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ASBESTOS IN ONTARIO

By

M.A. Vos

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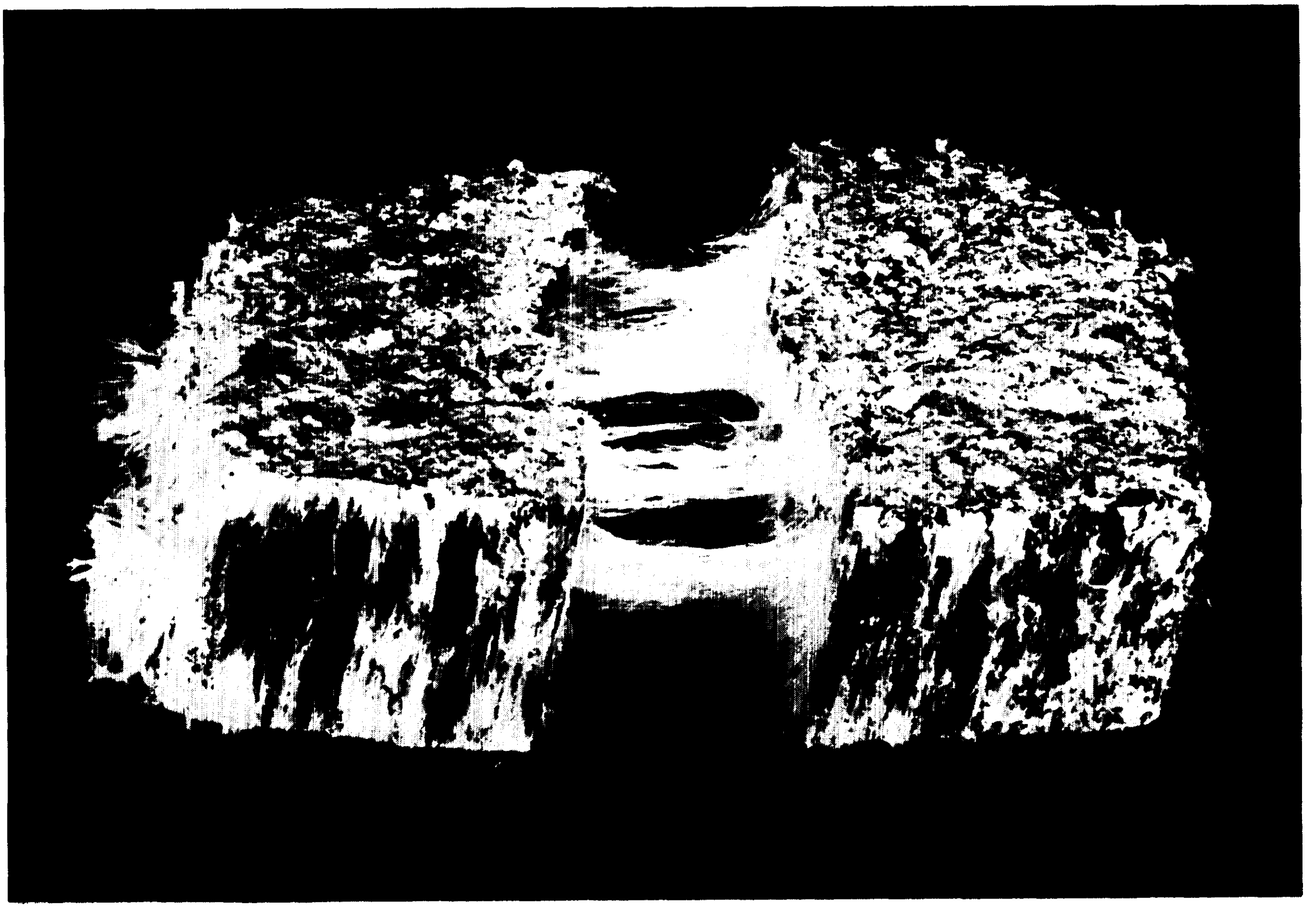

Photo 1 Chrysotile asbestos
(Courtesy Ward's Natural Science Establishment Inc., Rochester 9, N.Y.)

ASBESTOS IN ONTARIO

By

M.A. Vos[1]

INTRODUCTION

Asbestos has been mined in Ontario in minor quantities since 1901. Total production up to 1949 amounted to approximately 2,500 tons. In 1949 a large deposit of good-grade chrysotile asbestos was discovered in Munro Township, District of Cochrane, Ontario. For a period of fourteen years following development the Munro Mine was a substantial producer of chrysotile asbestos contributing to a Canadian production which, until then, originated almost exclusively in the Eastern Townships of Quebec. Intensive prospecting in the peridotite belts of northeastern Ontario has led to the subsequent discovery and development of other deposits. Two of these deposits are in production at present, in Warden and Reeves Townships respectively, and a third one, in Garrison Township, is in an advanced stage of development.

Acknowledgments

The present report is primarily a revision of "Asbestos in Ontario" by D.F. Hewitt and J. Satterly (1953). Many sections of that report have been incorporated unchanged. I am grateful to both authors for encouraging me in the compilation of the present report and for suggestions for improvements which I have carried out.

Information on the history of asbestos was largely obtained from "Asbestos Fundamentals" by H. Berger (1963) and from literature published by the industry.

Issues of the magazine "Asbestos" were a source of information on recent uses of asbestos.

I wish to thank resident geologists and their staff, and personnel in the Mining Lands Branch of the Ontario Department of Mines and Northern Affairs, for their assistance in gathering detailed information on the history of ownership and exploration of asbestos deposits in the province. A system of cross-filing of records according to commodity applied by H.L. Lovell, Resident Geologist at Kirkland Lake, was particularly helpful in this search.

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[1]Geologist, Industrial Minerals Section, Geological Branch. Manuscript accepted for publication by Chief, Industrial Minerals Section, 1 April 1971.

HISTORY OF ASBESTOS

The early use of asbestos in our civilization is indicated by many accounts. Pliny refers to the rare and costly cloth made of asbestos and used as a funeral garment for kings. The use of cremation cloths and of wicks for lamps made of asbestos dates back to antiquity. The raw material was supplied from deposits on Cyprus and in northern Italy.

Asbestos is referred to by Marco Polo who found in Siberia a cloth that would not burn. He tells of the routine hand processing of asbestos by Mongolian people. This asbestos was probably derived from the chrysotile deposits at Minusinsk, on the Yenisei River.

Attempts at establishing an asbestos industry in Europe did not commence until the beginning of the 18th century when asbestos paper and board is reported from Italy. Russian asbestos, from chrysotile deposits in the Ural Mountains, was spun in textiles during the reign of Peter the Great; this industry was later abandoned however. Gradually more uses were developed for the material which owes its uniqueness to the combined properties of being incombustible and fibrous. Even now these properties have not been combined economically in synthetic fibres.

In the 19th century British manufacturers of packings and heat insulation established links with Italian producers; in 1874 the Italo-English Pure Asbestos Company Limited was founded. Based in London, the company had plants at Turin (yarns and packing cords) and at Rome (asbestos board).

On the American continent asbestos paper and board were produced in Waltham, Massachussets in 1878. Italian fibre was used. Somewhat later small quantities of inferior asbestos from Staten Island were employed by M.W. Johns in the production of a roofing material composed of paper, pitch, burlap and asbestos. In Canada asbestos had been discovered earlier but production remained unsuccessful until, in 1876, an important discovery was made at Thetford, Quebec. Here the quality of the "rock wool" ensured success and rapid expansion of the asbestos mining industry. Another property in the area, known as "Webb's Ledge", was brought into production by W.M. Jeffrey in 1881. This became "Jeffrey's Mine", later to develop into the largest asbestos mine in the world.

Fruitful cooperation had been established between Mr. Johns and Thomas F. Manville, who had called on Mr. Johns' experience with asbestos for the production of heat insulation. In 1901 Johns-Manville was formed. In 1918 Jeffrey's Mine was transferred to Canadian Johns-Manville Company Limited. In 1926 another large Canadian producer, Asbestos Corporation Limited, was formed from nine existing companies.

In Europe asbestos had been used as a filtering medium in 1891 and was woven into brake bands for the first time in 1896. Eternit was patented in 1903 and the first pressure pipes were produced in Genoa in 1913.

In the United States asbestos was originally linked with basic magnesium carbonate in "85% Magnesia", at that time the standard insulation for steam piping and other equipment operating at temperatures up to 600°F. Many makers of this insulation retained a subsequent interest in the manufacturing of asbestos products.

The gradual rise in world consumption of asbestos in the early part of the 20th century is expressed in Figure 1, based on production figures by Wells published in "Asbestos" (Vol. 51, No. 4, p.2). The graph shows growth at an increased rate after the Second World War. This is mainly due to a wider use of asbestos in the building industry. The adaptability of asbestos for industrial uses promises a continued expansion of demand in the foreseeable future.

MINERALOGY OF ASBESTOS

The term "asbestos" is applied to minerals of the serpentine and amphibole groups with the common property of naturally occurring in a fibrous habit. The fibres must be strong, flexible and sufficiently heat resistant to be of commercial value. The longer fibres of good quality, particularly those of chrysotile, a fibrous form of serpentine, can be woven into textiles. Many uses of asbestos developed from this technique. Chrysotile is estimated to furnish 90 percent of the present world production of asbestos. It is the only asbestos mineral mined in Canada.

Crystalline fibres have a distinct advantage over animal or vegetable fibres like hair or flax in the extreme fineness of the structure. Chrysotile frequently breaks down to fibrils with a diameter of about one millionth of an inch according to Deer, Howie and Zussman (1962, Vol. 3, p.174). A length over diameter ratio of approximately 5,000 is to be expected for such fibrils.

Amphibole Asbestos

The structural characteristic of amphiboles is the linking of SiO_4-tetrahedra into double chains. The chains are laterally bonded by planes of cations (Ca, Mg, Fe) and some hydroxyl ions (Deer *et al*. 1962, Vol. 2, p.203).

Tremolite $Ca_2Mg_5Si_8O_{22}(OH,F)_2$

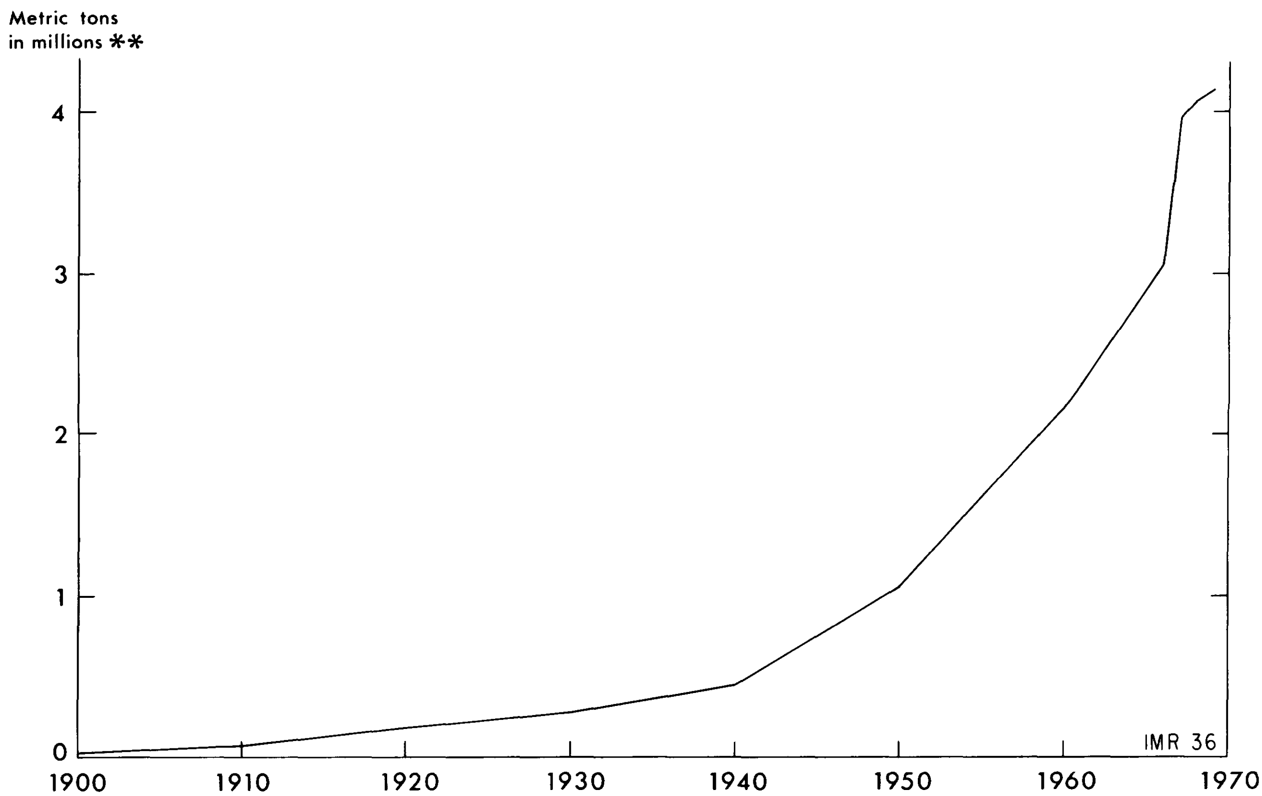
Actinolite $Ca_2(Mg,Fe)_5Si_8O_{22}(OH,F)_2$

These minerals are characteristic of a metamorphic environment. They can form by reaction of impure dolomite with quartz and water, producing calcite as a byproduct, or in metamorphosed ultramafic rocks, in assemblages of tremolite, tremolite-talc, and tremolite-carbonate-antigorite schists.

Commercial asbestos deposits sometimes consist of magnesium-rich actinolite and tremolite. Although of low tensile strength and poor spinnability, high resistance to acids may make the fibres suitable for acid filtration. Physical and optical characteristics are listed in Table 1.

Figure 1

WORLD PRODUCTION OF ASBESTOS, 1900 - 1969*



* 1900 - 1966 R. A. Wells "Asbestos" Vol. 51, No. 4, p. 2
1967, 1968 Canadian Minerals Yearbook
1969 Canadian Minerals Yearbook (estimated)
** Metric tons (1 short ton = .907 metric ton)

Table 1 PHYSICAL PROPERTIES OF ASBESTOS (AFTER BADOLLET 1951)

	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 of 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

Anthophyllite $(Mg,Fe)_7Si_8O_{22}(OH,F)_2$

The absence of Ca-, Na- and K-atoms allows for a different mode of stacking of the double chains in the crystal structure producing an orthorhombic symmetry in anthophyllite (Deer et al. 1962, Vol. 2, p.204).

Anthophyllite is commonly developed during regional metamorphism of ultramafic rocks and associated with talc in this context. Asbestiform anthophyllite is found in veins in serpentinite at Coffee Creek, Carville, California. The cross fibres in these veins are almost as fine and flexible as commercial grade chrysotile. A certain amount of replacement of Si, Mg or Fe by Al is permissible in the anthophyllite structure. Physical and optical characteristics are listed in Table 1.

Amosite $(Mg,Fe)_7Si_8O_{22}(OH)_2$

Amosite is the fibrous or asbestiform variety of members of the cummingtonite-grunerite series of amphiboles. The formula of typical amosite, a name which is derived from the first letters of Asbestos Mines of South Africa, can be written as: $Mg_2Fe_5Si_8O_{22}(OH)_2$. The South African deposits are the only known commercial deposits of amosite. The iron-rich fibre occurs in cross-fibre veins in a series of shales, slates, and quartzites associated with diabase sills. Much of the fibre is 6 inches or more in length. It is ash grey when fresh but frequently coloured brown to yellow by iron oxides. The fibre has good tensile strength but poor spinnability. Heat and acid resistance are high. Physical and optical characteristics are listed in Table 1.

Crocidolite $Na_2Fe_5Si_8O_{22}(OH)_2$

Crocidolite, or blue asbestos, is the fibrous variety of the sodium-rich amphibole riebeckite. A certain amount of replacement of Fe^{++} by Mg is common in the fibrous riebeckites (Deer et al. 1962, Vol. 2, p.335).

Crocidolite is of metamorphic origin. In South Africa and also in the Hamersley Ranges of Western Australia it occurs predominantly as cross fibre in seams parallel to the bedding in ironstones. It is remarkably close in chemical composition to the ironstones and probably merely enriched in sodium derived from the surrounding rock (Deer et al. 1962, Vol. 2, p.348).

Magnesium-rich crocidolite is found in slip fibre veins in semi-calcareous rocks in northern Rhodesia and Bolivia.

Crocidolite has high resistance to acids and alkalies but low heat resistance. It is unsuitable for heat insulation purposes. Further details of physical and optical characteristics are found in Table 1.

Serpentine Asbestos

Serpentine is a common, rock-forming hydrous magnesium silicate. The three principal polymorphs of serpentine which is believed to occur also in amorphous form, are chrysotile, lizardite and antigorite. Chrysotile is the asbestiform variety of serpentine. Picrolite, a fibrous form of antigorite, has no commercial value.

Serpentine is characterized by a layered structure consisting of double layers of a) linked SiO_4-tetrahedra and b) brucite. In Figure 2 a schematic representation of chrysotile shows how these layers are superimposed.

The manner of deposition of serpentine is still a matter of much discussion. Observations and experiments tend to indicate that most serpentine was formed through alteration of olivine and pyroxene by water vapour at temperatures below 500°C. It is frequently found in association with ultramafic rocks e.g. dunites, pyroxenites, peridotites.

When occurring in metamorphic limestones and dolomites, serpentine is believed to have originated from saturated aqueous solutions of calcium and magnesium carbonate and silica.

Much has been written on the likelihood of equal volume transformation of ultramafic rocks to serpentine as opposed to conversion with volume increase due to the addition of water. Equal volume transformation requires transport of about 30 weight percent of the original material in solution whereas conversion through hydration would increase the volume by about 35 to 40 percent according to Thayer (1966). Evidence for both concepts has been gathered in the controversy. It is conceivable that either of these processes, or a combination of both, operated in a given occurrence of serpentine.

Chrysotile $Mg_3Si_2O_5(OH)_4$

The silky fibres of chrysotile are the most important source of commercial asbestos. The fibres occur in lengths up to 6 inches or more but are normally less than 1/2 inch. They are generally found in cross-fibre veins and veinlets in massive serpentine.

Chrysotile fibre can be harsh and brittle as well as silky. It has poor resistance to acids and alkalies, but good tensile strength and very good spinnability. When low in iron chrysotile makes an excellent electric insulator. Details of physical and optical properties are found in Table 1.

