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DEPARTMENT OF MINES

GEOLOGICAL SURVEY

MINERAL RESOURCES

No. 1

Tungsten and Molybdenum

Part III.

KING ISLAND

BY

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Issued under the authority of

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



Tasmania.

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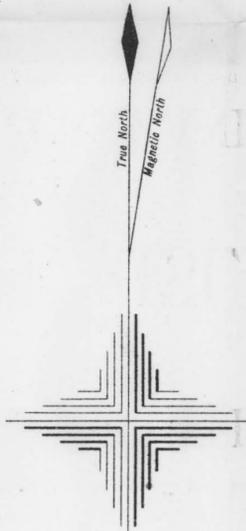
LOCALITY MAP

SHOWING POSITION OF

KING ISLAND

RELATIVELY TO TASMANIA AND VICTORIA

BASED ON ADMIRALTY CHART



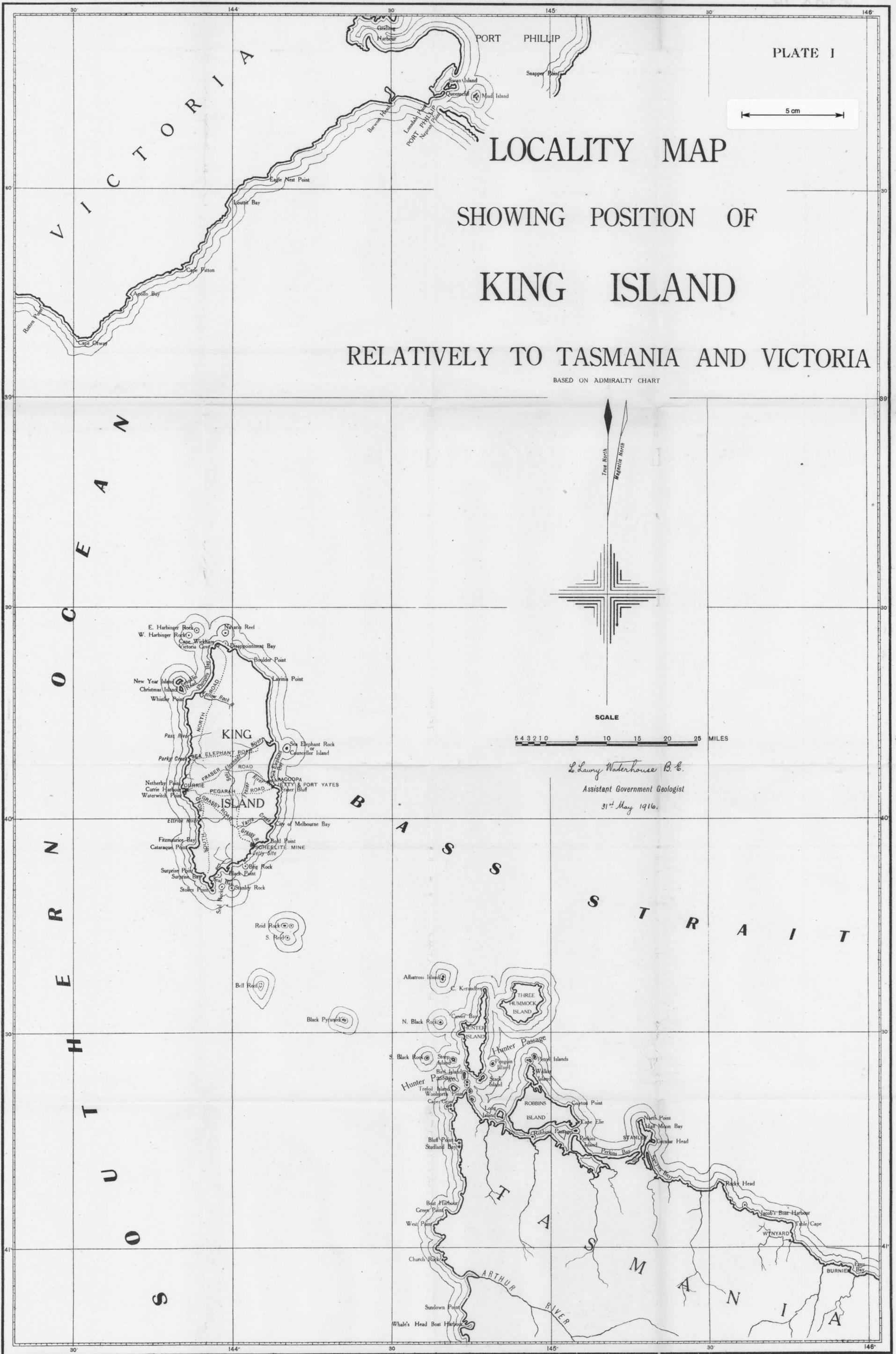
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Assistant Government Geologist

31st May 1916.



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Part III.

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I.—INTRODUCTION AND GENERAL.

(1) INTRODUCTION.

This report forms one of a series of publications prepared essentially for the State Munitions Committee, in order to make available the latest information concerning the tungsten and molybdenite resources of the State of Tasmania. The present report (Part III. of the series) deals with a deposit of scheelite (carrying some molybdenite also) which occurs on King Island, in Bass Strait. Further information concerning the general geology of King Island will be found in a separate report by the writer, which will be issued as a bulletin of the Geological Survey of Tasmania.

(2) HISTORY.

The deposit was discovered a few years ago by a veteran Tasmanian prospector (Mr. Tom Farrell), outcropping on the sea-shore. It was developed by the King Island Prospecting Association, and at the time of writing is understood to have been floated into a company known as "The King Island Scheelite Company, No Liability," with a nominal capital of £50,000 in 100,000 shares of 10s. each.

No official examination of the property has previously been made, although a report was recently furnished to the Prospecting Association by Mr. J. B. Lewis, of Melbourne.

(3) AREA OF PROPERTY.

The property held by the company consists of a mining lease (10P-M) of 78 acres, charted in the name of Alexander Campbell. This lease is on private property (owned by Mr. R. Cummins), but an option of purchase was given by the owner over about 200 acres of ground, which would be required by the company as a site for battery and concentrating plant, assay office, residences for manager and men, &c. The ground adjoining the mining lease is also private property.

(4) SITUATION.

King Island is situated in Bass Strait, to the north-west of Tasmania, about midway between Cape Grim and Cape Otway. The mine is situated on the sea-coast, in the south-eastern portion of the island, at the mouth of the Grassy River, and about 2 miles south-west of a projecting point known as Bold Head. The lease includes part of a block of 97 acres, and extends into another of 207 acres, both charted in the name of M. Parer, though owned by Mr. R. Cummins.

(5) ACCESS.

Access to the property is given by the road from Currie, the principal settlement, situated on the west coast of the island. The distance from Currie is estimated at 18 miles, though a survey does not appear to have been made. Owing to the generally level nature of the island, this road is mostly well graded to within a few chains of the mine. Many parts of it are metalled and in good condition; but there are other stretches which are loose sand or boggy soil, and will need attention before any regular traffic (especially if at all heavy) becomes possible; with such traffic the road would become practically impassable in wet weather. The last few chains from the tableland, on which the north-western corner peg of the lease is situated, to the mine workings, slope rather steeply, and no attempt has so far been made to grade a road, although this can be done without difficulty, a small amount of side-cutting being necessary.

It is probable, however, that as the mine is developed, and becomes a producer of scheelite on a commercial scale, water-carriage will be utilised, as the property is favour-

ably situated in this respect. The mine is situated within a mile of the southern end of a wide bay, of which the northern point is known as Bold Head. The southern point is of granite, and towards its base is a site which could well be utilised for a jetty. Such a jetty would be exposed to winds from the south-east, east, and east-north-east, but splendidly sheltered from all other winds, and quite as favourably situated, from this point of view, as the Government jetty at the Fraser Bluff, a few miles further north. The prevailing winds on the island are from the west, and seldom cease blowing from this quarter. The shelter afforded by such a site as that suggested is excellent under these conditions.

Adjacent to the actual jetty site is a small cove with a sandy beach, where machinery, &c., could probably be landed from a lighter under favourable weather conditions. The entrance to this cove carries about 6 feet of water; about 1 chain off, the depth increases to about 16 feet. A short distance south of this, at the base of the point, granite outcrops to the water's edge, and there are several projecting points of rock which might be utilised as a basis for a jetty. Some soundings were taken by the writer to obtain some idea of the practicability of a jetty scheme; the tide was medium to low at the time these measurements were taken. The most suitable position for a jetty appeared to be at one point where the granite on the shore was naturally fairly level, and where in the course of weathering several portions of the rock-mass had been separated from the main rock outcrop by encroachment of the sea, and now form tiny islands of rock. Such could, doubtless, be utilised if it were decided to erect a jetty at the spot. At about $1\frac{1}{2}$ chain off this point the depth was 18 feet. At about $2\frac{1}{4}$ and 3 chains, the depth registered was 28 feet. There was found to be very little variation at about the same distance off points on either side of the one particularly referred to above. The water deepens fairly gradually, 30 feet being registered at about 10 chains, and 45 feet at about 20 chains off shore. The water is deeper in places, however, and the bottom somewhat irregular, for 55 feet was the depth recorded about 3 chains, and 50 feet 5 chains away from another point.

Sufficient evidence was obtained to show that it would be practicable to construct a jetty which would easily berth steamers such as those trading to King Island at the present time. The bottom is evidently granite in this vicinity.

It has been stated in some quarters that the jetty recently completed at the Fraser Bluff will serve the scheelite mine. By air line, the distance between the two points is 10 miles. By road, however, the indirect route which must of necessity be taken considerably increases this distance. The route which would have to be taken at the present time would be along the main road towards Currie as far as a branch road running due north for several miles, and known as "Crowe's Road." This road connects with the Pagarah Road from Currie to the Fraser. The total distance by this route would be about 17 miles, and as parts of the road are in a bad condition at the present time, particularly that portion between the Grassy and Crowe's Roads, carting would be costly, and continuous traffic would be impossible in wet weather.

Between 1 and 2 miles would be saved if a road should be constructed to connect up the branch road from Pagarah Road to J. Hunter's block with that from the Grassy Road in to the Yarra Creek. There is a distance of about $1\frac{1}{2}$ mile between the end of these two roads, at present, covered with heavy timber.

Thus it will be seen that with the present road facilities there is little to be gained, in point of distance, between cartage to the Fraser Jetty and carriage to Currie.

The possibility of a tram connection with either jetty merits notice in passing. A tram to Currie would follow, approximately, the course of the present Grassy Road, and would be between 17 and 18 miles in length. A tram to the Fraser jetty would be constructed within a short distance of the coast-line. The country here carries abundant dead timber, and much thick scrub and undergrowth. The surface is uneven, owing to the various creeks running down to the coast. This route was not examined in detail, but if at all practicable it is very unlikely that the line would be less than 15 miles in length, and from the general nature of the country the cost would be heavy.

(6) TOPOGRAPHY.

The topography of the locality is such as to be favourable to mining operations. The south-eastern portion of the island consists of a plateau rising to about 400 feet above sea-level. It represents an old peneplaned surface which has been uplifted and modified by recent erosion. Along the coast this high ground slopes steeply to sea-

level, the seaward slopes being modified by the erosive action of various streams. There is usually a strip of level country a few chains wide along the foreshore, and small sand dunes have formed at intervals along this coastal strip, which is only a few feet above sea-level.

The principal stream along this part of the coast is the Grassy River, flowing a little east of south, and this has cut its gorge down to sea-level. This gorge is a typical young valley, and has steeply sloping sides. High up on the western bank of the river, a few chains from its mouth, is the north-eastern corner of the mining lease. The north-western corner is on the plateau, near its eastern edge, at an elevation of 370 feet above sea-level. Between these two corner pegs, and in the north-eastern portion of the section, is a creek flowing about south-east, which has also cut back into the hill. This creek does not carry very much water. The south-western corner of the section is on a terrace several chains wide, at an elevation of 200 feet above sea-level, and so intermediate between the higher plateau and the coastal strip. It is below the level of this terrace that most of the mining work has so far been carried out. The south-eastern corner of the section is truncated, the boundary-line of the section extending along the beach for $9\frac{1}{2}$ chains, and including the outcrop of scheelite ore originally discovered.

