Tasmania

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BULLETIN

No. 26

The Tin Field of North Dundas

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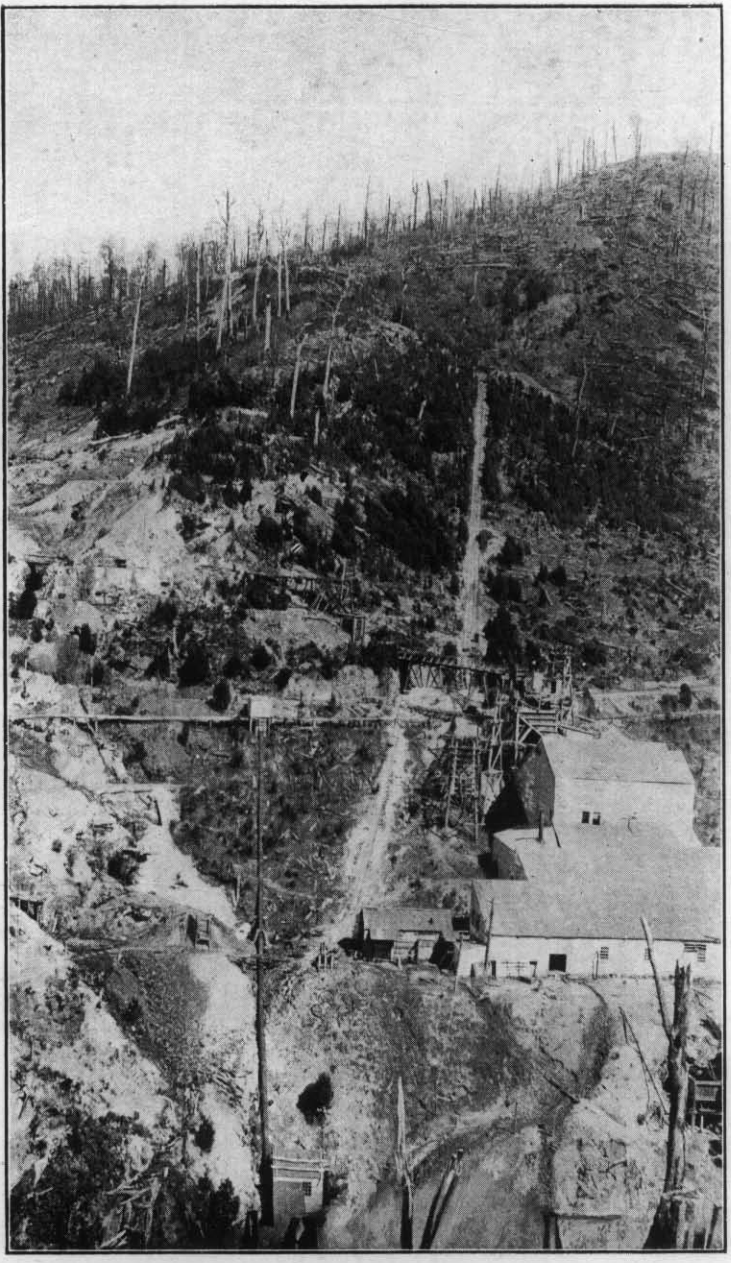
Issued under the authority of
The Honourable Sir NEIL ELLIOTT LEWIS, K.C.M.G.
Minister for Mines for Tasmania

Tasmania
JOHN VAIL, GOVERNMENT PRINTER, HOBART

1918



Renison Bell Mine. [J. B. Scott, Photo.