<u>Characteristics of Chrysotile</u>: Chrysotile shares with all other forms of serpentine the double layer structure of linked silica tetrahedra complemented with brucite. There is a certain amount of mis-match in this structure which is resolved crystallographically in different ways. In Figure 2 the layered structure is schematically represented. The layers are curved with SiO_4-tetrahedra on the inside of the curve. This is held to be the structure of chrysotile fibres which frequently appear as tubes in electronmicrographs. A strain-free layer has a radius of curvature of about 88Å (Deer *et al.* 1962, Vol. 3, p.174). Much of the massive serpentine in which veins of chrysotile

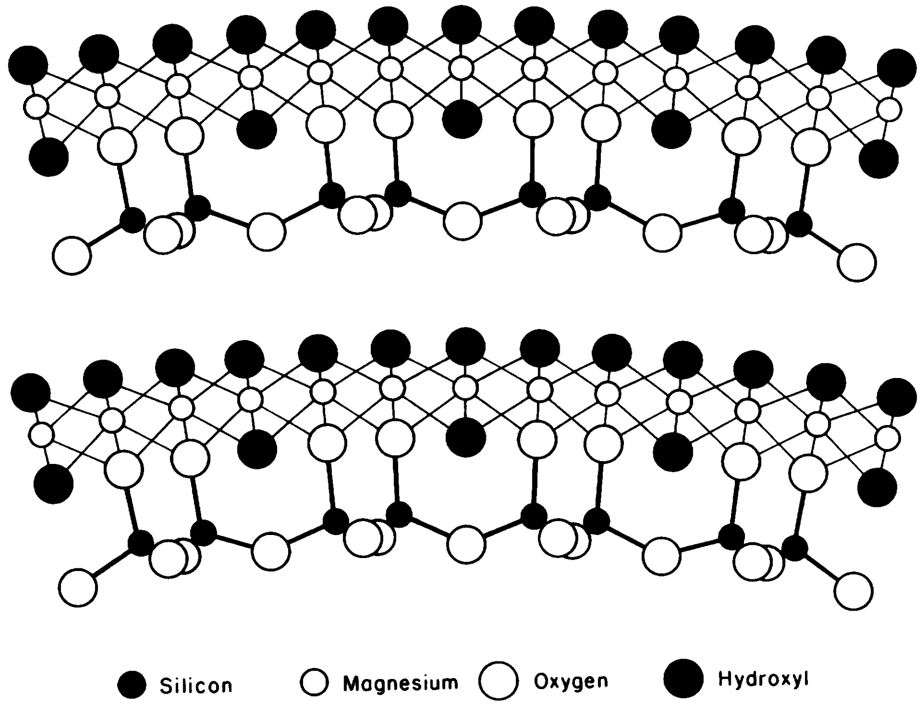


FIGURE 2 – Schematic representation of the structure of chrysotile asbestos. Fibre consists of $Mg(OH)_2$ layers on Si–O tetrahedra. (After Winer and Sirois 1967.)

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occur has the platy morphology of the polymorph lizardite (Deer et al. 1962, Vol. 3, p.173).

It is not well understood whether or not the "tubes" of chrysotile are hollow. Blocks of chrysotile which show a fibrous habit on the surface at times have been found to possess the density of massive serpentine. In such cases tubes and intertubular space may be filled with amorphous serpentine according to Winer and Sirois (1967, p.4).

The process of deposition of chrysotile in cross- and slip-fibre veins in massive serpentine is not clearly understood. Riordon (1957, p.8), in discussing the origin of the fibrous habit of both chrysotile asbestos and picrolite points out that there is "... certain evidence that indicates the original material of these veins was of the nature of amorphous serpentine and that later crystallization, under suitable conditions of stress relief during the cooling off period, produced the fibrous picrolite and asbestos". This hypothesis would find support in a loss of density in the transition from amorphous to fibrous serpentine. Measured densities of chrysotile range from the density of solidly stacked serpentine layers (2.56 gm/cm^3) to those compatible with 12 percent voids. As to the connection of chrysotile crystallization with shearing of the host rock Riordon (1957, p.8) remarks: "This late stage of crystallization evidently occurred at a time when all of the adjustments in the host rock had ceased".

Synthetic Fibres

The development of synthetic fibres has kept pace with the development of uses for asbestos. Glasses of different composition can be fiberized to form wool analogous to rock wool and slag wool; or they can be drawn into filaments suitable for use in textiles. The latter process requires drawing the viscous substance through cells with perforated platinum bottoms. High silica glasses can be produced in this manner with the help of a flux which is later removed by leaching. The resultant fibre is corrosion resistant and can withstand temperatures exceeding 1,000°C. Aluminium silicate fibres and fibres of pure quartz are made by costly blowing processes. Their use is limited to special high temperature applications.

More recently progress has been made in the techniques of growing crystalline fibres or "whiskers" from such diverse materials as sapphire, silicon carbide, boron carbide, graphite and iron. Combined with the proper matrix material these fibres can impart their strength to the composite, allowing for a much improved strength to weight ratio. The matrix material merely serves to transfer the stress load to the fibres. It should have a lower strain resistance or modulus than the fibres but sufficient bonding or shear strength. Thinner, longer fibres provide more surface per unit weight and are therefore preferable. They allow for a reduction in the shear strength requirements of the matrix. A comparison of natural and synthetic fibres is made in Table 2.

The production of synthetic fibres compels asbestos producers to look for ways to provide thinner fibres and fibres with improved bonding with the matrix.

Table 2 A COMPARISON OF NATURAL AND SYNTHETIC FIBRES (AFTER WRONSKY)*

	Strength p.s.i. Experimental	Strength p.s.i. Theoretical	Diameter (microns)	L/D	Strength to Weight Ratio	Minimum Matrix Shear Strength (p.s.i.)
Asbestos	820,000	1,500,000	0.02	5,000	9.1	75
Sapphire	2,800,000	6,000,000	10	100	19.6	7,000
Silicon Carbide	1,600,000	12,000,000			13.9	
Graphite	3,000,000	14,200,000	15	67	50.0	11,000
Glass	550,000	1,500,000	10	100	6.1	1,600
Iron	1,900,000	2,900,000	13	77	6.7	6,300
Steel	600,000	1,000,000			2.1	

*Reproduced from "Asbestos", Vol. 50, No. 2, p.8 and No. 3, p.4.

Synthesis of natural asbestos minerals has proven successful but not economic. Synthesis of amphiboles was facilitated by introducing fluorine into the crystal structure replacing the hydroxyl groups. The fibres do not have the strength and flexibility of amosite or crocidolite however.

USES OF ASBESTOS

Uses of asbestos are historically based on the combination of two characteristics, spinnability and fire resistance. The fact that cloth made of asbestos does not burn has earned asbestos its name, meaning: inextinguishable.

From its beginnings as the raw material of fire resistant cloth and incombustible lamp wicks asbestos has developed into a much desired and versatile product. It is sought after for its relative strength of fibre as well as its resistance to heat and corrosion and its low electrical conductivity. Over 3,000 applications are claimed by industry at present and more are being researched. The availability of asbestos has resulted in uses in basic industries such as building and road construction. Techniques of manufacturing asbestos in moulds rather than in woven form have allowed the utilization of short fibres which were previously considered a waste product of the milling process. Some uses of asbestos will be discussed in the following sections.

Insulators

Heat insulation is obtained with asbestos textiles, asbestos felts, asbestos foams, asbestos paper, asbestos board and moulded lightweight products of asbestos with hydrous calcium silicate or calcined diatomaceous silica. The latter product can withstand temperatures up to 1,900°F.

It is primarily the entrapped air in these loosely bound fibrous materials which prevents the conduction of heat. Textiles can be made into fireman's suits. Aluminized asbestos suits with a high heat reflectivity allow firemen to work near or even in the flames temporarily. Textiles also provide lagging in ships, boiler insulation, flameproof theatre curtains and fire-smothering blankets.

The prescribed amount of asbestos in textiles which are reinforced with organic fibre depends on the intended use. Under temperature conditions ranging from 350° to 900°F the corresponding asbestos percentage runs from 75 to 100.

Recent techniques of converting colloidal suspensions into foam have produced novel lightweight heat resistant insulation materials of chrysotile.

Asbestos paper built up of one or more plies bonded with a sodium silicate cohesive, or of alternating flat and corrugated sheets in so called air-cell paper, is extensively used as insulation of steam pipes. Mill board, a thick paper built up of several plies, is used under conditions up to

1,000°F as lining for stoves, ovens and kilns and also as table pads and mats. Moulded lightweight insulation is produced in flat or curved blocks for insulation of furnaces, and in half sections for insulation of pipes. Made of calcined diatomaceous silica blended with other insulating materials, and bonded with asbestos fibres, this compound withstands temperatures up to 1,900°F.

The traditional insulator of steam pipes, "85% Magnesia", is used at temperatures up to 600°F. It is a compound of 85 weight percent basic magnesium carbonate bonded with 15 percent by weight of asbestos fibre. The combination represents one of the larger early uses of asbestos.

In electrical insulation chrysotile is the only asbestos variety used. Chrysotile of low iron content and free of inorganic salts and magnetite is preferred. Salts like metallic chlorides and carbonates are sometimes present. They are usually hygroscopic and tend to lower the resistivity of asbestos products under conditions of high humidity. Some magnetite is commonly associated with chrysotile. According to the amount of magnetite remaining after opening and purification of the fibres, asbestos products are classified in types roughly defining the electrical characteristics of the textile. Uses of different types vary from thin-wall primary wire insulation (type II) via heavy-wall primary insulation (type IV) to overall wire and cable wraps and braids or cable fillers (type VI) for which the electrical properties of the textile are least important.

If asbestos paper is used for electrical insulation it is usually treated with a silicone varnish or lacquer in order to prevent it from absorbing moisture from the air. The dielectric strength of paper so treated is much higher than that of textiles. Asbestos electrical board, composed of asbestos fibres and binder cement impregnated with an insulating compound, can be used for mounting heavy electrical aparatus. It is used for switchboards, bench boards, testing tables, contacter panels and similar purposes.

Sound insulation or acoustical ceiling tile or panelling is applied in the larger part of all offices, schools, hospitals and homes in modern construction. Fire regulations and insurance specifications have encouraged the use of fire-rated, mineral-based acoustical products. The industry has turned increasingly to the use of asbestos fibre in this context. Amosite fibre is suitable because of its shrink resistance under conditions of high temperature. It is also fast-filtering which allows rapid release of water, increasing the speed of manufacturing of the board. Cost saving is obtained by using a method of spraying asbestos on walls and ceilings.

Friction Materials, Gaskets and Packing

Friction materials are employed in brake linings and clutch facings. The materials must be able to withstand the heat of friction developed upon application. When a brake lining is pressed against the rotating brake drum it is essential that the heat produced does not weaken the initial braking capacity of the system. Disc brakes are superior to drum brakes since a relatively larger surface is available for braking action. In disc brakes most of the surface of a rotating disc is actually free to cool while part of it is caught between the friction pads.

Although initially brake linings consisted of woven asbestos fabrics they are now usually made of moulds of asbestos fibre bonded in an organic matrix. Metallic reinforcings of brass, zinc or lead may be incorporated. The moulding technique allows use of much shorter fibres, including grade 7 chrysotile.

Conversion of mechanical clutching in cars to automatic transmission of power has not affected the asbestos industry untowardly. The eight to twelve metal discs in an automatic transmission are faced on one side with wafer thin paper containing asbestos fibre. The paper also contains organic fibre and an inorganic powder filler, and it is impregnated with phenolic resins. Immersed in the oil bath of the automatic transmission this paper is designed to function for at least 140,000 miles.

Asbestos is used in various ways in the manufacture of gaskets and packing for sealing of joints and of moving parts. Long fibres provide the strength needed with present high steam pressures. Packings of twisted or braided asbestos yarn and gaskets cut from asbestos cloth may be coated or impregnated with rubber compounds, oil or flake graphite. Mixtures of asbestos with clay, magnesia, graphite or cellulose and bonded by resins, lacquer or rubber dissolved in a volatile solvent, can be moulded into sheets. A high-grade packing of this type, according to Bowles (1959, p.61), will contain 2 parts of asbestos to 1 part of filler and may be reinforced with copper or lead foil.

Sealing problems in the automotive industry have been overcome with gaskets subject to controlled swelling. This property is obtained with a polymer binder which is designed to absorb a certain amount of fluid. Flange irregularities are sealed off due to swelling while disintegration of the gasket is prevented by the interlocking matted structure of the contained asbestos fibre. Cylinder heads of large diesel engines, conventionally sealed with copper rings, are now sealed with a special type of spirally wound gasket of compressed asbestos fibre plied to a strip of metal.

Structural Materials

The property of imparting strength to a matrix material has made asbestos fibre a desirable component of structural materials. Matrix materials include clay, asphalt, cement and plastics. Asbestos cement products in particular have raised the demand for asbestos and are a major factor in the promising outlook for the asbestos mining industry.

Asbestos cement products include materials for roofing, side wall and curtain wall construction, decorative panelling, partitioning and, in stronger corrugated panels, canal bulkhead retaining walls which prevent erosion of loose soil.

Construction of bridges and similar projects is simplified by using forms of asbestos cement. These forms blend with the regular poured cement and can be left in place upon completion.

Moulded and extruded asbestos cement products provide for special shapes required in industrial, architectural or ornamental designs e.g. furnace cylinder linings, especially curved siding and roofing sheets, promenade tiles, and patio pots.

Asbestos cement pipes are used in construction of water and gas mains, sewers and cable conducts. They are strong, light and resistant to corrosion and electrolytic action. Pipes are made of a slurry of Portland cement and additions of 15 to 20 percent asbestos and other ingredients. The slurry is deposited in successive layers on a rotating cylinder. Harsh chrysotile and crocidolite fibres are used. Their fast filtering effect improves the speed of production.

In a recent study of low cost housing a model house featured components of extruded asbestos cement. The components fit together in a flexible, modular system adaptable to a wide variety of shelter sizes and styles. They are bonded by a high strength, weather-proof adhesive which prevents wall panels from slipping in the post grooves and waterproofs the joints. A complete house it is claimed can be built by three men in less than fifteen days (Asbestos, Vol. 50, No. 12, p.6).

The combination of asbestos and asphalt, well known for its application in floor tiles and roofing shingles, has more recently been adapted as a paving material for roads, airports and bridge decks. The presence of short fibre asbestos in the asphalt mix allows raising of the asphalt content which is a desirable feature. A mix containing 3 percent asbestos and 7.7 percent asphalt is found to be water resistant and reduces air voids (Asbestos, Vol. 49, No. 8, p.4). In resurfacing of road decks an asbestos asphalt overlay of only 3/4 inch thick is usually applied, reducing the cost of raising curb stones, drainage points and maintenance outlets.

Combinations of fibres and matrix have been particularly successful in the plastics industry. Asbestos floor tiles combining asbestos with a thermoplastic binder of vinyl polymer resin, pigments, and an occasional inert filler material, are used in a wide variety of colours and patterns in industrial, commercial or residential buildings.

Epoxy laminates have been developed with tensile strengths of the order of 100,000 lbs. per square inch. The asbestos fibres in these products are aligned both in the plane of the laminate and in the direction of the major applied stresses.

The favourable strength to weight ratio of asbestos cloth, felt or paper impregnated with thermo-setting plastic resins has led to applications in the aircraft manufacturing industry e.g. cabin floors, hot air ducting and window frame insulators. Asbestos reinforced plastics are also useful as bearings. Addition of colloidal graphite or other lubricants in the compound allows production of "dry" or "semi-lubricated" bearings. These bearings are impervious to attack by salt water and are used in ship davits and accessory gear. There is no need to attempt to seal the bearings from the influence of salt water as was necessary with the conventional steel ball bearings which rapidly deteriorated when exposed to salt water spray.

In recent applications asbestos has successfully replaced the more costly colloidal silica as a viscosity control agent in some polyester resins. Asbestos is more readily wetted by the resin, it is claimed, and makes spraying of this resin easier and faster (Asbestos, Vol. 51, No. 3, p.30). It is used in spraying a primary thin gel coat on moulds for car body components before the base structure of glass fibre and polyester resin is sprayed on.

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 [1948, 1949, 1950, 1951, 1952] 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 [Foster and Borror 1946; Messel 1947] 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 [1947] 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 grade depends largely on experience. Foster and Borror [1946] 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 [1950] 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 [1947] 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 [1949]:

" '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 [Table 3] 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' " (Hewitt and Satterly 1953, p.17-18).

PRODUCTION METHODS

Mining

The bulk of Canadian asbestos is mined in open-pit operations. This method has allowed the development of large, low-grade orebodies. In some of the older mines operations have gone underground upon reaching the economic limit of open-pit mining.

The advantages of open-pit mining over underground operations may be illustrated by the history of Jeffrey Mine, Eastern Townships, Quebec, Canada's largest producer. This mine, active since 1881, had reached the economic limit of open-pit mining in 1950 and it was decided to continue operations underground. The method of block caving was adopted. Block caving of asbestos was first developed by Asbestos Corporation, in the King Mine in 1934. It is at present successfully employed in the King-Beaver Mine and the Bell Asbestos Mine, in the Eastern Townships of Quebec, both opened in 1878. However, in the Jeffrey Mine the method became expensive in comparison with open-pit mining, due to rising labour and material costs. Added to the costwise advantages of open-pit mining are a cleaner, drier ore and improved selection of ore for the mill. Ten years after conversion operations in the Jeffrey Mine were reconverted to open-pit mining. In an article in "Mining in Canada" of October 1967 the pit is reported to have a diameter varying from 3,500 to 3,800 feet at the surface. Close to 100,000 tons of material had to be moved daily, one third of which was ore, one half overburden and one sixth waste rock.