Advantage has been taken of the topography in prospecting the scheelite formation by driving adits into the slope of the hill, and the facilities offered are destined to play an important part in the future development of the mines.

It is unfortunate that a sufficiently long period of time has elapsed since the uplift of the old base-levelled surface, to enable the Grassy River to erode its channel to such an extent. Had the river erosion reached a less mature stage, sufficient fall would have been available to permit of the generation of power. The grade of the river-bed is too flat for some distance from the mouth to render this feasible, although the river will supply the water required for dressing purposes.

(7) WATER-SUPPLY.

No records of rainfall in the immediate vicinity of the mine appear to have been kept, but judging from records from other parts of the island the average annual rainfall in this district would probably be about 35 inches. This amount

is fairly well distributed throughout the year, and for no month is the fall negligible. The soil in the neighbourhood is clayey, and is inclined to retain moisture for some time; consequently the supply of water to the creeks is more regular than would be the case with a very open sandy soil. Under these circumstances it is not surprising to find that the Grassy River carries sufficient water throughout the year for the purpose of ore-dressing and other operations connected with the working of the mine. As noted above when referring to the topography, it is unfortunate that the river has not sufficient fall to allow of the generation of power, so far as it was examined. A race of some length would be required to bring in water at a sufficient elevation for utilisation in connection with the plant, and it will probably be found more economical to instal a pump at a suitable point in the lower reaches of the river, and raise water to the selected machinery site.

(8) TIMBER.

Although there is no green timber of any size in the neighbourhood, there is abundant dead timber standing, which will supply the demand which is likely to arise for some years to come. This timber was killed by an extensive bush-fire several years ago. It comprises mainly gum-trees, with some blackwood, and in most cases the trees rise to considerable heights before branching, yielding straight trunks of considerable size, which will be valuable for structural purposes. On the island there is a tendency for the standing dead timber to rot after some years, but at present much of it seems sound.

There will be need of timber for firewood as well as for structural purposes, and the demands in this direction can be supplied for some years without difficulty by timber in the immediate neighbourhood.

One or more short tramlines will be required to tap the best belts of timber, and these will be constructed at comparatively small expense along the brow of the ridge, and the timber sent down to the works at a lower level by a chute.

(9) MINING FACILITIES.

The property is very favourably situated, and offers splendid facilities for economic mining. The topographical features have been described, and it has been shown that

the land surface slopes steeply down to a narrow coastal strip a few feet above sea-level. It is on the face of this slope that prospecting operations have been carried out up to the present. The fact of the scheelite lode occurring below the surface soil on this steeply sloping hillside means that it may be not only tested, but also mined economically.

Adits may be driven on the course of the formation, and the advantages of driving in ore all the way are obvious. Crosscuts should be driven at intervals across the ore-body to disclose its width, structure, and value.

The advantages of working from adits in preference to shafts scarcely need comment. Nearly 200 feet of backs can be obtained by driving a low-level adit. This amount of backs, given a reasonably long shoot of ore, would represent a large tonnage with such a wide ore-body. Above 200 feet the hill rises more gradually, attaining a maximum of about 370 feet in the vicinity of the north-western corner of the section, but to obtain the same amount of backs here a much longer adit would be necessary than lower down the hillside.

An advantage of being able to work by adits in this particular case is that the ore-body will at the same time be prospected and opened up, and that ore will be won from the prospecting drives unless it should be found advisable, as indicated elsewhere, to drive in the country-rock and crosscut across the deposit.

Work carried out under the conditions existing on this property has the obvious advantage of ample space for tipping spoil. The topography, too, makes it possible to lower the ore by gravitation direct from the working adits to the treatment plant which would be situated at the foot of the slope. Tailings from the mill could be disposed of without any trouble after their valuable constituents have been extracted, by depositing them on the beach below, to be distributed by wave action.

A very important facility offered by the property is that a considerable amount of ore may be extracted by open-cut methods, which, of course, very considerably reduces working costs.

The ore itself, as already opened up, undoubtedly would be economical to work on account of its comparative softness, but this advantage may disappear when true unaltered primary ore is encountered.

II.—GEOLOGY AND MINERALOGY.

(1) ROCK FORMATIONS DEVELOPED.

It is necessary to deal briefly and in a general way with the rock formations developed in the neighbourhood of the mine. Both igneous and sedimentary rocks are represented; the latter occupy the bulk of the area of the mining lease, although the south-eastern corner peg is actually on the contact of granite and sedimentary rocks. Granite outcrops for 7 or 8 miles along the coast to the south of the mine, and appears to extend inland for at least 2 miles. Old slates and sandstones extend to the north for some distance, succeeded by a series of tuffs and igneous breccias about 3 miles north of the mine.

The granite is a handsome coarse-grained rock, carrying abundant phenocrysts of orthoclase felspar which give it a distinctly porphyritic facies; it is a porphyritic biotite granite. It is very fresh, and shows no signs of crushing. At the contact granite porphyry occurs, with occasional large crystals of pink orthoclase felspar.

The granite is traversed by occasional dykes of granite porphyry and of aplite, representing probably some of the later phases of the igneous intrusion. The granite *massif* is also traversed by narrow dykes of dense dark-blue basic rocks. Two of these rocks were examined microscopically, and one occurring on the point south of the mine, where it is proposed to construct a jetty, proved to be a basalt, while a few chains further south was a dyke 6 feet wide of hornblende-lamprophyre.

Closely associated with the scheelite lode and exposed in the No. 1 Adit is a dyke of aplite undoubtedly connected with the granite. It is a white rock, and is locally known as "porphyry." Microscopical examination shows that it is composed essentially of quartz, with some decomposed felspar and aggregates of muscovite mica. It carries both molybdenite and scheelite in places.

The scheelite lode is in the sedimentary rocks, but within about 12 chains of the margin of the granite *massif*. As is to be expected in such close proximity to the intrusive granite mass, the old sedimentary rocks are intensely altered. They appear sometimes as spotted schists, sometimes as very hard black flinty hornstones. The microscopical examination of thin sections of these rocks shows that there are developed quartz, albite, sericite, chlorite, biotite, and

magnetite—minerals typical of the contact metamorphic aureole of a granite *massif*. These rocks usually retain their banded structure, and although they have suffered intense alteration, they can as a rule be readily recognised as sedimentary rocks. In the immediate vicinity of the lode formation, bands of an intensely hard dense pink and green rock are developed. Microscopical examination of thin sections shows that these bands are composed essentially of aggregates of garnet in a groundmass of granular monoclinic pyroxene, with a little interstitial quartz. This rock, on account of its excessive hardness and toughness, gives trouble in mining operations, for it is not only very difficult to drill, but it shoots badly also. Fortunately, however, the bands so far encountered in the workings carried out have not been more than a few feet in thickness. This rock is referred to below as garnet-pyroxene rock.

The sedimentary rocks do not outcrop at many points in the vicinity of the mine, and no strike or dip can be assigned to the formation as a whole, nor is there any evidence of folding of the strata. In such close proximity to the huge intrusive mass of granite it is not surprising to find that the sediments are a good deal shattered. On the beach about 3 chains south of the originally discovered scheelite outcrop the sediments strike N. 21° E. and dip east at 49°. About 1 chain north of the outcrop the strike is east and west.

There is no evidence available to fix the age of the sedimentary rocks, although the writer believes them to be of approximately Ordovician age. The age of the intrusive granite cannot be fixed, but it may perhaps be Devonian. It is uncertain how far these rocks may be correlated with similar ones developed in Tasmania, but this question will be dealt with in the writer's general report on King Island, now in course of preparation.

Where exposed in the mine the footwall country-rock strikes at different points at angles varying from N. 35° W. to N. 50° W., and dips south-west at angles from 35° to 55°. On the other hand, the hanging-wall, as exposed, appears to strike about N. 50° E., and dips south-east at 25°. This apparent anomaly is referred to below.

A very interesting occurrence was noted in the open-cut at the entrance to the No. 2 Adit, viz., of water-worn gravel and shingle. This was accidentally located between 7 and 8 feet below the present surface in sinking a shaft through the surface material. This shaft has since been filled up. The bed of gravel is said to have been between

3 and 4 feet in thickness, and to have been resting directly on decomposed garnet rock. The pebbles are of all sizes, from gravels to boulders 6 inches in diameter, and are thoroughly water-worn. They consist mainly of quartzites and of fragments of rock similar to those found in the adjacent country. The elevation is about 130 feet above sea-level. No other such material has been disclosed, and the occurrence of one small patch of water-worn gravel so high above sea-level is rather puzzling. It may be a remnant of river gravel accumulated by some stream when the surface contour was different from that of the present day, but the writer is inclined to think it forms part of a deposit of beach shingle. As mentioned elsewhere, the land surface in this vicinity represents an old peneplaned surface which had been worn down approximately to sea-level, and subsequently uplifted by earth movements, and again subjected to the degrading action of atmospheric agencies. No positive evidence was obtained elsewhere as to whether this uplift was a simple movement or a succession of movements, but if the latter be true, a certain time-break between successive uplifts may be postulated, and during one of these intervals the shingle observed may have accumulated on the shore at sea-level, and have attained its present position by either a single movement or several movements, amounting to 130 feet. Further deposits may be disclosed as work proceeds, and they are of such geological interest that their occurrence should be recorded.

(2) THE NATURE OF THE ORE-BODY.

It is not the writer's purpose in this section to discuss the nature of the ore and the mode of origin of the deposit in minute detail, but rather to give a general description of the ore-body with a statement of what the writer believes to be its mode of origin.

(a) *Mineralogical Composition.*

The ore consists essentially of garnet (usually in well-formed crystals), showing a more or less defined banded structure. The other gangue minerals observed were quartz, epidote, calcite, monoclinic pyroxene, and actinolite. The metallic minerals noted were scheelite, molybdenite, pyrite, and bismuth; assays show the presence of tin, probably as cassiterite, although this mineral was not seen.

Scheelite (Tungstate of Lime, CaWO_4).—This is undoubtedly a primary mineral. It occurs both in amorphous masses and in definite crystals, doubly terminated tetragonal pyramids of small size being not uncommon. The largest crystal observed measured over 1 inch across. The colour is pale olive-green, streak white, hardness 5, specific gravity 5.91. The mineral shows distinct cleavages, has a sub-adamantine lustre, and is translucent on thin edges. The scheelite frequently occurs in quartz veins traversing the garnet formation and the aplite, and molybdenite is also often seen in these quartz veins. The two minerals are intimately associated. In several instances molybdenite was noted included in the heart of scheelite crystals, while in other cases masses of scheelite were surrounded by a rim of molybdenite flakes. The quartz veins referred to usually carry a little white mica, and in one case epidote was noted in addition to scheelite and molybdenite.

That scheelite is disseminated through the garnet formation as well as being present in the noticeable quartz veins is shown by the assay results published elsewhere in this report. The mineral is present also in the white aplite exposed in the No. 2 Adit, although only in small quantities.

Molybdenite.—This mineral has the usual physical characters, which do not call for special mention here. It occurs in tabular hexagonal crystals and plates, not usually exceeding one-quarter inch across. It is most abundant in the quartz veins which traverse the garnet formation, where it is not uncommonly accompanied by scheelite, and appears to be closely associated with the aplite dyke. Scattered flakes are seen in the aplite, and occasionally in dense garnet-calcite lode material with no visible quartz. On the whole the mineral is not abundant in the lode, and although from time to time small quantities of high grade ore may be hand-picked from vughs and bunches in the quartz veins, molybdenite is at present not of great economic importance.

Pyrite.—Pyrite is present in the ore, but in small quantities only, and in the ore at present opened up is not sufficiently abundant to be detrimental to the production of a high-grade concentrate. As the workings eventually extend to a greater depth, it is possible that the mineral may become more abundant, but there is no reason to believe that it is likely to prove a serious obstacle in the production of a marketable product.

Bismuth.—At one spot only (in the No. 1 West Crosscut of the No. 3 Adit) was native bismuth seen in the mine

workings, when several small fragments were obtained by the manager; it probably occurred, at the locality mentioned, in a quartz vein. Numerous assays made of samples from different parts of the mine showed that bismuth is not confined to this one locality. The details of these assays are recorded in a later part of this report.

