chemical composition and are dimorphous forms of serpentine formed under different conditions.

Chrysotile occurs in cross-fibre and slip-fibre veinlets cutting the serpentinized rock in a mesh or network pattern. On weathered surface the ultrabasic rock is white, green, or reddish-brown and is often cut up into oblong blocks by the seams of chrysotile, which weather out more easily, forming furrows across the outcrop. On fresh surfaces the rock is green or almost black.

Conditions necessary to the formation of chrysotile veinlets are thought to be: (a) a suitable ultrabasic host rock, probably, but not necessarily, already serpentinized; (b) faulting, to fracture the ultrabasic host rock and provide access for chrysotile-forming solutions; (c) a source of hydrothermal solutions and proper conditions of temperature and pressure for deposition of chrysotile in the fractured, serpentinized ultrabasic rocks. Where later intrusives cut the ultrabasic rocks, these may be the source of asbestos-forming hydrothermal solutions, and asbestos deposits may be localized in the ultrabasic rocks near such intrusives.

In Limestone and Dolomite

Deposits of chrysotile may also occur in limestone and dolomite that has been serpentinized. The chrysotile veinlets occur cutting massive serpentine. This type of deposit is worked in Arizona (43). Here the asbestos occurs as horizontal bands of cross-fibre chrysotile in serpentine, lying parallel to the bedding of the host rock, which is flat-bedded limestone. Hydrothermal solutions from diabase sills intruding the asbestos-bearing limestone are thought to have produced the chrysotile.

Chrysotile is found cutting massive serpentine in Grenville crystalline limestones at Kilmar, Quebec. This chrysotile, which is formed in limestone, is usually very low in iron and commands a premium for electric insulation uses.

Crocidolite and amosite occur closely associated in the African deposits and are found in veinlets cutting ferruginous quartzite close to dolerite intrusives (10).

ONTARIO OCCURRENCES

Production

There has been production of chrysotile asbestos from four deposits in northeastern Ontario. In 1917 the Slade-Forbes Asbestos Company reported a production of 10 tons of chrysotile valued at $2,150 from a deposit in Deloro township, district of Cochrane. From 1923 to 1926, the Bowman mine in Deloro township operated by the Porcupine Asbestos Mining Syndicate produced 194 tons of chrysotile with a value of $99,336. This included a large quantity of select long-fibred chrysotile, which commanded a price of $690 per ton. In 1937 and 1939 Rahn Lake Mines Corporation, Limited, produced 19 tons of chrysotile worth $970 from their property in Bannockburn township, Matachewan area, district of Timiskaming. The total Ontario production of chrysotile up to 1949 amounted to 233 tons, having a value of $102,456.

In 1950 the Munro mine of Canadian Johns-Manville Company, Limited, came into production and since then the chrysotile production in Ontario has been substantial. The total production from this mine to the end of 1952 is valued at $9,107,721. In 1951 Teegana Mines, Limited, re-opened the Slade-Forbes property and produced 38 tons of asbestos valued at $6,300.

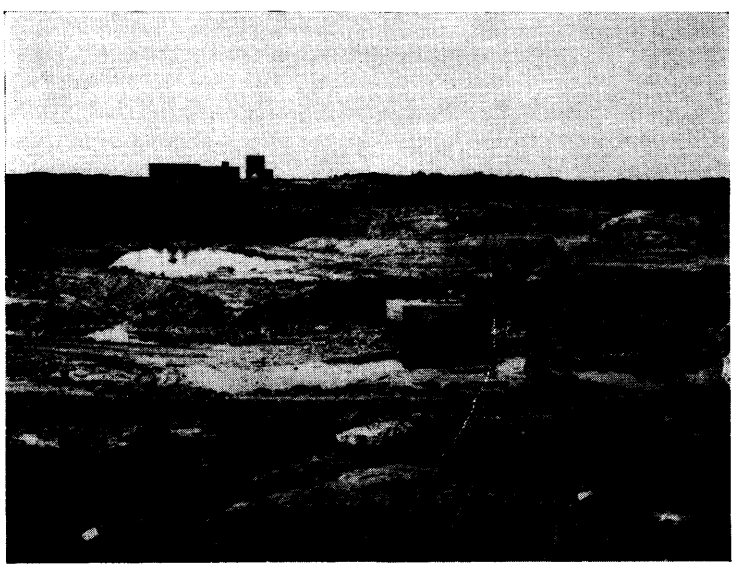
The production of chrysotile asbestos in Ontario is summarized in Table II.

TABLE II—CHRYSOTILE ASBESTOS PRODUCTION IN ONTARIO

YEAR	TONS	VALUE	MINE	OPERATOR
1917	10	$ 2,150	Slade-Forbes	Slade-Forbes Asbestos Company
1923	6	2,600	Bowman	Bowman Asbestos Mines
1924	172	91,900	Bowman	Porcupine Asbestos Mining Syndicate
1925	2	901	Bowman	Porcupine Asbestos Mining Syndicate
1926	14	3,935	Bowman	Porcupine Asbestos Mining Syndicate
1937	1	250	Rahn Lake	Rahn Lake Mines Corporation, Limited
1939	18	720	Rahn Lake	Rahn Lake Mines Corporation, Limited
1950	10,518	1,493,099	Munro	Canadian Johns-Manville Company, Limited
1951	26,549	3,766,769	Munro	Canadian Johns-Manville Company, Limited
	38	6,300	Slade-Forbes	Teegana Mines, Limited
1952	23,033	3,847,853	Munro	Canadian Johns-Manville Company, Limited
Total	60,371	$9,216,477		

The amphibole asbestos minerals, tremolite and actinolite, have been produced commercially in southeastern Ontario. The chief production came from a group of small properties in the actinolite area, which produced in the years 1901 to 1903, 1910, 1917 to 1931, and 1934. The Actinolite Mining Company, Limited, in Kaladar township, Lennox and Addington county, was the main operator. Production amounted to 2,187 tons of actinolite, valued at $27,309.

In 1945 and 1946 a small tonnage of tremolite asbestos, valued at $2,925, was produced by L. M. Carswell of Renfrew from a deposit in lot 22, concession IV, Blithfield township, Renfrew county.



Shovel removing overburden on A ore body, Munro mine, Canadian Johns-Manville Company, Limited. The view is to the southwest towards the mill and crusher building. The photograph was taken July 30, 1950.

DESCRIPTION OF PROPERTIES

Since the development of the Munro mine in 1949, there has been a great deal of prospecting for asbestos in northeastern Ontario. Airborne and ground geophysical surveys have been made over many of the peridotite-bearing areas, and extensive diamond-drilling has been carried out, In the Abitibi Peridotite Belt alone, over 250,000 feet of diamond-drilling for asbestos has been carried out since 1949. As a result of the exploration in northeastern Ontario, two new potential ore bodies have been indicated in Garrison and Reeves townships.

Table III lists occurrences of chrysotile asbestos in Ontario and properties where exploration has been carried out that have been brought to the attention of the writers.

A more detailed description of some of the properties is given in the following sections.

Munro Mine

The history of the development of the Munro mine and a description of its geology and ore bodies are given by N. W. Hendry (30). The geology of Munro township and the Munro mine are described by J. Satterly (39). The following information is derived largely from their two reports.

The Munro mine is located in Munro township, district of Cochrane, ten miles east of the town of Matheson. Canadian Johns-Manville Company, Limited, holds a group of 45 claims and 1 veteran lot in Munro and Beatty town-

ships; the A ore body, now being mined, is on lot 10, concession II, Munro township.

This occurrence of asbestos in Munro township was first reported in 1915 (39). After examination of surface outcrops in the fall of 1948, the Canadian Johns-Manville company acquired the property and began diamond-drilling in the spring of 1949. A total of 21,394 feet of diamond-drilling was carried out on the *A* ore body in 1949 and 1950, and 17,500 feet in 1951. In addition, 65,800 feet of drilling was done to explore the extension of the serpentine body in Munro and Beatty townships.

The geology and ore bodies at the Munro mine are described by Hendry (30) as follows:

Geology

"From an economic standpoint, the most important rock type occurring on the Johns-Manville property is a differentiated basic to ultrabasic sill-like body which has been outlined and traced for a total distance of three and a half miles, or from lot 9, Munro township, to lot 3, Beatty township. It has an average strike of N. 65°-70° W., though deviations from this are caused by cross faults. The sill varies in width from 900 feet on the east end to upwards of 1,000 feet in the vicinity of the Beatty-Munro township boundary. Diamond-drilling information indicates that it has a vertical attitude or dips steeply south.

"On the north and south, the sill is in contact with medium to basic volcanic rocks, classified as dacite and andesite. The volcanic-ultrabasic contact is sharply defined on the south side, as may be seen both in outcrop and in drill cores; no information is available on the north contact. The volcanic rocks at and near the contact show no marked alteration.

"In detail, and from north to south, the sill is composed of a gabbroic phase for a width of approximately 350 feet . . . Southward, the gabbro grades quite sharply into coarse-grained pyroxenite, a massive green rock, composed almost entirely of pyroxene, with crystals up to half an inch in size. The pyroxenite, in turn, is in contact with the main ultrabasic zone, namely, dunite and peridotite, now almost completely serpentinized. The contact is sharply defined and can be seen on the surface in the vicinity of *A* orebody; there is no evidence to suggest that either type is intrusive into the other. It is concluded that both are differentiates from a common magma and that they are of the same relative age. The ultrabasic zone of the sill varies in width from 500 feet in the vicinity of *A* orebody to 900 feet near the Munro-Beatty township line.

Open cut at the west end of the A ore body of the Munro mine, Canadian Johns-Manville Company, Limited. The view is to the southeast. Wagon-drills can be seen at the upper left. The photograph was taken July 30, 1950.

"At and near both margins of this ultrabasic zone, the rock is a dense, dark green to black, serpentinized dunite and peridotite, but toward the central part of the zone this grades into a core of medium to light green, granular, serpentinized dunite . . . In surface outcrop, the granular serpentine core is white weathering, in contrast to the brownish weathering of the border facies. It is almost entirely within the limits of the core of granular serpentine that the chrysotile asbestos veins of importance occur.

"At the east end of *A* orebody, and extending at least as far east as the north-south trending diabase dike in lot 10, is a mass of talc-carbonate.

"The talc-carbonate rock appears to envelop the serpentine mass at its east end. Along both the north and south margins it is present only as a very narrow band, or not at all, on the surface, but in ever increasing width in depth. Also, at a point 770 feet vertically below the surface on the most easterly outcrop of *A* orebody, a diamond-drill hole passed from serpentine into talc-carbonate, suggesting that the latter occurs as a great keel on the eastern end of the serpentine.

