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Tasmania

DEPARTMENT OF MINES

GEOLOGICAL SURVEY REPORT

No. 8

Asbestos in the Beaconsfield District

BY

A. MCINTOSH REID, Assistant Government Geologist

Issued under the authority of

The Honourable Sir NEIL ELLIOTT LEWIS, K.C.M.G.
Minister for Mines for Tasmania



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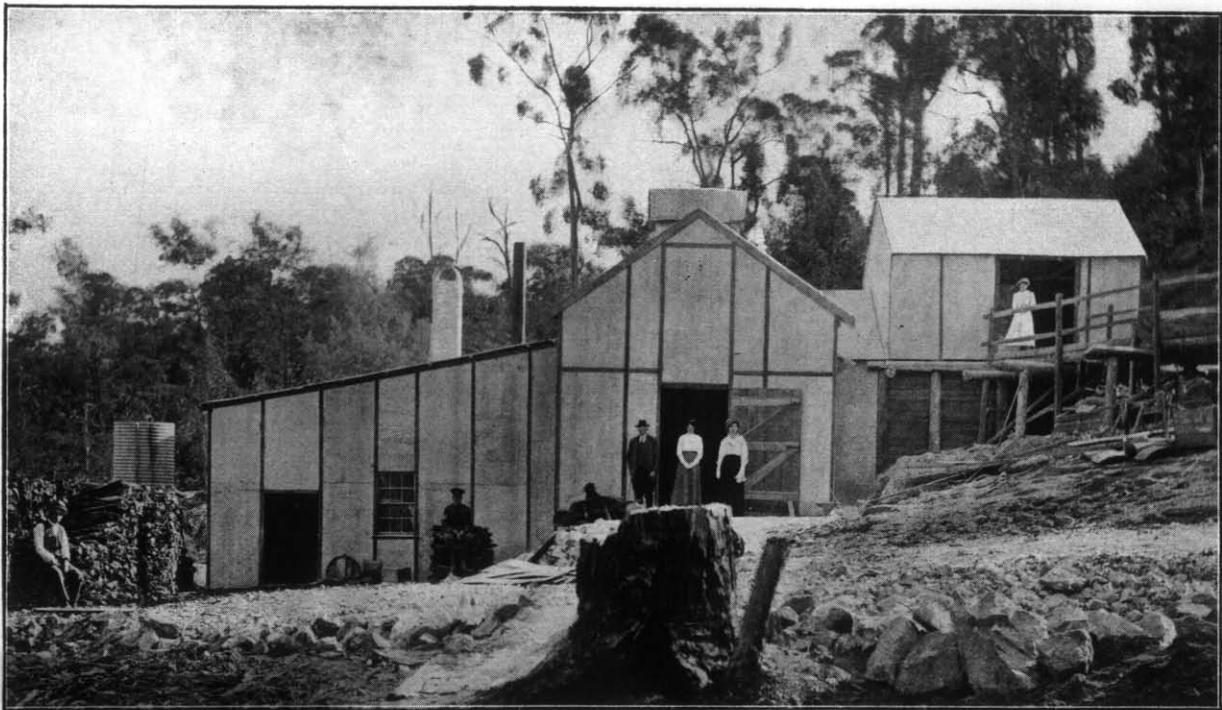


PHOTO. 1.—MILL BUILDING, DURABESTOS MINE.

Frontispiece.

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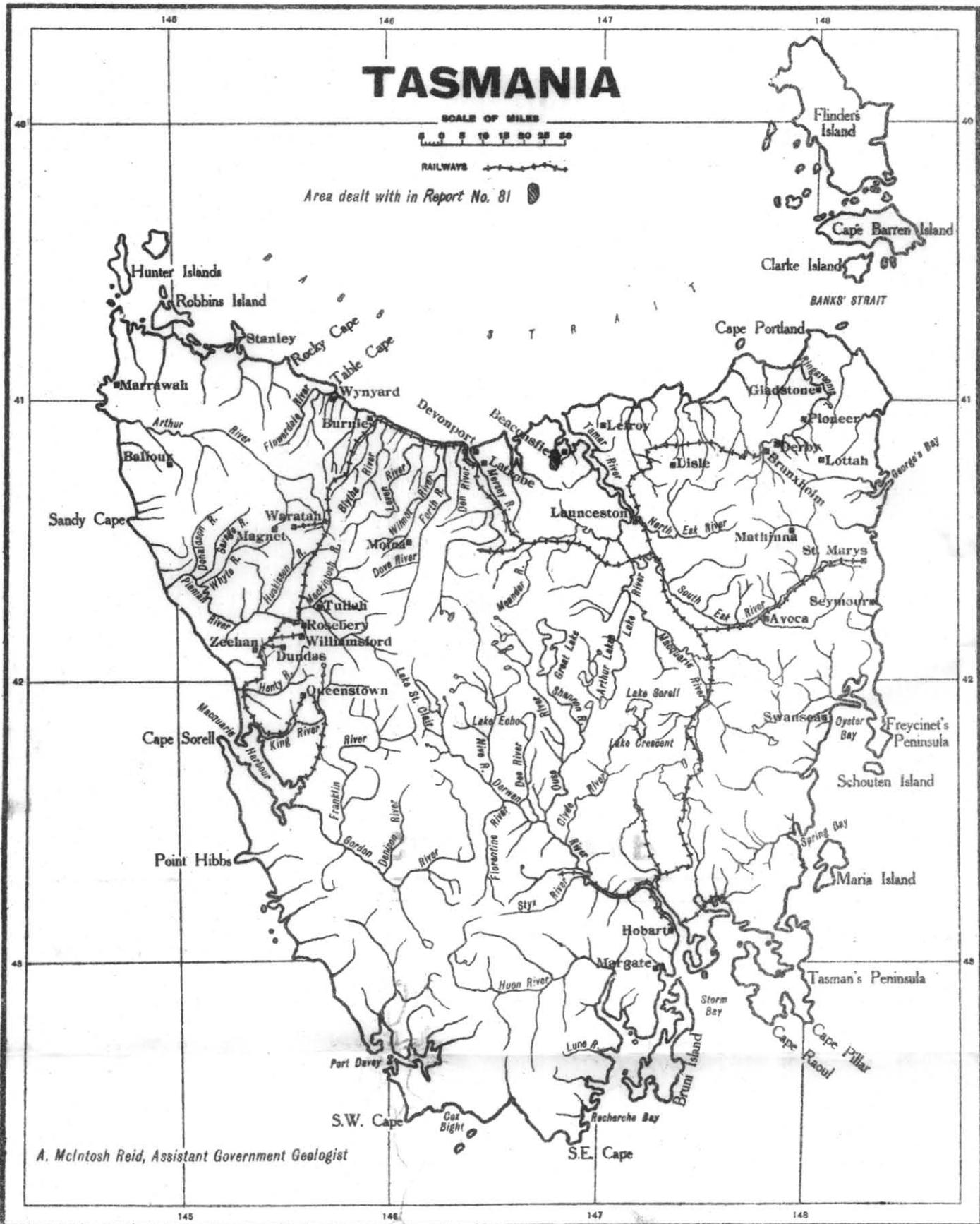
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TASMANIA

SCALE OF MILES
0 5 10 15 20 25 30

RAILWAYS

Area dealt with in Report No. 81



A. McIntosh Reid, Assistant Government Geologist

LOCALITY MAP

Photo Alographical by John Vail Government Printer Hobart Tasmania.

5 cm

Asbestos in the Beaconsfield District.

I.—INTRODUCTION.

A.—PRELIMINARY STATEMENT.

THE occurrence in the Beaconsfield district of the economic minerals which form the subject of this discussion has been known for over 30 years. As far back as 1899 an attempt was made by the Australian Asbestos Company to work these deposits on a commercial scale, but developments were not up to expectation, and in 1901 operations ceased. The great difficulty experienced in establishing a local market for this short fibre was another contributing factor in the failure of the company. In 1916 a further incentive was given to asbestos production in Australia by the demand for local material following the stoppage of supplies from Canada, the surplus output from that country being diverted to European markets. This led to a renewal of interest in known deposits, and attention was again directed to the Beaconsfield asbestos area. The Durabestos Company, of Sydney, after careful examination of the deposits, undertook active development on the most important properties. They erected there the first plant established in Australia for the concentration of asbestos ores, and for two years the operations of the company were entirely successful. Latterly, owing in a large measure to the irregularity and capriciousness of its occurrence, the cost of production of chrysotile-asbestos has increased by 50 per cent.; and, in consequence, it is the intention of the company at present exploiting the deposits to cease operations here and transfer the plant to another locality. Since the erection of the milling plant several other workings have sprung into existence, some of which give promise of satisfactory development.

The main objectives of this examination are to ascertain whether or not these apparently irregular, scattered occurrences constitute one continuous ore-channel and whether a modification of the methods employed in the exploitation of the deposits would make possible the re-establishment of the industry on a profitable basis.

B.—LOCATION AND AREA.

The Beaconsfield district is situate on the west side of the River Tamar, in the extreme north-eastern part of the County of Devon. The township of Beaconsfield is the main centre of population, and Beauty Point, 4 miles distant, is the nearest port. About $2\frac{1}{2}$ miles west of the township is the asbestos field, which extends between 4 and 5 miles in a north-north-westerly direction, and 1 mile from east to west. The actual area covered by the field is consequently very small.

II.—LITERATURE.