Table 3 CANADIAN CHRYSOTILE CLASSIFICATION

Group	Grade	Description	Guaranteed Minimum Shipping Test 1/2 in. Oz.	4M Oz.	10M Oz.	Pan Oz.
Group No. 1		No. 1 Crude - cross-fibre veins having 3/4 inch staple and longer.				
Group No. 2		No. 2 Crude - cross-fibre veins having 3/8 inch staple up to 3/4 inch. Run-of-mine Crude - consists of unsorted crudes. Sundry Crudes - consist of crudes other than above specified.				
Group No. 3		(Commonly referred to as textile or spinning fibres)				
	3D		10.5	3.9	1.3	0.3
	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 No. 4		(Commonly referred to as shingle or asbestos cement fibres)				
	4D		0	7.0	6.0	3.0
	4H		0	5	8	3
	4J		0	5	7	4
	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 No. 5		(Often referred to as paper stock grades but also considered as short shingle fibres)				
	5D		0	0.5	10.5	5
	5K		0	0	12.0	4
	5M		0	0	11	5
	5R		0	0	10	6
Group No. 6		(Waste, stucco, or plaster fibre)				
	6D		0	0	7	9
Group No. 7		(Shorts)				
	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
	7RF and 7TF Floats		0	0	0	16
	7W		0	0	0	16
Group No. 8		(Sand)				
	8S	under fifty pounds per cubic foot loose measure				
	8T	under seventy-five pounds per cubic foot loose measure				
Group No. 9		(Gravel and stone)				
	9T	over seventy-five pounds per cubic foot loose measure				

Production in 1966 amounted to 610,305 tons of finished fibre or 45 percent of all Canadian production in that year.

The trend in open-pit mining is towards use of larger, labour-saving equipment. In the Jeffrey Mine, according to the above report, equipment used in 1967 included 6- to 10-cubic yard power shovels, 40- to 100-ton trucks for ore haulage and two 35-ton skips for hoisting of ore to surface. The skips operate in counter balance along an inclined skipway built to be moved and extended to the next lower bench when mining progresses. Its design allows it to reach an eventual depth of 1,200 vertical feet, twice the depth of the floor in 1967.

Bench heights in open-pit operations vary with different operations and sometimes with depth within a mine. Heights ranging from 30 to 55 feet are common.

In Ontario production is exclusively from open-pit operations. Development of a new orebody in Garrison Township involves underground drifting and crosscutting but production will be by open-pit method.

In the past the now depleted Munro orebody was partially mined underground due to the narrowness of the surface outcrop. Its width allowed an open-pit operation to a depth of 300 feet only. Ore was taken out below this level to an ultimate depth of 637 feet. The deepest level in the mine was used for exploration purposes only.

Since its abandonment the Munro pit has turned into a lake which is 3,000 feet long and from 700 to 800 feet wide.

Milling

Possible uses of asbestos frequently depend on the degree of success achieved in milling. Producers are responsible for a uniform product. There must be close control of fibre length, length distribution, degree of fibre opening, filtration rates and colour. More than 100 grades of fibre are now available. These may be further blended on customers demand.

A dry-milling process is common for all Canadian asbestos producers. Ore is crushed by conventional methods in jaw and cone crushers and subsequently dried. Driers are either vertical or horizontal cylinders fired by coal, oil or natural gas. A drying method is chosen which prevents or minimizes milling of ore due to its movement through the drier.

Dry ore is kept in dry storage, usually in separate lots according to characteristics. The desired mill feed is blended by feeders drawing from these different lots in the storage area.

In the mill rock and fibre are separated by repeated crushing, screening and aspiration. Crushing and fiberizing are accomplished in several ways. Jaw, cone and gyratory crushers are used in the initial stages. Further crushing and fiberizing may be carried out in impact crushers, ball mills or hammer mills, combined or alternating with aspiration of the fibres. A schematic representation of ore treatment is given in Figure 3.

At the Normandie Mine in Quebec six Aerofall mills are used. They are 17 feet in diameter and 5 feet wide each, and revolve at 17.7 rev/min. Each mill carries a ball load of 18,000 lbs. of 5-1/4 inch steel balls. The crushed ore is conveyed by 90,000 cu.ft/min. of air per mill ("Mining in Canada", October 1967, p.26).

Aspiration of fibres usually takes place over shaking or gyrating screens, between stages of crushing or fiberizing. Fibres are lifted off the screen and passed on to graders, dusters and classifiers for cleaning and sizing while the material remaining on the screens may be returned for further crushing or be discarded as waste.

The process of aspiration resembles a large vacuum cleaning operation. The current of air, after depositing its load of fibres, passes through the fans to a dust collection chamber. The air is here forced through a multitude of bag filters which collect the remaining dust before the air is returned to the atmosphere. Electrical dust precipitation methods are applied in some plants.

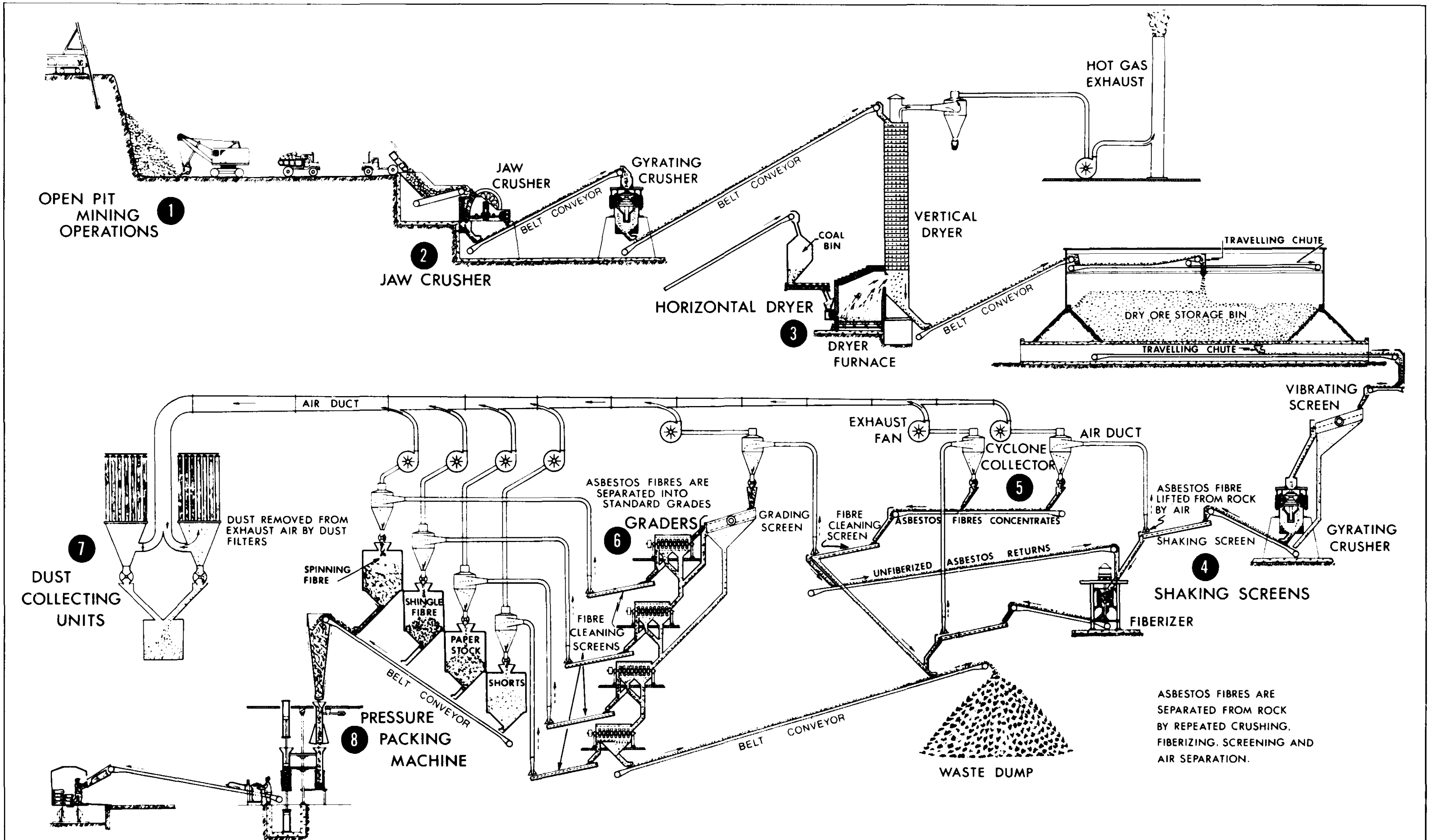
The volume of air used in aspiration requires an extensive filter installation. Jenkins (1949) estimates that 5,000,000 cubic feet per minute of free air will be exhausted in treatment of 3,000 to 4,000 tons of ore per day. Not more than 4 to 5 cubic feet per minute of free air can be filtered per square foot of fabric. Provisions for intermittent cleaning of the fabric by shaking adds to the minimum of 1 million square feet of fabric required in this instance.

Finished and graded fibres are collected in bins from which they can be drawn for packaging. The manner of packing depends on the grade of material. Fibres can be "pressure packed", "semi-pressure packed" or loosely packed, in paper or jute bags. The bags are loaded on pallets and usually kept in storage in separate lots until sample testing of these lots in the plant laboratory has been completed. The possibility of pressure packing 20-ton lots of short fibres and dust in specially designed railway cars is being investigated by one company at present.

Marketing

The volume of asbestos sold on the open market is small compared to an annual world production of approximately 4.5 million tons. Many contracts between producers and consumers are negotiated privately. Other producers may be integrated with manufacturing plants selling a minor part of their production only on the open market. This is largely the case with Canadian producers. In 1958 Canadian Johns-Manville Company Limited, the largest of these, owned 25 different manufacturing plants on the continent, three of which were located in Canada.

Canada has held first place as producer of asbestos until recently. Russia has taken over this position, but with only 15 percent of that country's



(From brochure of Asbestos Corporation Limited.)

Figure 3 — Flowsheet of an asbestos operation

production for sale, Canada remains the largest exporter. World production figures for asbestos are given in Table 4.

Table 4* World Production of Asbestos, 1968-1969

(short tons)

	1968	1969[e]
USSR	2,000,000	2,000,000
Canada	1,595,951	1,596,450[p]
Republic of South Africa	260,530	285,000[p]
China	165,000	165,000
Rhodesia	150,000	150,000
United States	120,690	127,000[p]
Italy	116,845	120,000
Swaziland	45,000	45,000
Other countries	60,000	60,000
Total	4,514,016	4,550,000

Source: Publications of the United States Bureau of Mines, and various trade journals.

p Preliminary; e Estimated except where indicated.

* Reproduced from Canadian Minerals Yearbook, preprint 1969.

Canadian asbestos producers are listed in Table 5.

Sales of Canadian asbestos dominate the international trade and price trends of Canadian products govern the market. Recent price increases announced by Canadian Johns-Manville Company Limited were followed by Asbestos Corporation Limited, the largest non-integrated producer in Quebec, and by other producers. Prices quoted in "Asbestos" (Vol. 51, No. 9, p.48), are given in Table 6.

Table 6 Asbestos Prices

CANADA — Per Ton of 2,000 lbs., f.o.b. Mine

(As of January 1, 1970)

	Canadian Currency		
Crude No. 1	$	..	$1,525.00
Crude No. 2		..	825.00
No. 3 (Spinning Fibre)	397.00	to	650.00
No. 4 (Shingle Fibre)	218.00	to	369.00
No. 5 (Paper Fibre)	157.00	to	184.00
No. 6 (Waste)		..	114.00
No. 7 (Refuse, Shorts)	48.00	to	95.00

Table 5*

CANADA, ASBESTOS PRODUCERS, 1969

Company	Location	Mill capacity tpd	Remarks
Cananadian Johns-Manville Company Limited Jeffrey Mine	Asbestos, Que.	32,000	Open pit. Mill expansion for further 100,000 tons fibre a year by 1970. Commencing 5-year open-pit expansion.
Asbestos Corporation Limited			
British Canadian Mine	Black Lake, Que.	11,200	Open pit. Two milling plants.
King-Beaver Mine	Thetford Mines, Que.	8,000	Underground and open pit. New $2-million replacement processing plant.
Normandie Mine	Black Lake, Que.	6,000	Open pit.
Bell Asbestos Mines Ltd.	Thetford Mines, Que.	3,000	Underground. Sinking new shaft.
National Asbestos Mines Limited	Thetford Mines, Que.	3,500	Open pit.
Lake Asbestos of Quebec, Ltd.	Black Lake, Que.	6,000	Open pit.
Flintkote Mines Limited	Thetford Mines, Que.	2,000	Open pit.
Carey-Canadian Mines Ltd.	East Broughton, Que.	4,000	Open pit.
Nicolet Asbestos Mines Ltd.	Norbestos, Que.	2,500	Mine ceased production Jan. 1969
Advocate Mines Limited	Baie Verte, Newfoundland	6,000	Open pit. 2-month strike in 1969.
Cassiar Asbestos Corporation Limited			
Cassiar Mine	Cassiar, British Columbia	2,400	Open pit.
Clinton Creek Mine	Clinton Creek, Yukon Territory	3,000	Most northerly open-pit mine in Canada.
Johns-Manville Mining & Trading Limited Reeves Mine	Timmins, Ontario	5,000	Open pit. First full year of operation in 1969.
Hedman Mines Limited	Matheson, Ontario	300	New plant tune-up in 1969.

*Reproduced from Canadian Minerals Yearbook, preprint 1969.

Values quoted recently for Ontario asbestos have varied from $37 per ton in 1967 to $178 per ton in 1959.

Market quotations for asbestos of other countries are not readily available since most contracts are negotiated privately. In 1965 the following average values per short ton were calculated from United States Department of Commerce import data and quoted in "United States Bureau of Mines Minerals Yearbook" (Table 7):

Table 7* Average value per short ton as calculated from import data

	Amosite	Chrysotile	Crocidolite
Republic of South Africa	$156	$177	$195
Southern Rhodesia	...	186	...
Australia	...	...	190

* Reproduced from United States Dept. of Interior, Bureau of Mines Minerals Yearbook, 1965.

Due to the minor weight percent of asbestos contained in most manufactured products, location of a manufacturing plant will be determined more by its proximity to a potential market than to a source of asbestos. In 1969 Ontario fibres of the Reeves Mine of Johns-Manville Mining & Trading Limited were shipped to at least eight different plants in the United States and Canada.

ONTARIO OCCURRENCES

Production

"There has been production of chrysotile asbestos from [six] 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" (Hewitt and Satterly 1953, p.3).

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 1964, when operations were terminated, amounted to about 355,819 tons of fibre valued at approximately $57,196,467. Production figures for 1962-64 in Table 8 combine production of Munro Mine, Hedman Mine and Reeves Mine, although the bulk of this production originated at Munro Mine.

In 1951 Teegana Mines Limited re-opened the Slade-Forbes property and produced 38 tons of asbestos valued at $6,300. In 1952 Van Packer Mines of Canada Limited produced 63 tons valued at $14,800 from the same property.

Metro Asbestos Processors Limited, in 1956 and January 1957, produced a similar amount of asbestos from the Bowman Mine, also in Deloro Township, making use of the milling facilities on the Slade-Forbes property.

Hedman Mine started pilot plant production in 1962 and was the sole Ontario producer in the period 1965-67 when a total production of 5,085 tons at a value of $195,017 was recorded. The former capacity of Ontario production was not regained until the mill at Reeves Mine was completed in 1968. Conversion of Hedman's operation from the pilot plant stage to production in the newly completed mill near Matheson took place in January 1969.

The production of chrysotile asbestos in Ontario is summarized in Table 8. It does not include shipment of bulk samples from the Garrison Township property of Canadian Johns-Manville Company Limited to the assay and test milling laboratory in Asbestos, Quebec, in 1968 and 1969.

"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" (Hewitt and Satterly 1953, p.4).

DESCRIPTION OF PROPERTIES

A great deal of prospecting for asbestos has been carried out in northeastern Ontario since development of the Munro Mine in 1949. Many of the peridotite-bearing areas were covered by airborne and ground geophysical surveys. Extensive diamond drilling has led to development of two new mines, in Warden and Reeves Townships; the development of a third, in Garrison Township, is in progress.

Table 9 lists deposits of chrysotile asbestos in Ontario and properties on which exploration has been carried out and recorded with the local Mining Recorder.

Some properties are described in more detail in the following sections.

Table 8 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 Sundicate
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
1951	38	6,300	Slade-Forbes	Teegana Mines Limited
1952	23,033	3,847,853	Munro	Canadian Johns-Manville Company Limited
1952	63	14,800	Slade-Forbes	Van Packer Mines of Canada Ltd.
1953	23,529	3,965,299	Munro	Canadian Johns-Manville Company Limited
1954	21,389	3,497,824	Munro	Canadian Johns-Manville Company Limited
1955	24,550	3,317,542	Munro	Canadian Johns-Manville Company Limited
1956	26,748	3,929,782	Munro	Canadian Johns-Manville Company Limited
1957	20,947	3,529,570	Munro	Canadian Johns-Manville Company Limited
1958	21,650	3,849,370	Munro	Canadian Johns-Manville Company Limited
1959	24,350	4,327,628	Munro	Canadian Johns-Manville Company Limited
1960	23,284	4,128,920	Munro	Canadian Johns-Manville Company Limited
1961	25,047	4,362,668	Munro	Canadian Johns-Manville Company Limited
1962	35,551	5,686,720	Munro Hedman	Canadian Johns-Manville Company Limited Hedman Mines Limited
1963	33,715	5,372,645	Munro Hedman	Canadian Johns-Manville Company Limited Hedman Mines Limited
1964	15,512	2,199,918	Munro Hedman Reeves	Canadian Johns-Manville Company Limited Hedman Mines Limited Johns-Manville Mining & Trading Limited
1965	1,758	69,258	Hedman	Hedman Mines Limited
1966	1,696	64,519	Hedman	Hedman Mines Limited
1967	1,631	61,240	Hedman	Hedman Mines Limited
1968	17,554	2,107,014	Hedman Reeves	Hedman Mines Limited Johns-Manville Mining & Trading Limited
1969	36,068	4,375,475	Hedman Reeves	Hedman Mines Limited Johns-Manville Mining & Trading Limited
1970**	38,000	4,961,000	Hedman Reeves	Hedman Mines Limited Johns-Manville Mining & Trading Limited

* Production 1917-1952 reproduced from Hewitt and Satterly (1953, p.4); Statistical Files, ODMNA
**Preliminary figures.