"Dikes ranging in composition from acidic to basic have been intersected by diamond-drill holes along the serpentine band with great regularity. The most common type is a facies of pyroxenite which occurs in the serpentine but has not been found to continue into the gabbro or the volcanics. A north-south trending dike of quartz-diabase

TABLE III—CHRYSOTILE ASBESTOS

No.	LOCATION	Number of Claims	NAME OF PROPERTY OR OPERATOR	CATEGORY
	District of Algoma:			
1	Irving tp., Oba river			
	District of Cochrane:			
2	Aurora tp.	7	Quebec Asbestos Corp. Ltd.	Prospect
	Calvert tp.	22		
3	Beatty tp., lot 1, con. III.		C asbestos body, Can. Johns-Manville Co., Ltd.	Potential producer
4	Clergue tp., lots 10-12, cons. III-IV.	10	Dom. Gulf Co.	Prospect
5	Clergue tp., lots 8-12, cons. I-II.	29	Dom. Gulf Co.	Prospect
	Dundonald tp., lot 1, con. I.			
6	Clergue tp., lot 12, con. III.		Alexo mine; diamond-drilling for sulphides by International Nickel Co. and Harlin Nickel Mines, Ltd.	Prospect
	Dundonald tp., lot 1, con. III.			
7	Deloro tp., central part.	3	Bowman mine; Porcupine Asbestos Corp., Ltd.	Production, 1923-26
8	Deloro tp., SE. part.	1	Slade-Forbes mine; Van Packer Mines of Can., Ltd.	Production, 1917-51
9	Dundonald tp., lots 1-2, cons. I-II.	9	T. Kruk, optioned to Quebec Asbestos Corp., Ltd.	Prospect
10	Garrison tp., NW. part.	14	S. J. Bird group, Can. Johns-Manville Co., Ltd.	Potential producer
11	Garrison and Rand tps.	45	E. group	Prospect
	Garrison tp.	11	W. group — Can. Johns-Manville Co., Ltd.	
12	Garrison tp., NW. part.	10	Colonial Asbestos Corp., Ltd.	Prospect
13	Garrison tp., NE. part.	19	Mining Corp. of Can., Ltd.	Prospect
14	Hanna tp., lots 5-8, con. I.		Can. Johns-Manville Co., Ltd.	Prospect
15	Harker tp., north-central part.	24	Hofmann group, optioned to Dom. Gulf Co.	Prospect
16	Harker tp., NE. part.	4	Hofmann E. group.	Prospect
17	Hepburn, Scapa, and Sargeant tps.	29	P. B. Zevely; optioned to Can. Johns-Manville Co., Ltd., in 1952.	Prospect
18	Holloway tp., Mount Lightning area.	16	Dom. Gulf Co.	Prospect
	Frecheville tp.			
19	Holloway tp., NW. part.	11	N. Strong group.	Prospect
20	Little tp., lot 1, con. VI.	2	International Nickel Co. of Canada, Ltd.	Prospect
21	Mann tp., lots 5-11, cons. III-IV.	39	Can. Johns-Manville Co., Ltd.	Prospect
22	Mann tp., lots 8-9, con. III; lots 7-9, con. VI.		International Nickel Co., of Can., Ltd., Can. Johns-Manville Co., Ltd., optioned S. group.	Prospect
23	Mann tp., lots 8-11, cons. IV-V.	27	Northland Mines, Ltd.	Prospect
24	Mann tp., lot 3, con. V.	4	Dom. Gulf Co.	Prospect
25	Mann tp., lots 1-4, con. I.	13	Dom. Gulf Co.	Prospect
26	Mann tp.	63	P. B. Zevely.	Prospect
	Hanna tp., SW. part.	15		
	Reaume tp.	9		
27	Mann tp., E. part.		Dom. Gulf Co.	Prospect
	McCart tp., N. part.	72		
	Newmarket tp., W. part.			
28	McCart tp., lots 7-10, cons. V-VI.	28	Arrow Timber Co., Ltd.	Prospect
29	McCart tp.	13	Quebec Asbestos Corp., Ltd., central group	Prospect
30	McCart tp.	12	Quebec Asbestos Corp., Ltd., N. group.	Prospect
31	McCart tp., lot 12, con. VI.	2	Dom. Gulf Co.	Prospect
32	McCool tp., lot 4, con. II. S. half.		F. W. Schumacher optioned to Dom. Gulf Co.	Prospect
33	McCool tp., lot 5, con. III; lots 2-3, con. IV; lot 12, con. V.		Arrow Timber Co., Ltd.	Prospect
34	McCool tp., lots 7-8, cons. I-II.	12	Camrose Gold and Metals, Ltd.	Prospect
35	McCool tp., lots 6-12, cons. II-IV.	81	Can. Johns-Manville Co., Ltd.	Prospect
36	McCool tp., lots 7-11, cons. V-VI.	32	Dom. Gulf Co., group I.	Prospect
37	McCool tp., lots 2-3, cons. I-II.	13	Dom. Gulf Co., group II.	Prospect
38	McCool tp., lots 1-2, con. III.	5	Dom. Gulf Co., group III.	Prospect
39	McCool tp., lot 5, cons. II-III.	16	A. J. B. Gray, Feldman group.	Prospect
40	McCool tp., lots 1-2, cons. I-II.	15	Quebec Asbestos Corp., Ltd.	Prospect

REMARKS	REFERENCES
Occurrence of fibre in peridotite dike.	Ont. Dept. Mines, Vol. XXXVIII, pt. 6, p. 125.
Geophysical survey, 1950; diamond-drilling: 1950, 2 holes, 1,200 feet; some fibre less than $\frac{1}{8}$ inch in serpentinized peridotite.	
300-foot shaft, 4,100 feet of cross-cutting and drifting, 1951; bulk sample 11,000 tons milled.	
Geological and geophysical survey, 1951; diamond-drilling, 1952: 2 holes, 1,819 feet.	
Geophysical survey and diamond-drilling, 1949-52: 13 holes, 6,604 feet; some fibre in dunite.	
Some fibre $\frac{1}{16}$ inch and less indicated in diamond-drilling in serpentinized peridotite.	
194 tons asbestos produced; valued at $99,336.	Ont. Dept. Mines, Vol. XXXVI, pt. 1, p. 86.
10 tons, value $2,150, produced in 1917; 38 tons, $6,300, in 1951; formerly Teegana Mines, Ltd.	
Geological and geophysical survey, 1950; some fibre in outcrop.	
Geophysical survey and diamond-drilling, 1950-51, 14,923 feet; drilling, 1952. Ore body indicated.	
Geophysical survey in 1949; diamond-drilling, 1951, 21 holes, 13,557 feet. Some fibre reported in serpentinized dunite. 16 claims held in 1953.	
No report of peridotite or fibre on property.	
Diamond-drilling for asbestos, 1946; 1951, 1,709 feet; no fibre observed in core.	
Geophysical survey, 1950-51; no surface exposures; claims allowed to lapse.	
Diamond-drilling, 1949, 3,031 feet; 1950, 7,051 feet; 1 percent fibre in dunite.	Ont. Dept. Mines, Vol. LX, pt. 7, p. 34.
Geophysical survey, 1950, thread fibre in peridotite outcrops.	
Some fibre in peridotite outcrops; dip-needle exploration; 1 hole drilled to depth of 532 feet; results not encouraging, option terminated.	
Geophysical survey and diamond-drilling, 1950, 9,000 feet; thread fibre in peridotite.	
Geophysical survey, 1950; some peridotite outcrops, no fibre reported.	
Few stringers of asbestos indicated in diamond-drilling of peridotite.	
Geophysical survey, 1950; diamond-drilling, 1951; 8 holes, 4,790 feet; some fibre in peridotite.	
Diamond-drilling, 1948; 5 holes; 1951, 1 hole, 701 feet, total 2,459 feet; some fibre to $\frac{1}{8}$ inch	
Geophysical survey, 1951; some fibre in peridotite.	
Diamond-drilling, 1 hole, 756 feet; harsh picrolite in peridotite.	
Diamond-drilling, 1951, 1 hole, 844 feet, no fibre; 1952, 1 hole, 876 feet; 1953, 1 hole, 601 feet.	
Diamond-drilling for sulphides, 1949, 27 holes, 20,000 feet; less than 1 percent fibre in peridotite. Development largely on claims T.25903, 25904, Mann tp.	
Diamond-drilling, 1950-52, 15 holes, 9,982 feet; trace of fibre in serpentinized peridotite.	
Diamond-drilling, 1950-51, 7 holes, 3,812 feet; some fibre to $\frac{1}{4}$ inch in serpentinized peridotite.	
Geophysical survey and diamond-drilling, 1950, 1 hole, 756 feet.	
Geophysical survey, 1950.	
Diamond-drilling, 1951, 1 hole, 562 feet; no fibre.	
Geophysical survey and diamond-drilling, 1951; good fibre indicated; no data available.	Ont. Dept. Mines, Vol. LXI, pt. 5, p. 27.
Geophysical survey, 1950; no fibre reported.	Ont. Dept. Mines, Vol. LXI, pt. 5, p. 23.
Geophysical survey and diamond-drilling, 1950-52, 13 holes, 6,759 feet; some thread fibre.	Ont. Dept. Mines, Vol LXI, pt. 5, pp. 23-24.
Geophysical survey and diamond-drilling, 1950-51, 10 holes, 6,759 feet; some fibre indicated; 16 claims held in 1953.	Ont. Dept. Mines, Vol. LXI, pt. 5, p. 24.
Geophysical survey and diamond-drilling, 1950-51, 24 holes, 16,196 feet; some fibre in dunite.	Ont. Dept. Mines, Vol. LXI, pt. 5, p. 24.
Geophysical survey and diamond-drilling, 1950, 3 holes, 1,696 feet; peridotite; no fibre reported.	Ont. Dept. Mines, Vol. LXI, pt. 5, pp. 24-25.
Geophysical survey and diamond-drilling, 1951, 5 holes, 2,903 feet; no fibre reported.	Ont. Dept. Mines, Vol. LXI, pt. 5, p. 25.
Geophysical survey and diamond-drilling, 1951-52, 3 holes, 3,018 feet; some fibre indicated.	Ont. Dept. Mines, Vol. LXI, pt. 5, p. 26.
Geophysical survey, 1950; diamond-drilling, 1952, 2 holes, 1,218 feet; some fibre in perioditite.	Ont. Dept. Mines, Vol. LXI, pt. 5, pp. 26-27.