The occurrence of bismuth is important, because of the possibility of the mineral causing a penalty to be imposed on the concentrate if it exceeds a certain amount. Bismuth is exceedingly detrimental in steel manufacture, and a scheelite concentrate carrying much bismuth would not be accepted for steel-hardening purposes. The amount of bismuth allowed at present is one-half per cent. in a scheelite concentrate, but tungstic acid is so urgently needed at present that probably slightly more than this amount would not render the product unsaleable, although a penalty might be imposed. Further reference is made to the presence of bismuth in discussing assay values of the ore.

Garnet.—The variety of garnet represented appears to be andradite. It is usually reddish in colour and translucent, and occurs in well-formed crystals up to about one-quarter inch across, the forms represented being usually a combination of the dodecahedron and tetragonal trisoctahedron. Owing to the importance of the mineral when the question of treatment is being considered determinations were made of the specific gravity of the garnet. The values obtained varied from 3.40 to 4.19. The hardness is about 6.5.

The garnet is attracted by the electro-magnet, and was found to be of about the same magnetic permeability as wolframite. This at once suggests a possible method of treatment. This question is dealt with elsewhere.

(b) Structure.

It is important to consider the structure of the ore-body as well as its mineralogical composition. Unfortunately, little definite information was available at the time of the writer's visit, and it is only in the light of further developments that the structure can be clearly understood.

The outcrop originally discovered by Mr. T. Farrell is on the beach at high-water mark; at certain times it is covered by drifting beach-sand. It consists of hard banded garnet-pyroxene rock carrying a little scheelite in places. These bands strike about N. 65° W., and dip vertically. A little work was done on the lode-formation just above high-water level, and a shaft was sunk 25 feet on the formation at a point $1\frac{1}{2}$ chain inland from the beach outcrop. From the

result of these workings it was assumed that the lode was really dipping vertically, and such an assumption was justified at the time. About 6 chains inland, at the base of the hill, an adit was driven, apparently on the line of strike, but failed to cut the lode-formation. The ore-body did not outcrop at the surface. Higher up the hill another adit (No. 3) was driven on the lode, and, still assuming that the dip was vertical, two other adits were commenced lower down (No. 2 and No. 1), and should have intersected the formation had it been vertical. The relative positions of these workings are shown in Plate II. Although in No. 2 Adit an aplite dyke carrying scheelite and molybdenite was disclosed, the ore-body as exposed above was not located. In No. 1 Adit hard garnet-pyroxene-calcite lode material was cut, but it is doubtful if this corresponds with the lode exposed higher up. These workings showed that the lode formation was not dipping vertically as was supposed. Crosscuts driven across the formation in the No. 3 Adit exposed both walls, and a study of these exposures yielded some important information. In the face of the short crosscut north-east the footwall is just exposed, and strikes N. 45° W., dipping south-west at 35° . At three points along the main drive the readings were respectively, strike N. 50° W., dip S.W. at 55° ; strike N. 35° W., dip S.W. at 55° ; and strike N. 35° W., dip S.W. at 52° . From these exposures it would appear that average values for the footwall would be strike N. 45° W., dip S.W. at 50° .

The hanging-wall was only exposed at one point, viz., in the face of the south-western crosscut from the No. 3 Adit, and here the strike appears to be N. 45° E., and dip S.E. at 25° .

It is unfortunate that further exposures of hanging- and foot-walls were not available, as the strike and dip cannot be definitely determined from these particulars. The strike and dip of the hanging-wall appear to be different from those of the footwall, but too much reliance cannot be placed upon a single observation. It is clear, however, that the formation is not dipping vertically, as was assumed from an examination of the original outcrop. From the available exposures of the footwall, the formation appears to be dipping (at the level of the No. 3 Adit) to the south-west at about 50° . Such being the case, it is easy to understand why the three lower adits (which were driven on the assumption that the lode-formation was dipping vertically) failed to cut the ore-body exposed above. Assuming the dip to be as above, the writer recommended the driving of a crosscut from the No. 2 Adit to intersect the formation

exposed above. This work was entirely successful, the ore-body being located, showing that the previous workings were too far to the north. The crosscut referred to was being driven at the time of the writer's examination, and the body of ore had not been cut through. The footwall here is not well defined. The aplite is in contact with an exceedingly hard banded garnet-pyroxene rock, and this appears to merge into typical garnet-calcite lode-material with irregular aggregates and veins of quartz carrying rich scheelite and a little molybdenite. The wall appears to strike about N. 10° W., and dip west at about 40° .

These observations of the strike and dip of the wall of the ore-body vary considerably, but emphasise one important point, viz., the necessity for prospecting along the line of strike, to determine definitely the structure of the ore-body in order that future work may be planned to advantage. If the exposures of footwall and hanging-wall in the No. 3 Adit as noted above represented true average values for these walls, it is clear that longitudinally the ore-body would taper out within a comparatively short distance ahead. As noted above, however, it is unsafe to attempt to predict on the evidence of the exposures available, since a purely local irregularity may account for the apparent discrepancy.

If the ore-deposit be a replacement of a bed of more or less impure limestone, as suggested below, it may be to some extent irregular in outline, though largely dependent upon the form of the original calcareous bed. There is no evidence to show the size or extent of such a bed.

Thus the small amount of information available to throw light on the true structure of the deposit serves to emphasise the importance of prospecting to definitely prove the extent of the ore-body.

There are indications that a small amount of faulting may have taken place, to judge by fissures intersected in driving. Thus in the No. 2 Adit, 11 feet beyond the winze, is a fissure striking N. 55° W., and dipping south-east at 60° ; this shows slickensides, and marks a change from hard banded garnet rock to shattered slate and quartzite succeeded by garnet-pyroxene bands. In the lower (No. 1) adit a well-defined fissure, now filled with kaolin, was intersected along the main crosscut south-west at 30 feet from the main adit, striking about N. 50° W., and dipping vertically; this fissure also marked a change in country. Again, in a small crosscut driven from further along the course of the same adit, a similar fissure was noted, and has the same strike and dip as that just noted; this also marks a

change to shattered country-rock. These three fissures apparently correspond, and mark a continuous fault-plane which may, perhaps, be continuous and correspond with the fissure intersected in the sharp elbow bend of the No. 3 Adit, which forms a regular water-channel. From the slickensides and shattered country-rock it seems evident that there has been some movement, but what influence this fault has upon the structure of the ore-body cannot yet be determined. It appears, however, to be in the footwall country. Other fissures were noted in some of the workings, but so far there is no definite evidence to show that faulting has modified the structure of the ore-body.

(c) *Mode of Origin.*

It remains to state briefly the writer's opinion as to the mode of origin of the deposit.

There can be little doubt that the deposit is genetically connected with the neighbouring granite *massif*, and that the metallic constituents were introduced with the granite magma, differentiation causing a partial concentration of these constituents in the still molten magma. These were expelled as gases at an extremely high temperature as the magma gradually cooled and consolidated, and penetrated the overlying sedimentary rocks which were at an extremely high temperature. The aplitic dyke may represent the main channel by which the metallic minerals were conveyed to their present position, the quartz and felspar representing granitic material which was expelled with the metallics from the cooling granite mass. It seems likely that the ore-deposit was formed when the chemically active and metal-bearing vapours and solutions came into contact with calcareous beds, which were almost completely replaced, the metals being deposited. The outstanding features which indicate that some such theory must be postulated to explain the mode of origin of the ore-body are:—

- (1) The banded structure of the deposit.
- (2) The occurrence of bands of country-rock altered to garnet-pyroxene outside the main body of ore.
- (3) The mineralogical composition of the ore, and especially the presence of so many lime-bearing minerals (scheelite, garnet, diopside, calcite, epidote, actinolite).
- (4) The close association with the aplite dyke which itself carries metallic values.
- (5) The high-temperature minerals present.

III.—THE MINE WORKINGS.

No mine plan was available on which the position of various workings was accurately fixed. The figures quoted are approximate only, having been determined by a rapid prismatic compass and aneroid survey.

The workings consist of adits (with crosscuts therefrom) and shallow shafts. The accompanying sketch-plan of the property (Plate II.) shows the approximate position and nomenclature adopted in naming these adits and shafts.

No. 1 Adit.—This was at the time of the writer's examination the lowest adit which was available for inspection. It is about 107 feet above sea-level, and was driven with the object of intersecting the ore-body which had been exposed higher up the hill, and which was assumed to be dipping vertically. The approach is 23 feet in length, and the adit is driven 17 feet on a bearing N. $74\frac{1}{2}^{\circ}$ W. through shattered soft white sandstone, which shows occasional cubical cavities caused by the decomposition and removal of crystals of pyrite. The rock is much softened by weathering. A crosscut to the north-east for about 20 feet through similar rock is now collapsed. On a bearing S. $37\frac{1}{2}^{\circ}$ W. a crosscut extends for 57 feet. For 30 feet the drive passed through similar decomposed white sandstones, merging into hard white quartzites carrying crystals of pyrite. Here there is apparently a fault-plane, represented by a fissure filled with clay, striking N. 50° W., and dipping vertically. Beyond this the slates are much shattered; they merge into soft clays (representing weathered slates) with a little hard garnet-pyroxene rock. At about 37 feet from the main drive are soft gritty clays, apparently carrying a little garnet, striking about east and west, and dipping vertically. Another 10 feet on, hard-banded garnet rock makes its appearance. In the face very hard green garnet-pyroxene rock occurs. At 10 feet from the face (47 feet from the main drive) a drive has been extended for 38 feet on a bearing N. 47° W., a short crosscut being driven north-east for 11 feet at a distance of 22 feet. The drive exposes well-banded garnet rock. Some bands of garnet rock are soft and partly decomposed; others are hard and contain abundant calcite and pyroxene (the latter mineral only distinguishable microscopically), while other bands again are intensely hard and tough, green and pink in colour, and consisting of garnet and pyroxene. In the face the rock is hard garnet-calcite, still showing a banded struc-

ture. These banded rocks have a general strike N. 70° W., and dip south at about 35°. In the 11 feet crosscut referred to, the strike is N. 60° W., and dip S.W. at about 30°. In this crosscut, 2 feet from the face, the garnet rock is traversed by a well-defined fissure—apparently a fault plane—striking N. 50° W., and dipping vertically. Beyond this the country-rock is a good deal shattered. This fissure apparently corresponds with that exposed in the crosscut from the main drive, as noted above.

As described below, the garnet rock exposed in the No. 1 Adit carries low scheelite values; it appears, however, to be a distinct formation from that exposed in the Nos. 2 and 3 Adits higher up the hill. No work was being carried on in this adit at the time of the writer's examination.

No. 2 Adit.—This was driven into the hillside from a point about 136 feet above sea-level, or 30 feet above No. 1 Adit. A small open-cut had been taken out at this point for 20 feet, the width being 30 feet. The surface material carries scheelite, and with the soil is a good deal of garnet in crystals and crystal aggregates derived in the course of weathering from the ore-body a little higher up the hillside; angular quartz is also noticeable. This material is 6 feet in depth, and rests on white aplite, which carries low tungstic acid values. From the face of this cut the adit is driven on a bearing of N. 47½° W. for 36 feet, when it bends to N. 14° E. for 26 feet to the face; 13 feet from the face a winze was sunk 10 feet. This was the condition of the adit when the writer first visited the property, but at his recommendation a crosscut was commenced from the bend in the drive 36 feet from the entrance, and had been driven 33½ feet on a bearing S. 44½° W., exposing good ore. There is a considerable variation in the rocks passed through in this adit. Driving was commenced in aplite somewhat softened by weathering. This rock was traversed by a quartz vein 5 feet from the entrance, width 3 to 18 inches, carrying a good deal of scheelite. At 17 feet from the entrance the junction of aplite with decomposed sedimentary rocks is to be seen striking N. 37° E., and dipping west at 26°.

On the south-western wall aplite appears in the lower portion of the drive, junctioning with shattered and fissured metamorphosed sedimentary rocks above; the aplite itself is much jointed. Similar conditions prevail to the easterly bend in the drive 36 feet in. At 5 feet beyond this aplite appears again in dyke form, with walls which are sharply defined, although irregular (apparently

following certain joint-planes of the sedimentaries). The adjacent sedimentary rocks are much decomposed, but merge into bands of very hard pink and green garnet-pyroxene rock.