The literature issued by the Geological Survey on this district is rather extensive. In the earlier publications relating to the geology and ore-deposits, brief mention only is made of the occurrence of asbestos in this area; but recently works solely confined to this subject have been published. The following publications relate to the district generally, and the asbestos deposits in particular:—

- (1) Gould, Charles: Report on the Country near Ilfracombe, in West Tamar District. (August, 1866.)
- (2) Twelvetrees, W. H.: Report on the Asbestos Deposits, Anderson's Creek, near Beaconsfield. (November 20, 1899.)
- (3) Twelvetrees, W. H.: Report on the Mineral Deposits of the Districts of Beaconsfield and Salisbury. (March, 1903.)
- (4) Twelvetrees, W. H.: Asbestos at Anderson's Creek.—Mineral Resources No. 4 of Geological Survey of Tasmania. (May 18, 1917.)

III.—GENERAL GEOLOGY.

The oldest formations in this area consist of schists and slates of Pre-Cambrian age. These strata occupy the whole of Asbestos Range on the west side of the serpentine belt, and extend northward to the sea. The range of hills which they occupy does not contain deposits of asbestos, and probably it owes its name to the proximity of the asbestos area.

On the east side are conglomerates, sandstones, and quartzites, tentatively ascribed to the Siluro-Ordovician. They belong to the gold-bearing series of Beaconsfield, and are parts of very extensive formations. The asbestos belt consists of serpentinised peridotites and pyroxenites, with small associated dykes of granitoid rock of an acid character. The basic and ultra-basic members compose the first differentiate of the stock magma which intruded the older sedimentary strata in Devonian time. They were themselves penetrated subsequently by the final differentiate represented by granitic dykes. The area occupied by these igneous rocks is confined to a belt extending in a north-north-westerly direction for 5 miles and about 1 mile from east to west. Although serpentinisation has been general over this comparatively small area, the original rocks have been found in places in their unaltered condition.

In the centre of the serpentine area are several disconnected knobs, which form a broken, crescent-shaped ridge of hills about $\frac{3}{4}$ -mile long and 10 to 12 chains wide. These knobs are occupied by a dark-coloured, granular rock, possessing the physical and mineralogical characters of granite.

This rock has been examined by W. H. Twelvetrees, Government Geologist, who makes the following comments thereon:—

“ The microscopic characters are those of a schist or gneiss; the constituent minerals are biotite, muscovite, quartz, felspar, with minute grains of apatite, and occasionally a crystal or two of tourmaline. Indications of strain and crushing are present.”

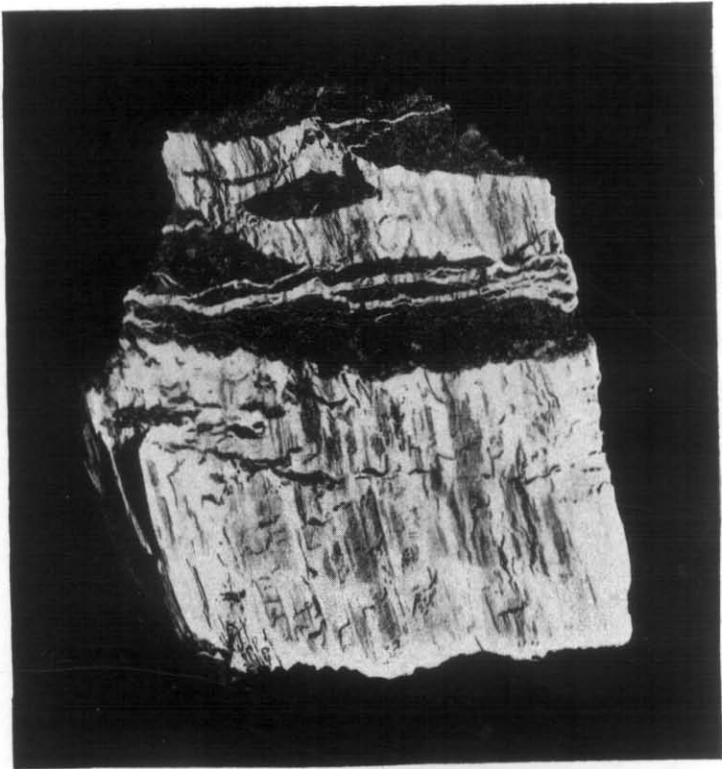
There has been considerable diversity of opinion concerning this rock. Some authorities consider it an altered sediment, the change being due to the effects of contact-metamorphism; others regard it as a crushed aplite or granite. The macroscopic appearance lends colour to the

first supposition, as it has generally the foliated characters of schists and the directional arrangement of its constituent minerals is very marked. However, in places schistosity is hardly developed at all; and its massive aspect is particularly striking.

The main components are those of a normal granite, of which tourmaline and apatite are common accessory minerals. Again, its occurrence, in proximity to the largest deposits of chrysotile, in the form of a dyke associated with similar masses of aplitic granite, suggests an igneous origin. Furthermore, the metamorphosis of the sandstone at the serpentine contact has resulted only in the formation of chalcedony, and the occurrence in this district of rock similar to that occupying Settlers' Hills has not been observed. The only difficulty presented in arriving at the conclusion that the rock is of igneous origin is to account for the development of such a high degree of schistosity, for with the Devonian ends the last great period of diastrophism. It is considered that schistosity was induced in the rock during the serpentinisation of the encasing peridotites. The alteration of olivine, one of the components of peridotite, to serpentine has been estimated to result in an increase of volume amounting to over 30 per cent. There must have been then a very great expansion even if a large portion of the silica and iron content of the peridotite were carried off during serpentinisation, and this expansion was certainly sufficient to effect a complete change in the structure of the encased granitic rock. Its schistosity and its appearance generally of a rock which has been subjected to intense strain has a parallel in the evidences of great movement exhibited in the serpentine by the intricate arrangement of slickensided surfaces and gliding-planes.

Small intrusions of granite occur at many other points on this field, notably near W. B. Smith's prospect, and in the south-east corner of P. Charriol's section, and again in the southern part of the field near the northern boundary-line of W. Barnes' property. These are mostly aplitic varieties. A little south-west of Nicholls' Bridge is an outcrop of granitoid rock, consisting of large idiomorphic crystals of hornblende set in a groundmass composed largely of turbid felspar and a little quartz; as normal hornblende granites occur in the vicinity, this appears to be an extraordinary development of the same rock, probably affected by the basic character of the serpentine, which it intrudes.

Remnants of Permo-Carboniferous limestone formations outcrop on James' land, about 1 mile northward of the main quarries on the eastern fringe of the serpentine belt. Isolated patches of Tertiary sediments occupy the surface here and there, and Quaternary gravels extend on both sides of Anderson's Creek.



A. M. Reid Photo.]

To face page 7.

PHOTO. 4.—PICROLITE IN PYROXENITE—CROSS-VIEW STRUCTURE.
($\frac{1}{2}$ nat.)

5 cm

IV.—ECONOMIC GEOLOGY.

A.—MINERALOGY OF THE ORE-DEPOSITS.

Asbestos.—In the Beaconsfield district two fibrous forms of serpentine are highly developed—(1) picrolite; (2) chrysotile. These varieties of serpentine, so similar in chemical composition, differ radically in external appearance and in physical properties.

Picrolite is a peculiar splintery variety of no commercial value. It closely resembles coarse-fibre asbestos, and is commonly found in association with chrysotile. The colour is usually white, sometimes grey, and light to dark-green shades are very common. It possesses a columnar or incipient fibrous structure; and, although brittle, it can be split into long splinters, in which condition it greatly resembles wood. Fibre up to 12 inches long occurs in veins more or less parallel to the walls, and perpendicular thereto it has been found over 3 inches long. Like chrysotile, it often occurs "frozen" to the walls in the cross-vein type, but in the slickenside or slip-fibre form it is separated therefrom by talcose material, and is easily detached.

An analysis of the splintery variety showed the following content:—

	Per Cent.
Silica (SiO_2)	37.90
Ferric oxide (Fe_2O_3)	12.40
Alumina (Al_2O_3)	3.20
Lime (CaO)	0.86
Magnesia (MgO)	33.60
Water (H_2O)	12.20

Picrolite is found in greatest abundance associated with partly serpentinised pyroxenites.

Chrysotile comprises the bulk of what is locally termed asbestos, and is of far greater economic importance than the other fibrous minerals occurring here. The fibres are occasionally up to 4 inches in length, usually pale-green in colour, silky, and very soft to touch. The length of fibre is subject to great variation, but the widths of particular veinlets are remarkably regular. In the main deposits the bulk of the fibre occurs from $\frac{1}{8}$ -inch to $\frac{3}{4}$ -inch

in length, but it is found from the merest thread up to 4 inches. The longer fibre is very often divided by thin seams of serpentine. Thin soft films separate the chrysotile-asbestos from the walls of the veins, thereby rendering the material easily detachable from the rock.

A comparison of the composition of the chrysotile occurring here and that obtained in Canada is given in the following table:—

Constituent.	Beaconsfield.	Canada.
SiO ₂	42.80	39.20
Al ₂ O ₃	2.24	0.99
Fe ₂ O ₃	5.04	2.97
FeO		
MgO	41.86	44.02
H ₂ O	8.46	8.85
	<hr/> 100.40	<hr/> 100.05

As a rule, the iron oxide content of the Canadian fibre is only half that quoted in the analysis given here. In other respects the composition is very similar.

Another variety of chrysotile is a white, fluffy mineral occurring usually in the form of slip-fibre several inches long. So much magnetite is associated with this kind that it has not the same properties of high tensile strength, flexibility, and fineness of fibre possessed by the pale-green mineral.