No.	LOCATION	Number of Claims	NAME OF PROPERTY OR OPERATOR	CATEGORY
	District of Cochrane—*continued*			
41	McCool tp., lots 6-7, cons. III-IV.	18	Rayville Matheson Asbestos, Ltd.	Prospect
42	Munro tp Beatty tp.	45 claims and 1 vet. lot.	Munro mine, Can. Johns-Manville Co., Ltd.	Production, 1950
43	Munro tp., lots 5-6, con. V.	8	Mangan-Dyer property, optioned to Quebec Asbestos Corp., Ltd.	Prospect
44	Munro tp., lots 5-7, cons. IV-V.	12	Potter-Doal property, optioned to Can. Johns-Manville Co., Ltd.	Prospect
45	Munro tp., lots 3-5, cons. IV-VI.		Quebec Asbestos Corp., Ltd.	Prospect
46	Munro tp. McCool tp.	86	Reoplata Mines, Ltd.	Prospect
47	Munro tp., lots 8-9, cons. IV-VI.	34	Strongford Asbestos Mines, Ltd.	Prospect
48	Munro tp., lot 1, con. VI. McCool tp. Milligan tp.	6 2 1	Flagro Mines, Ltd.	Prospect
49	Munro tp., lots 3-4, con. VI. Warden tp., lots 4-5, con. I.	9 4	H. M. Ford property, optioned to Can. Johns-Manville Co., Ltd.	Prospect
50	Reaume tp., lots 6-9, cons. V-VI.	32	Can. Johns-Manville Co., Ltd., NW. group.	Prospect
51	Reaume tp., lots 1-7, con. IV.	35	Can. Johns-Manville Co., Ltd., north-central group.	Prospect
52	Reaume tp., lots 1-3, cons. V-VI. Hanna tp., lots 12, cons. V-VI.	25	Can. Johns-Manville Co., Ltd., NE. group.	Prospect
53	Reaume tp., lots 7-10, cons. II-III.	21	Can. Johns-Manville Co., Ltd., S. group.	Prospect
54	Warden tp., lot 6, con. I.		S. J. Bird, Can. Johns-Manville Co., Ltd.	Prospect
55	Warden tp., lots 9-12, con. I.	11	Can. Johns-Manville Co., Ltd.	Prospect
56	Warden tp., lots 2-6, con. I.		Mangan-Dyer property, optioned to Van Packer, Mines of Can., Ltd.	Prospect
	Frontenac county:			
57	Oso tp., lot 11, con. V.		Mrs. T. Duffy farm.	
	Hastings county:			
58	Marmora tp., lot 12, con. IX.		Terryon farm.	
	District of Kenora:			
59	Red Lake Area.			
	District of Sudbury:			
60	Penhorwood tp.	24	Can. Johns-Manville Co., Ltd., N. group.	Prospect
61	Reeves tp., SE. quarter.	50	Can. Johns-Manville Co., Ltd.	Potential producer
62	Rennie tp., Trem lake—Butler lake area.		J. McDonough.	Prospect
	District of Thunder Bay:			
63	O'Sullivan lake, Toronto lake.	2	Claims T.B. 167, T.B. 207B.	
64	Shebandowan lake.			
65	Obonga lake.			
66	Conmee, Horne and Adrian tps., Thunder and Gold lakes.		Henry Fabis	Prospect
	District of Timiskaming:			
67	Bannockburn tp. Montrose tp. — Rahn Lake area.	24	York Asbestos Mines, Ltd., formerly Rahn Lake Mines Corp., Ltd.	Production, 1937, 1939
68	Knight tp., Tyrrell-Knight area.			
69	Langmuir tp. Carman tp., Cochrane district.	6	Dom. Gulf Co.	Prospect
70	Langmuir tp., SE. part.	25	Dom. Gulf Co.	Prospect
71	McArthur tp. Geikie tp. Bartlett tp. — Redstone river area.			
72	McElroy tp., SE. quarter.			
73	Midlothian tp., Lloyd lake.		Vanclieaf, Miller, Copeland, and Dillman groups; optioned to Can. Johns-Manville Co., Ltd., later Miller group optioned to Dom. Gulf Co.	Prospect
74	Semple tp., SE. part.		Dom. Gulf Co., group I.	Prospect
75	Skead tp., N. half			
76	Sothman tp., W. of Poutney lake.		Wrigley Syndicate, optioned to Asbestos Corp., Ltd., 1950.	Prospect

REMARKS	REFERENCES
Geophysical survey, 1951; diamond-drilling, 1951-52, 9 holes, 6,031 feet; some fibre in peridotite.	Ont. Dept. Mines, Vol. LXI, pt. 5, p. 27.
Production from open pit on A ore body since 1950.	Ont. Dept. Mines, Vol. LX, pt. 8, p. 36.
Geophysical survey and diamond-drilling, 1949-50, 3 holes, 1,208 feet; some fibre in peridotite; option dropped.	Ont. Dept. Mines, Vol. LX, pt. 8, p. 41.
Geophysical survey and diamond-drilling, 1949, 3 holes, 594 feet, option dropped.	Ont. Dept. Mines, Vol. LX, pt. 8, p. 41.
Geophysical survey, 1949; option dropped in 1950.	Ont. Dept. Mines, Vol. LX, pt. 8, p. 42.
Geophysical survey and diamond-drilling, 1950, 3 holes, 876 feet.	Ont. Dept. Mines, Vol. LX, pt. 8, p. 42.
Some fibre in dunite outcrops.	Ont. Dept. Mines, Vol. LX, pt. 8, p. 42.
Geophysical survey and diamond-drilling, 1951, 1 hole, 343 feet; no commercial fibre indicated.	Ont. Dept. Mines, Vol. LX, pt. 8, p. 41.
Geophysical survey, 1949; diamond-drilling, 1949-50, 2 holes, 1,194 feet; no commercial fibre indicated, option dropped.	Ont. Dept. Mines, Vol. LX, pt. 8, p. 41.
Geophysical survey, 1950; no exposures; diamond-drilling, 1952, 2 holes, 1,437 feet.	
Geophysical survey, 1950; no exposures; diamond-drilling, 1952, 1 hole, 800 feet.	
Geophysical survey, 1950; no exposures; diamond-drilling, 1952, 3 holes, 2,491 feet.	
Geophysical survey, 1950; no exposures.	
Diamond-drilling indicated some fibre in serpentinized peridotite sill.	
Diamond-drilling, 1949, 2 holes, 500 feet; a little fibre in serpentinized peridotite; claims allowed to lapse.	
Diamond-drilling, 1951, 11 holes, 1,964 feet; some fibre under 1/16 inch in 5 holes.	
Chrysotile in green serpentinized marble; mineralogic interests only.	Ont. Dept. Mines, Vol. LVI, pt. 6, p. 40.
Yellow chrysotile in serpentinized marble.	Ont. Dept. Mines, Vol. XXXIX, pt. 6, p. 29.
Some stringers of asbestos in massive serpentine rocks.	Ont. Dept. Mines, Vol. XXXVI, pt. 3, p. 12.
Geophysical survey, 1952; diamond-drilling, 1953, 5,828 feet.	
Geophysical survey, 1952; diamond-drilling, 1952-53, 40,685 feet; ore body indicated.	
Geophysical survey, 1952; diamond-drilling, 1953, chrysotile in outcrop.	
Asbestos fibre reported in serpentine rock.	Ont. Dept. Mines, Vol. XL, pt. 4, p. 71.
Peridotite intrusives.	Ont. Dept. Mines, Vol. XXXVII, pt. 4, pp. 133, 147.
Asbestos veinlets in serpentine.	Ont. Dept. Mines, Vol. XXXIX, pt. 2, pp. 54-59.
Asbestos veinlets in peridotite; surface sampling by Quebec Asbestos Corp., Ltd., and McIntyre Porcupine Mines, Ltd., in 1951.	Ont. Dept. Mines, Vol. XLI, pt. 2, p. 12.
Two shafts, some underground development by Rahn Lake mines; geophysical survey and diamond-drilling, 1951-52, 8,500 feet; some fibre indicated.	Ont. Dept. Mines, Vol. XLI, pt. 2, p. 39.
Asbestos veinlets in serpentinized peridotite.	Ont. Dept. Mines, Vol. XLIX, pt. 4, pp. 6-7.
Geophysical survey, 1951; peridotite with some fibre reported.	
Geophysical survey, 1951; asbestos fibre in peridotite.	Ont. Dept. Mines, Vol. XXXV, pt. 6, p. 44.
Asbestos fibre reported in serpentinized peridotite.	Ont. Dept. Mines, Vol. LIX, pt. 6, p. 37.
Some chrysotile to 3/8 inch in serpentinite sill.	Ont. Dept. Mines, Vol. LVI, pt. 5, p. 21.
Geophysical survey, 1950, 1952; diamond-drilling, 1950, 17 holes, 9,508 feet, fibre to 1/4 inch; Can. Johns-Manville Co., Ltd., option dropped; diamond-drilling, 1952.	
Geophysical survey, 1952; serpentinized peridotite body indicated.	Ont. Dept. Mines, Vol. LVIII, pt. 6, p. 29.
A few chrysotile veinlets in serpentinized peridotite sill.	
Chrysotile fibre to 1/8 inch in peridotite sill.	

crosses the ultrabasic sill at the east end of *A* orebody. Narrow dikes of felsite and lamprophyre have been seen in diamond-drill core but have not been observed on any of the serpentine outcrops.

Fractures

"Eight cross faults with strikes varying from north to northeast and displacements ranging from 50 to 600 feet are indicated to be present along the length of *A* orebody from diamond drilling and geophysical survey information. In addition to these, there are numerous minor cross faults with displacements from a few inches to several feet. Along the 2-mile band of serpentine, geophysical work alone has to date indicated no fewer than twenty-nine cross faults with displacements ranging from 50 to 1,130 feet. The one with the greatest displacement (1,130 feet) is in Beatty township, approximately two miles west of *A* orebody.

"A second system of faults is well developed and can be observed on the outcrops of *A* orebody. These strike N. 60°–70° W. and, in general, parallel the trend of the serpentine band and are normal to the first described fault system. Displacements range from a few inches to several feet as measured along two north-south striking dikes which cut the serpentine. These fractures are closely spaced in the central portion of the serpentine band and widely spaced or absent toward the margins. In most cases, the fractures are continuous for many feet and where any individual fracture terminates another begins either to one side or the other.

"The first set of fractures is not displaced by the second, and vice versa, thereby indicating that both sets

Chrysotile veinlets in serpentinized dunite. This is the original outcrop of the A ore body of the Canadian Johns-Manville company holdings in lot 10, concession II. The photograph was taken September 12, 1944.

are of the same age and were formed by the same forces. Considerable work remains to be done to solve the relationship between these strike and cross fractures within the area of the asbestos deposits.

Orebodies

"To date, areas of chrysotile asbestos mineralization of commercial interest have been outlined in whole or in part by diamond drilling along a 2-mile length of the serpentine band explored.

"A" Orebody

"*A* orebody lies within lot 10, concession II, Munro township, near the eastern end of the serpentine band. The zone of commercial mineralization is many hundreds of feet in length and width, and has been found to be continuous to the depth of the deepest vertical drill hole, which is several hundred feet. The orebody is contained between a strongly defined cross fault on the west and a zone of talc-carbonate alteration on the east.

The asbestos which constitutes *A* orebody is contained in the core of the ultrabasic sill or in the adjacent serpentinized dunite. More particularly, the veins are associated principally with a medium to light green, granular serpentine. Few and only narrow veins occur in the dark green, dense serpentine which borders the granular core.

"The cross fibre veins in *A* orebody vary in width from 1/32 of an inch to a maximum of 1 inch. There are two major sets of veins, one parallel to the direction of strike of the sill, or N. 65°–70°W., the other normal to this. These veins occupy the fractures described above. Both sets are equally well developed and are contemporaneous. The resultant pattern developed in the serpentine is a series of square or rectangular blocks ranging from several inches to, in some cases, several feet in size. Individual veins maintain a constant width and persist in remarkably straight lines for considerable distances. In addition to these major veins, numerous narrower and shorter veins occur in regular and irregular patterns within individual blocks. 'Regular' veins include the short gash type veins which extend for an inch or a few inches away from the major fractures; these are well developed throughout *A* orebody. 'Irregular' veins include those of any attitude, from horizontal to vertical, straight or curving, and variations of these, which may or may not be confined to an individual block.