Table 9 CHRYSOTILE ASBESTOS OCCURRENCES IN ONTARIO

Location	Number of Claims	Name of Property or Operator	Category	Remarks	References
District of Algoma:					
Irving Tp., Oba river				Occurrence of fibre in peridotite dike.	ODM Vol. 38, pt.6, p.125
District of Cochrane:					
Aurora Tp. Calvert Tp.	7 22	Quebec Asbestos Corp. Ltd.	Prospect	Geophysical survey, 1950, diamond-drilling 1950, 2 holes, 1,200 feet; some fibre less than 1/8 inch in serpentinized peridotite.	
Beatty Tp., con. III, lot 1		C asbestos body, Can. Johns-Manville Co. Ltd.	Potential producer	571-foot shaft, 4,317 feet of cross-cutting and drifting; bulk sample 11,000 tons milled.	
Clergue Tp., cons. III-IV, lots 10-12	10	Dominion Gulf Co.	Prospect	Geological and geophysical survey, 1951; diamond-drilling 1952; 2 holes 1,819 feet; claims abandoned.	
Clergue Tp., cons. I-II, lots 8-12 Dundonald Tp., con. I, lot 1	29	Dominion Gulf Co.	Prospect	Geophysical survey and diamond-drilling, 1949-52, 13 holes 6,604 feet; some fibre in dunite; claims abandoned.	
Clergue Tp., con. III, lot 12 Dundonald Tp., con. III, lot 1		Alexo Mine, diamond-drilling for sulphides by International Nickel Co. and Harlin Nickel Mines Ltd.	Prospect	Some fibre 1/16 inch and less indicated in diamond-drilling in in serpentinized peridotite; patented lands. Optioned to Alsop Mines Ltd.; 5 holes totalling 3,027 feet drilled in 1964.	
Deloro Tp., central part	3	Bowman Mine; Porcupine Asbestos Corp. Ltd.	Production 1923-26	194 tons asbestos produced; valued at $99,336; patented lands.	ODM Vol. 36, pt.1, p.86
		Metro Asbestos Processors Ltd.	1957	60 tons asbestos produced.	ODM Vol. 67, pt.2, p.3
Deloro Tp., SE part	1	Slade-Forbes Mine; Teegana Mines Ltd.	Production 1917	10 tons, valued at $2,150.	
		Van Packer Mines of Can. Ltd.	1951-52	38 tons, valued at $6,300 in 1951; 63 tons, valued at $14,800 in 1952; Sparton Asbestos Mines Ltd. has held the property since 1952.	
Dundonald Tp., cons. I-II, lots 1-4	9	Falconbridge Nickel Mines Ltd., lease	Prospect	Cons. I-II, lots 1-2 originally held by T. Kruk and optioned to Quebec Asbestos Corp. Ltd. in 1951. Geological and geophysical surveys carried out. Claims abandoned and reinvestigated for other interests. In 1960 Falconbridge Nickel Mines Ltd. carried out geological and geophysical surveys. From 1960-64 twenty three holes were drilled totalling 6,950 feet; 1,012 feet of asbestos-bearing serpentinite with fibre veins up to 1/8 inch wide were intersected.	
Garrison Tp., NW part	14	S.J. Bird group, Can. Johns-Manville Co. Ltd.	Potential producer	Geophysical survey and diamond-drilling 1950-51, 14,923 feet; drilling 1952. Orebody indicated. Vertical shaft, 314 feet deep sunk in 1968; 632-foot level established. Drifting and crosscutting for bulk sampling carried out in 1968-69. Exploratory drilling continued. Patented lands.	
Garrison and Rand Tps.	45	E. group, Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey in 1949; diamond-drilling 1951, 21 holes, 13,557 feet. Some fibre reported in serpentinized dunite. 16 claims held in 1953. Patented lands.	
Garrison Tp.	11	W. group, Can. Johns-Manville Co. Ltd.			
Garrison Tp., north-central part		Can. Johns-Manville Co. Ltd. including MacVeigh group	Prospect	Geophysical survey 1957; drilling 1954, 1958, 1967; total 12 holes 4,919 feet.	
Garrison Tp., NW part	10	Colonial Asbestos Corp. Ltd.	Prospect	No report of peridotite or fibre on property; patented lands, partly held by Normalloy Expl. and Holdings Ltd.	
Garrison Tp., NE part	19	Mining Corp. of Can. Ltd.	Prospect	Diamond-drilling for asbestos 1946; 1951, 1,709 feet; no fibre observed in core. Patented lands.	
Hanna Tp., con. I, lots 5-8		Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey 1950-51; no surface exposures; claims allowed to lapse.	
Harker Tp., north-central part	24	Hofmann group, optioned to Dominion Gulf Co.	Prospect	Diamond-drilling 1949, 3,031 feet; 1950, 7,051 feet; 1 percent fibre in dunite; patented lands.	ODM Vol. 60, pt.7, p.34
Harker Tp., NE part	4	Hofmann E. group	Prospect	Geophysical survey 1950, thread fibre in peridotite outcrops; drilled 2 holes, total 1,003 feet in 1955; 688 feet asbestos-bearing; veins up to 1/8 inch wide.	
Harker Tp., NW part Lamplugh Tp.	7 1	Can. Johns-Manville Co. Ltd. Ghost Mountain group	Prospect	Geological and geophysical survey 1960; drilled 4 holes, total 2,554 feet in 1961; fibre veins up to 1/4 inch wide in serpentinized peridotite.	

Location	Number of Claims	Name of Property	Category	Remarks	References
Hepburn, Scapa, and Sargeant Tps.	29	P.B. Zevely; optioned to Can. Johns-Manville Co. Ltd. in 1952	Prospect	Some fibre in peridotite outcrops; dip-needle exploration; 1 hole drilled to depth of 532 feet; results not encouraging, option terminated.	
Holloway Tp., Mount Lightning area Frecheville Tp.	16	Dominion Gulf Co.	Prospect	Geophysical survey and diamond-drilling 1950, 9,000 feet; thread fibre in peridotite; claims abandoned; resurveyed partly by Can. Johns-Manville Co. Ltd., partly by A.L. Parres in 1965.	ODM Vol. 62, pt.7, p.27
Holloway Tp., NW part	11	N. Strong group	Prospect	Geophysical survey 1950; some peridotite outcrops, no fibre reported; partly patented lands.	
Little Tp., con. VI, lot 1	2	International Nickel Co. of Canada Ltd., The	Prospect	Few stringers of asbestos indicated in diamond-drilling of peridotite; claims abandoned and restaked by others.	
Mann Tp., cons. III-IV, lots 5-11	39	Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey 1950; diamond-drilling 1951; 8 holes 4,790 feet; some fibre in peridotite; claims abandoned and partly resurveyed by other interests.	
Mann Tp., con. III, lots 8-9; con. VI, lots 7-9		International Nickel Co. of Canada Ltd., The, Can. Johns-Manville Co. Ltd., optioned S. group	Prospect	Diamond-drilling 1948, 5 holes; 1951, 1 hole 701 feet, total 2,459 feet; some fibre to 1/8 inch; some claims in con. III patented.	
Mann Tp., cons. IV-V, lots 8-11	27	Northland Mines Ltd.	Prospect	Geophysical survey 1951; some fibre in peridotite.	
Mann Tp., con. V, lot 3	4	Dominion Gulf Co.	Prospect	Diamond drilling, 1 hole 756 feet; harsh picrolite in peridotite; claims abandoned.	
Mann Tp., con. I, lots 1-4	13	Dominion Gulf Co.	Prospect	Diamond-drilling 1951, 1 hole 844 feet, no fibre; 1952, 1 hole 876 feet; 1953, 1 hole 601 feet; claims abandoned and partly resurveyed for other interests.	
Mann Tp. Hanna Tp., SW part Reaume Tp.	63 15 9	P.B. Zevely	Prospect	Diamond-drilling for sulphides 1949, 27 holes 20,000 feet; less than 1 percent fibre in peridotite. Development largely on claims T25903, 25904, Mann Tp.; included in six patented claims, Mann Tp.	
Mann Tp., E part McCart Tp., N part Newmarket Tp., W part	72	Dominion Gulf Co.	Prospect	Diamond-drilling 1950-52, 15 holes 9,982 feet; trace of fibre in serpentinized peridotite; claims abandoned; partly resurveyed for other interests.	
McCart Tp., cons. V-VI, lots 7-10	28	Arrow Timber Co. Ltd.	Prospect	Diamond-drilling 1950-51, 7 holes 3,812 feet; some fibre to 1/4 inch in serpentinized peridotite; some claims patented or leased by Victoria Algoma Mineral Co. Ltd.	
McCart Tp.	13	Quebec Asbestos Corp. Ltd., central group	Prospect	Geophysical survey and diamond-drilling 1950, 1 hole 756 feet.	
McCart Tp.	12	Quebec Asbestos Corp. Ltd., N group	Prospect	Geophysical survey 1950; south half lot 6, concession VI patented, other claims abandoned.	
McCart Tp., con. VI, lot 12	2	Dominion Gulf Co.	Prospect	Diamond-drilling 1951, 1 hole 562 feet; no fibre; claims abandoned.	
McCool Tp., S half con. II, lot 4		F.W. Schumacher optioned to Dominion Gulf Co.	Prospect	Geophysical survey and diamond-drilling 1951; good fibre indicated; no data available; patented lands.	ODM Vol. 61, pt.5, p.27
McCool Tp., con. III, lot 5; con. IV, lots 2-3; con. V, lot 12		Arrow Timber Co. Ltd.	Prospect	Geophysical survey 1950; no fibre reported; patented lands.	ODM Vol. 61, pt.5, p.23
McCool Tp., cons. I-II, lots 7-8	12	Camrose Gold and Metals Ltd.	Prospect	Geophysical survey and diamond-drilling 1950-52, 13 holes 6,759 feet; some thread fibre.	ODM Vol. 61, pt.5, p.23-24
McCool Tp., cons. II-IV, lots 6-12	81	Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey and diamond-drilling 1950-51, 10 holes 6,759 feet; some fibre indicated; 16 claims held in 1953; claims abandoned and partly restaked in 1961 by Can. Johns-Manville Co. Ltd.; geophysical survey 1961; drilled 2 holes, total 1,333 feet; up to 3/16-inch wide fibre veins.	ODM Vol. 61, pt.5, p.24
McCool Tp., cons. V-VI, lots 7-11	32	Dominion Gulf Co., group I	Prospect	Geophysical survey and diamond-drilling 1950-51, 24 holes 16,196 feet; some fibre in dunite; claims abandoned; included in airborne survey by Union Carbide Canada Mining Ltd.	ODM Vol. 61, pt.5, p.24
McCool Tp., cons. I-II, lots 2-3	13	Dominion Gulf Co., group II	Prospect	Geophysical survey and diamond-drilling 1950, 3 holes 1,696 feet; peridotite; no fibre reported; two claims on lot 3, concessions I and II patented; other claims abandoned.	ODM Vol. 61, pt.5, p.24-25

Location	Number of Claims	Name of Property	Category	Remarks	References
McCool Tp., con. III, lots 1-2	5	Dominion Gulf Co., group III	Prospect	Geophysical survey and diamond-drilling 1951, 5 holes 2,903 feet; no fibre reported.	ODM Vol. 61, pt.5, p.25
McCool Tp., cons. II-III, lot 5	16	A.J.B. Gray, Feldman group	Prospect	Geophysical survey and diamond-drilling 1951-52, 3 holes 3,018 feet; some fibre indicated.	ODM Vol. 61, pt.5, p.26
McCool Tp., cons. I-II, lots 1-2	15	Quebec Asbestos Corp. Ltd.	Prospect	Geophysical survey 1950; diamond-drilling 1952, 2 holes 1,218 feet; some fibre in peridotite.	ODM Vol. 61, pt.5, p.26-27
McCool Tp., cons. III-IV, lots 6-7	18	Rayville Matheson Asbestos Ltd.	Prospect	Geophysical survey 1951; diamond-drilling 1951-52, 9 holes 6,031 feet, some fibre in peridotite; claims held under lease.	ODM Vol. 61, pt.5, p.27
McCool Tp., cons. I and III Michaud Tp., con. VI	26	Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey 1963; company retains 3 claims in N half lot 3, con. I, and 3 claims in S half lot 7, con. III, McCool Tp.	
Moody Tp., east-central part Galna Tp.		Mistango River Mines Ltd.	Prospect	Two holes drilled 1962; some fibre under 1/16 inch in ultramafic rock; licence surrendered.	
Munro Tp. Beatty Tp.	45 and 1 vet. lot	Munro Mine, Can. Johns-Manville Co. Ltd.	Production, 1950	Production from open pit on A orebody since 1950. Underground development since 1954. Operations ceased in 1964. Total production over 8.5 million tons.	ODM Vol. 60, pt.8, p.36
Munro Tp., con. V., lots 5-6	8	Mangan-Dyer property, optioned to Quebec Asbestos Corp. Ltd.	Prospect	Geophysical survey and diamond-drilling 1949-50, 3 holes 1,208 feet; some fibre in peridotite; option dropped.	ODM Vol. 60, pt.8, p.41
Munro Tp., cons. IV-V, lots 5-7	12	Potter-Doal property, optioned to Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey and diamond-drilling 1949, 3 holes 594 feet, option dropped; patented lands.	ODM Vol. 60, pt.8, p.41
Munro Tp.,cons. IV-VI, lots 3-5		Quebec Asbestos Corp. Ltd.	Prospect	Geophysical survey 1949, option dropped in 1950. Geophysical survey by Union Carbide Exploration Ltd. in 1965.	ODM Vol. 60, pt.8, p.42
Munro Tp. McCool Tp.	86	Reoplata Mines Ltd.	Prospect	Geophysical survey and diamond-drilling 1950, 3 holes 876 feet.	ODM Vol. 60, pt.8, p.42
Munro Tp., cons. IV-VI, lots 8-9	34	Strongford Asbestos Mines Ltd.	Prospect	Some fibre in dunite outcrops. Ground largely held by Can. Johns-Manville Co. Ltd.	ODM Vol. 60, pt.8, p.42
Munro Tp., cons. III-V, part of lots 9-12	35	Centre Creek Group, Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey in 1961.	
Munro Tp., con. VI, part of lots 9-11		Warden Hill and Northwest Munro groups, Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey in 1962. Drilling 1963-64 on lot 9, con. VI; 6 holes totalling 2,971 feet; fibre veins up to 3/16 inch wide intersected.	
Munro Tp., con. VI, lot 1 McCool Tp. Milligan Tp.	6 2 1	Flagro Mines Ltd.	Prospect	Geophysical survey and diamond-drilling 1951, 1 hole 343 feet; no commercial fibre indicated. Claims abandoned and restaked for other interests.	ODM Vol. 60, pt.8, p.41
Munro Tp., con. VI, lots 3-4 Warden Tp., con. I, lots 4-5	9 4	H.M. Ford property, optioned to Can. Johns-Manville Co. Ltd.	Prospect	Geophysical survey 1949; diamond-drilling 1949-50, 2 holes 1,194 feet; no commercial fibre indicated, option dropped. Resurveyed and drilled by Can. Johns-Manville Co. Ltd. in 1963; 6 claims held on lot 3. Hedman Mines Ltd. holds lot 4, con. VI, Munro Tp. and S half of lots 4 and 5, con. I, Warden Tp.	ODM Vol. 60, pt.8, p.41
Reaume Tp., cons. V-VI, lots 6-9	39	Can. Johns-Manville Co. Ltd., NW group	Prospect	Geophysical survey 1950; no exposures; diamond-drilling 1952, 2 holes 1,437 feet. Claims abandoned and partly restaked for other interests.	
Reaume Tp., con. IV, lots 1-7	35	Can. Johns-Manville Co. Ltd., north-central group	Prospect	Geophysical survey 1950; no exposures; diamond-drilling 1952, 1 hole 800 feet; 1965, by Kerr Addison Mines Ltd.: 2 holes totalling 973 feet. Resurveyed 1970. Claims on lots 5-7, con. IV and V, held by E.F. Carr.	
Reaume Tp., cons. V-VI, lots 1-3 Hanna Tp., cons. V-VI, lot 12	25	Can. Johns-Manville Co. Ltd., NE group	Prospect	Geophysical survey, 1950; no exposures; diamond-drilling 1952, 3 holes 2,491 feet. Claims abandoned.	
Reaume Tp., cons. II-III, lots 7-10	21	Can. Johns-Manville Co. Ltd., S group	Prospect	Geophysical survey 1950; no exposures. Claims abandoned.	
Steele Tp., Peat's Point				Occurrence of minor amount of cross-fibre chrysotile in lenticular veinlets up to 1/2 inch wide in serpentinite. Not of economic interest at present.	ODM GR8, p.44