At 13 feet from the bend, or 49 feet from the entrance, a winze was sunk in the western wall to a depth of 10 feet. This exposes banded garnet and garnet-pyroxene rock in contact with aplite occurring in dyke form. Quartz veins, which sometimes carry a little scheelite, molybdenite, and pyrite, traverse the garnet rock or occur at the junction of aplite and garnet rock; these are obviously connected genetically with the aplite, which continues underfoot. From the winze to within 2 feet of the face is hard banded garnet rock. Here a fault plane showing slickensides, with a strike N. 55° W. and dip S.W. at 60° , marks a change to shattered slate country with some bands of hard black quartzite and a little garnet-pyroxene rock.

At the time of the writer's final examination of the workings a crosscut was being driven in ore in a south-westerly direction from the bend in the adit 36 feet from the entrance. At the collar of this crosscut aplite occurs dipping at about 25° and rising into the roof. This is in contact with a band of extremely hard green garnet-pyroxene rock, which shows a banded structure; the bands strike about north-west and dip south-west at about 35° . At 7 feet from the collar of the crosscut is a quartz vein showing in the roof, about 12 inches in width, which carries a little white mica, good scheelite values, and richer molybdenite than was seen at any other spot in the mine. On the south-east wall this quartz vein dips 2 feet in a distance of 3 feet horizontally, and then rises again into the roof 4 feet further along the course of the drive. This vein is apparently connected with the aplite intrusion. On the opposite wall, at 10 feet from the collar, is a small dyke of aplite about 12 inches in width bordered by a vein of quartz with white mica and rich scheelite. At 17 feet in aplite disappears in the north-west wall; quartz shows in the roof with scheelite, garnet, and mica. Banded garnet rock occurs here on the opposite wall, with scheelite. At 22 feet is an apparent wall, which is not very distinct, but appears to strike a few degrees west of north and dip west at 35° or 40° . There appears to be rather a merging into garnet lode material than a true wall, for from this point to the face the crosscut passes through crystallised garnet with calcite with irregular masses of quartz, the whole traversed by veins filled with soft decomposing micaceous material.

Sampling showed that this lode material carried good tungstic acid values, which is not surprising, as masses of scheelite are visible in places.

No. 3 Adit.—This was the highest adit, and that in which most ore was exposed. Aneroid readings indicated that it is about 172 feet above sea-level, or 36 feet above the No. 2 Adit. It is a tortuous drive, and the work has scarcely been carried out to best advantage. An approach has been cut on a bearing N. 37° W. for 64 feet to the entrance of the adit. At the entrance the floor is 21 feet below the surface. This is through soft decomposed garnet rock near the surface, merging into harder material at a greater depth. The garnet rock is banded and is traversed by quartz veins frequently parallel with the banding, and carrying both scheelite and molybdenite. From the present entrance crosscuts extend east and west to the walls of the formation, exposing a valuable section of the deposit. The main adit extends 24 feet on a bearing N. 33° W. through banded garnet rock, frequently soft, but with some harder bands of garnet-pyroxene and occasional quartz veins. Bending to N. 72° W. the main adit extends for 38 feet through country rock, consisting mainly of slate with some harder garnetiferous bands. There is a well-defined quartz vein at the end of this length of drive, striking N. 10° E., and dipping west at 65°. Water is fairly abundant here, and a good deal of limonite is being deposited. The drive now makes a sharp bend, and apparently runs on a course about parallel with that originally followed, as the bearing is S. 35° E. for 38 feet. This portion of the drive exposes mainly hard-banded garnet and garnet-pyroxene rock. At 31 feet a quartz vein was noted, and this appears to mark the change to softer (more weathered) garnetiferous lode material similar to that exposed in the crosscuts from the entrance to this level. The last section of the adit, 14 feet in length, is driven on a bearing of S. 23° W. through similar material. It appears that at the face the adit is only about 10 feet from the south-western crosscut, so irregular has been its course.

As noted above, crosscuts were driven from near the entrance to this adit, both north-east and south-west, exposing the width of the formation at this point. The former extends for 15 feet only, on a bearing N. 69° E., through soft garnetiferous lode material, exposing slate country rock (softened by weathering) in the face. The other crosscut bears S. 69° W. for 17½ feet, when it bends further to the south, continuing for 45 feet on a bearing S. 36° W. before

bending still further south. The final length bears S. 40° W. for 18 feet to the face, where soft decomposed slate country-rock is again exposed. This crosscut passed through crystallised garnet material, only partly coherent in places, but sometimes harder and carrying calcite. The banded structure is not always noticeable, but is frequently traceable. A little quartz is visible in places; one vein runs for some distance parallel with the banding of the ore (usually about horizontal), is one-quarter to 3 inches in width, and carries visible scheelite and molybdenite. Assay values quoted elsewhere show that the whole of the garnet formation exposed in these crosscuts carries scheelite.

Lowest Adit (Collapsed).—Near the foot of the hill, and about 6 chains from the shore, an adit was driven into the hill in the hope of cutting the ore-body, but only country rock (hard slates and quartzites) appears to have been passed through. This adit has now completely collapsed, but is said to have been driven for 120 feet. The general direction was N. 74° W.

Upper Adit (Collapsed).—Higher up than the group of main workings, about 5 chains north-west of No. 3 Adit, is another adit, now completely collapsed. This is said to have been driven 30 feet from the approach, and to have just cut hard garnet rock. It is to be regretted that the formation was not completely exposed here.

No. 1 Shaft.—This shaft was sunk on the scheelite deposit near the outcrop originally discovered. It is only about 120 feet from the outcrop on the beach which is covered at high tide, and on a terrace about 20 feet above sea-level. The shaft is partly full of water and quite inaccessible. It is said to have been sunk to a depth of 25 feet on a garnet formation carrying scheelite values. It is a little doubtful whether this formation is the same as that exposed in the adits higher up the hill. This question has been referred to when dealing with the structure of the ore-body.

No. 2 Shaft.—This shaft was sunk at the head of a small creek to a depth of 20 feet on a massive garnet formation carrying some fine scheelite. The shaft is situated about 4½ chains south-west of the No. 3 Adit, and at an elevation of about 150 feet above sea-level; it is now inaccessible on account of water. A grab sample from the heap of garnetiferous material at the collar of the shaft showed as a result of assay 1.55 per cent. of tungstic acid. This formation appears to be a distinct one from that opened up by

the main workings. A trench (now partly full of water and inaccessible for sampling) exposes about 25 feet of similar garnet material to that exposed in the No. 3 Adit, with aplite just showing on the east side of the trench. No change in the formation is said to have been observed at the bottom of this shaft.

No. 3 Shaft.—This shaft was sunk on a terrace high up on the hillside about 10 chains north-west of No. 3 Adit. Aneroid readings show that the elevation is about 300 feet above sea-level. The shaft was sunk on what was supposed to be the line of outcrop of the main ore-body, but the result was negative, and work was abandoned after sinking 35 feet through hard metamorphosed slate country-rock, which sometimes showed faulting on a small scale.

Garden Workings.—About 25 chains west of the main workings the approach to an adit was commenced at the head of a small creek. Solid rock was not exposed, but garnets are present in the surface material, from which small quantities of scheelite can be obtained on vanning. There appears to be in this vicinity an ore-body quite distinct from any other exposed on the property, which should be prospected.

IV.—ASSAY VALUES.

In the previous chapter a general description has been given of the different workings and of the nature of the ore and country-rock opened up by the workings. It remains to discuss assay values of the ore exposed on the property. All samples were taken by the writer, and were assayed by Mr. W. D. Reid, Government Assayer in the Geological Survey Laboratory, Launceston. In all samples tungstic acid was determined, as this is the most important constituent. A little molybdenite was visible in some samples, but clearly it was not present in sufficient quantity to be an important constituent of the ore. Hence the metal was not determined in all samples, but only in sufficient of the samples to demonstrate the low values actually existing in the ore. Reference has been made in dealing with the mineralogical composition of the ore to the presence of bismuth and cassiterite as impurities, and to the importance of these minerals should they be present in appreciable quantities. The official proclamation dealing with the purchase of wolframite and scheelite specifically states that neither bismuth nor tin must exceed $\frac{1}{2}$ per cent. in the concentrate. It becomes essential, then, to determine the quantities of these impurities present, and this has been done in the case of all really representative samples of ore taken. It is of interest to note that although bismuth was detected by Mr. T. Farrell in one locality, the presence of tin in the deposit does not appear to have been suspected; it proves to be fairly widely disseminated, although in comparatively small amounts.

With reference to the actual constituent determined in the samples, it is of less value to know the actual scheelite content than that of tungstic acid, as ore values are based on the latter constituent. Should the scheelite (Ca WO_4) content be desired, however, it may be derived from the tungstic acid (WO_3) on multiplying by 1.24. Similarly, the molybdenite value (Mo S_2) may be obtained from that quoted for molybdenite (Mo) on multiplying by 1.668, and the cassiterite value (Sn O_2) from metallic tin (Sn) on multiplying by 1.27. The factors quoted are approximately correct. It sometimes happens that there are replacing elements in the minerals which would vary the factors slightly.

With reference to the mode of sampling, the samples were broken as nearly as possible at right-angles to the

dip of the formation. Samples taken at this angle, but at 7-foot intervals when measured horizontally along the wall of a drive, would be 5 feet apart when measured at right-angles to the line of the samples. The occurrence of veins of quartz carrying visible scheelite, in places running parallel to the banding, might lead to grave discrepancies if samples were taken parallel to the banding of the ore.

The results of sampling were as follow:—

(WO_3 = Tungstic Acid, Mo. = Molybdenum, Bi. = Bismuth, Sn. = Tin.)

No. 1 Sample.—From No. 3 Adit, south-western cross-cut face; hanging-wall country-rock.

Result: WO_3 , trace.

No. 2 Sample.—From No. 3 Adit, south-western cross-cut, eastern wall 7 feet from face; hard crystallised garnet with quartz veins; width 7 feet.

Result WO_3 , 2.80 per cent; Mo., 0.14 per cent.; Bi., 0.17 per cent; Sn., trace.

No. 3 Sample.—From No. 3 Adit, south-western cross-cut, eastern wall, 14 feet from face; hard garnet rock with softer bands; width, 7 feet.

Result: WO_3 , 1.30 per cent.; Bi., 0.01 per cent.; Sn., 0.015 per cent.

No. 4 Sample.—From No. 3 Adit, south-western cross-cut, south-eastern wall, 21 feet from face; lode-material similar to No. 3; width, 7 feet.

Result: WO_3 , 0.88 per cent.; Mo., 0.011 per cent.; Bi., 0.045 per cent.; Sn., 0.15 per cent.

No. 5 Sample.—From No. 3 Adit, south-western cross-cut, south-eastern wall, 28 feet from face; material similar to No. 3; width, 7 feet.

Result: WO_3 , 0.40 per cent.; Bi., trace; Sn., nil.

No. 6 Sample.—From No. 3 Adit, south-western cross-cut, south-eastern wall, 35 feet from face; material similar to No. 3; width 7 feet.

Result: WO_3 , 1.10 per cent.; Mo., trace; Bi., 0.025 per cent.; Sn., 0.017.

No. 7 Sample.—From No. 3 Adit, south-western cross-cut, south-eastern wall, 42 feet from face; material similar to No. 3; width, 7 feet.

Result: WO_3 , 1.22 per cent.; Bi., 0.013 per cent.; Sn., trace

No. 8 Sample.—From No. 3 Adit, south-western crosscut, south-eastern wall, 49 feet from face; banded hard and soft garnet lode material with some quartz; width, 7 feet.

Result: WO_3 , 1.83 per cent.; Mo., 0.09 per cent.; Bi., 0.085 per cent.; Sn., 0.20 per cent.

No. 9 Sample.—From No. 3 Adit, south-western crosscut, south-eastern wall, 56 feet from face; similar material to No. 8; width, 7 feet.

Result: WO_3 , 1.66 per cent.; Mo., nil; Bi., 0.08 per cent.; Sn., trace.