"Two types of cross-fibre veins occur in *A* orebody, namely, the one-fibre veins and the two or more fibre

veins. The two types are distributed about evenly through the orebody. The break or breaks in the fibre may occur along the centre or near either side of a vein and may be continuous in a straight line or may be irregular. The breaks are generally filled with serpentine or magnetite.

"The asbestos in *A* orebody is a harsh grade of fibre. It possesses considerable strength and can be 'teased' between the fingers into a relatively soft, cottony mass. Individual fibres are sufficiently harsh before teasing that they will penetrate the skin, yet when bent they will not break. The fibre is harshest at the east end of the orebody, close to the contact of the serpentine with the talc-carbonate rock, becoming progressively less harsh to the west.

"Magnetite is present in abundance in the orebody. It occurs in greatest quantity in seams up to half an inch wide and in disseminated form within the limits of the area of fibre mineralization. It can be found in seams along the margins of every asbestos vein and also as a filling in a great many of the breaks in the two or more fibre veins. Magnetite in disseminated form occurs throughout the serpentinized mass and is most abundant, in this form, in the darker types of serpentine.

"The fibrous materials, slip-serpentine and picrolite, are present throughout the orebody. Slip-serpentine is developed along the fault faces and appears as a translucent, pale green coating. The brittle, coarse-fibred picrolite is best developed around the margins of the fibre zones but nowhere occurs in large amount.

"B" Area

"The area of asbestos mineralization termed *B Area* extends from the cross fault at the west end of *A* orebody westward along the serpentine band for several hundreds of feet. For the total length of the area, three cross faults have

Chrysotile asbestos veinlets in serpentinized dunite, showing the original outcrop at the east end of the A ore body of the Munro mine, lot 10, concession II. The photograph was taken September 12, 1944.

been postulated, with displacements ranging from 50 to 250 feet. None of these faults is visible on surface outcrops; their presence and position have been deduced from irregularities of the serpentine contacts.

"The cross-fibre veins range in width from 1/32 of an inch to a maximum of 9/16 of an inch; one-fibre veins predominate. The fibre is a harsh to semi-harsh variety.

"The predominant vein system in *B* area is parallel to the strike of the sill. Veins normal to this set are present but are spaced at much greater intervals than in *A* orebody. Other veins with irregular strikes and dips, subsidiary to the major sets, are developed to a moderate degree throughout this area.

"Dark green to almost black, serpentinized dunite is the predominant rock type of the ultrabasic portion of the sill in *B* Area. Only relatively narrow and irregular sections of the lighter green, granular serpentine occur, and it is within the limits of these that the most abundant fibre is developed.

"As in *A* orebody, magnetite is abundant both in the form of seams along the borders of the asbestos veins and in disseminated form in the serpentine.

"B" Area Extension

"Two areas of asbestos mineralization, respectively one and two miles west of *A* orebody, are so similar in all known respects that they will be described under the one general heading. Our knowledge of these areas is far from complete and, due to the fact that they are completely covered by a considerable thickness of overburden, information is limited to that obtained from drill cores.

"The drilling indicates that the more easterly of these areas contains chrysotile veins of commercial interest over a length and width of several hundred feet. The other, about one mile to the west and in Beatty township, is also indicated to be of considerable magnitude.

"Two outstanding differences have been noted in these 'extension' areas as compared with the *A* and *B* areas. First, the fibre is paler green in colour than that of *A* orebody and much softer and silkier in texture. Second, there is very little magnetite, either in association with the veins or in the serpentine. As a consequence, the serpentine is much lighter green than that in the two areas to the east.

"The veins in the *B* extension areas range in width from 1/32 of an inch to 1¼ inches; some are one-fibre and others two or more fibre veins.

"In summary, it can be said that asbestos veins occur along the total length of two miles of the serpentine band explored by diamond drilling to date. However, only in certain areas, whose combined length totals many hundreds of feet, are veins present in sufficient concentration to be of commercial interest."

C Body

The B Area extension referred to in Hendry's paper has since been divided into "B Extension" and "C Body." The latter body is located on lot 1, concession III, Beatty township, two miles west of the A ore body. Since this portion of the peridotite sill is completely covered by a thick mantle of overburden, no surface examination could be made. In 1949 and 1950, 30,459 feet of diamond-drilling was done on the C body. In 1950 the company decided to sink a shaft and take a large bulk sample for mill tests. A 314-foot shaft was sunk, and a level established at 300 feet. The shaft is located in volcanics on the south side of the vertical-dipping peridotite sill. In 1951 some 2,972 feet of crosscutting and 1,176 feet of drifting were carried out, and a bulk sample of 11,000 tons was milled at the Munro mine. The fibre from the C body is said to be softer than that from the A ore body. The fibre-bearing zone of the C body is approximately 1,300 feet long and 600 feet wide. Milling results on the bulk samples from the C body have not been published, and no data are available on whether or not the material is of commercial grade.

Current Production

Current production is from the open pit on A ore body. The ultimate rim-to-rim size of the open pit will be 2,200 by 800 feet, and it is expected that this open pit can be carried to a depth of 300 feet. The mill is currently running at a capacity of 75 tons per hour on a 22-hour-day basis. The production is largely Group 4 fibre, with a limited amount of Group 6.

Bowman Mine

In 1923 Bowman Asbestos Mines opened a property east of Mackay lake in central Deloro township. The property consisted of three claims, P. 8415, P. 8709, and P. 9745. Six tons of asbestos valued at $2,600 was produced in 1923. In 1924 the property was taken over by Porcupine Asbestos Mining Syndicate, which produced 172 tons of asbestos valued at $91,900 in 1924 and 2 tons of asbestos valued at $901 in 1925. In 1926 the Bowman mine was taken over by Porcupine Asbestos Corporation, Limited, and a production of 14 tons of asbestos valued at $3,935 was reported for that year. There has been no reported production since 1926.

The following description of the operations of this mine is taken from Volume XXXVI of the Ontario Department of Mines, 1927, part 1, page 86:

"Operations were carried on from March 1 to August 15, 1926. The power line from the Ankerite mine to the asbestos property was completed and the plant operated by electrically driven machinery. A Chicago pneumatic compressor, type NSB, 14 by 12 inches, was driven by a 75 h.p. induction motor, and a 3 h.p. motor drove a Fairbanks-Morse centrifugal pump.

"The rock was mined in an open pit, and drilling was done with two tripod and two plugger drills. The rock was hoisted from the pit by a swing derrick operated by a double-drum contractor's hoist driven by a 35 h.p. induction motor. A steel box, capacity 1½ cubic yards, is used to carry the rock, which was being handled at the rate of 150 cubic yards a day. Most of the crude asbestos was hand-picked in the pit, and a further saving was made by cobbing and hand-picking in a cobbing shed.

"After being hoisted from the pit, the rock was dropped into side-dump cars and hauled to the cobbing shed by an 8-ton gasoline-driven locomotive.

"The asbestos occurs in narrow veins in small fracture zones running nearly north and south in a large mass of dark-green serpentine. The open pit also takes this direction, and at the time of suspending operations the pit had reached a depth of 60 feet, a width of 50 feet, and a length of 130 feet. A determined effort was made to develop a commercial body of asbestos, but it was found that while the quality of the asbestos was equal to that of the Quebec deposits, there was not a sufficient quantity of the fibre to make the venture a paying one. The average length of fibre saved was one inch, and it was of No. 1 quality. In composition the Deloro asbestos is very much like that of Quebec except that the alumina and iron content are lower and the combined water higher, making it more adaptable for spinning and general manufacture."

Slade-Forbes Mine

The Slade-Forbes property is located in southeastern Deloro township, district of Cochrane, and consists of one claim, number P. 6886. The Slade-Forbes Asbestos Company produced 10 tons of asbestos valued at $2,150 from an open pit on this claim in 1917.

In August, 1943, the property was optioned to Canadian Johns-Manville Company, Limited, for a 12-month period. A test shipment of 1,500 pounds of ore and 500 pounds of hand-cobbed fibre was shipped to the company laboratory for testing. The option was dropped.

From January, 1948, to October, 1949, the Bell Asbestos Company held the property under option and tested a small shipment of material from the open pit. The option was dropped.

Teegana Mines, Limited, optioned the property in October, 1949. Five neighbouring claims were also optioned. A limited amount of work was done on the property and, in 1951, a shipment of 38 tons of fibre valued at $6,300 was reported. In the fall of 1951 the property was optioned to Van Packer Mines of Canada, Limited. Detailed geological and geophysical mapping of the deposit was carried out, and 1,000 feet of diamond-drilling was done in 1951.

Chrysotile asbestos occurs in cross-fibre veinlets in granular, serpentinized dunite of apple-green colour. An open pit, 40 feet square and 10–15 feet deep, was sunk on the main showing by the Slade-Forbes Asbestos Company. Fibre occurs on the outcrops, in the neighbourhood of the pit, and in the pit itself. The veinlets are up to 2 inches wide and are rather harsh; considerable talc-carbonate alteration is present. Fibre is also present in a second showing, 350

feet southeast of the pit. A dike of fine-grained, grey granite, 100 feet wide, striking N. 80°E., cuts the serpentinized peridotite south of the open pit.

In the open pit, a fault is exposed striking east-west and dipping 75°N. One set of fractures, carrying fibre, parallels this fault; another set strikes N.10°E. and also carries fibre. In the open pit the fibre appears to make up approximately 5 percent of the rock and is exposed over an area about 50 feet in diameter.

Bird Group, Canadian Johns-Manville Co. Ltd.

The Bird group comprises 14 surveyed unpatented claims, L. 54617–28 and L. 54644–45, in the northwestern part of Garrison township, district of Cochrane, between highway No. 101 and the north boundary of the township. In 1950, a showing of chrysotile asbestos in serpentinized dunite was explored by S. J. Bird with eight short, diamond-drill holes totalling 1,207 feet. The property was optioned to Canadian Johns-Manville Ontario, Limited, and ultimately purchased by it in 1952. The company made a geophysical (magnetometer) survey of the claims and, by the end of 1951, had carried out 14,923 feet of drilling in 26 holes. Five additional claims adjacent to the Bird group, L. 56784–85, L. 56828–29, and L. 58457, were also acquired by the company.

The general geology is shown on the Ontario Department of Mines map No. 1949-1, by J. Satterly. Surface exposures are confined to the north row of claims and indicate a dunite-gabbro complex intrusive into basic volcanics. Banding in the gabbro dips 65°N. The contact between the dunite and gabbro is marked by a shear zone with dips of 25°–67°N. Cross-fibre chrysotile asbestos is present in a few small outcrops on claims L. 54619 and L. 54621. The magnetometer survey showed a wide anomaly, and subsequent diamond-drilling confirmed the presence of serpentinized peridotite and dunite for a width of about 2,400 feet. On the south side of the main anomaly, a smaller anomaly projected southwestward. Drilling of this anomaly, which lies within claims L. 54628, L. 54627 and L. 56829, disclosed an ore body varying in width from 300 to 500 feet and 1,700 feet long. The dunite-volcanics contact dips 45°–60° NW. Data on the fibre content are not available for publication.

F. W. Schumacher Property

The south half of lot 4, concession II, McCool township, owned by F. W. Schumacher, was optioned to the Dominion Gulf Company in 1951. A ground magnetometer survey made in that year traced an anomaly, believed to be peridotite, across the property. This anomaly was drilled as part of a joint-exploration programme by Asbestos Corporation, Limited, and the Dominion Gulf Company.