Location	Number of Claims	Name of Property	Category	Remarks	References
Warden Tp., con. I, lot 6		S.J. Bird, Can. Johns-Manville Co. Ltd.	Prospect	Diamond drilling indicated some fibre in serpentinized peridotite sill. Ground has been acquired by Hedman Mines Ltd.	
Warden Tp., con. I, lots 9-12	11	Can. Johns-Manville Co. Ltd., Stairs group	Prospect	Diamond drilling 1949, 2 holes 500 feet; a little fibre in serpentinized peridotite; claims allowed to lapse. Restaked and surveyed by Can. Johns-Manville Co. Ltd. in 1963-64 (magnetometer survey). Claims abandoned.	
Warden Tp., con. I, lots 4-7 Munro Tp., con. VI, lots 4-6	29	Hedman Mines Ltd., Mangan-Dyer property	Production 1962	Company incorporated in 1956. Drilling and bulk sampling completed in 1960. Production from open pit started in 1962. In 1969 the 600 ton per day plant became operational.	
Frontenac County: Oso Tp., con. V, lot 11		Mrs. T. Duffy farm		Chrysotile in green serpentinized marble; mineralogic interests only.	ODM Vol. 56, pt.6, p.40
Hastings County: Marmora Tp., con. IX, lot 12		Terryon farm		Short cross-fibre, yellow chrysotile in serpentinized marble.	ODM Vol. 39, pt.6, p.29
District of Kenora, (Patricia Portion): Red Lake Area				Some stringers of asbestos in massive serpentine rocks.	ODM Vol. 36, pt.3, p.12 and GR45, p.46
North Caribou Lake, Round Lake and Sandy Lake deposits				Narrow cross-fibre and slip-fibre asbestos veins in serpentinized ultramafics in four locations. Small deposits of poor quality.	ODM MP28, p.36
District of Sudbury: Greenlaw Tp. Hotstone Lake Area				Stringers and veinlets of antigorite and chrysotile asbestos less than 1/4 inch wide in serpentinite.	ODM GR63, p.26,33
Penhorwood Tp., east-central part		Can. Johns-Manville Co. Ltd., Montgomery Lake group	Prospect	Geological survey. Two holes drilled in 1955, total 1,008 feet. Asbestos veins up to 3/16 inch wide in serpentinized peridotite. Patented lands.	ODM Prelim. Geol. Map P.419, 1967
Penhorwood Tp., north-central part		Can. Johns-Manville Co. Ltd., Jehann group. Jehann South Extension and West Jehann group II	Prospect	Geological survey. Lands largely patented.	ODM Prelim. Geol. Map P.419, 1967
Penhorwood Tp., north-east part, Reeves Tp., southeast part	78	Can. Johns-Manville Co. Ltd.	Prospect	Geological survey.	ODM Prelim Geol. Maps P.418,P.419, 1967
Reeves Tp., southeast part	37	Johns-Manville Mining & Trading Ltd., Reeves Mine	Production 1968	Drilling in 1957, 1964, 1965 and 1966. Exploration shaft sunk in 1963-64. Bulk samples taken from two levels were test-milled at Munro Mine in 1964-65. Open pit production started in May, 1968.	ODM Prelim. Geol. Map P.418, 1967
Rennie Tp., Trem Lake-Butler Lake Area		J. McDonough	Prospect	Geophysical survey 1952; diamond drilling 1953, chrysotile in outcrop. Claims abandoned.	
Sothman Tp., W of Pountney Lake		Wrigley Syndicate, optioned to Asbestos Corp., Ltd., 1950	Prospect	Chrysotile fibre to 1/8 inch in peridotite sill. Claims abandoned and partly restaked for other interests.	ODM Vol. 62, pt.6, p.23
District of Thunder Bay: Cirrus Lake Area, NE corner of Cawanogami Lake	18	Can. Johns-Manville Co. Ltd., Fisher claims		Geological and geophysical survey in 1953. Chrysotile asbestos of good quality in veins up to 3/8 inch wide.	ODMNA GR43, p.52-53
Cirrus Lake Area, Goodchild Lake				In 1969, drilling by Mexico Exploration (Canada) Ltd. of 3 holes totalling 1,152 feet indicated peridotite with asbestos veins up to 1/4 inch wide.	
O'Sullivan Lake, Toronto Lake	2	Claims TB167, TB207B		Cross-fibre asbestos veinlets up to 3/16 inch wide in serpentinite. In 1958 Panther International Mining Co. Ltd. drilled 5 holes totalling 1,438 feet in the Toronto Lake deposit.	ODM GR55, p.41
Obonga Lake				Asbestos veinlets in serpentine.	ODM Vol. 39, pt.2, p.54-59
Conmee, Horne and Adrian Tps., Thunder and Gold Lakes		Henry Fabis	Prospect	Asbestos veinlets in peridotite; surface sampling by Quebec Asbestos Corp. Ltd., and McIntyre Porcupine Mines Ltd. in 1951. Geophysical survey and drilling by Acorn Mining Syndicate in 1969 in search of kimberlite.	
Moss Lake Area				Small bodies of serpentinized peridotite with narrow veins of brittle asbestos.	ODMNA GR85, p.19

Location	Number of Claims	Name of Property	Category	Remarks	References
District of Timiskaming:					
Bannockburn Tp., Rahn Lake Area; Montrose Tp., Rahn Lake Area	24	York Asbestos Mines Ltd., formerly Rahn Lake Mines Corp. Ltd.	Production 1937, 1939	Two shafts, some underground development by Rahn Lake Mines; geophysical survey and diamond-drilling 1951-52, 8,500 feet; some fibre indicated. Property held by Planet Asbestos Mines Ltd. in 1968.	ODM Vol. 41, pt.2, p.12
Bannockburn Tp.		Claims MR46941, 44, 45, 52, 53		Geophysical survey and drilling in 1967-68 by 54-36 Incorporated. Minor chrysotile fibre in serpentinized peridotite.	
Benoit Tp., con. III, lot 11		O. Hagen		Three holes totalling 157 feet indicated thread veins of chrysotile in serpentine.	
Cairo Tp.		Demarco claims		Cross-fibre asbestos in serpentinite. Drilled by Asbestos Corp. Ltd. in 1954 (2 holes) and by Rochester and Pittsburgh Coal Co. (3 holes) in 1957. Claims abandoned.	ODM GR51, p.50
Catharine Tp., NE part				Hair and thread veins of chrysotile fibre in serpentinized peridotite. Claims held by Asbestos Corp. Ltd., Can. Johns-Manville Co. Ltd. (1960-62 and 1963-67) and MacGregor (1970). Geological and geophysical surveys by Can. Johns-Manville Co. Ltd.	ODM GR18, p.10
Kerrs Area, Lake Abitibi, Kerrs Tp., cons. II-III, lots 1-2		Area Mines Ltd., including Kraft property	Prospect	Geophysical surveys 1964-65. Kraft property in Kerrs Township drilled in 1963 and 1966; 5 holes totalling 2,031 feet intersected serpentinized peridotite with chrysotile fibre veins up to 3/8 inch wide. Some claims retained by Kraft.	ODM GR37, p.18,23
Knight Tp., Tyrrell-Knight Area				Asbestos veinlets in serpentinized peridotite.	ODM Vol. 41, pt.2, p.39
Langmuir Tp.; Carman Tp., Cochrane District	6	Dominion Gulf Co.	Prospect	Geophysical survey 1951, peridotite with some fibre reported. Resurveyed by Mespi Mines Ltd. in 1966. One hole drilled at 45°; fibre bearing from 6-311 feet.	ODM Vol. 49, pt.4, p.6
Langmuir Tp., SE part	25	Dominion Gulf Co.	Prospect	Geophysical survey 1951; asbestos fibre in peridotite. Claims abandoned and restaked repeatedly for other interests.	ODM Vol. 49, pt.4, p.6
Langmuir Tp., south-central part		Can. Johns-Manville Co. Ltd., LaMotte group	Prospect	Three holes drilled in 1958 totalling 902 feet. Fibre veins up to 1/8 inch wide in serpentinized peridotite. Claims abandoned and restaked for other interests.	ODM Vol. 49, pt.4, p.6
Langmuir Tp., south-central part		Nicolet Asbestos Mines Ltd.		Three holes totalling 120 feet drilled in 1958. Up to 2% asbestos was intersected on claim 41834 in veins less than 1/8 inch wide in serpentinized peridotite. Claims abandoned and restaked for other interests.	
Langmuir Tp., west-central part		McWatters Gold Mines Ltd.		Drilling of 45° hole intersected fibre-bearing serpentinized peridotite from 525-790 feet on claim P50874.	
McArthur Tp., Geikie Tp., Bartlett Tp., Redstone River Area				Asbestos fibre reported in serpentinized peridotite. Drilling of 3 holes (1957, 1959) by Paymaster Consolidated Mines intersected some fibre veins up to 1/4 inch wide. Claims abandoned.	ODM Vol. 35, pt.6, p.44
McElroy Tp., SE part				Some chrysotile to 3/8 inch in serpentinite sill.	ODM Vol. 59, pt.6, p.37
Midlothian Tp., Lloyd Lake		Vanclieaf, Miller, Copeland, and Dillman groups; optioned to Can. Johns-Manville Co. Ltd., later Miller group optioned to Dominion Gulf Co.	Prospect	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. Allied Mining Ltd. acquired option on leaseholds of Asbestos Lloyd Mines Ltd. in 1971.	ODM Vol. 56, pt.5, p.21
Midlothian Tp., central and east-central parts	51	Can. Johns-Manville Co. Ltd.		Aeromagnetic survey flown in 1969.	
Montrose Tp., east-central part	1	W.G. Newman		Drilling in 1954 intersected fibre-bearing serpentinite under heavy overburden.	

Location	Number of Claims	Name of Property	Category	Remarks	References
Semple Tp., SE part part		Dominion Gulf Co., group I	Prospect	Geophysical survey 1952; serpentinized peridotite body indicated. Claims abandoned. Partly resurveyed (1965) and drilled (1965, 1967) by Mining Corp. of Canada (1964) Ltd. in 1965 and by Daniel Mining Co. Ltd. in 1967. Numerous fibre veins up to 1/4 inch were reported.	
Skead, Catharine and McElroy Tps.		Can. Johns-Manville Co. Ltd.		Airborne survey in 1964. Claims abandoned and partly restaked for other interests. Serpentinized peridotite in places veined with asbestos.	ODM Vol. 58, pt.6, p.29

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 [1951]. The geology of Munro township and the Munro mine are described by J. Satterly [1951b]. 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 townships; the A ore body, now being mined, is on lot 10, concession II, Munro township [Satterly 1951b].

"This occurrence of asbestos in Munro township was first reported in 1915. 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 [1951] 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.

" '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 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 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 fratures 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

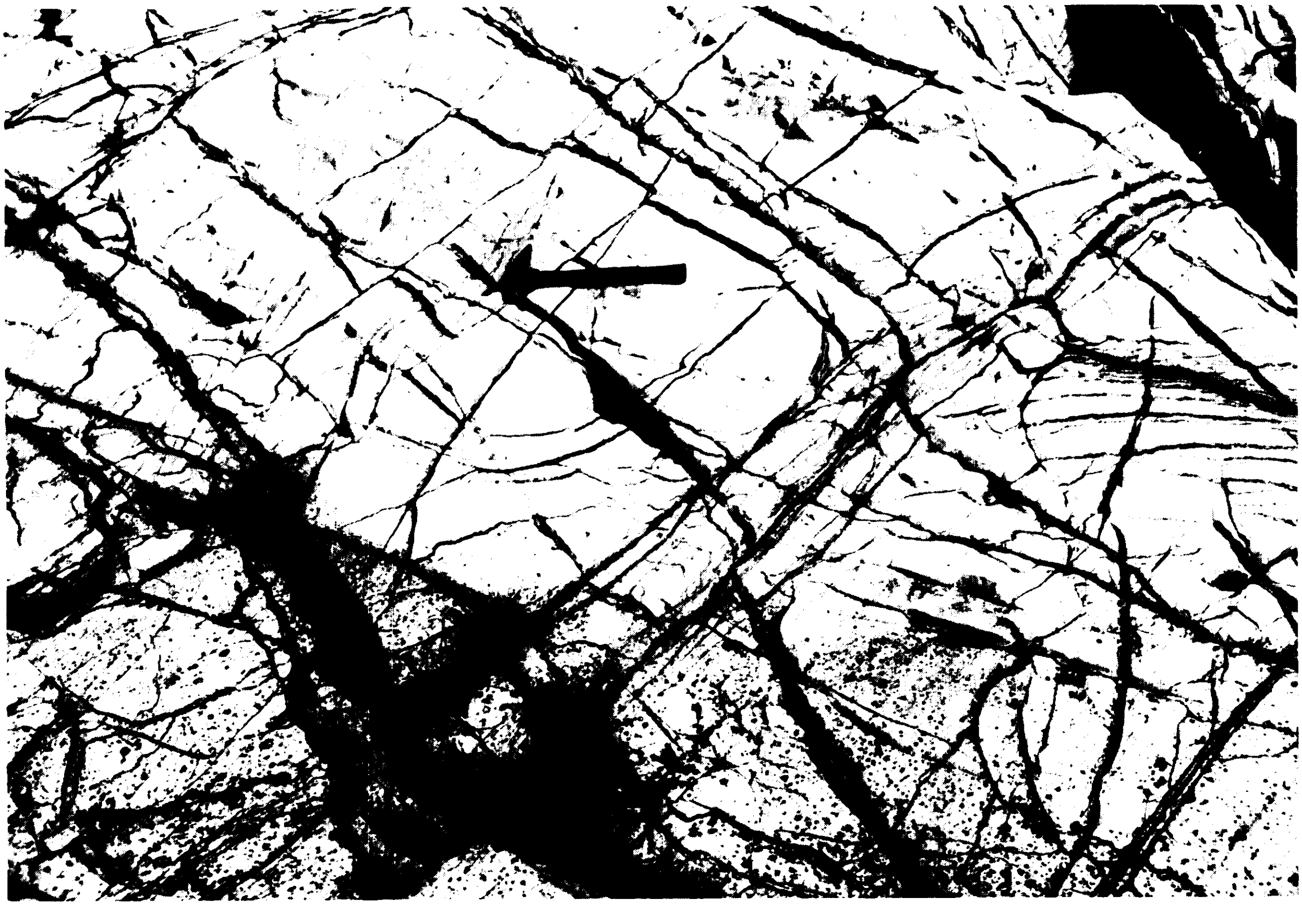


Photo 2 Chrysotile veinlets in serpentinized dunite
(Hewitt and Satterly 1953, p.10)

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 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

Photo 3 Chrysotile asbestos veinlets in serpentinized dunite etc.
(Hewitt and Satterly 1953, p.11)

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 1-1/4 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" (Hewitt and Satterly 1953, p.5, 10-12). Further development of "C" orebody or Barton Creek Mine, accompanied by extensive diamond drilling and bulk sampling, took place in 1956. The shaft was deepened to 571 feet and a level established at 525 feet in 1957. In the same year a total of 38 holes was drilled from surface and some buildings completed on the property. No further developments have been reported but an attempt has been made to connect the existing orebodies through a westerly drive from Munro Mine on the 635-foot level. This drive was discontinued in midyear 1963.

History of Mining

Mining at Munro Mine has been confined to "A" orebody on lot 10, concession II, Munro Township. The open pit on this property came into full production in 1950 with a capacity of more than 500,000 tons annually. Production from the open pit was maintained at a high level reaching a maximum of 774,820 tons in 1957. Open-pit production dropped off in 1958 and ceased in January 1959.

Development of underground operations in "A" orebody had been initiated in 1954. A four-compartment, vertical shaft had been sunk to a depth of 30 feet by the end of that year. In 1955 the shaft was deepened to 822 feet and haulage and crusher levels were established at 637 feet and 693 feet respectively. In 1956 an additional service shaft was sunk and levels were cut at 80, 160, 300, 430, 515, 560, 600 and 613 feet. The depth of the main shaft was increased to 882 feet; 620 tons of ore were produced from underground operations.

In 1957 a total of 66,803 tons were hoisted from underground and increased to 210,654 tons in 1958. Full conversion to underground mining took place in 1959. The total amount of ore hoisted until cessation in 1964 was 3,839,060 tons. This tonnage compares with 5,043,641 tons obtained from the open pit. However, a total of 359,062 tons or over 9 percent of the underground-produced ore was discarded.

Underground development at the Munro Mine continued from 1959 to 1963. An internal shaft sunk from the 637-foot level reached a depth of 949 feet below surface in 1961. It was deepened to 1,204 feet in 1962. Two levels at 737 and 900 feet as well as haulage levels, and a crusher level at 997 feet, were established. Upon connection of the two shafts at the 941-foot haulage level in 1963 a crusher chamber and sumps were added. The B-1 zone, reached by a westerly drive towards "C" orebody, was extensively drilled in 1962.

Underground mining was by blast hole stoping method. Slusher drifts were abolished in favour of mucking machine draw points. Below the 635-foot level the orebody proved too narrow. Mine openings below this level were used for exploration purposes only.

Alterations to the mill for treatment of the underground-produced ore were complete in 1961 but modifications were necessary to cope with the wetter ore. Up until 1964 new equipment was added to the mill. In 1963 grade 7-H, an asbestos fibre used in asphalt mixes, was added to the two grades formerly produced.

A section through "A" orebody, compiled by the Geological Staff of Canadian Johns-Manville Company Limited, is reproduced in Figure 4. It shows the depth of the open pit which has now reverted into a lake of about 3,000 feet long and 700 to 800 feet wide.

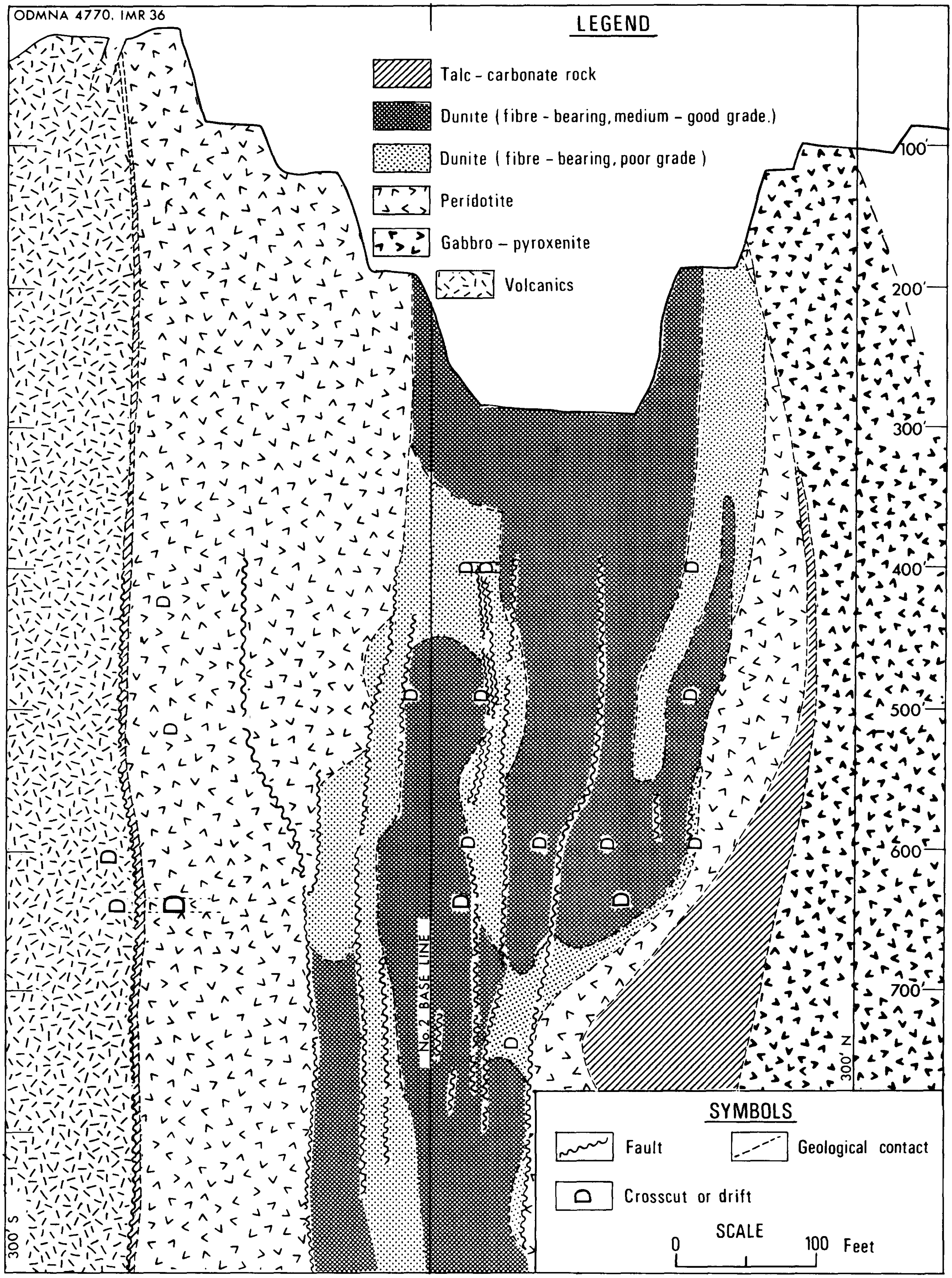


Figure 4 – Section through Munro "A" Orebody (after section by Canadian Johns-Manville Company Limited.)