No. 10 Sample.—From No. 3 Adit, south-western crosscut, south-eastern wall, 63 feet from face; similar material to No. 8; width, 7 feet.

Result: WO_3 , 0.93 per cent.; Mo., trace; Bi., 0.026 per cent.; Sn., 0.016 per cent.

No. 11 Sample.—From No. 3 Adit, south-western crosscut, south-eastern wall, 70 feet from face; similar material to No. 8; width, 7 feet.

Result: WO_3 , 2.51 per cent.; Bi., 0.015 per cent.; Sn., 0.30 per cent.

No. 12 Sample.—From No. 3 Adit, northern crosscut, south-eastern wall, $3\frac{1}{2}$ feet from adit; hard and soft garnet lode material.

Result: WO_3 , 1.03 per cent.; Mo., 0.027 per cent.; Bi., trace; Sn., 0.11 per cent.

No. 13 Sample.—From No. 3 Adit, northern crosscut, south-eastern wall, hard and soft garnet lode, footwall side, $10\frac{1}{2}$ feet from adit; width, 7 feet.

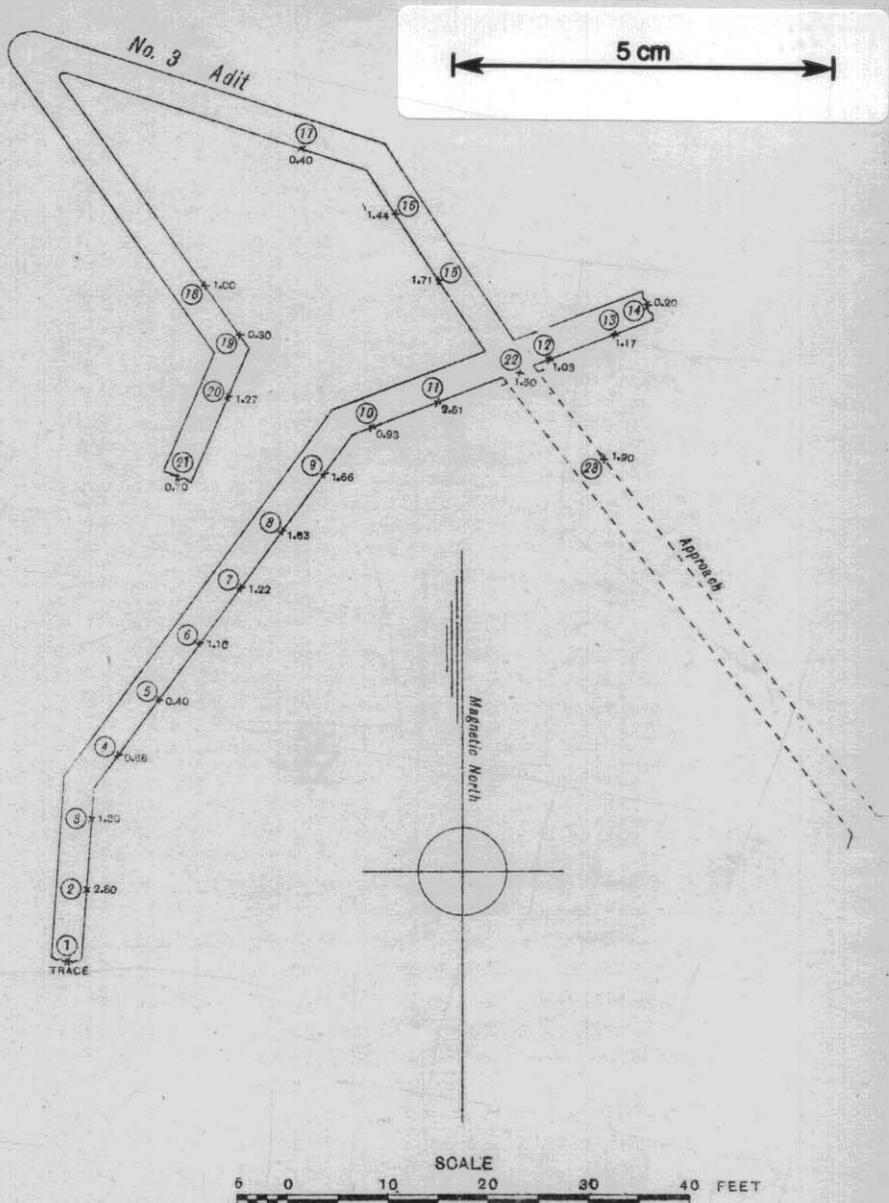
Result: WO_3 , 1.17 per cent.; Bi., nil; Sn., 0.012 per cent.

No. 14 Sample.—From No. 3 Adit, northern crosscut face; footwall country-rock.

Result: WO_3 , 0.20 per cent.

No. 15 Sample.—From No. 3 Adit, south-western wall, 10 feet beyond crosscuts; bands of soft garnet with harder garnet-pyroxene bands and a little quartz; width, 7 feet.

Result: WO_3 , 1.71 per cent.; Mo., trace; Bi., nil; Sn., nil.



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FIG. 3.—Assay Plan of No. 3 Adit showing Tungstic Acid Percentages.

No. 16 Sample.—From No. 3 Adit, south-western wall, 18 feet beyond crosscuts; similar material to No. 15; width, 7 feet.

Result: WO_3 , 1.44 per cent.; Bi., nil; Sn., trace.

No. 17 Sample.—From No. 3 Adit, south-western wall, beyond bend, 30 feet from crosscuts; very hard banded garnet-pyroxene rock; width, 7 feet.

Result: WO_3 , 0.40 per cent.

No. 18 Sample.—From No. 3 Adit, north-eastern wall, 31 feet beyond very sharp bend (21 feet from face); soft garnet lode material, with very hard garnet-pyroxene bands; width, 7 feet.

Result: WO_3 , 1.00 per cent.; Bi., nil; Sn., 0.015 per cent.

No. 19 Sample.—From No. 3 Adit, north-eastern wall, at final bend 6 feet beyond No. 18, and 15 feet from face; very hard garnet-pyroxene rock, with some softer garnet material; width, 7 feet.

Result: WO_3 , 0.30 per cent.; Mo., trace; Bi., nil; Sn., nil.

No. 20 Sample.—From No. 3 Adit, south-eastern wall, 6 feet beyond No. 19, and 9 feet from face; soft garnet lode material, with hard band, with quartz at bottom of adit; width, 7 feet.

Result: WO_3 , 1.27 per cent.; Bi., trace; Sn 0.018 per cent.

No. 21 Sample.—From No. 3 Adit face; hard and softer bands of garnet rock; width, 6 feet.

Result: WO_3 , 0.70 per cent.; Mo., trace; Bi, nil; Sn., 0.012 per cent.

No. 22 Sample.—From No. 3 Adit entrance, immediately over junction with crosscuts, from subsoil ($3\frac{1}{2}$ feet below surface) down for 6 feet across bands; soft oxidised material consisting mainly of coarse garnets.

Result: WO_3 , 1.50 per cent.; Bi., nil; Sn., 0.013 per cent.

No. 23 Sample.—From No. 3 Adit entrance, north-east wall, 12 feet south-east of No. 22, from $4\frac{1}{2}$ feet below surface to floor of adit approach, 12 feet; soft oxidised material consisting mainly of coarse garnets.

Result: WO_3 , 1.90 per cent.; Bi., nil; Sn., 0.011 per cent.

No. 24 Sample.—From No. 2 Adit, north wall, 10 feet from entrance; hard fissured aplite; height, 6 feet.

Result: WO_3 , 0.41 per cent.; Mo., 0.04 per cent.; Bi., nil; Sn., nil.

No. 25 Sample.—From No. 2 Adit, both walls, 20 feet from entrance, upper 3 feet; hard banded garnet and garnet-pyroxene rock, with some softer bands to their junction with aplite.

Result: WO_3 , 0.20 per cent.; Mo., trace; Bi., 0.012 per cent.; Sn., nil.

No. 26 Sample.—From No. 2 Adit, both walls, 20 feet from entrance, lower 3 feet, immediately below No. 25; white aplite, with occasional softer bands.

Result: WO_3 , 0.16 per cent.; Mo., 0.013 per cent.; Bi., nil; Sn., trace.

No. 27 Sample.—From No. 2 Adit, 33 feet from entrance, on shoulder of drive and crosscut; top partly softened garnet rock, bottom aplite, with soft rock at floor of drive; height, 6 feet.

Result: WO_3 , 0.55 per cent.; Mo., trace; Bi., nil; Sn., trace.

No. 28 Sample.—From No. 2 Adit, winze 13 feet from face, from roof to bottom of winze west wall; banded hard and soft garnet rock, with quartz and aplite 3 feet from bottom; height, 16 feet.

Result: WO_3 , 0.40 per cent.; Mo., 0.02 per cent.; Bi., nil; Sn., nil.

No. 29 Sample.—From No. 2 Adit, new south-western crosscut, shoulder adjoining adit, 33 feet from entrance; upper 3 feet partly decomposed aplite, lower 3 feet soft banded garnet rock; height, 6 feet.

Result: WO_3 , 0.41 per cent.; Mo., 0.16 per cent.

No. 30 Sample.—From No. 2 Adit, new south-western crosscut, south-eastern wall, 7 feet from shoulder on main adit; top 12 inches soft micaceous pug with quartz, then banded garnet and hard garnet-pyroxene rock; width, 7 feet.

Result: WO_3 , 0.85 per cent.; Bi., nil; Sn., 0.014 per cent.

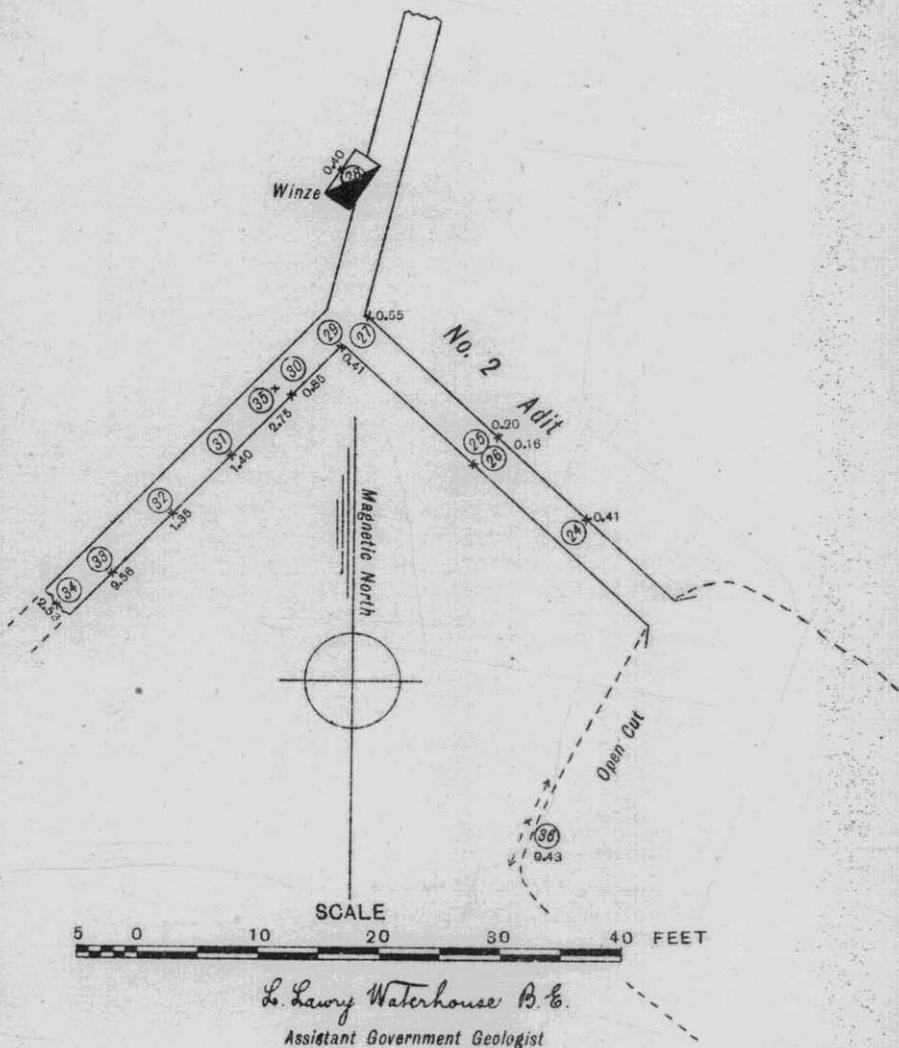


FIG. 2.—Assay Plan of No. 2 Adit showing Tungstic Acid Percentages.