In 1951 and 1952 a large amount of diamond-drilling was done, and some good lengths of fibre-bearing peridotite were cut. Information on the drilling results is not available for publication.

Reeves Property

The original asbestos showing in southeastern Reeves township was staked by J. C. Bromley and subsequently optioned to the Canadian Johns-Manville Company, Limited, in 1951. The company holds a block of 50 claims in the southeastern part of Reeves township. A geophysical survey was carried out in 1952 and by the end of 1952, 26,349 feet of diamond-drilling had been carried out. An additional 14,336 feet of diamond-drilling has been carried out in 1953 on the same group and on another group of claims in Penhorwood township, just to the south of the Reeves deposit.

The property is located 40 miles southwest of Timmins and is best accessible by air from South Porcupine. Chubb lake in the southeast corner tof the township lies 1½ miles east of the showing, and serves as a landing depot.

An irregular-shaped stock of serpentinized dunite cuts Keewatin basic volcanics, chiefly andesite. The volcanics strike east-west. To the south, the dunite mass is bounded by quartz diabase. The diabase and dunite are probably of Haileyburian age. A later diabase dike, about 80 feet wide, striking a few degrees west of north and dipping steeply to the west, cuts the dunite, andesite, and quartz diabase.

The serpentinized dunite is cut by numerous asbestos-bearing fractures. The fibre-bearing zone, striking N. 60°W., is about 2,400 feet long, from 200 to 750 feet wide, and is cut into two parts by the diabase dike mentioned above. The most pronounced set of asbestos-bearing fractures strikes east and dips from flat to 45°N. A minor set of fractures strikes north-south.

Exploration work to date has been encouraging, but data as to the grade and potentialities of this deposit are not yet available for publication.

Rahn Lake Asbestos Mine

The Rahn Lake asbestos deposit is located in northwestern Bannockburn township, district of Timiskaming, 35 miles northwest of Elk Lake. H. C. Cooke in Rickaby's report (37) describes the deposit as follows:

"The asbestos seen by the writer is in a lenticular body of peridotite on the south shore of the lake, which strikes north 40 degrees west and dips steeply to the southwest. The body was traced for a distance of about 1,700 feet northwest, where it passes under a covering of swamp and drift. At the southeast end it appears to pinch out. A shallow pit has been dug at the southeast end of the peridotite body, at its contact with the rhyolite, which forms the country rock. The peridotite, here highly serpentinized, is filled with veinlets of asbestos up to one-quarter inch in width, over a width of 5 or 6 feet. The formation of the asbestos seems to be genetically connected with a small boundary fault, which has sheared the serpentinized peridotite, obliterating the remains of all original textures and forming a featureless serpentine highly slickensided. At a distance from the fault plane the serpentinized peridotite retains its original granular texture, and asbestos veinlets are not present in it . . .

"At the extreme northwest end of the peridotite mass, on the portage out of Rahn lake, a little further stripping has been done along the southern contact with the rhyolite, and there essentially the same conditions are observable as have been described, except for the lack of the supposed fault breccia. The veinlets of asbestos are somewhat wider, and specimens were obtained showing fibre an inch in length. The major part is, of course, less than this."

In 1922 a small inclined shaft was sunk on this showing on the Rahn Lake portage by the Empire Asbestos Company, Limited (37). No production was reported. In 1934 Rahn Lake Mines Corporation took over the property

consisting of 24 claims in Montrose and Bannockburn townships. A total of 2,000 tons of asbestos-bearing rock was mined in 1935 and 1936 from two shafts; shaft 1 was 9 by 10 feet and 100 feet deep; shaft 2, 12 by 20 feet and 55 feet deep. Some 50 feet of crosscutting and drifting was done. In 1937, 1 ton of asbestos valued at $250.00 was shipped from the property; stations were cut at 90 feet in shaft 1 and at 60 feet in shaft 2 and 70 feet of drifting was done. In 1938, No. 1 shaft was deepened to 130 feet, and 80 feet of crosscutting done on the 100-foot level. In 1939 the property was operated from September 1 to December 20. No. 1 shaft was deepened to 140 feet, and 275 feet of drifting was done on the 100-foot level. A total of 1,179 tons of asbestos-bearing rock was hoisted. Sorting produced 604 tons of crude ore, which was treated in a pilot mill on the property until a new mill at Elk lake was completed. A production of 18 tons of asbestos valued at $720.00 was reported in 1939.

In 1940 the property was acquired by Montrose Mines, Limited, for $10,000 cash and 1,100,000 shares of the new 3,000,000-share company. The Johnson's Company of wetford Mines, Quebec purchased 240,000 shares of Montrose Mines and optioned another large block of stock. After the Johnson's Company had tested the property the options were dropped. In 1949 Andrew Lucas of Toronto purchased the mining leases and buildings from Montrose Mines and, in 1950, organized York Asbestos Mines, Limited, to take over development of the property.

A magnetometer survey was carried out on the property in 1951 by Lundberg Exploration, Limited, and diamond-drilling of the anomalies indicated was recommended. The company reported that 8,500 feet of diamond-drilling was carried out in 1951 and 1952, chiefly on No. 5 zone, an anomaly lying in the southwestern part of the property, a mile south of the main shaft. A peridotite body, 700 by 800 feet carrying some short-fibre chrysotile, was outlined.

EXPLORATION IN THE ABITIBI PERIDOTITE BELT

Since the development of the Munro mine, considerable exploration has been carried out on the dunite-peridotite sills in a belt 80 miles long extending from Reaume to Holloway township. The work done to date is summarized in Table III.

Reaume and Hanna Townships

There are a number of outcrops of serpentinized peridotite on lots 9–12, concessions V and VI, Reaume township, in which chromite was discovered in 1914 (45). Recent aeromagnetic data indicated a number of large anomalies interpreted as peridotite elsewhere in Reaume and Hanna townships. There are no exposures in the areas of the anomalies, and the cover of drift is thick. Ground magnetometer surveys and diamond-drilling, totalling 4,728 feet, were carried out on several groups of claims in these townships by Canadian Johns-Manville Company, Limited. The presence of peridotite bodies was confirmed, and some thread fibre was observed in some of the core. Results in these townships were not encouraging.

Mann, Newmarket, and McCart Townships

A large amount of exploration has been done in peridotite bodies in these townships both for asbestos and for copper and nickel sulphides. A group of 39 claims in Mann township held by Canadian Johns-Manville Company, Limited, was drilled in 1951. Eight holes, totalling 4,790 feet, were completed, and some fibre from 1/16 to 1/8 inch in length was observed in serpentinized peridotite core. Two groups of claims in Mann township were held by the International Nickel Company of Canada, Limited, and 13 diamond-drill holes were drilled in 1948 by that company. Some 1/8-inch fibre in a drill hole on claim T.27955 was reported. A little fibre was indicated in some of the other holes. The Canadian Johns-Manville Company, Limited, optioned the south group in concession III from the International Nickel Company, Limited, and drilled one hole of 537 feet in 1951. Results were not encouraging.

The Dominion Gulf Company holds one group of four claims in concession V, Mann township, and one diamond-drill hole of 756 feet indicated some picrolite in serpentinized peridotite. This company also holds a group of 72 claims in eastern Mann, northern McCart, and western Newmarget townships. Several diamond-drill holes were sunk, but only traces of fibre were encountered in the serpentinized peridotite. The P. B. Zevely property consisting of 63 claims in Mann township, 15 claims in southwestern Hanna township, and 9 claims in Reaume township, was originally staked for base metals. Some 27 holes, totalling 20,000 feet, were drilled in 1949 for sulphides, most of the work being done in Mann township. Some fibre less than 1/8 inch was found in sections of serpentinized peridotite.

The Arrow Timber Company, Limited, holds four patented lots in concessions III and V of McCart township and, following preliminary work on the north half of lots 6 and 7 of concession V, an additional 24 claims were staked. The dunite-peridotite sill exposed on the property forms a relatively flat sheet dipping gently to the north. This sill is overlain by a series of thin andesitic flows. The peridotite sill has a thickness of about 200 feet. Good exposures of fibre occur in a surface outcrop, about 250 feet in diameter, on the north half of lot 7, concession V. Over 50 per cent of the fibre exceeds 1/8 inch in length. Seven diamond-drill holes totalling 3,812 feet were drilled in 1951.

Quebec Asbestos Corporation, Limited, held two groups totalling 25 claims in McCart township in 1950. One diamond-drill hole was put down on claim T.29615 of the central group in 1950. Results were not encouraging.

Aurora and Calvert Townships

A block of 39 claims was held in Aurora and Calvert townships by Quebec Asbestos Corporation, Limited, and a geophysical survey was carried out in 1950. This indicated a number of anomalies interpreted as peridotite and two diamond-drill holes, totalling 1,200 feet, were drilled in 1950 in one anomaly south of Nellie lake. In hole No. 2 less than 2 percent fibre, under 1/8 inch, occurred between 554 and 570 feet, in the serpentinized peridotite.

Dundonald and Clergue Townships

Dominion Gulf Company holds a group of 10 claims in lots of 10–12, concessions III and IV, Clergue township, district of Cochrane. A geological and geophysical survey was carried out on these claims in 1951, and in 1952 two diamond-drill holes, totalling 1,819 feet, were put down. Asbestos fibre less than 1/16 inch was reported from 387 to 553 feet in serpentinized dunite from the core of hole No. 12. From 411 to 536 feet, there were 113 veinlets 1/6 inch in size. Hole No. 13 showed sparse fibre in serpentinized dunite from 733 feet to 808 feet. There were 13 veinlets at 1/8 inch and 96 veinlets at 1/16 inch.

Quebec Asbestos Corporation, Limited, optioned a group of 9 claims in lots 1 and 2, concessions I and II, Dundonald township, from T. Kruk. Fibre was reported in two surface outcrops of serpentinized dunite on lot 2, concessions I and II. A geological and geophysical survey was carried out in 1950.

Walker and Wilkie Townships

Two large blocks of claims were staked in Walker and Wilkie townships by Canadian Johns-Manville Company, Limited, on the basis of aeromagnetic surveys. Later, ground magnetic surveys failed to confirm the anomalies, and the claims were allowed to lapse. There is an exposure of peridotite on lot 3, concession III, Wilkie township.

Warden Township

In Warden township just north of the Munro township boundary, a banded complex of peridotite and pyroxenite, 630 feet wide, is exposed. This ultrabasic band, extending for four miles acrose the township from the Munro boundary, has been explored by S. J. Bird, and the Canadian Johns-Manville Company, Limited. Drilling by S. J. Bird on lot 6 of concession I indicated some 1/8-to 1/4-inch fibre in a serpentinized peridotite sill 110 feet wide. The Canadian Johns-Manville group of 11 claims in lots 9 - 12 of concession I, was mapped and two diamond-drill holes, totalling 500 feet, were completed in 1949. Sparse fibre was reported in one hole with a few veinlets up to 1/16 inch. Fibre up to 1/8 inch in length occurs in cross-fibre veinlets in serpentinized peridotite outcrops on lots 9 and 12.