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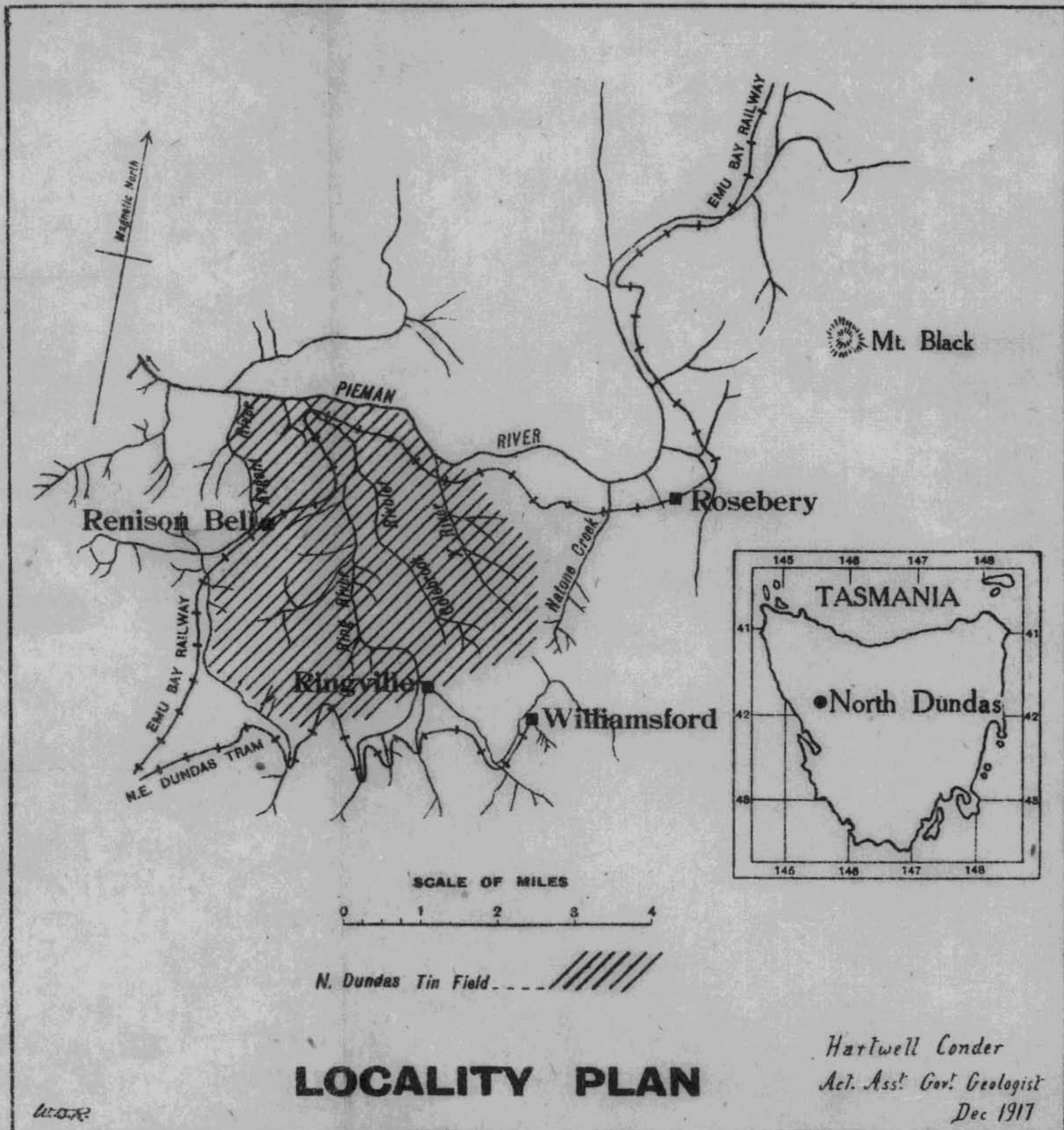

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The Tin Field of North Dundas, Renison Bell, and X River.

I.—INTRODUCTION.

Reports on these districts were made by Mr. L. Keith Ward in 1909, and published as Geological Survey Bulletins Nos. 6 and 12. The copies of Bulletin No. 6 being exhausted, it was decided—in view of the changes and developments that had taken place—not to reprint it, but to prepare a revised edition. Since, too, the X River field both geologically and physically is very closely united to the Renison Bell field, the scope of the Bulletin was enlarged to include this as well.

When Mr. Ward reported on these two fields, they were in what may be described as the second stage of development for mining propositions. Progress had advanced beyond the prospecting, and beyond the alluvial stages, and the companies concerned were on the point of installing machinery to deal with the large bodies of ore which had been proved to exist. In the past eight years many tons have been crushed, and over 1000 tons of concentrates sent to the smelters, but on the whole the district has not fulfilled its early promise. The reason for this and the prospects for the future are dealt with at length in this report.

Since Mr. Ward's report, much of the dense bush, especially in the vicinity of the township has been removed by the hand of man or by bush fires, and access and examination in these parts is far easier and more complete. Far more work, too, has been carried out on many of the claims, and more information made available in regard to the ore occurrences. On the other hand, many of the leases have been surrendered, and many of the old workings, especially on the outlying properties, have collapsed and could not be inspected. These were as pages torn from the book of the district, and it was impossible to confirm or check the data that had been recorded in the past upon their leaves.

The responsibility for this report rests with the present writer, but he has without hesitation availed himself of the careful and complete description embodied in Mr. Ward's report. It was necessary in order to grip the problem at all, to traverse again, briefly, much of the ground covered by Mr. Ward, but when this was not possible, Mr. Ward's conclusions have been adopted *in toto;* in other respects attention was especially concentrated on the new work and fresh developments that have taken place since his visit.

It will be understood that no report of this nature would pretend to be final. In matters of observation alone every year sees fresh ground cleared of its blanket of scrub, new features disclosed for the geologist. In matters, too, of interpretation of the lode systems, finality is for the future.

With regard to the actual workings on the various properties, these have increased so largely of late years that a complete description of them has become impossible within the limits of a bulletin. Only the more important are dealt with in detail, and the remainder are considered on general lines.

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II.—PREVIOUS LITERATURE.

Three official reports were issued by Mr. A. Montgomery, Government Geologist; two in 1893, and one in 1895. These dealt mainly with the alluvial ground in the vicinity of Gormanston and Dolcoath Creeks and certain lode formations already then uncovered and prospected by tunnels. The outlet to the district then was over the Confidence Saddle to Zeehan, and the Renison Bell mine, though known, was very little prospected.