Amphibole-asbestos, in origin, appearance, and composition, is quite distinct from chrysotile. It is true asbestos, a fibrous variety of hornblende, and it is found closely associated with pyroxene and hornblende rocks. It is found 3 to 12 inches long, occupying well-defined fissures, which extend over considerable distances.

The analysis of this mineral, made by W. D. Reid, Government Assayer, is as follows:—

	Per Cent.
SiO ₂	54.88
MgO	18.94
CaO	12.15
Fe ₂ O ₃	10.04
Al ₂ O ₃	2.60
H ₂ O	1.20



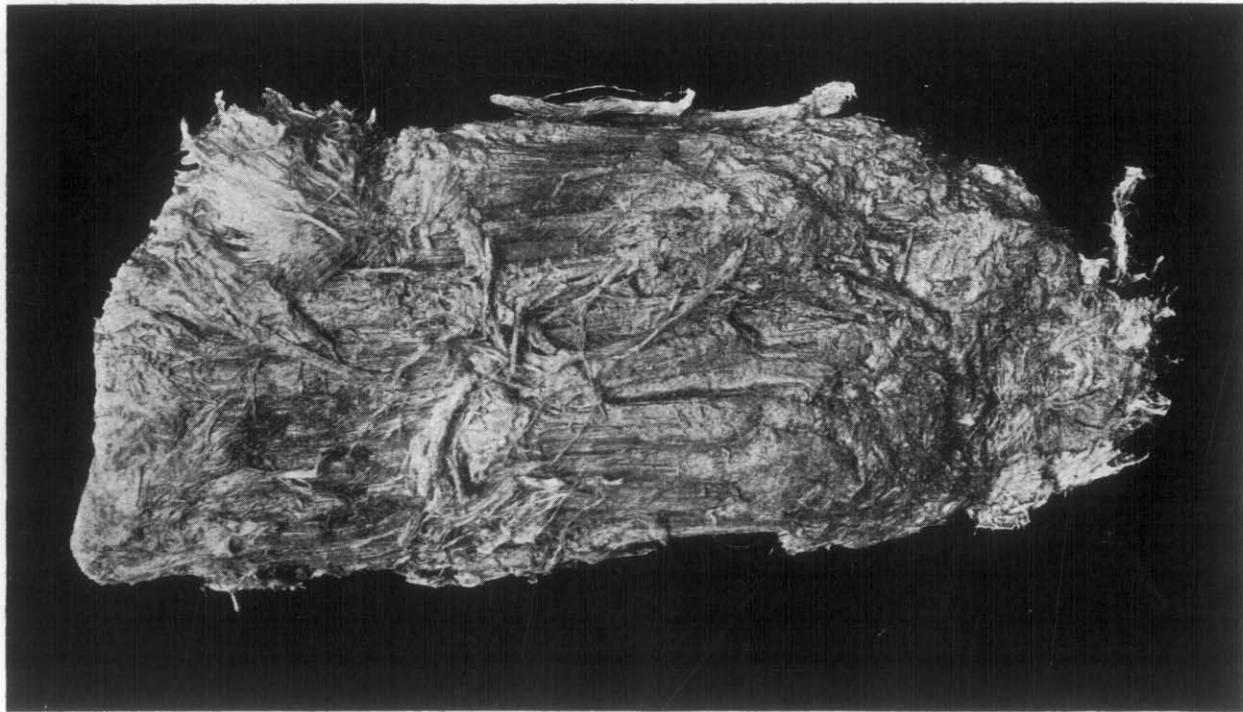
A. M. Reid Photo.]

PHOTO. 5.—PICROLITE—PARALLEL-VEIN STRUCTURE. ($\frac{1}{2}$ nat.)

To face page 8.



5 cm

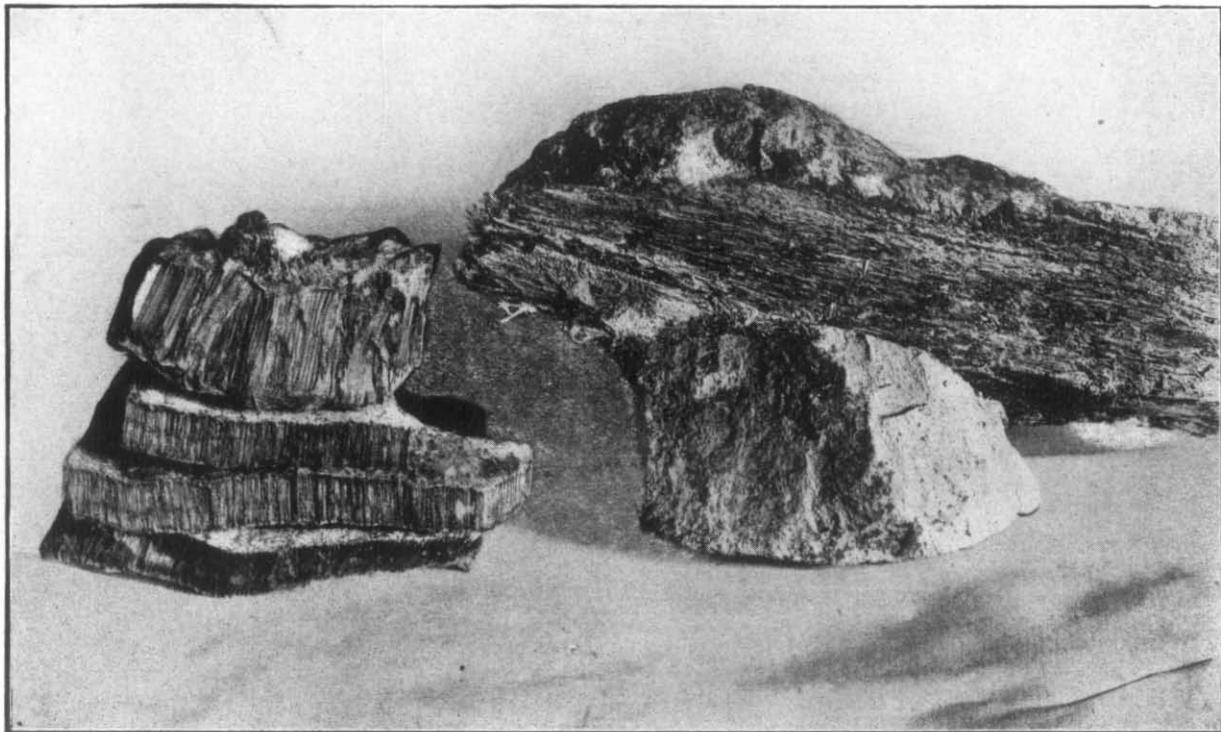


A. M. Reid Photo.]

PHOTO. 6.—AMPHIBOLE ASBESTOS: CHARRIOL'S QUARRY. ($\frac{1}{3}$ nat.)

To face page 9.

5 cm



A. M. Reid Photo.]

To face page 9.

PHOTO. 7.—FIBROUS MAGNETITE: CROSS-VEIN AND PARALLEL-VEIN STRUCTURES. ($\frac{1}{2}$ nat.)

According to this analysis the composition is almost identical with the typical hornblende asbestos of Italy. The presence of so much lime, and its nearly anhydrous nature, distinguishes it from chrysotile. In colour it is white, in some places with light-yellow tints due to iron oxide. It is brittle, and the tensile strength is low. When teased out it has the appearance of cotton.

Magnesite ($MgCO_3$) occurs as a white incrustation on the joint surfaces in serpentine, from which it was derived. During the serpentinisation of the original peridotitic rock, this mineral was formed by the action of carbonaceous solutions on the olivine component.

Scapolite, a calcium-aluminium silicate, occurs as a granular rock with plagioclase felspar in vein form about 15 inches wide in the face of the old hill quarry. Its nature, appearance, structure, and mode of occurrence suggest an alliance with the granitic dyke-rocks. Intimately associated with the scapolite rock is pink rhodinite, a metasilicate of manganese.

Millerite, a sulphide of nickel (NiS), is sparsely distributed in the forms of capillary clusters and radiating fibres of a brassy colour and lustre.

Osmiridium, a natural alloy of iridium and osmium, in varying proportions, has been recovered from the alluvial drifts of Anderson's Creek. It is usually accompanied by gold in small quantities.

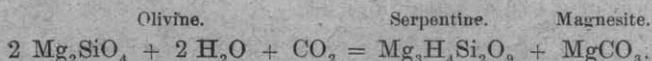
Magnetite and *hematite* are found in considerable abundance accompanying the asbestos veins. Both occur also associated with chromiferous iron in large masses on Mt. Vulcan and Scott's Hill. The deposits in these hills have been worked for their iron content. Fibrous magnetite simulating the habit of both cross-vein and slip-fibre chrysotile and amphibole asbestos, and also in intimate association with these minerals, is commonly found filling narrow veins in the serpentine rock. Its occurrence in this form in the centre of the asbestos vein material indicates a contemporaneous formation. In places the fibrous condition of the magnetite is very delicate, the degree of fineness being determined by the nature of the associated chrysotile or asbestos. Blebs and stringers are of common occurrence also on the walls of the veins and as disseminations in the enclosing rock.

Magnetite was formed from the iron compounds set free by the breaking-down of the peridotite rocks under the influences inducing serpentinisation.