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" (Hewitt and Satterly 1953, p.12). In 1956 open-pit operations were carried out under option by Metro Asbestos Processors Limited. Seven thousand tons of ore were mined from September to December 1956; 5,200 tons of this ore were treated in the mill on the Sparton Asbestos property. Operations ceased in January of 1957 and a production of some 60 tons of fibre was reported at that time.

"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 1-1/2 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' " (Hewitt and Satterly 1953, p.12).

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" (Hewitt and Satterly 1953, p.12). From April to August, 1952 Van Packer Mines Limited mined 2,932 tons of ore of which 2,822 tons were treated in a re-designed mill. After production of 63 tons of fibre the property reverted back to Teegana Mines Limited.

The property was taken over by Sparton Asbestos Mines Limited, after incorporation of this company in October, 1952. The mill has been used by Metro Asbestos Processors Limited, in 1956-57, for treatment of ore from the Bowman Mine.

"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" (Hewitt and Satterly 1953, p.12-13).

Garrison Property

The Bird group of claims comprises 14 patented claims in the northwestern part of Garrison Township, District of Cochrane, north of Highway 101. 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. Canadian Johns-Manville Ontario Limited, took an option on the property and ultimately purchased it in 1952. A magnetometer survey and drilling of 26 holes totalling 14,923 feet had been completed in 1951. At present Canadian Johns-Manville Company Limited holds patented claims L.56784-5, L.56828-9, L.58457, the Garrison-East and -West groups of claims, and the McVeigh group. Together these claims cover the ultramafic sill stretching across the northern part of Garrison Township. The McVeigh group was acquired in 1956 to secure the down-dip extension of the orebody.

The East and West groups were surveyed magnetically in 1949 and drilled in 1950-51. A total of 21 holes amounting to 13,557 feet was drilled. Fibre-bearing serpentinized dunite was encountered in these holes.

In 1968 development work on the property was contracted. A vertical three-compartment 314-foot deep exploration shaft was sunk on claim L.54626 and the 632-foot level established at a depth of 294 feet below the collar. In August 1969 a total of 7,735 feet of drifting had been carried out. Six crosscuts at 200-foot intervals were established for bulk sampling purposes. Stockpiles of the samples were kept on surface in preparation of shipment to Asbestos, Quebec. In the orebody veins of 1/8 inch to 1/2 inch wide could be observed, in places forming a maximum of 40 percent of the rock volume. Surface drilling was carried out ahead of underground drifting in order to outline the orebody.

"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" (Hewitt and Satterly 1953, p.13).

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

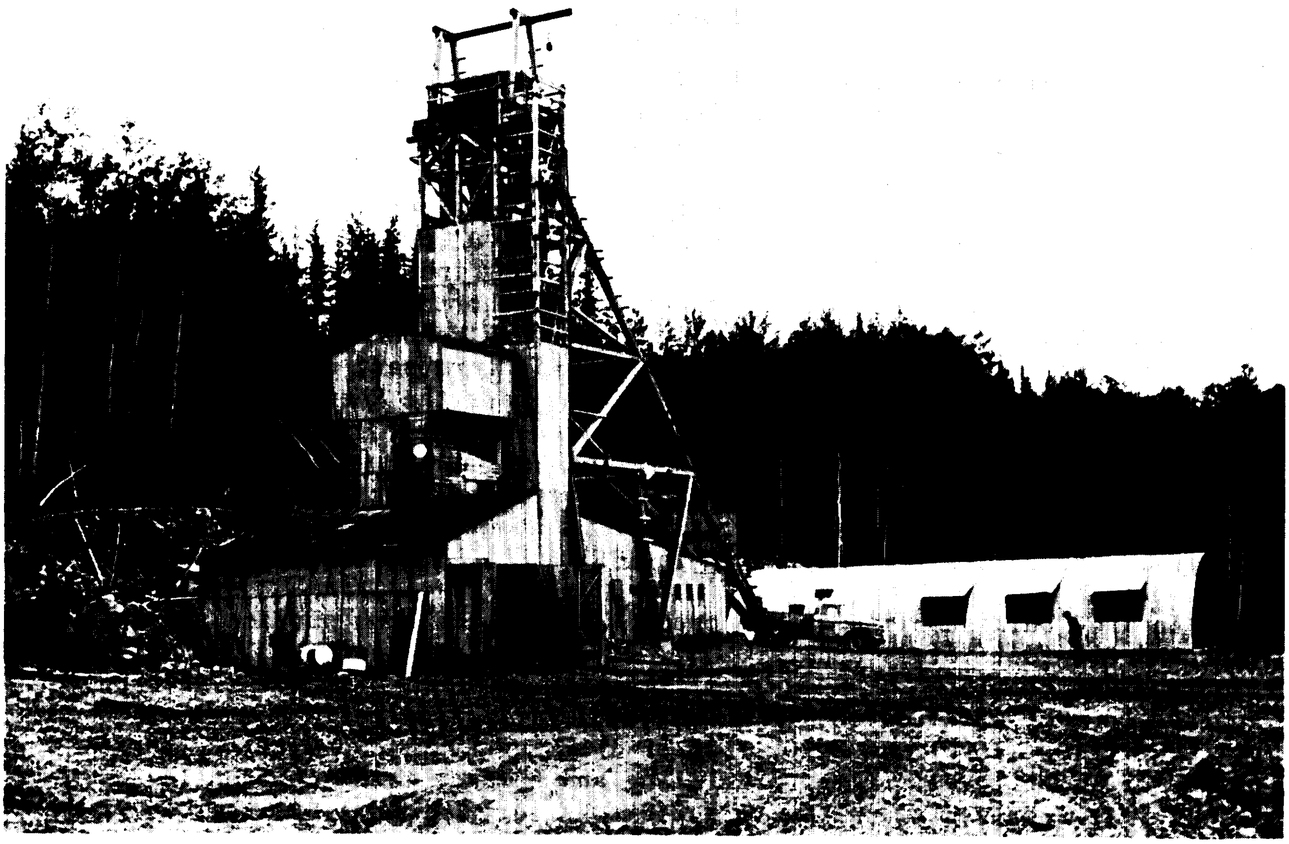


Photo 4 Headframe of exploration shaft,
Canadian Johns-Manville Company Limited, Garrison Township.

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" (Hewitt and Satterly 1953, p.13).

Reeves Mine

The Reeves Mine is operated by Johns-Manville Mining & Trading Limited, a wholly owned subsidiary of Canadian Johns-Manville Company Limited. The property consists of 37 claims in Reeves Township. The claims were originally staked by J.C. Bromley and optioned to Canadian Johns-Manville Company Limited in 1951. The company carried out extensive development work in 1952 and 1953. Adjacent groups of claims in Reeves and Penhorwood Townships were investigated in this period and some have been retained. They include the Jehann, Jehann South Extension and West Jehann Group II in the north-central part and the Montgomery Lake Group in the east-central area of Penhorwood Township. Claims in the northeast section of Penhorwood Township form part of the complex of claims surrounding the Reeves Mine, which includes the Reeves North East Extension, the Reeves Fringe and the Penhorwood Fringe Group.

Access to the Reeves Mine is gained by turning south from Highway 101 on a company constructed access road at a point about 40 miles southwest of Timmins. The access road was built in 1952 and 1953 to facilitate exploration.

In 1964 bulk sampling of the orebody took place from surface and from the 140- and 252-foot levels underground. An exploration shaft had been sunk in 1963 and was completed at a depth of 277 feet in 1964. The total development footage in 1964 amounted to 1,829 feet of drifting and 1,770 feet of crosscuts on the 140-foot level and 2,207 feet of drifting and 1,550 feet of crosscuts on the 252-foot level. Diamond drilling and surface trenching continued in 1965. Test samples, amounting to 8,248 tons in 1964 and 1,848 tons in 1965, were milled in the Munro plant. The exploration shaft had been filled again early in 1965.

In 1966 stripping of overburden and removal of waste rock took place in preparation of open-pit mining. Buildings were raised and equipment installed, some of it transferred from the Munro Mine. The "Johns-Manville Mining & Trading Limited" was incorporated in July of this year to take over operating control of the Reeves Mine.

Stripping, removal of waste rock and construction of buildings continued in 1967. The mill was completed and started to operate on May 3, 1968. A total of 701,521 tons of ore, or 3,500 tons daily, was treated for the remainder of that year. The production rate was increased to 4,400 tons daily in 1969, employing a total of 165 people.

Stripping of overburden on December 31, 1968 amounted to a total of 377,717 tons while 5,124,140 tons of waste rock had been removed.

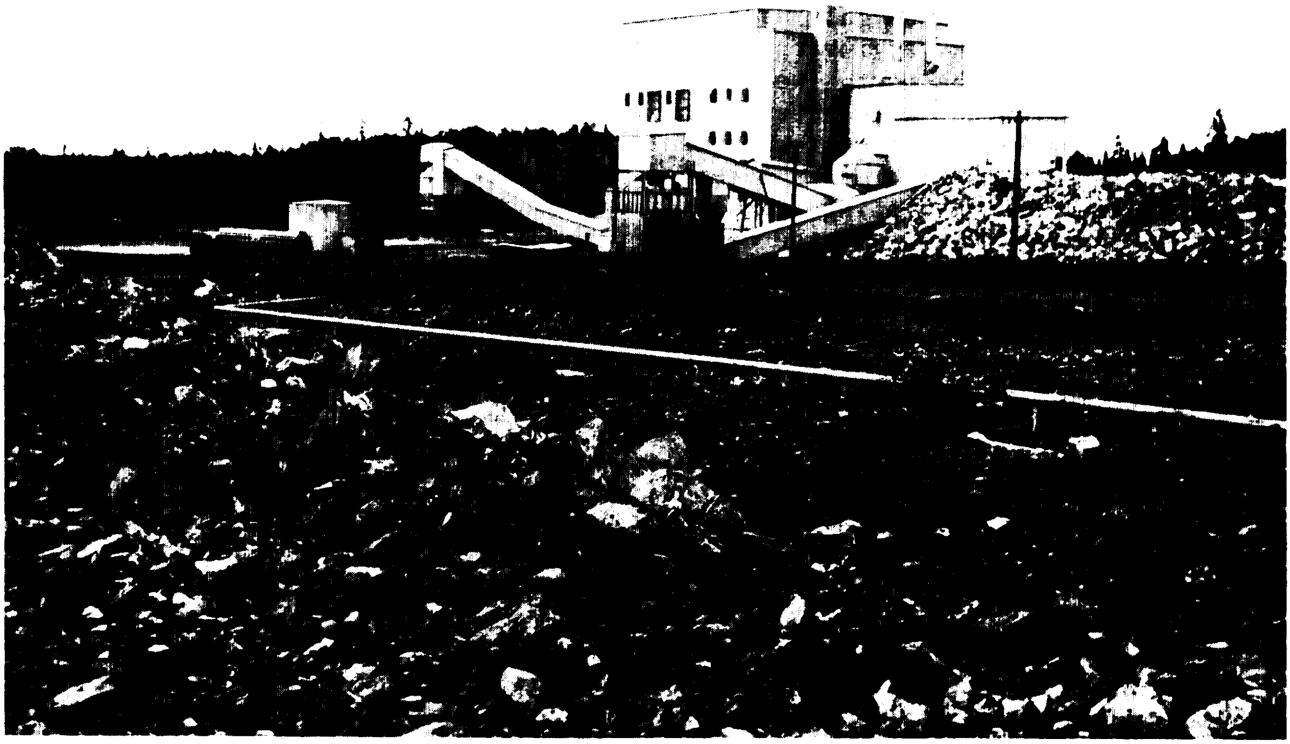


Photo 5 Mill and crusher building, Reeves Mine, Johns-Manville Mining & Trading Limited.

The Orebody

The Reeves asbestos deposit is located within the northern part of a large irregular-shaped serpentinite body striking across the foliation of the country rock. This serpentinite is surrounded by a complexly folded mass of mafic metavolcanics, pyroclastics and metasediments, underlying the southern third of Reeves and most of Penhorwood Townships. Contacts of mafic and ultramafic intrusions in these rocks commonly show carbonatization.

The orebody is described by Milne (1967a) as follows:

"The ore body is roughly wedge-shaped, elongated N60° W, with a length of 2,100 feet and width varying from 750 feet on the west to 200 feet on the east. It is enclosed on the north, west and east by barren serpentinite, about 100 feet wide, in contact with metavolcanics. The south or footwall side of the ore body is marked by an east-west fault zone that dips 45° N in the serpentinite. Some 1 inch asbestos fibre was observed but mostly it is less than 1/4 inch in length. Two steeply-dipping diabase dikes, about 100 feet apart, trending slightly west of north, cut the centre of the ore body".

Shear zones in the serpentinite have been interpreted as shallow north-dipping thrust faults. They are particularly evident in the ore zone and it is believed by Milne that a second foliation or fracture cleavage in the area is related to these shear zones.

The serpentinite in contact with the dikes contains no ore. The barren area forms the separation between the east and west pits on the property.

Mining

Two pits were being operated in 1969. At the time of visiting the fourth 35-foot bench had been started, bringing the floor to a depth of about 130 feet. The ultimate pit size will depend on the depth of ore. An area of 1,800 by 1,300 feet is expected for the west pit which will be mined to a depth of about 550 feet. The east pit is scheduled to reach a depth of only 360 feet. The exploration shaft was originally sunk here with drifts going through the barren zone with diabase dikes to the west pit. Drilling of 5-inch holes in a 17- by 20-foot pattern is carried out with two Gardner-Denver PR 143 air pressure percussion drills mounted on tracks. An aluminized Dupont A4 slurry is used as blasting agent.

Three 3-1/2-cubic yard Bucyrus Erie 71B shovels and one 3-cubic yard Dominion shovel, as well as two 5-cubic yard Caterpillar 980 front-end loaders were used in 1969. Eight 35-ton trucks transported ore, waste rock and tailings on the property. The crusher was fed by front-end loaders from a slip-stockpile.

Milling

Crushing with a primary 48- by 60-inch jaw crusher, a secondary Symons cone crusher and 4 Hazemag impact crushers, combined with screening in three intermittent stages, produces mill feed and 35 to 40 percent tailings. Six to seven percent fibre is aspirated off in the mill by vacuum aspiration. In fiberizing, one impact stage is applied to fibres and two impact stages to the secondary product. Dedusting and blending of sizes is carried out in trommels with sieves.

The general tenor of fibre content in ore runs 2-1/2 to 3 percent with the richest ore up to 4 percent. Different grades of ore from both pits are blended for increased efficiency in milling. An expected future annual production of 40,000 tons will include 15,000 tons of fibre and 25,000 tons of shorts. The bulk of fibre produced is used in asbestos cement sewer pipe and in asphalt. A blended grade, referred to as R35-360, is used in building construction e.g. paper and wallboard.

The products of the mill are pressure packed in 100 lb. bags and shipped by truck to Timmins. Twenty-ton vans handle 20 one-ton pallets (20 bags) each. From Timmins the products are shipped by rail to the plant in Port Credit or to any of eight plants in the United States.

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 [Rickaby 1932] 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 coarse, 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 [Rickaby 1932]. 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 Thetford 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" (Hewitt and Satterly 1953, p.13-14).

In August 1968 leased claims covering Rahn Lake Asbestos Mine were held by Planet Asbestos Mines Limited.

Hedman Mine

Hedman Mines Limited was incorporated in 1956 to take over the Mangan-Dyer group of claims. The property consists of 29 mining claims located in lots 4-7, concession I, Warden Township and lots 4-6, concession VI, Munro Township. The claims were drilled in 1951 by Van Packer Mines of Canada Limited. Short fibre chrysotile asbestos was found in areas of serpentinized peridotite.

Growing demand for short-fibre asbestos prompted further investigation in 1959. A drill program of 33 holes totalling 12,896 feet was completed in 1960. Bulk samples from outcrops, totalling some 15,000 lbs, were collected in the early part of 1960 and sent to the Quebec Department of Mines for testing.

The first units of a pilot mill were installed in rented facilities in Matheson in 1961 and pilot plant production commenced in February 1962. The following information has been made available by the company.

The Orebody

Asbestos showings on the Hedman property occur in east-west-striking sills of mafic to ultramafic rock within a series of mafic volcanic rocks dipping south at approximately 80°. A 500-foot wide zone of "brown weathering serpentine" carries veinlets of chrysotile asbestos over a width of 200 feet. A parallel 500-foot wide zone of differentiated ultramafic rock, separated by mafic lavas, occurs to the north of this serpentinized peridotite. In the latter zone dark green to black serpentinized dunite and peridotite near the edges grade into a core of medium green, granular serpentinized dunite, here referred to as the "white weathering serpentine". This "white weathering serpentine" carries the more important asbestos showings on the property. It is exposed at intervals over a length of 700 feet. Drilling has indicated an additional 600 feet. The apparent width of the granular core, which carries a constant load of thread fibre veinlets, is about 390 feet. Besides cross-fibre veinlets, predominantly less than 1/32 inch wide, some slip-fibre as long as 3/16 inch is encountered in these rocks. Central to the serpentinized core and following it for its total length of exposure is the 30-foot wide so-called "squeeze zone". The rocks in this zone have a contorted appearance.

Transverse faults through the orebody have not been accurately determined but an apparent pronounced offsetting of the north contact of the granular core at one location suggests their presence. The apparent offset here is 70 feet with the west part moving north. The sill is cut by north-trending diabase dikes.

Visual estimation of the tenor of ore is made difficult by the high proportion of extremely fine fibre veinlets. Modifications in the milling technique have allowed up to 77 percent recovery from some of the drill core and as much as 75 percent from bulk samples.

Reserves of indicated plus inferred ore based on an open pit depth of 300 feet were calculated to amount to 10,300,000 tons in 1964. Mineralization is known to extend beyond the projected depth. Occurrences of sulphide mineralization on the property with values in nickel, cobalt and copper have been reported.