Munro Township

Between 1949 and 1951 the peridotite-dunite sills in the northeast half of Munro township were explored by a number of companies. In 1949 the H. M. Ford property was optioned by Canadian Johns-Manville Company, Limited, and an additional nine claims in Munro and four in Warden township were staked. A geophysical survey was carried out on nine of these claims in 1949, and two diamond-drill holes, totalling 1,230 feet, were put down in 1949 and 1950. Serpentinized dunite and peridotite, carrying a few thread veins of chrysotile asbestos, were cut by the holes. The option was dropped on the Ford claims in 1950.

In 1952, Flagro Mines, Limited, held a group of nine claims at the corner common to the four townships of Warden, Milligan, McCool, and Munro. A geophysical survey of the group was carried out in 1951, and additional surveys were made in 1952 on 12 additional claims in Munro and McCool townships held under option. An anomaly indicated by the survey was explored in 1951 by a single, vertical diamond-drill hole 343 feet deep in lot 1, concession VI, Munro township. The serpentinized peridotite intersected showed only a little asbestos fibre of no commercial value.

In 1949 and 1950, Quebec Asbestos Corporation, Limited, held an option on the Mangan group of eight claims in lots 5 and 6, concession V. A magnetometer survey was made, and three diamond-drill holes, totalling 1,208 feet, were completed, cutting serpentinized dunite carrying a little cross-fibre chrysotile asbestos in veinlets mostly 1/16 inch or less in width.

In 1949, Canadian Johns-Manville Company, Limited, held an option on the Potter-Doal group of twelve claims. Following a geophysical survey, the company drilled three holes totalling 594 feet in serpentinized peridotite that carried fairly harsh chrysotile asbestos of poor-grade ore in lengths not exceeding 1/8 to 1/4 inch.

In 1950, Reoplata Mines, Limited, had a geophysical survey made on a group of 10 claims which indicated two linear anomalies; one of these was found to be serpentinized peridotite by three drill holes totalling 876 feet. Sparse thread-fibre chrysotile was found in this drilling.

In 1951, Van Packer Mines of Canada, Limited, had an option on the Mangan-Dyer group of claims in Munro and Warden townships, and drilled 11 holes totalling 1,964 feet in exploration for asbestos. N. Hogg records 1 to 2 percent fibre in veinlets less than 1/16 inch in serpentinized dunite in the five holes in Warden township.

McCool Township

Exploration for asbestos in McCool township was carried out during 1950–52 by airborne and ground magnetometer surveys and diamond-drilling on a number of dunite and peridotite bodies. The overburden is deep, and some of the bodies are not exposed at the surface. Exclusive of the Schumacher property, 66 holes, totalling 41,712 feet, were drilled in the period 1950–52.

In 1950 the Arrow Timber Company, Limited, carried out ground magnetometer surveys on their four patented half-lots.

Camrose Gold and Metals, Limited, held a block of 12 claims in 1951. A ground magnetometer survey was carried out in 1950. From 1950 to 1952 a band of serpentinized dunite was explored by 13 diamond-drill holes totalling 6,759 feet. The dunite intersected by the holes contains some chrysotile asbestos fibre.

Canadian Johns-Manville Company, Limited, held, by staking or under option, 81 claims; 16 claims are held in 1953. These claims cover much of the area underlain by a hairpin-shaped syncline of basic and ultrabasic intrusives. In 1949 the company made a ground magnetometer survey of the claims and in 1949–51 put down 9 drill holes totalling 6,579 feet.

In 1951, the Dominion Gulf Company held three groups of claims in the township and also held the

Schumacher property under option. These groups were explored by a diamond drill programme in 1950–51 carried out jointly with Asbestos Corporation, Limited. Group I in the northwestern part of the township comprises 32 claims. Geophysical surveys indicated a large anomaly that was confirmed on drilling to be serpentinized dunite. Twenty-four holes, totalling 16,196 feet, were drilled. Chrysotile asbestos is present in a few holes as cross-fibre veinlets mostly less than 1/32 inch and rarely as much as 1/8inch wide. Group II of 13 claims in the south-eastern part of the township was explored by geophysical surveys in1950 and by three diamond-drill holes totalling 1,696 feet. These surveys revealed two linear bands of peridotite. Group III of five claims near the east boundary of the township was explored by magnetometer surveys in 1950 and 1951.Two anomalies were indicated, and one of these was explored by five diamond-drill holes totalling 2,903 feet. These showed the anomaly to be due to a serpentinized peridotite. No asbestos fibre was observed in the core.

A. J. B. Gray holds several groups of claims. There are no surface exposures of peridotite on the claims. On the Feldman group in the southeastern part of the township, geophysical survey in 1951 indicated one strong linear anomaly and a number of smaller ones parallel to it. One anomaly was tested by a diamond-drill hole 1,197 feet in length. An anomaly over the keel of the McCool syncline was explored by two holes totalling 1,821 feet. These holes confirmed the presence of peridotite and contained some asbestos fibre. On the Geisler Lake group on the west side of the township, a **V**-shaped anomaly, believed to be due to peridotite, was found by a magnetometer survey made in 1951. This has not been explored by drilling.

Quebec Asbestos Corporation, Limited, holds a group of 11 claims in the southeastern part of McCool township, adjoining Michaud township, and 4 claims under option from T. Kruk. A magnetometer survey was made in 1950 and indicated three anomalies. The northeast anomaly is known to be peridotite as it is well exposed. No asbestos fibre was exposed in the outcrops. The northwest anomaly has not been explored. It is a continuation of the peridotite band found on Group II of the Dominion Gulf Company. The south anomaly was investigated in 1952 by two diamond-drill holes, totalling 1,218 feet. The holes confirmed the presence of peridotite. A few veinlets of chrysotile asbestos were found in one hole.

Rayville Matheson Asbestos, Limited, holds a group of 18 claims in the centre of the township. There are no outcrops of peridotite. In 1951, a magnetometer survey was made and indicated a narrow anomaly trending northwest. This anomaly was explored in 1951–52 by nine holes totalling 6,031 feet, Asbestos fibre veinlets were noted in five of the nine holes drilled. The country rock is serpentinized dunite or peridotite.

Garrison Township

Bodies of serpentinized peridotite and dunite are well exposed in the northwestern and, to a minor extent, in the northeastern parts of the township. The whole of the northern part of the township, adjacent to the north boundary, has been staked for asbestos and was largely held by Canadian Johns-Manville Company, Limited.

The most important group, originally held by S. J. Bird, was optioned in 1950 and later acquired by Canadian Johns-Manville Company, Limited.

The west group of Canadian Johns-Manville Company, Limited, consists of 11 claims on which a magnetometer survey was completed in 1949. There are no exposures of peridotite; the survey indicated a narrow linear anomaly believed to be peridotite trending northwest.

The east group of Canadian Johns-Manville Company, Limited, consisted of 45 claims on which a magnetometer survey was made in 1949. It was explored in 1951 by 21 holes totalling 13,557 feet. No information is available at this time for publication on the asbestos fibre content of the cores recovered. The greater number of the claims held by option or staking has subsequently been dropped, and in 1953 only 16 claims are held in this group.

The Mining Corporation of Canada, Limited, owns a group of 19 claims in the northeastern part of the township. Peridotite is exposed in two small outcrops and was intersected in two drill holes, totalling 1,709 feet, put down in 1946 and 1951. No asbestos fibre was found in these holes. A geophysical survey in 1945 traced the south boundary of a band of peridotite across the northern part of this claim group.

Harker Township

In Harker township dunite and peridotite form part of the Ghost range intrusive in Harker, Lamplugh, Holloway, and Frecheville townships.

C. E. Hofmann owns a group of 20 claims adjacent to the north boundary. Veinlets of chrysotile asbestos from 1/20 to rarely as much as 1/2 inch are found in serpentinized dunite. These showings were explored by diamond-drilling in 1949 in 13 holes totalling 2,899 feet; in addition 11 shallow holes, totalling 132 feet, were drilled below an old pit exposing asbestos fibre.

In 1950, the Hofmann claims and four additional claims were optioned to Dominion Gulf Company and Asbestos Corporation, Limited, and were explored in 1950 by 10 holes totalling 7,051 feet.

C. E. Hofmann also holds four claims in the northeastern part of the township. A geophysical survey was made on these claims in 1950 and indicated the boundaries of the peridotite-dunite band. No drilling has been carried out on this group.

Holloway Township

Dominion Gulf Company holds a group of 16 claims in Holloway and Frecheville townships near Lightning Mountain. A magnetometer survey was carried out in 1950 and outlined a V-shaped anomaly which is very poorly exposed at surface by outcrops of peridotite. This anomaly was explored in 1950 by 14 diamond-drill holes totalling 8,806 feet. Some asbestos fibre is present in some of the holes. This is at the east end of the Ghost Range intrusive (see also Harker township).

The N. Strong property of 11 claims is on the south side of the eastern extension of Ghost Range in the northwestern part of the township. Peridotite is poorly exposed, and no asbestos fibre was seen. A dip-needle survey of the property was made in 1950. No drilling has been carried out.

GRADE AND EVALUATION OF ASBESTOS DEPOSITS

The favourable areas for prospecting for asbestos are the peridotite belts. Special attention should be given to the ultrabasic rocks in the neighbourhood of later intrusives and faulting. Where little outcrop is exposed, the magnetometer, both ground and airborne, has been effectively used to delineate the size and shape of the serpentinized intrusives. Serpentinized dunites and peridotites usually carry a considerable percentage of secondary magnetite. The magnetometer is a useful tool for outlining the area of ultrabasic rocks but does not give any indication whether asbestos fibre is present. Diamond-drilling is necessary to determine the presence of fibre.

Having established the presence of asbestos fibre in outcrop or in drill core, the initial step is to have the fibre examined as to its exact properties and quality. As is the case in many industrial minerals, asbestos fibre from various deposits may differ greatly in physical properties; specifications are often indefinite and hard to evaluate in specific terms. Marketing often depends on actual tests of behaviour in the particular process of manufacture in which the fibre is to be used. The important factors in grading asbestos fibre are fibre length, tensile strength, flexibility, spinnability, colour, chemical composition, cleanliness of fibre and tendency to slime in wet processes, harshness or softness of fibre, and porosity. In a series of articles recently published on asbestos research, M. S. Badollet (1,2,3,4,5) has outlined the main tests for asbestos fibres and has described the effects of processing on the physical properties of the fibre. Poor milling practices may have an adverse effect on the fibre.

A preliminary laboratory examination of sample material by experienced asbestos operators will indicate to what uses the fibre is most suited.

Initial exploration of the prospect to determine the percentage of asbestos fibre present, and the grade, will involve surface examination and diamond-drilling. Estimation of grade is based on visual examination of outcrops and core (12,14) and bulk sampling. In diamond-drilling it has been found that AXT core with a diameter of 1-1/4 inch is most suitable. The grade of the core is estimated by measuring the widths of the cross-fibre veinlets to the nearest 1/32 inch and recording the number of each size range, e.g. 1/32, 1/16, 3/32, 1/4 inch, etc., in a given length of core. These widths are totalled in inches to give the total width of fibre in the given footage of core. Assuming that the veinlets cut the core at an average angle of 45 degrees, this total width is then multiplied by 1-1/2. Divide by 12 to convert inches to feet and express this footage of fibre as a percentage of total length of core. This gives the percentage of fibre in the core. By totalling the widths of each fibre length, i.e. 1/32, 1/16, 3/32, 1/4 inch, etc., an estimate can be made of the percentage of each fibre grade in the core. Messel (14) suggests as a guide that "the following fibre lengths when milled usually will give grades in the following groups: 1/16 to 1/8 inch, groups 6 and 7; 1/8 to 1/4 inch, groups 4 and 5; 1/4 inch and over, group 3." Referring to the current table of prices for these groups, a rough estimate of the dollar value per ton can be made.