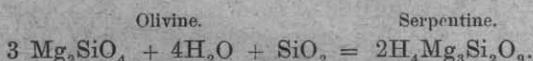
Chromite, composed of oxides of iron and chromium (FeCr_2O_4), is widely distributed throughout the serpentine belt. It was an original and insoluble constituent of the basic magma, from which it was segregated with the peridotite differentiaté. In the serpentine it is plainly visible in allotriomorphic grains and in very small octahedra, and it is contained also in the iron ore deposits on Mt. Vulcan and Scott's Hill.

B.—THE ORIGIN OF THE ASBESTOS DEPOSITS.

Chrysotile-asbestos is a crystallised variety of serpentine, and, like all asbestiform minerals, is secondary and contained only in metamorphic rocks. It follows that serpentine is an alteration product, and not a primary rock. This mineral is a hydrated silicate of magnesia, infusible and (in rock form) amorphous. A typical production of serpentine is from rocks containing olivine. It commonly results from the action of carbonic acid solutions on peridotite, the probable reaction being as follows:—



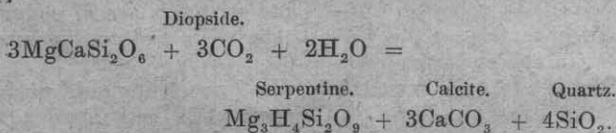
Under the action of hot carbonated waters containing silica, part of the iron component of the peridotite is frequently carried off and part converted into magnetite. In this case, the change from olivine to serpentine is effected in the following manner:—



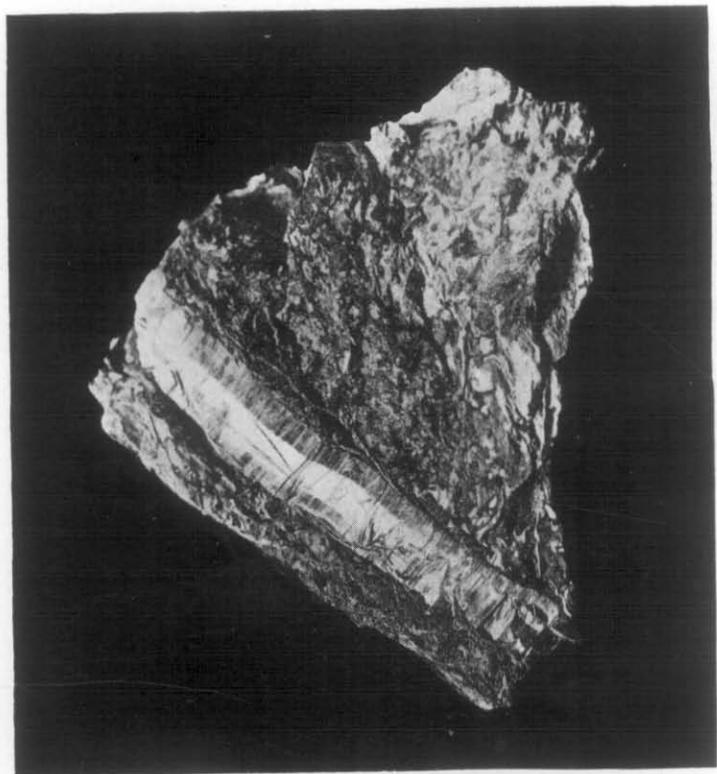
Peridotites are particularly prone to this alteration.

Serpentinisation commences in minute fissures in the crystals of olivine, and continues until the whole is converted into a mass of fine fibrous material.

Pyroxenes also are converted into serpentine under similar conditions. This is illustrated in the following equation:—



5 cm



A. M. Reid Photo.

To face page 11.

PHOTO. 2.—CHRYSTILE-ASBESTOS IN MOTTLED SERPENTINE. ($\frac{1}{3}$ nat.)

Peridotite consists of pyroxenes and olivine; pyroxenite consists of pyroxenes alone. These rocks are not sharply delineated here, but show a gradual merging of one to the other.

The heated carbonaceous solutions were derived from granitic dykes which intruded the basic formations. It may be affirmed that the presence of granite is essential to complete serpentinisation and the formation of asbestos, and the lineal extent of the granitic dykes determines the range of the field of these secondary minerals. Serpentine is easily soluble in heated carbonated waters, and from such solutions it was deposited in its perfectly fibrous form, chrysotile-asbestos. Usually this asbestiform mineral occurs as veins or cross fibre, but slip-fibre chrysotile is commonly found. The term vein or cross fibre is applied to the deposition of asbestos fibre perpendicular to the walls of fissures. Slip-fibre is that whose lines of orientation are obliquely inclined to the walls of the enclosing rock. The thickness of the veins varies from mere threads up to several inches, but the largest bulk of the asbestos quarried is between $\frac{1}{4}$ -inch and $\frac{1}{2}$ -inch in length. These veins occur often in a very irregular manner, but as a general rule they are arranged in parallel formation in conformity with the structural planes of the serpentine rock in which they are contained. Sometimes they continue unbroken for many feet; in other cases they split up and coalesce at short intervals.

Precipitation in some few instances has taken place in open fissures; but generally in incipient fractures or cracks. It is supposed that the serpentine mass has undergone a process of hydration and swelling, and with the subsequent shrinkage minute fractures were formed. In some cases, without being slip-fibre, crystallisation is in long threads parallel to the joint planes or lengthwise to the fissures. In this instance it appears that the chrysotile was deposited in open fissures. It is absurd to suggest that the ribbon-like structure of some chrysotile occurrences represents the fillings of open fractures. These narrow bands of chrysotile are separated by amorphous serpentine of equal length. They occur in parallel arrangement of remarkable regularity; but individual veins split up and cross over to neighbouring veins, and in other cases they coalesce. In some instances the reticulation is very intricate, the branching veins dying out gradually in amorphous serpentine. Apparently precipitation of chrysotile immediately succeeded the formation in the serpentine of

minute fractures due to tensional strain following shrinkage. The walls of the wider veins almost invariably have slickensided surfaces of picrolitic material.

It is interesting to note that fibrous magnetite affecting the habit of both cross-vein and slip-fibre chrysotile is of very common occurrence here. The cross-fibre is from $\frac{1}{4}$ -inch to 1-inch long, and shows the central line of junction sharply marked between the growth of fibres from opposite walls. In some specimens there is a bending of fibres in opposite directions, suggesting differential slipping of the walls on one another due to compressive stresses. In slip-fibre magnetite there is a transition from massive magnetite to the fibrous form, just as there is massive serpentine grading into chrysotile. The insensible mergence of one to the other is particularly striking. The so-called "slip-fibre" structure of magnetite and chrysotile is often erroneously applied to fibre deposited lengthwise with the walls. It is difficult to account for this occurrence, unless it be due to the replacement of pre-existing slickensided material.

Many theories⁽¹⁾ have been advanced in explanation of the origin of cross-fibre veins, particularly those of chrysotile. Most of these theories presuppose the existence of open fissures, in which the vein-minerals were deposited. It is conceivable that some cross-fibre veins may have been formed in pre-existing fissures, but in most cases this is mechanically impossible. Taber, in his paper on the "Origin of Veins of the Asbestiform Minerals," discusses in detail the many theories advanced by well-known investigators,⁽²⁾ and as the result of his own observation arrives at the following conclusion:—

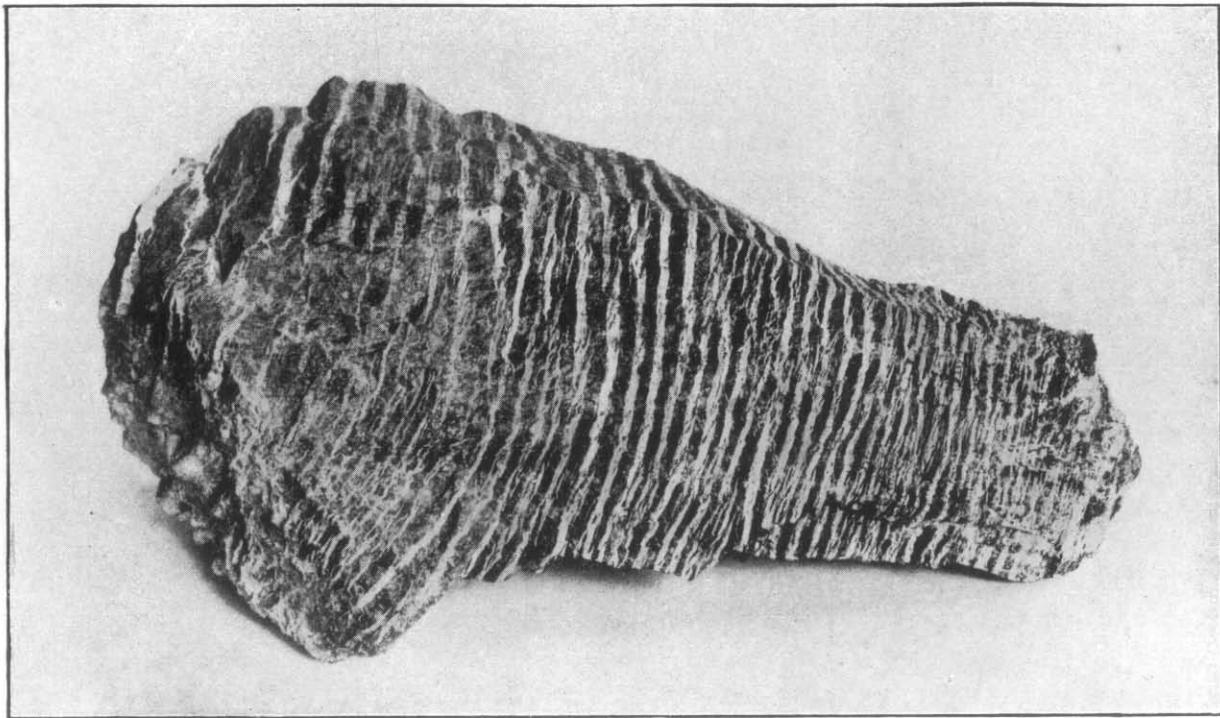
"Cross-fibre veins are formed through a process of lateral secretion, the growing veins making room for themselves by pushing apart the enclosing walls. The fibrous structure is to be attributed largely to the mechanical limitation of crystal growth through the addition of material in only one direction. In the case of asbestiform minerals the fibrous structure is accentuated by a normal prismatic habit and cleavage."