5 cm

No. 31 Sample.—From No. 2 Adit, new south-western crosscut, south-eastern wall, 14 feet from adit; upper 12 inches quartz, then hard garnet-pyroxene and softer garnet rock, $2\frac{1}{2}$ feet from bottom soft greenish country-rock with a little garnet; width, 7 feet.

Result: WO_3 , 1.40 per cent.; Mo., trace; Bi., trace; Sn., trace.

No. 32 Sample.—From No. 2 Adit, new south-western crosscut, south-eastern wall, 21 feet from adit; soft garnet lode material, with occasional harder bands and a little quartz; width, 7 feet.

Result: WO_3 , 1.35 per cent.; Bi., trace; Sn., 0.018 per cent.

No. 33 Sample.—From No. 2 Adit, new south-western crosscut, south-eastern wall, 28 feet from adit; soft garnet lode material, with some quartz and visible scheelite; width, 7 feet.

Result: WO_3 , 9.56 per cent.; Mo., 0.16 per cent.; Bi., nil; Sn., 0.22 per cent.

No. 34 Sample.—From No. 2 Adit, new south-western crosscut face, 33 feet from adit; firm garnet lode material, with soft bands and irregular masses of quartz; height, 6 feet.

Result: WO_3 , 2.53 per cent.; Bi., trace; Sn., 0.30 per cent.

No. 35 Sample.—From No. 2 Adit, new south-western crosscut roof, 7 feet from adit; special sample of quartz vein, width 12 to 15 inches, showing richest molybdenite seen in mine, and visible scheelite.

Result: WO_3 , 2.75 per cent.; Mo., 2.51 per cent.; Bi., trace; Sn., trace.

No. 36 Sample.—From open-cut at entrance to No. 2 Adit, 30 feet south of adit entrance, below surface soil, 6 feet below actual surface; sample of partly-weathered aplite exposed in bottom of cut; width, 8 feet.

Result: WO_3 , 0.43 per cent.; Mo., trace; Bi., nil; Sn., nil.

No. 37 Sample.—From No. 1 Adit, south-western crosscut, 46 feet from main adit (10 feet from face), south-eastern wall opposite north-western drive; very hard garnet-pyroxene rock, with soft bands of decomposing garnet lode material; width, 7 feet.

Result: WO_3 , 1.32 per cent.

No. 38 Sample.—From No. 1 Adit, 10 feet forward from No. 37, along north-western drive, south-western wall; mainly very hard garnet-calcite rock, with some softer bands; width, 6 feet 6 inches.

Result: WO_3 , 0.43 per cent.

No. 39 Sample.—From No. 1 Adit, north-western drive, 20 feet forward from No. 37, south-western wall at collar of short crosscut; well-banded hard garnet-pyroxene rock and very hard garnet-calcite rock, with some bands of soft garnet; width, 7 feet.

Result: WO_3 , 0.64 per cent.; Mo., 0.03 per cent.; Bi., trace; Sn., nil.

No. 40 Sample.—From No. 1 Adit, north-western drive, 30 feet forward from No. 37, south-western wall; similar material to No. 39; width, 7 feet.

Result: WO_3 , 0.86 per cent.

No. 41 Sample.—From No. 1 Adit, north-western drive; face (38 feet forward from No. 37) extremely hard and tough garnet-calcite rock, banded; width, 5 feet 6 inches.

Result: WO_3 , 0.50 per cent.

No. 42 Sample.—Sample from heap of soft garnet material at collar of No. 2 Shaft (20 feet).

Result: WO_3 , 1.55 per cent.

The accompanying diagrams (Figures 1, 2, and 3) show graphically the positions of the principal samples and their tungstic acid content as revealed by assay. The molybdenum, bismuth, and tin values are omitted from the diagrams to avoid complicating them too much.

It is clear from the explanations given above that a general average of all the assay values is not justified to arrive at the average value of the ore exposed, as some of the samples are not samples of ore. Thus Nos. 1 and 14 represent hangingwall and footwall country-rock respectively, and carry only very low tungstic acid values. Then, again, some of the samples (*e.g.*, No. 17) appear to be beyond the boundaries of the ore-body proper, and should be excluded in attempting to arrive at an average value.

Several samples were taken from the garnet-calcite formation exposed in the lowest (No. 1) adit, and all carry scheelite; but the writer is not satisfied that this formation really forms part of the ore-body exposed in the adits

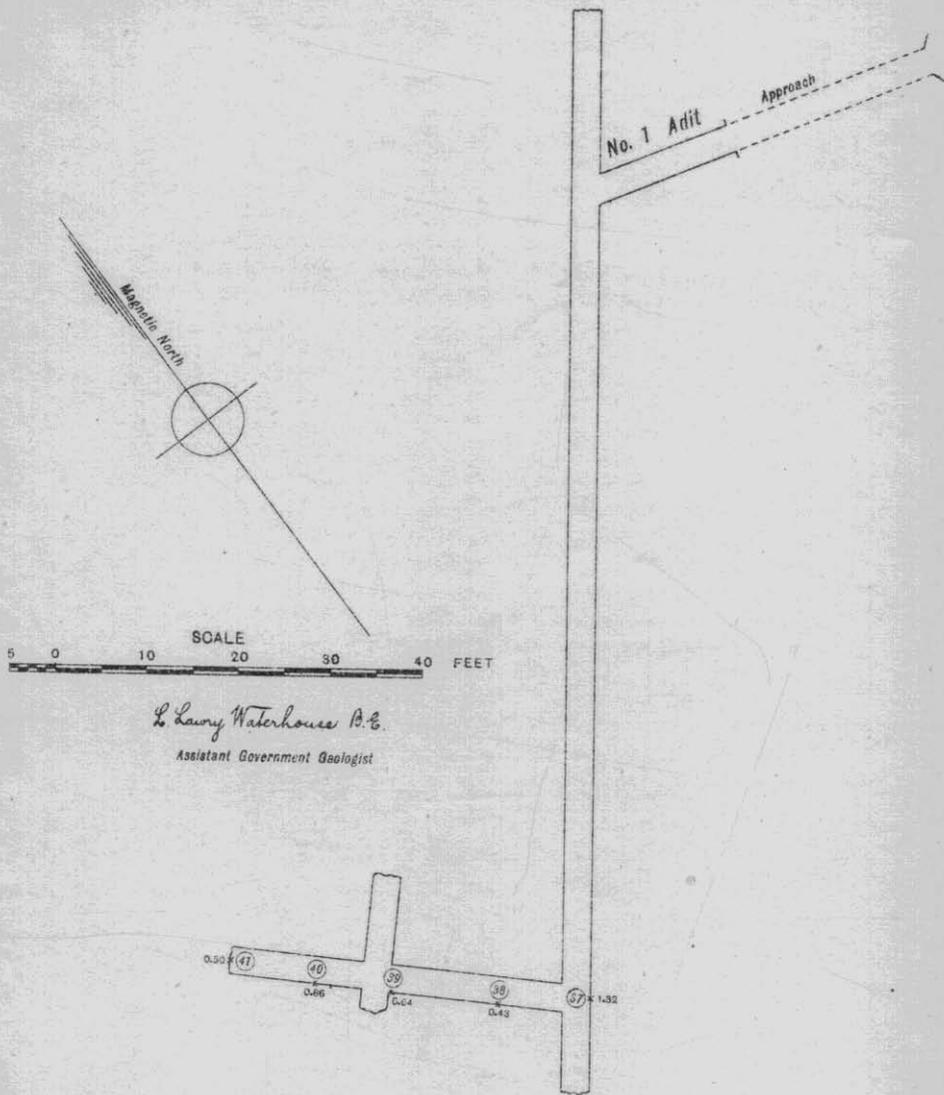


FIG. 1.—Assay Plan of No. 1 Adit showing Tungstic Acid Percentages.

5 cm

above (Nos. 2 and 3), and hence he considers that these values should be excluded in estimating the average. The average value of the ore exposed in this adit is 0.75 per cent. tungstic acid (or £1 16s. 1d. gross on the basis of the present price, 48s. 1d. per unit).

Another feature is worthy of comment. In the No. 2 Adit are several exposures of aplite (locally called porphyry) from which samples were taken. The rock is associated with the ore-body, and itself carries low values (0.33 per cent. as an average of three samples taken), but cannot be regarded as ore. In the same adit some of the hard garnet-pyroxene carries very low values, but must be regarded as merely altered country-rock. It would be rejected in working the deposit on a commercial scale.

No. 35 Sample, which was taken essentially to determine the actual molybdenite value of a quartz vein showing that mineral abundantly, can scarcely be regarded as typical ore, although several quartz veins were noticed in places between the actual lines of samples taken, carrying visible scheelite. In actual working, of course, such enrichments would go to raise the average value of the ore.

Sample No. 42 also appears to be from a separate formation and although nearly of average value, should be neglected in trying to arrive at the true average value of the ore-body exposed.

Taking the average of 25 samples (viz., Nos. 2-13 inclusive; 15, 16, 18-23 inclusive; and 30-34 inclusive), the average value of the ore sampled in the main formation is 1.69 per cent. tungstic acid. Of this aggregate amount, the writer considers that at least 80 per cent. should be covered in treatment; *i.e.*, the net value of the ore is 1.35 per cent. tungstic acid. On the basis of 48s. 1d. per unit of tungstic acid (the price guaranteed by the Commonwealth Government) the ore has a net value at the present time of, approximately, £3 5s. per ton.

The values, other than those of tungstic acid, are worthy of comment.

It has been commonly reported that the ore is of value because of its molybdenum content, as well as its tungstic acid. An inspection of the deposit showed that this was scarcely likely to be correct, and the assays made confirm this opinion. As noted above, Sample No. 35 was taken especially because the quartz was rich in molyb-

denite, to try and ascertain the real value of an ore which showed the mineral freely. The assay showed only 2.51 per cent. of molybdenum (Mo), equivalent to 4.19 per cent. of molybdenite (Mo S_2). This sample, however, is not by any means representative. As recorded above, some samples of ore carry only traces (6 out of 12 samples of ore returning only "trace"), although only one assay gave a negative result. The average of these 12 samples, however, is only 0.024 per cent. molybdenum—a figure much too low to encourage the hope that it may prove payable. This figure would be equivalent to .04 per cent. molybdenite, and although at the time of writing the Government guarantees 93s. 10d. per unit of molybdenum sulphide for concentrates carrying 90 per cent. of the mineral, in practice the recovery would be too low to warrant any attempt being made to save the mineral, beyond hand-picking and throwing aside for treatment, when sufficient accumulated, any high-grade ore which might be encountered in the course of opening up and working the scheelite deposits. Richer patches of molybdenite may be encountered in quartz veins traversing the formation, such as that exposed in the No. 2 Adit from which Sample No. 35 was taken.

It is necessary to comment on the occurrence of bismuth and tin in the ore as revealed by the assay results quoted above: both metals are fairly widely distributed, although in small quantities.

In the 25 samples referred to above, bismuth is recorded as absent from 10, and present in traces only in six others. The average value for the 25 samples is .0126 per cent. metallic bismuth. According to calculations made, with a theoretically perfect concentration of the metal this amount of bismuth in the ore would bring the percentage in the scheelite concentrate to, approximately, .5 per cent., but as there is likely to be some loss, the amount finding its way into the concentrate is likely to be less than the limit mentioned.

Theoretically, with an average ore value of 1.69 per cent. tungstic acid, and .0126 per cent. bismuth, if the concentrate be assumed to carry 70 per cent. tungstic acid, if 80 per cent. of the scheelite be saved and 90 per cent. of the bismuth, the percentage of bismuth expected in the concentrate would be about .586 per cent. If only 80 per cent. of the bismuth were saved, the amount expected in the concentrates would be .521 per cent. It must be borne in mind, however, that these figures are merely theo-

retical, and the amount actually saved in practice may be considerably less than that calculated.