Mining

The open-pit mine is located in lot 5 or 6, concession I, Warden Township, about 8 miles north of Highway 101 at a point 14 miles east of Matheson. Part of the access road was constructed by Hedman Mines Limited in 1959, connecting the property with the secondary Centre Hill-Potter Doal access road 3 miles to the southwest. When visited in 1969 the open pit was 28 to 36 feet deep. Rounds were drilled by a Toyo 150-B air pressure drill mounted on a Gardner-Denver wagon. Blasting agents were dynamite, in sticks of 1-3/4 inch diameter, combined with Nylite in equal proportion. A 3-1/2 cubic yard, rubber-tired Trojan 3000 front-end loader was used to load the two 20-ton trucks with ore at the face for transport to the plant in Matheson. The rock surface in the pit area is uneven. It is washed after stripping to prevent contamination of the ore.

Milling

From pilot plant operations it was learned that the ore is most suitable for production of a single uniform grade of asbestos. Some of the long, higher grade fibres are sacrificed in a simplified milling technique producing a clean, uniform, short-fibre asbestos grading in group 7. Its main use is as a filler in plastics. Using this technique, a recovery of 64.85 percent or $28.53 per ton of ore, was made in the pilot plant from January to April 1964.

Construction of the Hedman plant on a 97-acre site, straddling the Ontario Northland Railway 3/4 mile east of Matheson, was undertaken in 1967. The plant was completed in January 1969. It has a crushing and milling capacity of 600 tons daily; 14 grades of fibre are produced which are blended into one uniform product. Up to 50 percent magnetic and other tailings were being stockpiled in 1969. It is hoped that the market will eventually absorb as much as 85 percent of the ore. In 1963 tests were carried out in the laboratory of the Ontario Department of Mines which suggest that some of the products may be useful as a filler material in asphalt, roofing and shingles, floor tile, possibly in pesticides and as a component in secondary magnesium phosphate carriers in the fertilizer industry.

The Hedman plant is fully automated, employing a maximum of 10 men. Moisture in the building is controlled by two air cooling machines. Crushed ore is dried in a gas-fired drier of 25 tons per hour capacity. When dry it is led through a battery of fiberizers in which an air current separates sand from fibre. The fiberizers are a combination of impact crusher and grinder. They consist of a vertical drum in which the core rotates at 2,400 revolutions per minute; ore is centrally fed at the top and thrown against the sidewalls. Blades on the core will rub falling grains against the corrugated surface of the sidewall which consists of a specially designed corrosion resistant metal; sand collects at the bottom of the drum while fibres are lifted off in the rising air current.

The dry, short-fibre product is hard to pack. It is mechanically compressed with paddles in 100 lb. bags. The possibility of shipping in bulk in 20-ton containers is being investigated however.

EXPLORATION IN THE ABITIBI PERIDOTITE BELT AND OTHER AREAS

Development of the Munro Mine has stimulated intensive exploration on the dunite-peridotite sills in a belt stretching 80 miles from Reaume to Holloway Townships as well as on ultramafic rocks in other parts of the province. The work carried out to date is summarized in Table 9.

Exploration in the Abitibi Peridotite Belt

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

Photo 6 Hedman's plant near Matheson

1914 ...[Hopkins 1918]. 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" (Hewitt and Satterly 1953, p.14) and claims have lapsed or they have been restaked for other interests. Ground in lots 6, 7, 8 and 9, concessions IV, V and VI, Reaume Township is partly held by Upper Canada Mines Limited, Prospectors Airways and E.T. Carr. Kerr Addison Mines Limited drilled two holes in 1965, located in north half lot 6, concession IV. A minor amount of asbestos was encountered in these holes.

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 [held] 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 Newmarket 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" (Hewitt and Satterly 1953, p.14).

In 1965 serpentinized peridotite with a few narrow veins of asbestos fibre up to 1/8-inch wide was intersected in a drill hole sunk by Jonsmith Mines Limited on claim P68515, located in lot 5, concession II, Mann Township.

"The Arrow Timber Company, Limited [held] 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" (Hewitt and Satterly 1953, p.14). The patented claims are presently leased by Victoria Algoma Mineral Company Limited; other claims have been dropped by Arrow Timber Company Limited, and some were restaked for other interests.

"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" (Hewitt and Satterly 1953, p.14).

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" (Hewitt and Satterly 1953, p.14).

Dundonald and Clergue Townships

"Dominion Gulf Company [held] a group of 10 claims in lots of 10-12, concession 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 1/16 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. [This ground has been partly resurveyed for other interests. No further drilling is reported.]

"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" (Hewitt and Satterly 1953, p.14-15).

In 1960, 1962 and 1964 geological and geophysical surveys and drilling were carried out on claims in lots 1, 2, 3 and 4, concessions I, II and III, Dundonald Township. Four claims in concession I and 4 claims in concession II are held under lease by Falconbridge Nickel Mines Limited. Alsof Mines Limited investigated claims on the northwest quarter, lot 1 and north half, lot 2, concession III, part of which is patented ground held by E.G. Kelly. Drilling of 28 holes totalling 9,977 feet intersected 1,598 feet of serpentinized peridotite and dunite with up to 1/8-inch wide veins of slip and cross fibre chrysotile on lots 2, 3 and 4, concession I, lots 3 and 4, concession II, and lots 1 and 2, concession III.

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" (Hewitt and Satterly 1953, p.15).

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 ultramafic band, extending for four miles across the township from the Munro boundary contains the Hedman open pit discussed previously. Exploration by S.J. Bird and Canadian Johns-Manville Company Limited, including drilling on lot 6, concession I and, in 1949, on the 11-claim group in lots 9-12, concession I, failed to indicate ore grade. The Stairs group of claims in lots 9-12, concession I was restaked by the company in 1963 and a magnetometer survey was carried out in 1964. The claims were allowed to lapse. 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" (Hewitt and Satterly 1953, p.15). Further investigations, including magnetometer and electromagnetic surveys and drilling of 3 holes with a total depth of 831 feet were carried out in 1963 by Canadian Johns-Manville Company Limited. As a result the south quarter of lot 3, concession I, Warden Township and 6 claims on lot 3, concession VI, Munro Township are now held by the company under lease or as patented ground.

The northwest part of Munro Township including the Northwest Munro, the Warden Hill and the Centre Creek groups of claims, has been investigated by Canadian Johns-Manville Company Limited by electromagnetic methods and drilling in the period from 1961-1964.

Drilling in 1963 and 1964 on lot 9, concession VI intersected a total of 717 feet of asbestos-bearing serpentinized peridotite in 6 holes with a combined footage of 2,971 feet. A fibre showing on this lot carries a 3/4-inch veinlet of asbestos. Narrower veins occur in outcrop in neighbouring lot 8.

"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" (Hewitt and Satterly 1953, p.15). Claims were dropped and the ground was resurveyed by Kennco Explorations Limited in 1965.

"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. [The claims are now patented].

"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. [The claims are now patented].

"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" (Hewitt and Satterly 1953, p.15). Hedman Mines Limited now holds under lease or as patented ground claims covering the south halves of lots 4 and 5, concession I, Warden Township as well as lot 4, concession VI, Munro 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. [Drilling reported in 1954 and 1961 amounted to 3 holes totalling 1,999 feet].

"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" (Hewitt and Satterly 1953, p.15). Part of this ground was covered by a magnetometer survey and drilling was carried out by Canadian Johns-Manville Company in 1961. Two holes, 570 feet and 763 feet deep, drilled on the southeast quarter, lot 7, concession II and southwest eighth, lot 7, concession III respectively, intersected serpentinized ultramafic rock with fibre veins up to 3/16 inch wide underneath heavy overburden.

"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 1 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 1/8 inch wide. Group II of 13 claims in the south-eastern part of the township was explored by geophysical surveys in 1950 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 " (Hewitt and Satterly 1953, p.15-16).

Drilling of one hole in the northwestern part of the township was reported in 1954 by Betts Mining Syndicate Limited. The hole was sunk at an angle of 60° through 258 feet of overburden on the northwest quarter, south half, lot 12, concession VI and intersected 408 feet of asbestos-bearing serpentine. The area has since been included in an airborne survey by Union Carbide Canada Mining Limited.

Ground in the southeastern and eastern parts of the township was included in an electromagnetic and magnetometer survey by Canadian Johns-Manville Company Limited in 1963. Three claims covering the north half, lot 3, concession I, excluding the northwest quarter, are held by this company. Other claims in lot 3, concessions I and II are now patented and held by different parties.

"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, [held] 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" (Hewitt and Satterly 1953, p.16). These claims were allowed to lapse and part of the ground was included in a geophysical survey by Canadian Johns-Manville Company Limited in 1963.

"Rayville Matheson Asbestos, Limited, [held] 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" (Hewitt and Satterly 1953, p.16). Fifteen of the above claims are still held under lease. Claims on the southwest three-eighths, lot 7, concession III were patented in 1965 and are held by Canadian Johns-Manville Company Limited.

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, is largely held and presently under development by Canadian Johns-Manville Company Limited. Previous to the present development initiated in 1968 drilling was reported in 1954 (3 holes totalling 1,000 feet), 1958 (7 holes totalling 3,299 feet) and 1967 (2 holes totalling 620 feet).

"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" (Hewitt and Satterly 1953, p.16). The claims have been patented.

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" (Hewitt and Satterly 1953, p.16). Drilling on this group was reported in 1955. Two holes totalling 1,003 feet intersected 688 feet of asbestos-bearing serpentinized peridotite. Asbestos occurs in veins up to 1/8 inch wide. Estimated fibre content did not exceed 2 percent in the best of these holes.

In 1961, following a geological and geophysical survey, four holes were drilled by Canadian Johns-Manville Company Limited on the Ghost Mountain group of claims located at the north boundary of the township, central to the west half. All holes, totalling 2,554 feet, intersected asbestos-bearing serpentinized peridotite. Fibre veins up to 1/4 inch wide were intersected.

Holloway Township

"Dominion Gulf Company [held] 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)" (Hewitt and Satterly 1953, p.16). Drilling of a 700-foot hole in 1953 indicated a little asbestos fibre from 170 to 230 feet with a maximum length of 1/8 inch. Part of the ground was resurveyed by Canadian Johns-Manville Company Limited and by A.L. Parres in 1965.

"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" (Hewitt and Satterly 1953, p.16).

Kerrs Township

In the period 1963-1966 interest was shown in asbestos prospects in Kerrs Township and in the adjacent area to the east by Area Mines Limited. Geological and magnetometer surveys were carried out in 1963, 1964 and 1965 and drilling took place in 1963 and 1966. Serpentinized peridotite with chrysotile fibre veins up to 3/8 inch wide was intersected on claims on lots 1 and 2, concessions II and III, Kerrs Township. Five holes totalling 2,031 feet have been reported. Of the claims in Kerrs Township a few have been retained by J.E. Kraft, the owner.

EXPLORATION IN OTHER AREAS

In the following section exploration in areas other than the Abitibi peridotite belt will be discussed.

Deloro Township

In 1970 serpentine with traces of chrysotile in thread veins was intersected in drilling totalling 790 feet in the south-central portion of Deloro Township, District of Cochrane. Drilling was undertaken by MacKenzie and Watson on ground previously held by Dominion Gulf Company. An outcrop of serpentine with a 1/8 inch wide vein of asbestos occurs on an adjacent group of claims surveyed by H. Schlesinger.

Skead, Catharine and McElroy Townships

In 1960 and 1964-1965 the Canadian Johns-Manville Company Limited carried out geological and geophysical exploration in Skead, Catharine and McElroy Townships, southeast of Kirkland Lake, District of Timiskaming. The area of interest was surveyed by air in 1965. A total of 111 consecutive claims, 37 in McElroy, 13 in Catharine and 61 in Skead Township were covered by this survey. The geology is characterized by a thick, completely serpentinized peridotite sill which crosses the northern concessions of Skead Township and extends into McElroy Township. In places the peridotite is reportedly veined with asbestos. Asbestos-bearing serpentinized peridotite is also found in sill-like bodies in the northeastern part of Catharine Township. The airborne magnetometer survey confirmed outlines of the geologically mapped serpentinites.

Benoit Township

Exploratory drilling has been carried out on lot 11, concession III, Benoit Township, northwest of Kirkland Lake. Three holes totalling 157 feet intersected thread veins of chrysotile in serpentine. The claims were allowed to lapse.

Cairo Township

In 1954 and 1957 drilling took place in Cairo Township on claim MR25840, located about 1/3 mile southeast of the junction of Highways 65 and 66. Two holes drilled in 1954 and 4 holes drilled in 1957, totalling 1,559 feet, intersected serpentinized peridotite with some cross-fibre asbestos veins up to 1/4 inch wide. The claims were allowed to lapse.

Montrose and Bannockburn Townships

Fibre-bearing serpentinized peridotite was intersected underneath 193 feet of overburden on claim MR18001 in Montrose Township, near the east boundary north of the 4 mile post. Two holes totalling 612 feet were drilled in 1954.

Seven diamond drill holes totalling 1,405 feet intersected some fibre-bearing serpentinized peridotite on claims MR46941, MR46944, MR46945, MR46952, and MR46953 in Bannockburn Township. Drilling corroborated results of a magnetometer survey carried out in 1967 by 54-36 Incorporated.

Midlothian Township

The holdings of Asbestos Lloyd Mines Limited in the Lloyd Lake area, central Midlothian Township, have recently been acquired under option by Allied Mining Corporation Limited. In 1971 this company is reported to have assembled a total of 1,300 acres of mining rights in the area for further exploration and development. Canadian Johns-Manville Company Limited has surveyed adjacent ground to the east. In 1969 an aeromagnetic survey over 51 claims in the central and east-central parts of Midlothian Township was flown in this context.

McArthur Township

Claims were drilled in McArthur Township. Two holes drilled in 1957 and 1 hole drilled in 1959, south and southwest of the centre of the township, showed asbestos in altered peridotite and dunite, in veins up to 1/4 inch wide. The claims were allowed to lapse.

Langmuir Township

In Langmuir Township 3 holes were drilled in 1958 on claims located at the south boundary of the township, south of the centre. Short holes indicated asbestos in veins up to 1/8 inch wide and to a maximum of 2 volume percent. The ground has repeatedly changed hands. The LaMotte group of claims in this area was drilled in the same year by Canadian Johns-Manville Company Limited. Three holes, totalling 902 feet, intersected fibre-bearing serpentinized peridotite with fibre veins up to 3/16 inch wide. The company did not show further interest in the claims.

Semple Township

In Semple Township four diamond drill holes totalling 1,317 feet were drilled in 1967 by Daniel Mining Company Limited on claims in the south-central part. The claims had been investigated by Mining Corporation of Canada (1964) Limited in 1965, in search of sulphides. They form part of a large block of claims originally held by Dominion Gulf Company. The asbestos is reported to occur at the nose of a folded mass of peridotite, underneath heavy overburden. Numerous fibre veins with some veins up to 1/4 inch wide were encountered.

Reeves and Penhorwood Townships

In the Sudbury District exploration was carried out in Reeves and Penhorwood Townships, described in connection with Reeves Mine development.

Conmee Township

In the Thunder Bay District exploratory drilling in 1969 in search of kimberlite in Conmee Township intersected peridotite and some dunite with asbestos in two separate 25-foot sections. A magnetometer survey and a total of 713 feet of drilling on the northeast quarter, south half, lot 11, concession VI were conducted by Acorn Mining Syndicate on a group of claims held by J.A. Aldridge.

Cirrus Lake Area

In the Cirrus Lake area, District of Thunder Bay, near the northeast corner of Cawanogami Lake, M. Fisher staked nine claims in 1951 and another nine in 1953. MacLeod-Cockshutt Gold Mines Limited investigated these claims in 1951 in search of copper-nickel mineralization. In 1953 Canadian Johns-Manville Company Limited optioned the claims and conducted geological and magnetometer surveys on the ground. The occurrence of a serpentinite intrusion in metavolcanic amphibolites was reported by the staff geologist. Outcrops of strong, silky cross-fibre chrysotile in veins up to 3/8 inch wide and of excellent quality, were reportedly encountered in a medium to light green serpentine. The claims were allowed to lapse. Fibrous serpentine was also found in 1953 in a hole drilled by Pick Nickel Mines Limited on claim TB45170, 1-3/4 miles north-northwest of the Fisher claim block. In 1969 drilling by Mexico Exploration (Canada) Limited on claim TB131770, 1/2 mile northwest of the Fisher claim block, intersected sections of peridotite with up to 1/4 inch wide asbestos veins.

Toronto Lake Area

In 1958-1959 the Toronto Lake asbestos occurrences were reinvestigated. They are described by Pye (1968). Isolated outcrops of serpentinite are believed to be possibly part of a single, easterly-striking, lens-like mass up to 500 feet wide, dislocated by a number of northeast- and northwest-striking faults. Thin veinlets of cross-fibre asbestos up to 3/16 inch wide cut the serpentinite. The showings were originally explored by Johnson's Company Limited in 1950. Claims were dropped and restaked by Panther International Mining Company Limited in 1958. In 1959 this company drilled 4 holes, totalling 1,438 feet, on the property. All holes intersected peridotite or serpentinite with at times numerous cross-fibre veinlets 1/16 to 3/32 inch wide.

SELECTED REFERENCES

Abraham, E.M.
1950: Geology of McElroy and part of Boston Townships; Ontario Dept. Mines, Vol. 59, pt.6 (published 1951). Accompanied by Map 1950-3, scale 1 inch to 1,000 feet.

Asbestos (trade journal, issued monthly)
- Stover Publishing Co., 131 North York Rd., Willow Grove, Pa. 19090, USA.

Badollet, M.S.
1948: Research on asbestos fibre; CIMM, Trans., Vol. 51, p.131-134.

1949: Filterability of asbestos fibres used in wet processes; CIMM, Trans., Vol. 52, p.260-264.

1950: Processing asbestos fibres, effects on physical properties; CIMM, Trans., Vol. 53, p.321-325.

1951: Asbestos, a mineral of unparalleled properties; CIMM, Trans., Vol. 54, p.151-160.

1952: Asbestos floats; CIMM, Trans., Vol. 55, p.185-189.

Bateman, A.M.
1923: An Arizona asbestos deposit; Econ. Geol., Vol. 18, p.663-683.

Berger, H.
1963: Asbestos fundamentals; Chemical Publishing Co. Inc., 212 Fifth Ave., New York, N.Y., USA.