This theory appears to provide an adequate and feasible explanation of occurrences common to all fields, but there

(1) Taber, Stephen: "The Origin of Veins of the Asbestiform Minerals," Proceedings of National Academy of Sciences, Vol. 2, Dec. 1916, p. 659.

(2) Cirkel, Fritz: "Chrysotile Asbestos—Its Occurrence, Exploitation, Milling, and Uses," Ed. 2, Report No. 69, Canada Department of Mines.

5 cm



A. M. Reid Photo.]

PHOTO. 3.—RIBBON STRUCTURE OF CHRYSOTILE-ASBESTOS. ($\frac{1}{3}$ nat.)

To face page 13.

are in these deposits certain peculiar features which invite further inquiry. It is not conceivable that the ribbon-like structure of the ore, showing alternate bands of amorphous serpentine and chrysotile one-tenth to one-quarter-inch wide, and continuing with remarkable regularity for considerable distances along well-defined ore-channels 3 to 5 feet wide, is due to incipient fracture. These ore-channels have more or less well-defined slickensided walls, commonly composed of picrolite, and containing slip-fibre asbestos and fibrous magnetite. It is considered that these channels occur along lines of weakness induced in the basic rock as the results of the granitic intrusion. Expansion following the alteration of the rock to serpentine is sufficient to close all appreciable openings, but the subsequent shrinkage in the hydrated rock results in the reopening of the fissures providing access for superheated carbonated solutions in which serpentine is easily soluble. From the evidence available it appears that the chrysotile has been deposited in channels under great pressure from super-heated waters, which, penetrating the rock, dissolved the material of the serpentine until the solution became thoroughly saturated. It is conceivable that with slightly altered conditions of temperature and pressure the point of saturation would be changed and the mineral deposited in the amorphous and crystallised forms alternately.

It is not possible in these pages to attempt a detailed discussion. The hypothesis, as outlined in the foregoing statement, is put forward for the purpose of stimulating further investigation.

V.—THE MINING PROPERTIES.

A.—WUNDERLICH LTD.

(Leases 6479-M, 70 acres; 6340-M, 10 acres; 6341-M, 80 acres.)

1.—*Situation, &c.*

These sections, at one time leased by the Durabestos Company, of Sydney, are situate $2\frac{1}{2}$ miles west of the township of Beaconsfield. They comprise the area in the centre of the serpentine belt taken up in 1899 by the Australasian Asbestos Company, which worked the deposits for two years, and shipped 374 tons of cobbled stone to the mainland. The history of this enterprise, however, is concerned chiefly with the operations of the Durabestos Company, whose mining rights of the property have only lately been transferred to Wunderlich Limited. Prospecting operations commenced in 1916, and produced such satisfactory results that the following year witnessed the establishment of the industry.

The property is easily accessible from Beaconsfield by way of the Leonardsburgh-road passing westward about 1 mile north of the mine, and connected therewith by a 2-ft. gauge tramway; and it is reached more directly by the woodcutters' road, which passes right through the property, and connects with that to Holwell. The surface outline consists of rounded hills and hollows, with fairly flat stretches in the valley of Anderson's Creek. The greater part of the area is occupied by serpentine; on the western borders granitic dyke-rocks protrude here and there, and in the extreme north-east Ordovician sandstones of the Beaconsfield series crop out. Stunted eucalypti of various kinds are scattered over the hills, and tea-trees are found in the valleys. Land where serpentine and asbestos occur is unsuitable for agriculture or any other purpose, because the soils formed from decomposed serpentine lack the alkalis so necessary for plant growth. This accounts for the scanty vegetation hereabouts.

2.—*The Ore-bodies.*

The deposits extend diagonally through Sections 6341-M, 6340-M, and 6479-M, in a north-westerly direction, more

or less parallel to the associated granitic dykes and the structural planes of the encasing serpentines. They have been explored over a total distance of 50 chains, and have been proved over 10 chains in width. The most important are confined to a narrow ore-channel about 300 feet in width, and although there are considerable gaps in the chain of workings on this line, it is quite evident this is one continuous vein-system. The earliest explorations were confined to the deposits occurring in the hilly country enclosed in Section 6340-m, because the conditions for quarrying, dumping, and transport of ore to mill were so much better there; but, contrary to expectation, the extension of developmental work led to the discovery of much richer deposits in the flat country on Section 6341-m. This raised the questions whether the higher development of fibre favours the softer, almost completely serpentinised rock, which is more prone to decay and disintegration; and, if this be so, whether or not the flat country bordering Anderson's Creek would prove to be the most important source. As the development of chrysotile-asbestos is directly dependent upon the degree of serpentinisation effected in the rock, it follows that greater possibilities exist in the soft, easily-worn serpentines of the flat country than in the harder, less-altered rocks occupying the hills. In passing, it may be mentioned that there remains outside the holdings of this company a considerable extent of unexplored flat country, in proximity to the granitic dykes, which is worthy of very careful attention. As the eastern borders of the serpentine belt is approached the number of veins rapidly decreases until the rock becomes too poor to work.

3.—*Development.*

The deposits have been investigated at a number of points by means of long, deep trenches, prospecting shafts, and quarries of considerable dimensions. These works have provided information sufficient to arrive at a true estimate of the value of the deposits, and have provided also splendid opportunities for geological observation.

From the old quarry near the north-east corner of Section 6340-m, a 370-ton parcel of asbestos-stone was extracted and sent to the mainland. As it stands now, very little chrysotile can be seen in the face of the quarry, but veins of picrolite occur here and there. A 12-inch

vein of scapolite containing rhodonite was passed through in these workings. It is probably connected with the granitic dykes, which outcrop 12 chains to the westward.

A little south-west of these workings is No. 2 quarry, which was sent in on an outcrop of fibre-bearing rock about 10 feet wide. A little high-grade chrysotile shows in the end; but it is very short and irregularly distributed. In the north-west corner a shaft has been sunk to 30 feet from the floor of the quarry. Good cross-vein chrysotile up to $1\frac{1}{4}$ inch in length was passed through, but the average was only $\frac{1}{4}$ -inch, and at the bottom there was very little of it.

No. 3 quarry is very close to the last mentioned. It is 80 feet long and 30 feet wide. The rock here, as in No. 2, is only partly serpentinised, and contains only average-grade fibre from $\frac{1}{2}$ -inch to 1 inch in length. The original rock was largely pyroxenite, almost unaltered masses of which show on the eastern side.

Farther round the hill, about 3 chains to the north-west, No. 4 quarry has been cut 100 feet into the hill. It is about 40 feet wide and 35 feet deep. On the north side, near the end, are veins of cross-fibre chrysotile from $\frac{1}{2}$ -inch to 1 inch wide, containing fibre of excellent quality. Not a great deal is showing, but the quantity is sufficient to pay for extraction, and in the operation its linear extent would be determined. Here also are numerous ribbon-veins of chrysolite one-tenth to one-eighth of an inch wide, the uncrystallised serpentine separating them being about the same width. Ore of this grade is suitable for certain requirements, and the greater part of the valuable material is recoverable in milling. The serpentine at this point is a mottled light to dark-green rock, possessing a peculiar opaline appearance. It is seamed with minute fissures filled with magnetite, and larger blebs of the same mineral are scattered through the rock, increasing in quantity as the walls of the chrysotile veins are approached. One wall appears practically free from magnetite, while the other is completely lined with this mineral. Magnetite also appears in fine fibrous form in intimate association with the asbestos. The chrysotile sometimes has serpentine partings, often obliquely inclined to the line of orientation of the fibre, which is normal to the walls. It is usually deposited on bright slickensides of picrolitic material, from which it is easily separated.

One of the largest open-cuts is No. 5, near the north-west corner of Section 6340-m. It is a long, deep cutting, nearly at right angles to the trend of the veins. From the floor a prospect shaft has been sunk 40 feet deep in comparatively poor material. Bunches of good milling ore show in several places on the walls and in the end, but the overburden is so great that it could not be profitably recovered. A narrow dyke of granitoid rock of somewhat basic character intersects the serpentine here. It is evidently an abnormal rock variety, influenced by the ultra-basic rocks which it intrudes.

In the flat country south of the small hill, nearly encircled by this group of workings, a number of deep trenches have been cut in an easterly direction across the strike of the ore-channel. It is reported that exceptionally good silky fibre, equal in quality to the best found on the field, has been exposed in these trenches; but, on the average, the length and quality are not abnormal, and there is no great quantity of the richer material. Several chrysotile ore-channels have been cut in these trenches, one or two of which contain enough high-grade fibre to justify further development.