The success of this type of visual estimation of gradedepends largely on experience. Foster and Borror (12) have described the method of estimating ore reserves at the Jeffrey mine on the basis of core-drilling and visual reading of the core. Comparison of these estimates with actual mill recovery allows an empirical formula for the ore body to be set up as a basis for further forecasts, and a fair degree of accuracy can be obtained.

The visual estimation of ore grade should be supplemented by milling tests on large representative bulk samples. Figures on grades of asbestos ore are based on actual recovery in the milling process. There are usually some losses in the shorter-fibre range. Badollet (3) discusses the effect of the number of willowing passes on the loss of fibre length for various types of asbestos. For accurate evaluation of the asbestos deposit it is essential to have milling tests run.

Tenor of Ore

Because of the complexity of the factors involved, it is difficult to state what grade constitutes a commercial asbestos ore. The bulk of the fibre now being mined in Quebec ranges from 1/4 to 1/2 inch in length. Messel (14) classifies asbestos ore as follows: 5 per cent, good-grade ore; 3 to 5 percent, medium-grade ore; 0 to 3 percent, poor ore. It is obvious, however, that a 3 percent ore with long fibre will be more valuable than a 6 percent ore with short fibre. Ores grading less than 2 percent are commercial in some large deposits in the eastern townships of Quebec. If the tonnage is large enough, ore valued from $1.25 to $1.50 per ton is worthy of consideration. The average grade in the eastern townships is reported to be about $2.50 per ton. In high-cost, small-tonnage underground operations the tenor of ore is considerably higher.

Specifications

In 1931 Canadian asbestos manufacturers agreed on a uniform standard classification of asbestos fibre into 9 groups. This classification was recently described by G. F. Jenkins (10):

"Canadian asbestos fibres are graded within definite limits and production is controlled by means of the Quebec Standard Testing Machine, which has become the accepted measure of fibre length by which milled asbestos is sold. All grades except crudes, sand and gravels, are controlled by this standard. The machine consists of a nest of four rectangular cast-aluminum boxes clamped onto a table that is shaken by an eccentric. The bottom box serves as a pan and the three superimposed sieves have screens of successively larger meshes. From the top, down, the mesh sizes are: 1/2 inch opening, 4-mesh and 10-mesh. All screens and dimensions are to exacting specifications.

"To make a test, 16 ounces of asbestos is placed on the uppermost tray, which is then covered and tightly clamped. The machine is started and allowed to run at 328 r.p.m. for exactly 600 revolutions, when it is stopped by an automatic device. At the end of this time, the asbestos remaining on each sieve is weighed and the test is recorded to the nearest tenth of an ounce.

"The Canadian classification of chrysotile asbestos specifies the minimum shipping test for each grade; i.e., the minimum number of ounces of fibre there shall be on each of the upper screens and the maximum there shall be in the pan. For convenience of designation, fibres have been divided into numbered groups and each group has been subdivided into grades, identified by letters of the alphabet. Space does not permit an itemization of all the recognized grades but, by way of explanation, in the following list of groups there are a number of

grades, each with its minimum guaranteed test, under each group heading. In group No. 3, for example, there are five grades, the longest of which is 3F with a guaranteed test of 7-7-1.5-0.5 (i. e., ounces on screens of 1/2-inch, 4-mesh, 10-mesh, and pan, respectively, the whole adding up to 16 ounces). The shortest grade in this group is 3Z with a test of 0-8-6-2.

Group No. 1. Crude No. 1 (3/4-inch staple and longer).
Group No. 2. Crude No. 2 (3/8-inch staple up to 3/4-inch).
Group No. 3. Textile and spinning fibres (testing 0-8-6-2 and over).
Group No. 4. Shingle fibres (testing below 0-8-6-2 and including 0-1.5-9.5-5).
Group No. 5. Paper fibres (testing below 0-1.5-9.5-5 and including 0-0-10-6).
Group No. 6. Waste, stucco, or plaster fibre (testing 0-0-7-9).
Group No. 7. Refuse or shorts (testing 0-0-5-11).
Group No. 8. Sand—a mill product weighing less than 75 pounds and more than 35 pounds per cubic foot.
Group No. 9. Gravel and stone—a mill product weighing more than 75 pounds per cubic foot."

A more detailed breakdown of these groups within the standard Canadian chrysotile classification is shown in Table IV.

TABLE IV—CANADIAN CHRYSOTILE CLASSIFICATION

Designation	2-Mesh	4-Mesh	10-Mesh	Pan
	ounces	ounces	ounces	ounces
Group 3:				
3F	7	7	1.5	0.5
3K	4	7	4	1
3R	2	8	4	2
3T	1	9	4	2
3Z	0	8	6	2
Group 4:				
4H	0	5	8	3
4K	0	4	9	3
4M	0	4	8	4
4R	0	3	9	4
4T	0	2	10	4
4Z	0	1.5	9.5	5
Group 5:				
5D	0	0.5	10.5	5
5K	0	0	12	4
5M	0	0	11	5
5R	0	0	10	6
Group 6:				
6D	0	0	7	9
Group 7:				
7D	0	0	5	11
7F	0	0	4	12
7H	0	0	3	13
7K	0	0	2	14
7M	0	0	1	15
7R	0	0	0	16
7T	0	0	0	16
Floats 7RF or TF	0	0	0	16

USES

The longer fibres of groups 1, 2, and 3 can be woven into cloth which is especially useful because of its fireproof qualities. Asbestos cloth is used in making fireproof safety clothing, curtains, awnings, conveyor belts, brake-band linings, clutch facings, mechanical packings, and gaskets. Long fibre is also used in making compressed sheet packings for high pressure steam boilers and pipes and for cable filler coverings in electrical cable installations.

One of the most important uses for asbestos is in friction materials used for brake linings, clutch facings, etc., where a non-inflammable material that will convert the kinetic energy into heat and rapidly dissipate that heat, is required. Brake linings are of three types: the moulded type, in which asbestos fibres are bonded by an organic bond and strengthened by metallic reinforcement, uses fibre from groups 4 to 7; the rubberized-fabric type, consisting of multiple layers of woven material strengthened by wire-reinforced asbestos yarn, uses spinning-grade fibre; the woven

type of lining is a woven fabric made from spinning-grade fibre. The development of moulded friction materials using shorter fibre has assisted greatly in alleviating the shortage of the spinning grades formerly used exclusively for this purpose.

Groups 4 and 5 are widely used in asbestos-cement products such as pipe, roofing shingles, and siding. These groups are also used in making 85-percent magnesia block and pipe insulation materials. Group 5 fibre is suitable for asbestos paper and millboard manufacture. Groups 6 and 7 are used in asphalt asbestos floor tile, boiler and roofing cements, undercoating compounds for automobiles and other vehicles, caulking compounds, dry-wall joint-fillers, lubricating greases, asphalt and cold-water paints, plastics moulding powders, welding rods, insecticides, and acoustic plaster. For many of these uses, asbestos floats, 7 RF or TF, offer "the advantages of being a low-cost inorganic filler, which will improve impact strength and provide good workability, good binding qualities, heat resistance, fair acid and alkali resistance, large surface area and availability in commercial quantities" (5).

Badollet (1) estimates that the asbestos manufacturing industry in the United States and Canada could consume upwards of 450,000 tons of fibre per year as follows: asbestos cement products (sheets, pipe, shingles), 200,000 tons; asphalt tile, 120,000; asbestos paper, millboard, brake linings, clutch facings, pipe coverings, roofing, etc., 130,000 tons; plastic industry, 8,000 to 11,000 tons.

MINING METHODS

Most of the Canadian asbestos production has come from open-pit operations. Low-cost mining has allowed the development of large low-grade ore bodies (18). At many of the deposits in the eastern townships of Quebec the economic limit of open-pit mining has been reached.

Pioneer work by the Asbestos Corporation, Limited, at the King mine disclosed that the asbestos ore bodies could be successfully mined by the low-cost, block-caving method (19, 20). Block-caving has been used at the King mine since 1934, and the mine is currently producing at the rate of from 3,500 to 4,000 tons per day.

The largest asbestos mine, the Jeffrey mine of the Canadian Johns-Manville company, has been an open-pit operation for many years, but the limit of open-pit mining is being approached, and the mine is now producing from the underground workings as well as the open pit. Block caving is being employed underground, and a recent paper by Lindell (16) describes the operation.

MILLING

Canadian asbestos producers all use a dry-milling process in which the asbestos fibre is released from the gangue by crushing and removed from the gangue by strong air currents.

The accompanying generalized flowsheet of a Canadian asbestos mill, together with a description of milling machines used in Canadian mills is taken from G. F.Jenkins' article on asbestos in the A.I.M.E. volume "Industrial Minerals and Rocks", 1949:

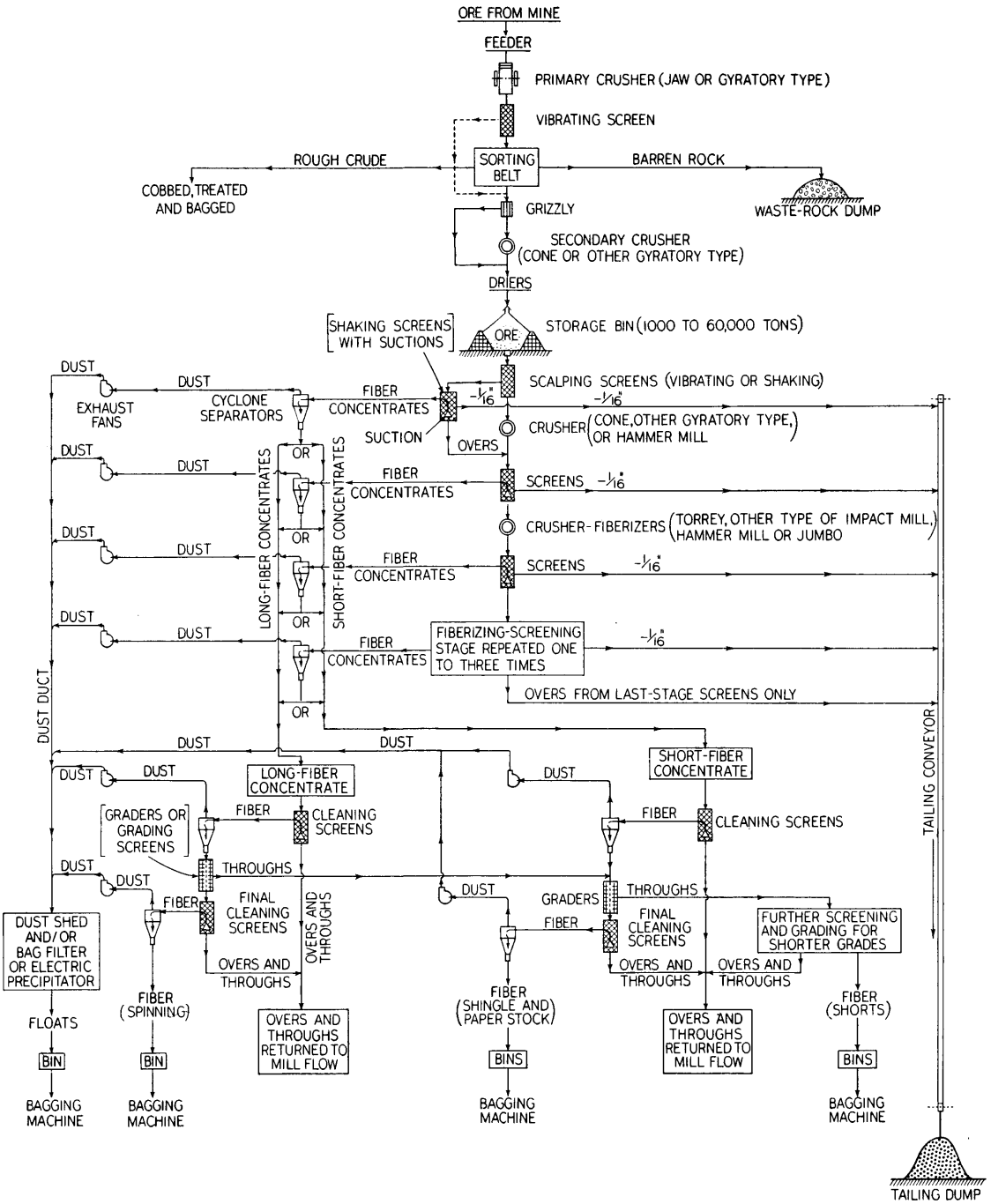
"Primary jaw crushers are generally 36 by 42 inches in size but some operations are using 48 by 60-inch machines requiring 200 to 250 horsepower and with a capacity of 250 tons per hour on average ore. For the most part, they are of standard design, although it is preferable to have a smaller angle of nip than usually is possible with a standard frame and, at the same time, retain full size opening. It is considered that the nip angle should be 21° to 23°. Most manufacturers of jaw crushers build machines with a special deep frame to attain this smaller angle between the fixed and the swinging jaw. The desirability of this feature arises from the fact that often there is a tendency for pieces of serpentine ore to slip as the crusher jaws apply pressure, resulting in a jumping action by the rock and therefore decreased efficiency.

"Driers may be either the conventional rotary kiln type or the vertical stack. The former is of standard design, consisting of a rotating cylinder 40 to 60 feet long by 4 to 6 feet in diameter. The drier may be installed so that the hot furnace gases pass out along the outer shell before returning through the cylinder itself where they are in contact with the ore. For increased efficiency and to lessen the tube-mill action of the larger pieces of ore on the fibre-bearing fines, the dried cylinders sometimes are divided into segments, or smaller cylinders or tubes are built within the main shell, so that the ore and gases are confined to spaces of smaller cross-sectional area, in which there is a better mingling of the two as well as less grinding action on the fibre.

"The vertical drier consists of a square stack, generally 7 by 7 feet in cross section by 50 feet high. Ore is introduced at the top and falls through a rising current of heated air together with the gases of combustion from a coal-fired furnace. It is retarded and dispersed in its fall by a gridwork of cast-iron bars throughout most of the height of the stack, requiring about 20 seconds to reach the discharge chute at the bottom. Forced draft is introduced under the furnace grates and the gases are drawn from the top of the drier by an induced-draft fan through a cyclone collector, where a small amount of dried fibre and dust is caught, before exhausting into a smokestack.

"Storage bins to which the dried ore is conveyed, in addition to serving the normal purpose of a uniform supply of mill feed, allow time for the ore to cool and to lose up to one per cent of the remaining moisture. The bins often are made by depositing two high parallel ridges of mill tailings and constructing a reinforced-concrete tunnel with draw points in the valley between the ridges. The angle of repose of the tailings forms the bin bottom; a steel-frame structure covered with corrugated asbestos provides cover.

"Screens, so widely used in an asbestos mill, serve a dual purpose—the normal one of sizing and secondly as planes from which the fibre can be lifted away from the rock by aspiration. For the latter reason a shaking action is preferable to a vibrating action, as it permits the fibre to bed above the rock and to be more effectively separated. Screens usually are constructed in the mine shops. They are made with wooden frames, reinforced where necessary with steel, and actuated by roller-bearing eccentric, although where a long stroke at slow speeds is desired ordinary bearings and even a crank-type eccentric may be used. In size they are generally either 4 or 5 feet in width by 11 feet or more in length. The support usually is by pieces of hardwood shaped to allow the necessary degree of flexibility. Screens often are arranged in pairs, back to back, with one eccentric shaft serving both.



GENERALIZED FLOWSHEET OF CANADIAN ASBESTOS MILLS (FROM G. F. JENKINS. "ASBESTOS", CHAP. 2, *Industrial Minerals and Rocks*, AMER. INST. MIN. MET., 1949, BY PERMISSION OF THE PUBLISHERS)

"Suction hoods are made with an opening of from 2 to 5 in. and are sufficiently long to extend across the full width of the screen. They are suspended above the lower end of the latter and are adjustable as to height. The tapered upper section of the hood converges into an air duct, commonly 15 in. in diameter, which conveys the air to a cyclone collector where the fibre is dropped, and thus through the exhauster fan. One fan may serve a number of suctions, approximately 15 horsepower being required for each 15-inch pipe and suction.

Dust Collection

"As a considerable amount of dust escapes collection, the air discharged from the fans is conducted usually to a settling chamber, often constructed in the form of a large shed in which there are burlap baffles to assist in the removal of the dust, before the air is exhausted to the atmosphere. These so-called dust sheds, however, are insufficiently effective and in the more populated areas are being supplemented by more positive means of filtration or precipitation. A system of electrical precipitation has proved quite efficient at one large plant but others have favored the use of bag filters. The latter are built in units in which there are commonly 144 to 224 fabric tubes 8 to 10 inches in diameter by 18 feet or more in length per unit. Air is introduced into the tubes from below and filters through the fabric, depositing the dust on the inside surface. Multiple units are built, so that the air supply can be diverted periodically by a timed mechanism and, at the same time, the bags or tubes are shaken mechanically to dislodge the layer of accumulated dust. Accepted practice is to have sufficient fabric area so that not more than 4 to 5 cubic feet per minute of free air is being filtered per square foot of fabric. For this reason a mill treating 3,000 to 4,000 tons per day and exhausting some 5000,000 cubic feet per minute of free air requires an extensive filter installation.

Crushing and Grading

"Several other machines are named in the flowsheet which are little used except in asbestos milling and therefore should have some further mention.

"The Torrey cyclone is a machine in which ore previously crushed to 2 inch or less is further reduced by impact. The machine consists of a vertical cylindrical shell 54 inches in diameter by 5 feet high, enclosing a central upright shaft. Ore, fed on the top, falls onto a circular table or "spider" bolted around the shaft and in turn supporting four radiating vanes of manganese steel. Since the whole assembly is revolving at high speed, the material is thrown outward by centrifugal force and is caused to impinge against heavy grooved castings. As the ore falls, it is caught in a conical hopper, which, in turn, guides it to a lower spider and vane assembly on the same shaft, for a second stage of crushing by impact in the same way.

"The Jumbo has a horizontal cylindrical body 3 feet in diameter by 6 feet long. The inside periphery is lined throughout with serrated chilled iron castings. A central horizontal shaft supports a number of arms with heavy detachable wearing tips cast with a beveled face on one side. The feed entering the upper part at one end is subjected to a rubbing and grinding action, as it is moved the length of the machine by the propeller-like action of the beveled tips, and it is discharged through an opening in the bottom at the opposite end.

"Graders may be either conventional trommels, or, as the name is generally applied, a modification of this machine in which the cylinder of perforated plate remains stationary and the material (fibre in this case) is moved from one end to the other by arms, clamped to a revolving central shaft and twisted to give the necessary forward pitch. In size these generally are about 7 feet long by 26 inches inside diameter."

The newest development in asbestos milling is the introduction of the Aerofall mill. This mill is now being used at the Beaver mine of Asbestos Corporation, Limited, Thetford Mines, Quebec.

MARKETING

Current prices for Quebec chrysotile, per short ton, f.o.b mines, United States funds, as quoted in "Metal and Mineral Markets," March 12, 1953, are given in Table V.

TABLE V—ASBESTOS PRICES

Group	Price
No. 1—Crude No. 1	$960 to $1,500
No. 2—Crude No. 2	595 to 900
No. 3—Spinning fibres:	
3F	514
3K	436
3R	371
3T	348
3Z	321
No. 4—Shingle stock	150 to 200
No. 5—Paper stock	109 to 137
No. 6—Waste, stucco, and plaster fibre	77
No. 7—Refuse or shorts	35 to 70

The following seven companies are the chief producers of asbestos in Canada:

Asbestos Corporation, Limited, Thetford Mines, Que.
Bell Asbestos Mines, Limited, Thetford Mines, Que.
Johnson's Company, Limited, Thetford Mines, Que.
Quebec Asbestos Corporation, Limited, East Broughton, Que.
Canadian Johns-Manville Company, Limited, Asbestos, Que.
Nicolet Asbestos Mines, Limited, 70 Pine St., New York 5, N.Y.
Flintkote Mines, Limited, Thetford Mines, Que.

These seven companies operating 12 mines in the eastern townships of Quebec, and one mine in Ontario, produce over 70 percent of the world's asbestos.

Five of these seven companies mine, mill, and fabricate asbestos products and consume a large part of their own production. The Asbestos Corporation and Johnson's Company are independent producers who deal in raw asbestos only. Their production, as well as part of the production from the other companies, is sold on the open market. Most of the fibre is shipped directly to the consumers.

A small production of asbestos was reported in 1951 by Teegana Mines, Limited, from Deloro township, Ontario, and by the St. Laurent Asbestos Company from St. Odilon, Quebec. Numerous other asbestos deposits are being explored in Ontario, Quebec, and British Columbia; several of these deposits are in the development stage, and give promise of being substantial producers. Three new companies have mills under construction: Cassiar Asbestos Corporation at McDame Mountain, British Columbia; Dominion Asbestos Mines, Limited, at St. Adrien, Quebec; and Newfoundland Asbestos, Limited, at Lewis Brook, Newfoundland.

In 1951 the total Canadian asbestos shipments from producers amounted to 973,198 tons valued at $81,584,345. Details are shown in Table VI.

TABLE VI—ASBESTOS SHIPMENTS, 1951*

Grade	Tons	Value
Crude No. 1, 2, and other	748	$ 568,725
Milled—Group 3	33,136	10,494,587
" 4	188,130	27,780,601
" 5	111,735	11,124,444
" 6	223,471	15,965,603
" 7	386,823	15,085,973
" 8	29,155	564,412
Total	973,198	$81,584,345

Figures from Dominion Bureau of Statistics.

In 1952 the total tonnage of asbestos shipments was down slightly at 928,487 tons, but owing to a high percentage of better grades of fibre this production was valued at approximately $88,000,000.

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