With regard to tin (which is very probably present as cassiterite), only three of the 25 samples showed negative results on assay, although five others returned traces, the amount in the remainder ranging from .011 to .3 per cent. The average value is .0576 per cent. metallic tin. The tin is certainly not likely to prove of economic value, but it may prove detrimental in the concentrate. An expression of opinion on this point, however, is not of much value in the complete absence of details of any practical concentration tests on the ore.

Such tests are essential before any definite statement can be made. It is interesting, however, to try and anticipate the behaviour of the tin which is shown to be present in the ore. In the first place there is no positive evidence as to the form in which the tin exists in the ore, although it is most likely present as cassiterite in a very finely-divided form. Then, again, there is nothing to show whether it is more intimately associated with one than another of the minerals of the ore. Should it, for example, be included in the scheelite, as traces of molybdenite are, it may be difficult to separate in the final stages from that mineral.

Calculating theoretically, as was done in the case of bismuth, to try and get some idea as to the tin (supposing it to exist as cassiterite) likely to find its way into the concentrate, it is probable that the extraction will not exceed about 30 per cent. with such extremely fine ore. Assuming the average ore value to be 1.69 per cent. tungstic acid, and 0.0576 per cent. tin, with a concentrate assaying 70 per cent. tungstic acid and a recovery of 80 per cent of the scheelite, theoretically the concentrate might be expected to carry about 0.895 per cent. tin. It does not appear to the writer likely that more than 30 per cent. of this very fine tin will be saved, and it is not improbable (in view of the evidence afforded by the treatment of certain ores on the West Coast of Tasmania in which the so-called "slime tin" is present), that the concentrate will be found to carry only traces of the objectionable metal.

On the whole, the writer considers it unlikely that bismuth or tin will be present in the concentrate in sufficient quantities to be really detrimental. Even should the metals increase slightly beyond the amounts noted, the main product (scheelite) is so urgently needed that the

penalties are not likely to be heavy for the small amounts of the metals present. In the event of richer shoots of either metal being encountered, as the main concentrating plant will be designed essentially to save a lighter mineral (scheelite) than either bismuth or cassiterite, it may be found possible to isolate a small quantity of heavy concentrate from the tables, which would be rich in the objectionable metals, and which would (if sufficient accumulated) be sold as a complex ore for special treatment, leaving the main bulk of the concentrate impoverished to such an extent in these particular metals as to prove a high-grade scheelite ore, and command prices accordingly. It is extremely unlikely, however, that such treatment will be found necessary.

Thus the bismuth and tin recorded, while not in their present quantities detracting materially, if at all, from the value of the ore as a tungstic acid product, indicate that a look-out should be kept for these metals in future work, and that the concentrate obtained from any parcels of ore treated experimentally should be examined carefully.

V.—COSTS.

It scarcely comes within the scope of a geological survey report to deal in any detail with costs of plant, of mining and of treating the ore, although some reference is necessary.

Viewing the question broadly, it is clear that the deposit is not a small rich one, but that it is likely to prove a large and comparatively low-grade one. Such being so, it becomes important that working costs should be reduced to a minimum by carrying out mining and treatment operations on a moderately large scale. Fortunately, the mine is very favourably situated for economic mining (as noted elsewhere), and as open-cut methods may be employed, actual mining costs are likely to be low, and the property has other facilities, which have been referred to elsewhere.

In the case of a property such as that under review, it is absolutely essential that adequate provision be made for prospecting and developmental work. Certain recommendations are made below in this connection.

At the present time little skilled labour is available on the island for mining work, although doubtless this will be remedied when operations commence in earnest on the property. The lack of skilled miners, however, is sure to make itself felt for a time, and will tend to increase working costs in the early stages above what will be found later to be a normal figure.

Likewise, treatment costs are certain to be heavier in the earlier stages—which must, of necessity, be experimental to a large extent—than they will be under normal conditions when initial difficulties have been overcome.

As to actual costs, although the writer cannot go into the matter, it may be advisable to give some estimate, and for this purpose the following extract is quoted from a professional report by Mr. J. B. Lewis, mining engineer, Melbourne, published in the prospectus of the King Island Scheelite Company, No Liability:—

“*Working Costs.*—These would depend on what proportion of the ore could be worked by open-cut, and the amount treated. Open-cut working would allow the ore to be delivered at the treatment plant at 3s. to 4s. per ton. Stopping would cost 8s. or 9s. per ton; crushing and concentrating, &c., 4s. 6d. per ton. If half the ore were

won by open-cut work and half by stoping, the average cost per ton would be 10s. or 11s. To this must be added prospecting and developing work; or we should be prepared for costs of 12s. per ton, with a plant treating 300 tons per week. Such a plant would be equivalent to a 10-head battery. Bags, freight charges, insurance, management, &c., would probably add 3s. per ton. Stripping would doubtless more than pay for itself, as the material stripped would carry more mineral than would pay for its treatment. It is probable that after experience with the ore and the plant, the above costs could be reduced. Under similar circumstances costs have been obtained as low as 6s. per ton, in place of the 10s. or 11s., shown above; but all will depend on the plant being kept at its full capacity. Costs would thus be about £225 per week."

In the same report, under the heading "Cost of Plant," Mr. Lewis continues:—

"*Cost of Plant.*—A steam or gas plant generating electricity, with separate motors for stone-breaker, battery or other crushing plant, concentrators, and pump for dressing and boiler water, and possibly for a conveyor conveying ore from mine to hopper over stone-breaker, would be the simplest, and possibly the most efficient, arrangement. Included in plant should be buildings for mine office, assay office, manager's residence, and huts for men, there being no accommodation in the neighbourhood. For this a sum of £10,000 should be provided."

Mr. Lewis then estimates:—

	Per ton.
"Working costs, including all charges, management, &c.	£ s. d. 0 15 0
Interest on capital, 5 per cent., depreciation, &c., 20 per cent.	0 3 4
	0 18 4

300 tons, at 18s. 4d. per ton £275 0 0"

The above costs, as worked out by Mr. Lewis, and published in the company's prospectus, are quoted without comment.

It is interesting to contrast these working costs with actual ore values, as revealed by assays of samples taken by the writer. Assuming for sake of comparison the ton-

nage upon which Mr. Lewis has based his costs—viz., 300 tons per week, of a gross value of 1'69 per cent. tungstic acid, at 48s. 1d. in Melbourne, if the extraction be 80 per cent., the value per week would be £975.

If the extraction fell to 70 per cent., the value per week would be £853.

The extraction should, in the writer's opinion, more nearly approach 80 per cent. than 70 per cent., and might even slightly exceed the former figure with careful concentration, after preliminary tests have shown the best methods to employ.

Thus, on the costs quoted above, there is likely to be a considerable margin of profit if the ore maintains the average, as shown by assay.

VI.—TREATMENT.

The question of treatment of an ore of this description cannot be dealt with in full detail in such a report as the present, when no experimental work has been carried out (owing to lack of facilities), but certain outstanding features and broad principles should be referred to.

In attempting to concentrate one particular mineral, it is essential to pay attention to the minerals from which it has to be separated. As already described, the mineral which forms the bulk of the gangue of the ore is garnet, which usually occurs in crystal form, crystals varying from 1/16th inch across; aggregates of crystals are sometimes much larger than this. The specific gravity of the garnet was found to vary between 3.40 and 4.19 (the variation is doubtless due to impurities included in the garnet, which could not be mechanically separated therefrom). For the purpose of this discussion, the highest value (4.2) may be assumed, as this provides the worst case with which it will be necessary to deal. As noted elsewhere, other outstanding features of the garnet are its hardness (about 6.5) and toughness.

On the other hand the economically important mineral scheelite has a specific gravity of 5.91. It occurs in minute grains disseminated through the garnetiferous gangue, as well as in crystals of about the same size, and larger than the garnet, and in amorphous masses several inches across: it is appreciably softer than the garnet (hardness about 5), and is brittle. From these characteristics it is clear that the concentration, to be efficient, will need to be carefully carried out. There is not the difference between specific gravities of mineral and gangue as usually exists in an ore to be concentrated. The writer is of opinion, however, that the difference is sufficient to enable a satisfactory concentrate to be obtained, *provided the crushed ore is carefully classified*. The classification before concentration on tables will be found essential to ensure a satisfactory recovery of values, as particles of slightly unequal size of garnet and scheelite will be of so nearly the same weight that either an impure concentrate will be obtained by the admixture of garnet with the scheelite, or else there will be a loss of scheelite in the tailings with the garnet.

The difference in hardness and tenacity of the two minerals, however, is also likely to have an important bearing on concentration. Given the same amount of crushing, the tendency must be for the softer mineral to slime, compared with the harder, and the relative tenacities increase this tendency. This suggests at once that after a coarse crushing, it may be possible to separate from the gangue some at least of the scheelite while still in a coarse state. In designing the treatment plant, provision should be made for this separation, for the more the scheelite is slimed, the heavier the treatment loss will be.

For the preliminary crushing, a reciprocating jaw rock-breaker appears preferable to a gyratory crusher, as more slime would be produced by the latter style. The coarsely-broken ore would then probably be ground with rolls in preference to a stamp battery, for the same reason (to minimise sliming). After classifying the crushed material the coarse ore could be treated in jigs, by which the coarse scheelite would be saved. The size of the product giving the most satisfactory results in this operation can only be determined by experiment. The tailings from the jigs will probably pay for grinding and treatment with the undersize from the rolls.

The finer material will need careful classification before treatment on concentrating tables, and experiment will show whether a fine regrinding plant for the middlings is necessary. The final treatment for the slimes should be by canvas tables. It is almost certain that if these be made of sufficient size, the fine scheelite won from them will justify their installation, and that serious losses will occur without them or satisfactory substitutes.

Suspecting from blow-pipe tests (no analysis being available) that the garnet was an iron-lime garnet, fairly rich in iron, the idea occurred to the writer that this mineral might be attracted by the electro-magnet, and that if so, this feature might be utilised in treating portion of the concentrate, should such treatment be considered desirable. In order to obtain some definite information on this point a sample was obtained by mixing the residual portions not required for assay of samples Numbers 2 to 13, 15, 16, 18 to 23, 31 to 37, and 42, described above, and submitting the bulk sample to Mr. J. R. Pound, M. Sc., manager of Messrs. Hinman, Wright, and Manser's electro-magnetic separation plant, this gentleman having kindly offered to test a sample. This test was witnessed by the writer, and the result is extremely interesting.

and may have an important practical bearing on the production of a high-grade concentrate.

Mr. Pound has supplied the following notes on the test:—

“Notes on the Behaviour of Scheelite Ore from King Island, on Treatment by Wetherill Magnetic Separators.

“An average sample of Grassy River ore was received at the works of the S. & M. Syndicate Ltd., Cimitiere-street, Launceston. The works are equipped with Wetherill magnetic separators, and a description of the plant and process is given in the Geological Survey Bulletin, No. 14, page 58. The usual work carried on by the syndicate is the separation of wolfram from tin and bismuth ores.

“The sample of scheelite was crushed and divided into two sizes—the coarse size of minus 5 and plus 11 mesh, and the fine size of through 11 mesh. This sample gave 11 lb. of coarse, and 30 lb. of fine, material. The coarse portion was treated on a Wetherill separator, and it was found that the garnet in the ore was of, approximately, the same magnetic permeability as wolfram, and was the sole magnetic mineral in the ore. The result of the test was thus to give the garnet as the magnetic part, leaving the scheelite, quartz, &c., as the non-magnetic part. Practically no garnet passes into the non-magnetic portion, and the garnet product is clean, save for a small amount of adhering matter. Of the fine portion of the sample, a small fraction was treated with similar results. The conclusion is that the garnets in the ore can be satisfactorily removed by ‘magnetic separation,’ leaving the scheelite in the clean non-magnetic portion. The process promises to be commercially practicable on a scheelite-garnet concentrate, which could easily be obtained by dressing.

(Signed) J. R. POUND.”

The plant on which this test was carried out is usually employed for separating wolframite from cassiterite and bismuthinite (bismuth sulphide). The capacity of the plant is not large, and the cost of treatment would be too high to render it commercially practicable to treat crude ore of the average value of that already exposed in the mine. The separation of garnet from scheelite, molybdenite, and

quartz was undoubtedly clean, although in this case the garnet was magnetic and removed, while the scheelite (unlike wolframite) was non-magnetic, and went over the tail of the table.