The main quarry in the north-west corner of Section 6341-m is one of considerable dimensions. As shown on the plan accompanying this report, it has a very irregular shape, the outline being determined by the erratic trend of the asbestos-bearing zones. The richer rock has been extracted, and the comparatively barren serpentine left untouched. In order to work at depth to the best advantage it will be necessary to extract both the lean and rich material in the one operation. A more or less rectangular-shaped pit will result, giving ample room to operate on the several zones simultaneously; by this arrangement, also, the supply of ore can be regulated, and the output greatly increased.

There are two benches, each 15 feet deep, in the main open pit, the second one being of only small area. The pit has a length of 450 feet, and a maximum width of 200 feet, the average being about 100 feet. Haulage of ore and waste rock is effected by means of an inclined tramway up to the top of the dump. The motive power for the purpose is a small portable steam-engine. Ample space is provided for dumping waste, and adequate storage-bins for the fibre-bearing rock. Most of the water comes from the surface, and is collected at the deepest point. A small force-pump operated by hand is used to drain the

pit. Under ordinary conditions two hours pumping daily suffices to keep the water from overflowing the sump.

It is obvious because of the magnitude of the workings that here are the most continuous and richest deposits known on the field. There are three quite distinct ore-channels separated by dark-green serpentine and bronzitic rock. In the main, or west, channel the ore is very uniform in its course, in its size, and in its quality. It has been worked over 300 feet in length and 30 feet in depth. In the south end of the upper bench there is showing 4 feet width of fair-grade cross-fibre chrysotile; the north end is rather poor, but in a trench a little further on good-grade material occurs. In the lower bench is a 5-ft. band of ribbon vein-fibre of good grade. This band continues unbroken the length of the bench, and shows in both ends. Accompanying this occurrence are veins of white chrysotile fibre 6 inches long, which is not slip-fibre. Intimately associated with this material are fine fibres of magnetite, evidently deposited simultaneously. These and slickensided-picrolite veins are evidently the fillings of open fissures. Gliding-planes and fissures in the serpentine appear to have fairly uniform dips at high angles to the westward. The central ore-channel, in many respects similar to the preceding, has produced a considerable quantity of asbestos. It has been developed to a depth of 30 feet, and over 200 feet in length. The ore in both the south and north ends is very poor, and the prospects for an immediate improvement are not encouraging. The third or eastern ore-channel has likewise received much attention, and a fair amount of fibre-bearing rock has been recovered in the process of exploration and development. Only a small amount, however, shows in the end of the northern drive; and the southern portion is now blocked up with waste rock.

No. 7 is a small quarry about 3 chains southward of the main workings, sunk on the edge of the rising ground to a depth of 15 feet. Some very fair stone has been recovered from the workings.

High up on the hillside are Nos. 8 and 9 open-cuts. Both long and short fibre occur encased in dark-green serpentine. Operations here have not produced profitable results.

In addition to the developments just described, many other works of a minor character have been accomplished, all of which augment the information available regarding this interesting occurrence.

4.—*Milling Asbestos Ores.*

In order to clearly explain the principle of the method of treatment adopted in the separation of the asbestos from the gangue material and its preparation in marketable condition, it is necessary to mention several machines comprising the plant, and give an outline of the functions of each of them.

It is essential that the rock be dry before treatment. In open quarries and mine workings the rock is always more or less moist at the time of breaking from the working faces; it must, therefore, be subjected to the preliminary operation of drying. In dry weather the natural evaporation is usually sufficient to render the ore free of surplus moisture, but artificial means are more often necessary to effect this result. Several appliances are in use. The methods commonly employed in small mills are simple in the extreme. One consists of an arrangement by means of which the ore is heated by steam-pipes; another is an adaptation of the open-hearth furnace; while the simplest is a flat sheet of iron resting on brick supports, and heated from underneath by wood fires. The rotary drying cylinder, however, is the appliance most extensively employed for this purpose in works of large capacity. It consists essentially of a hollow steel tube, 30 feet long and 3 to 4 feet in diameter, set at an inclination of about 7 degrees and rotating six to eight times per minute.

Experience shows that crushing the rock before drying is necessary in wet seasons in order to ensure an almost complete absence of moisture; but this practice is not general.

In the process of milling, the first operation is the crushing of the fibre-bearing rock to a size suitable for its further reduction in rolls. Invariably this is accomplished by means of a jaw-crusher of the Blake type. In large mills there are two of these, and rotary crushers of the Gates type are usually installed, in addition, to relieve the rolls of a great deal of heavy work, thereby increasing the capacity of the plant. Rolls are used in the final crushing operation to liberate the chrysotile-asbestos from adhering waste-rock.

After having passed through the rolls the asbestos is subjected to the process of fiberising. The lumpy asbestos in this operation is disintegrated and split into such fine fluffy material that it is easily recoverable from any

remaining gangue by means of suction fans. Fiberisers of several kinds are employed. The machine which has come into general use is that known as the "Cyclone." It has a far greater capacity than any other fiberiser, and although the cyclone by its violent action destroys part of the fibre, its advantages are so many that all other machines have been discarded in its favour in large mills. It consists of two beaters of the screw-propeller type, driven at a speed of 2000 revolutions per minute in opposite directions in a cast iron casing. The air currents created by the fast-revolving beaters throw the particles against each other, and by mutual concussion they are reduced to fine grains, and even to impalpable powder.

Owing to the difficulty experienced by the Durabestos Company, of Sydney, in obtaining a cyclone fiberiser during the war period, a wattle-bark disintegrator was substituted as a makeshift in their Beaconsfield mill. In every respect it has proved suitable in its new application.

The following description of the milling plant and the method of operation employed at the works of the Wunderlich Ltd. is taken directly from particulars supplied by Mr. G. Gurman, engineer for the company:—

The mill is designed for the treatment of 20 tons of crude ore per day of eight hours. This output could be considerably increased if the capacity of the screens was greater. Only one grade is being produced in this plant, the very fine material of short fibre being discarded. Several grades could be produced by having screens of different sizes.

This mill is so laid out that very little attendance is necessary, only six men being employed; but it is too compact and cramped in room to be really efficient. It is housed in a building 40 feet by 50 feet, the walls and roof of which are covered with panelling slabs and tiles made of asbestos cement by the Durabestos Company, of Sydney. The site, on the side of a small hill near the centre of the workings was so selected that the dump would not cover valuable ground.

The total cost of the machinery and building materials, their transportation and erection, was less than £2000.

In the process of milling the ore goes through the following stages of treatment:—

- (1) The first operation is the thorough drying of the ore. This is accomplished in wet seasons by artificial means, but in dry weather natural

evaporation is usually sufficient to render the ore in a condition suitable for the subsequent treatment.

- (2) From storage bins the dried fibre-bearing rock gravitates to a Blake crusher running at 200 revolutions per minute. The rock, after passing through the crusher, drops on a push-conveyor, which carries it to a set of rolls revolving at 120 revolutions per minute. The rolling operation reduces the material to 25 millimetre size. The crushed material is now raised by a bucket elevator and delivered to a disintegrator, which breaks up the brittle portion of the rock to fine sand, and fiberises the asbestos until it has the appearance of cotton. A disintegrator consisting of a revolving dish and beaters run at 1100 revolutions per minute is employed in this operation. The type adopted is that used in the disintegration of wattle-bark.
- (3) The fiberised asbestos is conveyed from the disintegrator by a shaking trough to a shaking screen, through which the sand passes to another push-conveyor and is carried to the dump, while the fluff passes down to the lower end of the screen.
- (4) A narrow spout connected to a suction fan at this point extends right across the screen, with mouth close down to it. The fiberised material is at once caught up by the suction generated by the fast-revolving fan (1200 revolutions per minute), and deposited in a settling chamber. There are two chambers, and, as one is filling, the clean fluffy asbestos is being bagged for shipment in the other.

The plant is driven by a 35-horsepower portable engine, running at the rate of 86 revolutions per minute.

In practice, it is found that a certain amount of crushed waste rock on the shaking screens is advantageous in assisting to keep the light, fluffy material in motion, and bringing it on top of the rock, thereby increasing the effectiveness of the suction fan in the removal of the material to the settling chamber.

In the operations of crushing and fiberising the dried ore a considerable amount of the accompanying waste material is reduced to an impalpable white dust. The

dust escapes in great volume from the disintegrator, and it is partly kept in suspension by the air-currents created by the moving machines. The problem of its removal is now being dealt with by the use of fans and covers for the machines.

After having been fiberised and separated from adhering gangue, the chrysotile is bagged and shipped to the Wunderlich works in Sydney. This short fibre had but small value a few years ago. Now it has come into use in the manufacture of roofing tiles and panels. In this process it is mixed with cement, and, after special treatment, it is subjected to considerable pressure, and formed into flat sheets of various sizes.