Berry, L.G.
1940: Geology of the Langmuir-Sheraton area; Ontario Dept. Mines, Vol. 49, pt.4 (published 1942). Accompanied by Map 49h, scale 1 inch to 1 mile.

Bowles, O.
1934: Asbestos - domestic and foreign deposits; United States Bur. Mines, Information Circ. 6790.

1935a: Asbestos; United States Bur. Mines, Information Circ. 6817.

1935b: Asbestos, milling, marketing and fabrication; United States Bur. Mines, Information Circ. 6869.

1937: Asbestos; United States Bur. Mines, Bull. 403.

1959: Asbestos; United States Bur. Mines, Information Circ. 7880.

Bruce, E.L.
1926: Geology of McArthur, Bartlett, Douglas and Geikie Townships (Redstone River area), District of Timiskaming; Ontario Dept. Mines, Vol. 35, pt.6, p.37-56 (published 1927). Accompanied by Map 35h, scale 1 inch to 3/4 mile.

Bruce, E.L., and Hawley, J.E.
1927: Geology of the basin of Red Lake, District of Kenora (Patricia Portion); Ontario Dept. Mines, Vol. 36, pt.3, p.1-72 (published 1928). Accompanied by Map 36d, scale 1 inch to 1 mile.

Chellson, H.C., and Denovan, R.A.
1941: Operating the World's largest asbestos mine; Eng. and Min. J., Vol. 142, Nos. 9, 10 and 11.

Deer, W.A., Howie, R.A., and Zussman, J.
1962: Rock-forming minerals, 5 vol., Longmans, Green and Co.

Foster, G.K., and Borror, C.D.
1946: Asbestos fibre exploration and production forecasts by core drilling; CIMM, Trans., Vol. 49, p.79-80.

Graham, A.R.
1930: Obonga Lake chromite area, District of Thunder Bay; Ontario Dept. Mines, Vol. 39, pt.2, p.51-60 (published 1931). Accompanied by sketch map.

1932: Tyrrell-Knight area; Ontario Dept. Mines, Vol. 41, pt.2, p.25-61. Accompanied by Map 41b, scale 1 inch to 3/4 mile.

Harding, W.D.
1947: Geology of the Olden-Bedford area; Ontario Dept. Mines, Vol. 56, pt.6, 100p. (published 1951). Accompanied by Map 1947-5, scale 1 inch to 1 mile.

Hendry, N.W.
1951: Chrysotile asbestos in Munro and Beatty Townships, Ontario; CIMM, Trans., Vol. 54, p.28-35.

Hess, Harry Hammond
1939: Island arcs, gravity anomalies, and serpentinite intrusions; 17th International Geol. Congress, Moscow, Vol. 2, p.263-283 (English Translation).

Hewitt, D.F.
1949: Geology of Skead Township, Larder Lake area; Ontario Dept. Mines, Vol. 58, pt.6, 43p. (published 1951). Accompanied by Map 1949-3, scale 1 inch to 1,000 feet.

Hewitt, D.F., and Satterly, J.
1953: Asbestos in Ontario; Ontario Dept. Mines, Industrial Mineral Circ. 1 (revised edition), 23p. Accompanied by sketch map, scale 1 inch to 2 miles.

Hopkins, Percy E.
1918: Notes on Lake Abitibi area; Ontario Bur. Mines, Vol. 27, pt.1, p.200-214.

Jenkins, G.F.
1949: Asbestos; Chapter 2 in Industrial Minerals and Rocks, AIME, New York.

Kindle, L.F.
1931: Kowkash-Ogoki gold area, District of Thunder Bay; Ontario Dept. Mines, Vol. 40, pt.4, p.55-104 (published 1932). Accompanied by Map 40f, scale 1 inch to 2 miles.

Knight, C.W., Burrows, A.G., Hopkins, P.E., and Parsons, A.L.
1919: Abitibi-Night Hawk gold area, District of Timiskaming; Ontario Bur. Mines, Vol. 28, pt.2, p.1-70. Accompanied by Map 28b, scale 1 inch to 2 miles.

Lindell, K.V.
1952a: World's largest asbestos producer uses block caving and concreted slusher drifts; Mining Engineering, Vol. 4, No. 3, p.265-271.

1952b: Rail and truck haulage at Canadian Asbestos open-pit; Mining Engineering, Vol. 4, No. 4, p.364-365.

Low, J.H.
1951: Magnetic prospecting methods in asbestos exploration; CIMM, Trans., Vol. 54, p.388-395.

Marshall, H.I.
1947: Geology of Midlothian Township; Ontario Dept. Mines, Vol. 56, pt.5, 24p. Accompanied by Map 1947-4, scale 1 inch to 1,000 feet.

Maynard, J.E.
1929: Oba area, District of Algoma; Ontario Dept. Mines, Vol. 38, pt.6, p.114-125 (published 1930). Accompanied by Map 38c, scale 1 inch to 2 miles.

Messel, M.J.
1947: Examination and valuation of chrysotile asbestos deposits in massive serpentine; AIME, Tech. Pub. 2285.

Milne, V.G.
1967a: Reeves Township, District of Sudbury; Ontario Dept. Mines, Prelim. Geol. Map P.418, scale 1 inch to 1/4 mile. Geology 1966.

1967b: Penhorwood Township, District of Sudbury; Ontario Dept. Mines, Prelim. Geol. Map P.419, scale 1 inch to 1/4 mile. Geology 1966.

Osborne, F.F.
1930: Non-metallic mineral resources of Hastings County; Ontario Dept. Mines, Vol. 39, pt.6, p.22-59 (published 1931). Accompanied by Map 39h, scale 1 inch to 3.95 miles.

Piuze, L.C.
1950: Conversion to truck haulage at Asbestos Corporation's British Canadian Mine; CIMM, Trans., Vol. 53, p.218-224.

Pye, E.G.
1968: Geology of the Crescent Lake area, District of Thunder Bay; Ontario Dept. Mines, GR55. Accompanied by Map 2100, scale 1 inch to 1 mile.

Rickaby, H.C.
1932: Bannockburn gold area; Ontario Dept. Mines, Vol. 41, pt.2, p.1-24. Accompanied by Map 41a, scale 1 inch to 3/4 mile.

Riordon, P.H.
1957: The asbestos belt of southeastern Quebec; p.3-8 in The geology of Canadian industrial mineral deposits, 6th Commonwealth Min. and Met. Congress, 247p.

Rogers, W.R., and Young, A.C.
1927: Mines of Ontario in 1926; Ontario Dept. Mines, Vol. 36, pt.1, p.75-178 (published 1928).

Ross, James Gordon
1931: Chrysotile asbestos in Canada; Canada Dept. Mines, Mines Branch Pub. 707.

Ross, J.G., and Staff
1934: Block-caving at the King Mine; CIMM, Trans., Vol. 37, p.184-218, 358-364.

Rowe, R.C.
1939: Mining and milling operations of the Canadian Johns-Manville Company, Limited, at Asbestos, P.Q.; Canadian Min. J., Vol. 60, No. 4, p.185-212.

Satterly, J.
1951a: Geology of Harker Township; Ontario Dept. Mines, Vol. 60, pt.7, 47p. (published 1952). Accompanied by Map 1951-4, scale 1 inch to 1,000 feet.

1951b: Geology of Munro Township; Ontario Dept. Mines, Vol. 60, pt.8, 60p. (published 1952). Accompanied by Map 1951-5, scale 1 inch to 1,000 feet.

1952: Geology of McCool Township; Ontario Dept. Mines, Vol. 61, pt.5, 30p. (published 1953). Accompanied by Map 1952-2, scale 1 inch to 1,000 feet.

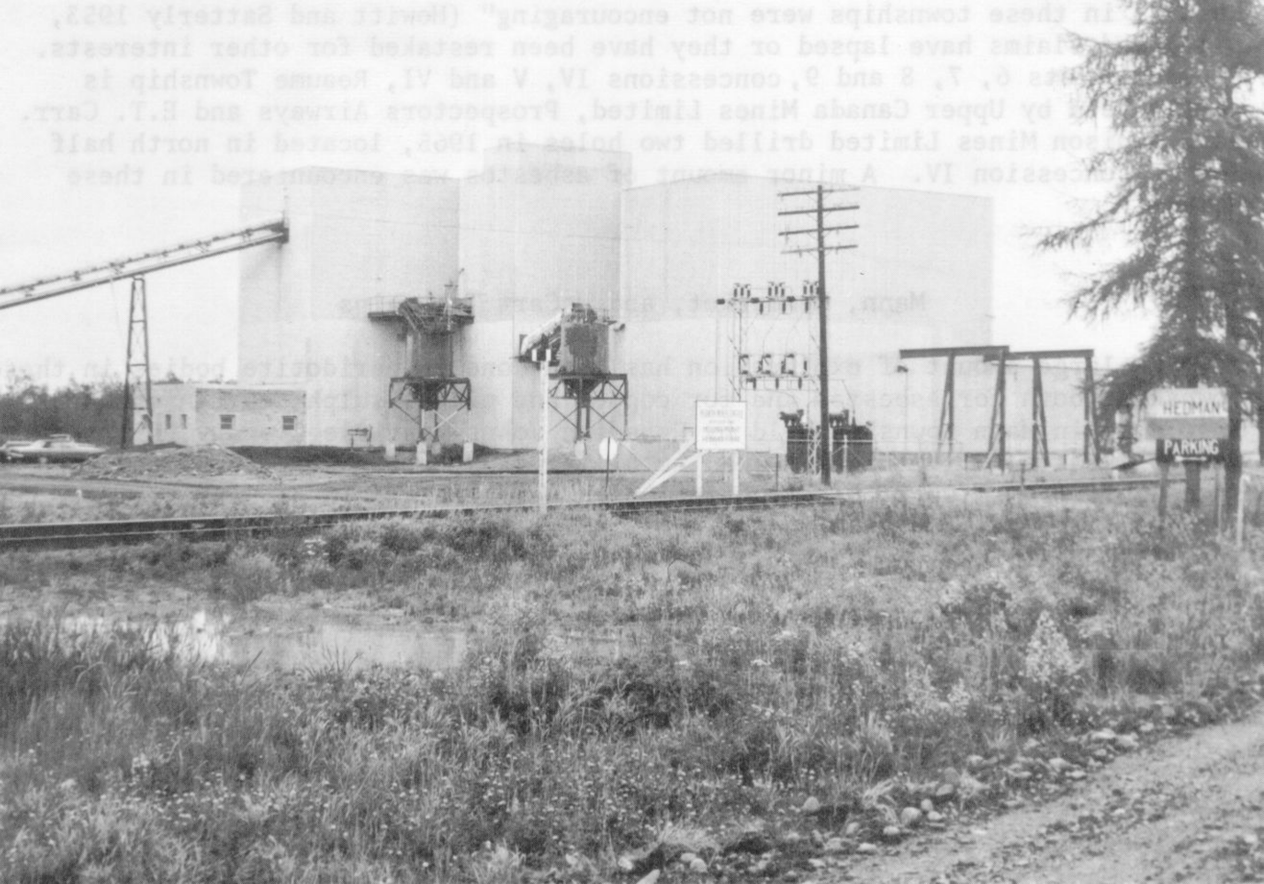
Sherman, G.
1950: Review of progress in the caving of asbestos ore; AIME, Trans., Vol. 187, p.467-474.

Sherman, G., *et al.*
1941: Caving at Johnson's asbestos mine; CIMM, Trans., Vol. 44, p.453-477.

Thayer, T.P.
1966: Serpentinization considered as a constant-volume metasomatic process; American Min., Vol. 51, p.685-710.

Watson, R.J.
1928: Platinum-bearing nickel-copper deposit on Lower Shebandowan Lake, District of Thunder Bay; Ontario Dept. Mines, Vol. 37, pt.4, p.128-149 (published 1929). Accompanied by sketch map, scale 1 inch to 1 mile.

Winer, A.A., and Sirois, L.L.
1967: An investigation of the surface of chrysotile asbestos fibre; Canada Dept. Energy, Mines and Resources, Mines Branch. Reprint Series RS49, 31p.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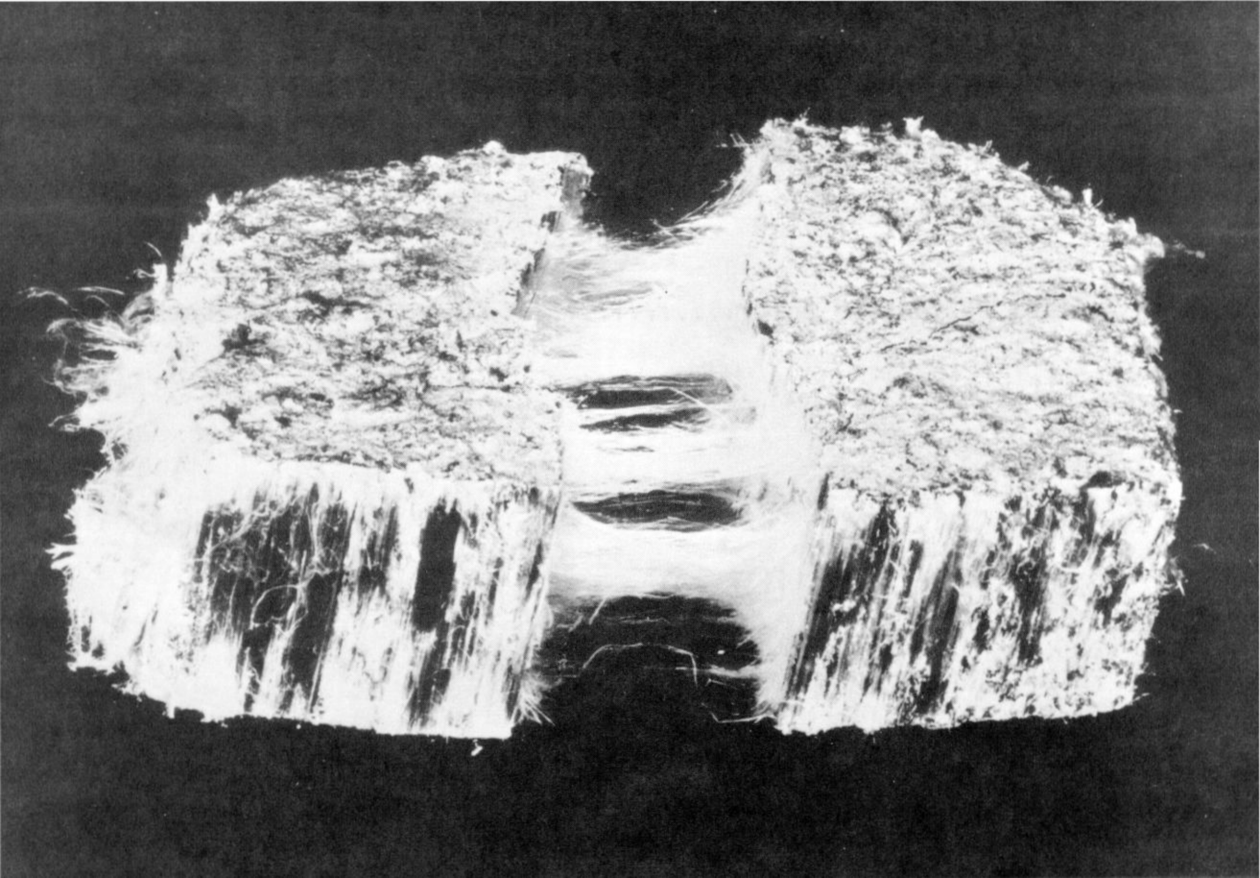

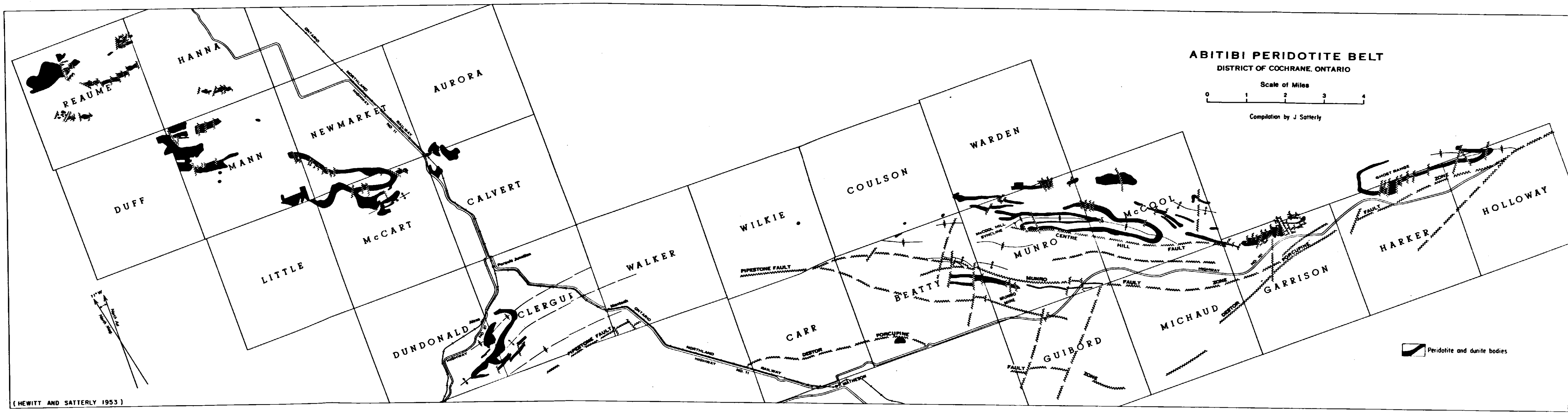

ABITIBI PERIDOTITE BELT
DISTRICT OF COCHRANE, ONTARIO
Scale of Miles
0 1 2 3 4
Compilation by J. Satterly
Peridotite and dunite bodies
(HEWITT AND SATTERLY 1953)
REAUME
HANNA
AURORA
NEWMARKET
MANN
DUFF
CALVERT
McCART
LITTLE
DUNDONALD
CLERGUE
WALKER
WILKIE
COULSON
WARDEN
MUNRO
McCOOL
BEATTY
CARR
GUIBORD
MICHAUD
GARRISON
HARKER
HOLLOWAY
PIPESTONE FAULT
DESTOR
PORCUPINE
FAULT
ZONE
MUNRO ESKER
McCOOL HILL SYNCLINE
CENTRE HILL FAULT
GHOST RANGE
ONTARIO NORTHLAND RAILWAY
HIGHWAY NO. 11
MATHESON