In order to determine what values were actually contained in the various products, the latter were submitted to Mr. W. D. Reid, Government Assayer, who reported:—

“Coarse material before treatment, 1.85 per cent. tungstic acid; coarse non-magnetic portion, 7.52 per cent. tungstic acid; coarse magnetic (garnet) portion, 0.31 per cent. tungstic acid; fine material before treatment, 1.82 per cent. tungstic acid; fine non-magnetic portion, 8.04 per cent. tungstic acid; fine magnetic (garnet), 0.22 per cent. tungstic acid.”

These results are extremely interesting, as indicating that a comparatively clean separation of garnet from scheelite and other minerals is possible. The low tungstic acid value in the magnetic product in each case is not surprising, as some of the scheelite, quartz, &c., would adhere to the garnet particles, which would be attracted by the electro-magnet. It will be noticed that this is more marked in the case of the coarse than in the fine material, as would be expected, the finer crushing liberating more of the attached scheelite. The higher value of the non-magnetic portion in the case of the fine material than in the coarse (although the fine was slightly lower grade than the former), is also doubtless to be explained by the fact that the finer crushing would enable some of the garnet to be attracted by the magnet, which in the coarse material had passed over into the non-magnetic product, owing to the size of the attached particles of quartz, scheelite, &c.

There would not be any difficulty at all in producing a high-grade concentrate from the non-magnetic product, owing to the low specific gravity (compared with scheelite) of the quartz and accompanying gangue minerals.

It is extremely interesting to notice as one result of the electro-magnetic test that the ore carries about 70 per cent. of garnet.

If, then, it be found in practice that the scheelite losses are high in attempting to get rid of all the garnet in the gangue, and produce a high-grade concentrate, it may pay to produce a concentrate carrying more garnet, in order to save more scheelite, and finally remove the garnet from this concentrate by electro-magnetic treat-

ment, when obviously a very much smaller tonnage would be treated than would be the case when dealing with crude ore.

The treatment to be finally adopted can only be determined after a certain amount of experimental work has been carried out.

As to the bulk of concentrate produced, if 300 tons of ore be treated per week, and the concentrate assays 70 per cent. tungstic acid, the amount expected would be about $5\frac{3}{4}$ tons per week.

In preparing for open-cut workings, it will be necessary to strip the surface material to expose the actual lode outcrop. Judging by the surface material exposed in the approach to No. 3 Adit, this surface material carries sufficient scheelite to pay for its treatment.

The question of a machinery site need not be discussed at any length. The plant will be situated on the level strip on the foreshore, at the base of the hill-slope on which the mine workings are situated. This would be about 25 feet above sea-level. It appears advisable that before the exact site be decided upon, some further prospecting work be carried out to determine the trend of the ore-body below the No. 2 Adit. The position of the ore-body will largely determine the most suitable position for a main low-level working adit, and this, in turn, will be one factor which should be considered before the treatment plant be erected.

With regard to water for the treatment plant and for boilers, this will doubtless be derived from the Grassy River, and, as noted elsewhere, it is likely that the most convenient plan will be to pump the water from the river to a main storage tank slightly higher than the plant, and distribute it from this tank by gravitation.

Reference has already been made to the advantages offered on the mine for the economical handling of material, disposing of waste, and of getting rid of the impoverished tailings from the treatment plant.

VII.—RECOMMENDATIONS.

The foregoing description of the property indicates the general lines on which future operations should be conducted. In the writer's opinion the first work carried out should have for its objective the proving of the extent of the main ore-body, both laterally and vertically. Undoubtedly a very promising ore-body has been exposed, but it is essential that more work should be done, particularly in view of the somewhat uncertain structural features, to definitely prove its extent.

The most obvious way to attempt to prove the lateral extent of the ore-body is by surface trenching. The hill slope is flatter above the No. 3 Adit than lower down and it is worth while trying to trace the lode in this way. The surface overburden may, however, prove too deep to give satisfactory results in this way, although the overlying material is likely to carry abundant garnet, and to yield traces, at least (and perhaps payable quantities), of scheelite. It must be made clear that there is no actual outcrop of the ore-body at the surface, and therefore this trenching, if carried out, will necessarily have to be along the approximate line of strike, as calculated from the ore-body exposed in the workings.

But, in addition to any surface work, or replacing it, if both operations cannot be carried out, should be some underground work. Since payable ore has been exposed in both Nos. 2 and 3 Adits, it is advisable to follow this by continuing one or other of these adits. Since No. 2 Adit would give a greater amount of backs than No. 3, it might well be continued, although No. 3 has been driven further on the course of the ore-body. The plan to be carried out should be to drive either on or adjacent to the ore-body, and from this main drive crosscut at regular intervals to expose the full width of ore. It is important to extend these crosscuts beyond the apparent edge of the ore-body, because of the possibility of mineralised bands of country-rock occurring outside the main ore-body.

Such work would give valuable information as to the true strike and dip of the ore-body, and would enable future work to be planned more confidently than can be done at the present time. For instance, this work would enable the position of the permanent deep adit (from which eventually the main mining operations will be car-

ried out) to be definitely fixed. This deep adit and winzes therefrom will, of course, yield valuable information as to the vertical extent of the ore-body.

The question as to whether the adits should be continued in ore or in country-rock will need consideration. As exposed in the No. 3 Adit, the ore is soft, and would mainly be classed by the miner as "picking ground." The country-rock carries bands of green and pink garnet-pyroxene rock, which are to be avoided where possible on account of their extreme hardness. Fortunately, such bands are usually narrow, and if they prove continuous for any length along the line of strike, it may be found practicable to drive along these as walls, although it will be essential to cross-cut through the bands as well as through the ore. Although the ore is so soft as exposed in the No. 3 Adit, it must be expected that the material will be harder as greater depth below the surface is attained, where the surface waters have not the same action in weathering the ore. An important reason why the ore-body should be opened up by cross-cuts, as recommended, is that further sections will be available for sampling.

Mention has previously been made of the writer's opinion that the No. 1 Adit exposes garnet rock (carrying scheelite), which may belong to a different formation from that exposed in the adits higher up the hill. Although this material is very hard and tough, it would, in the writer's opinion, be worth while driving crosscuts in both directions from the present face. Such crosscuts would expose the width of the body of ore showing in the present face, and if the main ore-body be dipping to the south-west, as it appears to be in the adits above, this should be intersected if the crosscuts were continued, and a section across it at this level would yield useful information.

Not the least important work to be undertaken in the near future is the prospecting of the scheelite-bearing formations on the property other than that already partly opened up. This work might well be undertaken simultaneously with the exploitation of the main deposit. So little is known of these deposits that no opinion can be expressed as to their value, although assays indicated that scheelite is present in encouraging quantities in at least one of the outcrops exposed. The nature of these ore-bodies is apparently similar to that of the one already partly opened up.

With regard to plant, this could probably be erected advantageously in units. Although a good deal of ore has been partly exposed, no definite tonnage can be calculated, and the condition of the mine is not such as to warrant the erection of a large and costly plant at the present stage, in the writer's opinion. It is, however, especially to be noted that no work has been done to prove that large quantities of ores are absent, and that indications are all very favourable. Exploitation work may confidently be undertaken. In the meantime plant might well be erected to commence treating some of the ore exposed, such plant being regarded as one unit to be added to later on, as larger tonnages of ore of satisfactory values are proved. In erecting this unit, provision should be made for extension on the lines indicated. By working on some such plan, a start could be made to produce a marketable scheelite concentrate in reasonable time.

If the ore exposed in the No. 1 Adit be typical of that which will be encountered in the deeper workings of the mine, it will probably be found advisable to instal an air-compressor and rock-drills; such, however, need not be considered at the present juncture.

When work on the general lines indicated has been carried out, the future development of the property can be planned confidently, in the light of information obtained by this preliminary work.

VIII.—SUMMARY AND CONCLUSION.

Before concluding this report, it is advisable to summarise the general conclusion arrived at as a result of the examination of the property.

An ore-deposit consisting largely of garnet has been partly opened up in a position which offers distinct advantages for economical mining. There is no treatment plant on the property, and no scheelite has been produced up to the present. Only a small amount of work has been done, and no ore has been blocked out, nor has any great length along the line of strike been proved. The width, however, is considerable, being about 65 feet at right-angles to the dip, and 85 feet as exposed by horizontal crosscuts, and there is no sound reason for doubting the existence of a large tonnage of ore. The garnet formation carries scheelite, both disseminated through its mass, and in rich masses in quartz veins traversing the main formation. The average value, as exposed, was found to be 1.69 per cent. tungstic acid, a value which at present prices is sufficient to yield reasonable profits under existing conditions. The richer masses of scheelite in the quartz veins may tend to increase the average grade of the ore above the figure quoted above. The ore carries traces of impurities, but probably not in sufficient quantities to affect the value of the ore. At the worst, no more than a light penalty is likely to be imposed on the concentrate as a result of these impurities, and it is doubtful whether sufficient will be concentrated with the scheelite to justify even a light penalty. The ore does not appear to offer any special treatment difficulties, and a large percentage of the scheelite present should be saved. Tests made indicate that, if necessary, electro-magnetic separation methods could be utilised to separate the garnet from the scheelite.

While the structure of the main ore-body is not quite clear, owing to the small amount of work which has been done, recommendations have been made that work be carried out along definite lines to prove this, and open up more ore. Until this is done, it is not possible to estimate the amount of ore available, or the tonnage which could be treated per week, and therefore the actual scheelite output which will be possible is still a matter of conjecture. With very little more work it is likely that suffi-

cient ore would be opened up to justify the erection of a treatment plant, which should be in the form of a unit to be added to, as more ore is rendered available by developmental work. If 300 tons of ore be treated per week, as may be done a little later on if the ore-body opens up as it promises to do, with present values $5\frac{3}{4}$ tons of scheelite concentrate, worth about 70 per cent. of tungstic acid, would be produced per week. Such an output would be extremely valuable at the present juncture, not merely from the financial standpoint, but because of the difficulty of obtaining sufficient supplies of tungstic acid to meet the existing demand for steel-hardening purposes, and thus a double incentive exists for pushing on with the active development of the property.

In addition to scheelite, the ore carries a little molybdenite, but not sufficient to be of economic value.

Associated with the main ore-body is a dyke of aplite which itself carries a little scheelite, but samples taken indicate that values are too low to prove payable.

It is important to note that apart from the main ore-body, at least two other scheelite-bearing garnet formations exist on the property, one at least of which carries payable values at the only point at which it is exposed. Both formations should be prospected, as bodies of ore may be opened up which will add largely to the available tonnage.

It is generally understood that the King Island Scheelite Company, No Liability, has been floated, and that arrangements are being made to actively develop the property. Such work is heartily recommended. With a sound developmental policy, there appears to be no reason why this mine should not become an active producer of scheelite in the near future. The property has good prospects, and is worthy of the attention of investors—bearing in mind the warning given above, that the urgent need at the present time is for active developmental work.

As indicated on the plans accompanying this report, some of the prospecting work has not in the past been carried out to best advantage. This is particularly true of No. 3 Adit, in which the face of the south-western crosscut cannot be far from the surface, and in which the adit, after bending back practically parallel to itself, is within a few feet of the abovementioned crosscut. Past work has, however, been carried out without any survey (to the writer's knowledge), and it would be advantageous to have future work planned on more definite lines.

The writer here desires to point out that the plan of the property (Plate II.), and Figures 1, 2, and 3, representing assay plans of the different levels, are *sketch* plans only; they are based on a rapid prismatic compass survey. The contours on Plate II. are only very approximate, being merely sketched in to give a general idea of the topographical features of the mining lease, and make no pretence of being accurate in detail. More detailed work could not be undertaken in the short time available.

In conclusion, the writer wishes to record his appreciation of the valuable assistance rendered during his examination and sampling of the property by Messrs. Tom and Bert Farrell, and Chester Richardson. Messrs. Farrell also supplied useful information concerning the property and the workings which they carried out. To each of these gentlemen the writer tenders thanks.

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