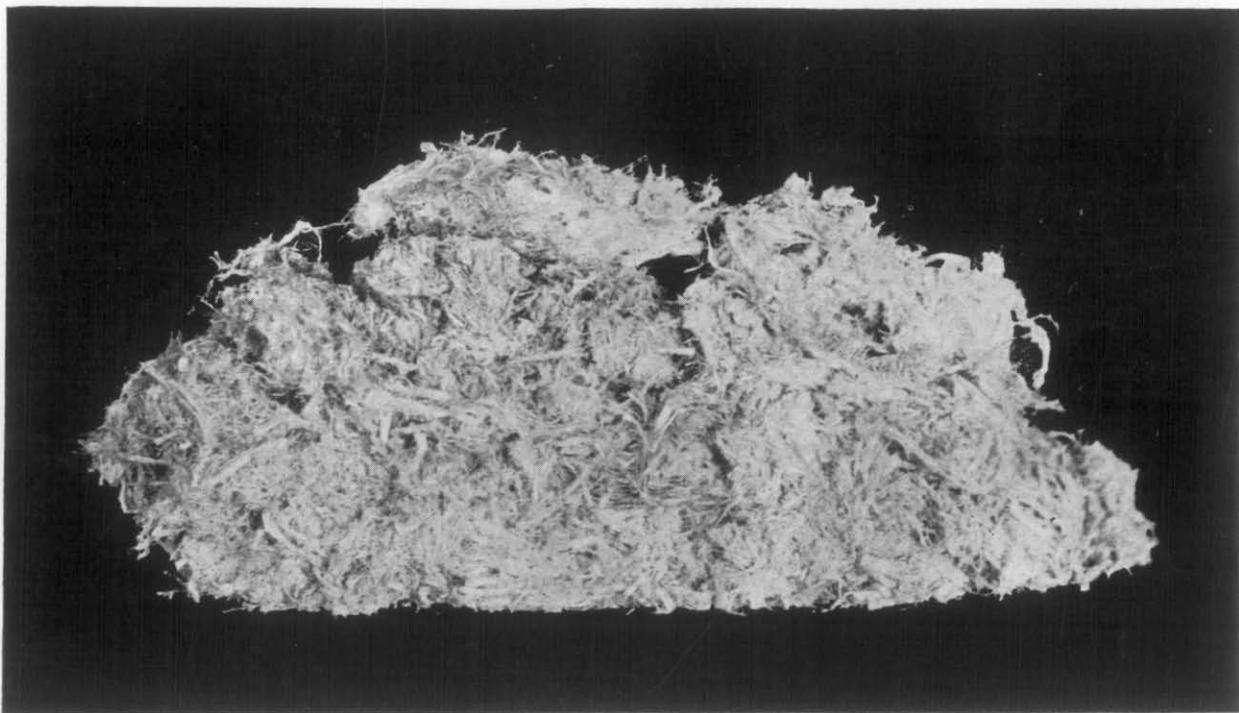
5.—*Production of Fibre.*

No accurate statistics relating to the cost of production of chrysotile fibre are available. It is reported that during the first year's operations the cost of mining and milling the fibre-bearing rock amounted to £20 per ton. Latterly, however, owing largely to the erratic occurrence of the ore and the increased cost of materials, this sum has advanced to £34. At the latter figure the recovery of short fibre chrysotile is not profitable.

Production commenced on 4th October, 1917, and continued almost without interruption up to 26th March, 1919. During this period over 440 tons of chrysotile fibre, valued at £10,000, was recovered, and shipped to Sydney. Details of the output are given in the following table:—

Period.	Waste Rock Removed.	Fibre-bearing Rock Produced.	Fibre-bearing Rock Milled.	Chrysotile Fibre Recovered.
	Tons.	Tons.	Tons.	Tons.
October, 1917, to October, 1918 ...	35,957	3,782	3,020	354·69
November, 1918, to March, 1919	12,897	1,488	1,394	86·78
Total for 18 months	48,854	5,270	4,414	441·47

An analysis of this table shows that nearly 10 tons of barren waste rock are removed in order to obtain 1 ton of fibre-bearing rock, and that from this selected ore only 10 per cent. consists of recoverable chrysotile. In other words, only 1 ton of marketable fibre is obtained from



A. M. Reid Photo.]

PHOTO. 8.—FIBERISED ASBESTOS READY FOR THE MARKET. ($\frac{1}{2}$ nat.)

To face page 22.

5 cm

100 tons of the rock extracted. Assuming the value of short fibre to be £22 10s. per ton, and deducting from that sum the cost of milling 10 tons of selected ore, at 8s. per ton, the cost of mining the crude material and the transportation of selected ore works out at 3s. 8d. per ton. This should allow a fair margin of profit over working expenses.

6.—*General Remarks.*

It is impossible to arrive at a correct estimation of this property, because the grade of material extracted latterly has fallen much lower than the average of the past year, and an estimate based on earlier production is therefore valueless. It is quite safe to assume that the known deposits will retain their average grade, and that new makes of ore will be discovered as development proceeds. There are numbers of surface outcrops as yet unexplored which certainly warrant attention.

Owing to its erratic occurrence exploration for chrysotile by means of shafts is not conclusive, and in many cases it is entirely misleading. Trenches, too, have no ultimate value. They may expose deposits covered by surface material, but the apparently barren portions may overlie the richest ore. All this goes to show that the data obtained as the result of these operations do not necessarily provide safe criteria to work upon. It is considered that the several deposits belong to one continuous vein-system, and that the most productive ore-channel passes just east of the mill, close to the south-west corner of Section 6340-m, thence obliquely across the tramway towards the creek.

Operated on a large scale, after the manner of the great Canadian chrysotile companies, these deposits may prove payable at present market rates.

B.—SECTION 7498-m, 20 ACRES: LESSEE, HARTWELL
CONDER.

This section lies in the angle formed by the southern boundary of Section 6479-m, and the western boundary of Section 6341-m. Its western boundary follows Settlers' Hill Range, and Anderson's Creek bisects it from east to west. As the granite ridge is approached the colour of the soil changes gradually from a light greyish yellow to a deep brick-red, this latter colouration being due to iron oxide.

The north-west corner is nearly in line with the most productive ore-channel on the adjacent property, but in only one place on the section has there been any excavation. This is a small open-cut just below the bridge crossing Anderson's Creek near the south-east corner. Here occur veinlets of light to dark-green chrysotile from the smallest threads up to $\frac{1}{2}$ -inch fibre, contained in dark-green serpentine. At this point there is a remarkable development of magnesite filling minute seams in the rock. In some places it occurs as a white film, and in others, where the cracks are wider, as pellucid and white opaque nodules. The asbestos fibre, though short, is of good quality, but the quantity in proportion to barren material is small.

This prospect is worthy of more attention.

C.—JACKSON'S PROSPECT.

On the eastern boundary of Section 6145-M, near the bank of Anderson's Creek, and on the west side of Settlers' Range, a few shots have been put into an outcrop showing very good fibre contained in dark-green serpentine.

The chrysotile-bearing rock crops out above loose iron-stone material for about 50 feet, thence it becomes completely obscured.

North-eastward of this, in the bed of Anderson's Creek, is a similar occurrence. Like that just described, the deposit consists of dark-green chrysotile, from $\frac{1}{2}$ -inch to $\frac{3}{4}$ -inch long, set in serpentine of the same colour. Here long white slip-fibre chrysotile is found in well-defined veins coursing north-westward, with the structural planes of the rock.

D.—W. B. SMITH'S PROSPECT: LEASE 6150-M, 80 ACRES.

A few weeks prior to the suspension of mining operations by the Wunderlich Company, the owner of this property commenced the extraction of chrysotile-asbestos from an outcrop near the south-west corner of his section. A little north-westward of these workings, aplitic granite protrudes; and south-eastward, on the opposite side of a small creek, are two more projections of the same rock. The basic rock here is a dark-green serpentine, similar to that occurring farther southward.

The property is easily accessible from Beaconsfield by way of the Leonardsburgh-road.

The workings consist of two small open-cuts, the lower of which has been sent in to intersect the fibre-bearing rock exposed in the upper. This line of chrysotile rock following the eastern flank of a small hill courses west of north, in conformity with the main occurrences. Outcrops of fibre appear at intervals for over 300 feet; further continuity was not determined. From the upper cut, two men extracted in eight days a trial parcel of high-grade cobbled material weighing $6\frac{1}{4}$ tons. This was considered so satisfactory that the lower cut was started, but was not extended far enough to reach the upper workings, in the bottom of which unusually good fibre is showing. The veinlets are commonly of the ribbon type, from $\frac{1}{8}$ -inch to $\frac{1}{4}$ -inch long, but individual vein fibre is found up to $\frac{3}{4}$ -inch. In the lower cut fibrous magnetite, affecting the habit of white slip-fibre chrysotile with which it is associated, is particularly abundant. It is noteworthy that the development of fibrous magnetite is closely associated with granitic intrusives.

Operations here can be conducted in the most economical manner. No preliminary developmental work is necessary, and exploitation may be undertaken with the smallest outlay of capital.

E.—PAUL CHARRIOL'S SHOW: LEASE 7323-M, 80 ACRES.

This is situate north-west and adjoining Smith's property, about 1 mile from the Durabestos Mine. The road from York Town to Beaconsfield passes within a few chains of the quarry, and the Leonardsburgh-road is only 20 chains distant. Near the south-east corner of the section intrusions of granitoid rock interrupt the general sequence of serpentinised basic rocks. They are oval-shaped masses of small extent projecting here and there through the serpentine, but are evidently parts of one subjacent body. The original pyroxenite has been completely serpentinised, and the metamorphosis carried another stage in rock decomposition, the resulting material being largely composed of soft greenish-yellow talc.

A narrow dyke of quartz-felspar rock, 3 to 12 inches wide, penetrates the serpentine, and shows up in the face of the quarry. This rock varies greatly in composition from point to point. In some places it is preponderatingly felspathic; in others it is quartzo-felspathic; while varieties

consisting entirely of hornblende and felspar have been repeatedly observed. It has the microscopic structure of aplite, and is an abnormal development of the granitic type.

The asbestos occurring here is the fibrous variety of monoclinic amphibole, and is generally referred to as "amphibole asbestos," in contradistinction to chrysotile, which is the asbestiform variety of serpentine. Its anhydrous nature and large lime content further distinguish it from other fibrous minerals. The fibre occurs here in sharply-defined veins coursing north-westerly, and dipping north-easterly at an inclination of 65 degrees. In the face of the quarry, several veins ranging from 1 to 4 inches wide occur in parallel formation. The asbestos is found with the line of orientation of the fibre perpendicular to the walls, also obliquely inclined thereto, and in some places lengthwise with the walls. In the last condition the fibre occurs from 6 inches up to 12 inches in length. Seamy partings of talc separate the asbestos from the walls. The occurrence here is in striking contrast to that of chrysotile in the other deposits described earlier in these pages. There is a certain regularity in its course on both strike and dip which is lacking in chrysotile veins, and the size of the openings and length of fibre is much greater. The amphibole-asbestos has not the tensile strength, the flexibility, nor the delicacy of fibre possessed by the higher grades of chrysotile.

These deposits have been opened up in a quarry 100 feet long by 40 feet wide, and 30 feet deep at the end. It is actually an open-cut driven on the course of the asbestos veins into a small hill. In the centre of the cut a prospect shaft has been sunk about 15 feet below the floor. Work was discontinued here owing to the heavy influx of water. There are indications of improvement in the quality of the fibre as the workings are carried below the decomposed rock into firm serpentine.

The total output of this quarry amounts to 20 tons of high-grade asbestos. With this were recovered considerable quantities of splintery white picrolite of no present value.

Further exploration is necessary before work on a large scale can be undertaken. The present prospects are decidedly good, but it is advisable to proceed with caution, as asbestos deposits are notoriously erratic in their occurrence.

VI.—CONCLUSION.

The closing of the asbestos milling works, and the cessation of quarrying operations by Messrs. Wunderlich Ltd., who have lately taken over the Durabestos property here, will be keenly felt in the Beaconsfield district. Since the decline of the gold-mining industry, for which this district was at one time so famous, the development of the asbestos deposits has brought some measure of relief to the inhabitants. It was hoped that the establishment of these works would resuscitate mining in the district, and bring back the condition of industrial prosperity enjoyed for so many years; but, notwithstanding all the natural advantages under which the industry was launched, the business connected with the exploitation of the deposits has not been prosperous. Although the aggregate loss is not great, the cost of extraction has of late risen alarmingly; so much so, that the continuance of operations under present conditions cannot be contemplated. It was only after very careful consideration that the decision was arrived at to remove the milling plant to their properties at Baraba, New South Wales, and to temporarily suspend operations at their Beaconsfield quarries.

Developments lately have been very disappointing. It is unfortunate at this stage that low-grade ore is showing in all the quarries, and no discoveries of value have been made for some time. The grade of the material is very much lower than the average produced in Canada. Nearly 100 tons of stone are removed in order to obtain 1 ton of marketable chrysotile fibre, whereas in Canada the proportion is not more than 40 to 1. The facilities for economical exploitation are so many here that only a trifling increase in asbestos content is necessary to place the enterprise on a profitable basis.

It is impossible to give, with any degree of exactitude, the extent and value of the asbestos-bearing ground. The whole serpentine belt is more or less asbestos-bearing, but the richer workable deposits are confined to certain definite channels. Indications have been observed which lead to the conclusion that the asbestos is more highly developed in the vicinity of the granitic dykes, which penetrate the serpentine at several points. The association is so pronounced that attention is particularly directed to this fact in the search for chrysotile deposits. Another point

worthy of notice is that a higher development of asbestos is possible only in completely serpentinised rocks. Notwithstanding the fact that a large amount of work has been accomplished by the companies operating here the greater part of the serpentine belt is as yet unexplored. The low-lying country in Anderson Creek Valley offers exceptional inducement in this regard, but exploration should not be limited to this locality, as there are good indications in places far removed from that quarter. It must be remembered that asbestos deposits are invariably erratic and sporadic in their occurrence, and consequently it may be safely anticipated that richer "makes" of ore will be discovered alternating with comparatively barren zones as development proceeds. Asbestos deposits are of deep-seated origin, therefore no apprehension need be entertained that they are merely superficial phenomena, and that they will not extend to any great depth.

It may prove advantageous to mine the rich shoots of ore instead of quarrying them, as some are confined to comparatively narrow channels, and are continuous for several hundred feet. The development accomplished by the companies operating here at different times will prove of considerable value in designing the methods for future work. There is every probability that further attempts will be made to operate the mines to better advantage when conditions for their exploitation improve.

A. McINTOSH REID,

Assistant Government Geologist.

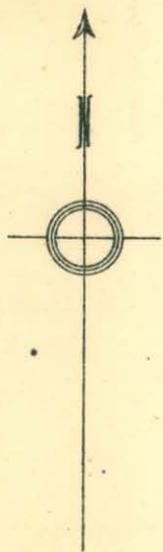
Geological Survey Office,

Launceston, 5th December, 1919.

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GEOLOGICAL SKETCH MAP OF ANDERSON'S CREEK MINING AREA

Plate II.

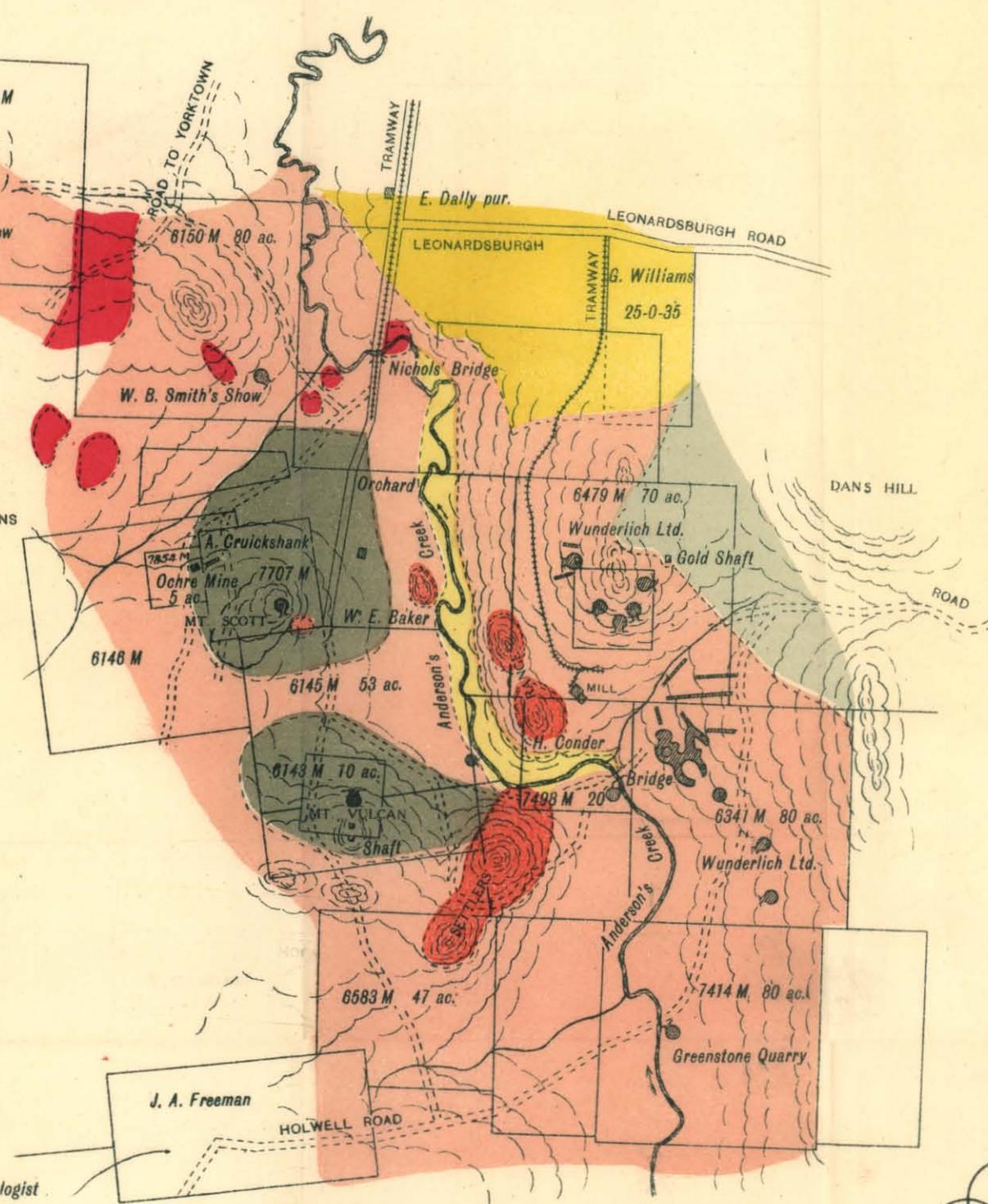


5 cm

SCALE 0 10 20 30 CHAINS

Legend

- QUATERNARY GRAVELS
- TERTIARY DEPOSITS
- IRON ORE DEPOSITS
- DEVONIAN SERPENTINE
- DEVONIAN APLITIC GRANITE
- DYKE OF GRANITOID ROCK
- PRE-SILURIAN SANDSTONES,
GRITS. & CONGLOMERATES
- Asbestos & Iron Ore Quarries
- Asbestos Trenches



W. H. Twelvetrees, Government Geologist.
A. McIntosh Reid, Assist. Govt. Geologist.