The next official visit was made by Mr. Twelvetrees, Government Geologist, in 1900. The report is entitled: "Report on the Mineral Districts of Zeehan and Neighbourhood," and brief allusion is made to the Renison Bell mine.

In 1902, Mr. G. A. Waller, Assistant Government Geologist, issued a "Report on the Tin-Ore Deposits of North Dundas." This deals mainly with the several mining properties, with a short account of the geology of the areas concerned. Mr. Waller supplemented this report by an interesting paper entitled: "Some Modern Theories Concerning Ore Deposits," read before the Australasian Association for the Advancement of Science in 1902, which dealt with the pyritic tin lodes of North Dundas.

In 1908, Mr. L. Keith Ward spent four months of continuous field work at Renison Bell, and his very complete report was issued as Bulletin No. 6 of the Geological Survey in February, 1909. Shortly after this he made a hurried trip to the X River just before his appointment as Government Geologist in South Australia, and a brief report on that portion of the district was issued as Bulletin No. 12.

The district is also referred to in Mr. Donald Clark's "Australian Mining and Metallurgy," 1904, pp. 221 *et seq.*; while in the "Proceedings of the Australasian Institute of Mining Engineers," Mr. H. Herman in his paper on "The Tinfields of Australia," includes this area.

III.—THE HISTORY OF MINING ON THE FIELD.

The mining history of the field dates back to about 1890, when many prospectors were traversing the district. During this earliest period of prospecting little, if any, thought was entertained of the possible presence of tin ore, and attention was given first of all to any gossanous outcrops which might, in the opinion of the prospectors, prove to be the cappings of silver-lead ores.

It is probable that some of the early workings, of which no history can now be obtained, belong to this period. Tunnels were driven for short distances, and then the sections were abandoned, for the silver contents of the gossans proved always low.

The tunnel driven into the Dreadnought Hill is an example of these workings which is notable, in that the rich tin-bearing lode-stuff was actually penetrated without its character being recognised.

The first actual discovery of tin ore on the field was made in June, 1890, when Mr. Ringrose Nicholson found tin ore in the Ring River, in the neighbourhood of its junction with Dolcoath Creek. This discovery was not followed by any active mining operations at the time, and little notice was taken of it until a temporary set-back in the Zeehan field caused a number of men to look for work which would tide over the bad times. Payable alluvial tin ore was then found, and the prospectors followed the course of Dolcoath Creek and Gormanston Creek up to Pine Hill. In the course of this prospecting the lode-formations on the Boulder Company's ground were found, and some work had been done on these at the time of publication of Mr. Montgomery's report in 1893.

The Gormanston boulders were discovered by Mr. T. Strong in November, 1893, but no rush resulted, as tin was at that time at a low price.

Between this period and that of Mr. Montgomery's later visit in 1895, the work of prospecting the lodes was restricted mainly to the ground in the vicinity of Dolcoath and Gormanston Creeks.

The prospecting of the Renison Bell lease had been begun, but it does not seem to have been fully appreciated at that time that the gossan outcrops were the cappings of tin ore-bodies. In fact, the report of Mr. Montgomery includes a strong recommendation to the company to test the lode for tin and gold.

The next important step in the development of the field was the construction of the Emu Bay Railway, which was carried through in 1900, and a connection was thus made with both Zeehan and the remainder of the island.

The railway line necessitated a large cutting on the Renison Bell lease, which actually penetrated the main lode-system on that property.

In 1901, the presence of cassiterite both in the gossan outcrops and in the pyritic bodies had been fully recognised, and sampling had given a very fair idea of the values to be expected. The credit for this belongs, as far as can be ascertained, to Mr. Charles Stevens, who was then manager of the Renison Bell property. The detrital material was also sampled carefully by shallow pits and its value roughly ascertained.

It proved very difficult, however, to procure capital for developing the property, and in 1905 the detritus was let on tribute to Mr. H. E. Evenden, who proved conclusively its payable nature.

This gave an impetus to the field and led to the installation of batteries at the Renison Bell, Boulder, Montana, and Central Mines, and to tailings plants on the Duncombe and Maddox, while the detrital material was closely searched for.

This second phase, following on the crude treatment of the alluvials, has lasted till the present time, with a spasmodic attempt by the Renison Bell Company to inaugurate the third phase by the treatment of pyritic ores.

It has proved most difficult to get the complete figures for the tonnage that has been treated and the quantity of ore produced in this district.

Omitting the tonnage before 1905, which in its total must have been considerable, the following figures have been arrived at:—

In the case of the Renison Bell they were supplied by the management.

In the other instances they are collected from the Government returns.

Renison Bell (crushed 90,000 tons)	800 tons tin oxide about 68%
Boulder and Boulder Dreadnought	530 tons
Montana	320 tons
Other properties	430 tons
Total	2080 tons

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At £120 per ton this means £249,600, or nearly a quarter of a million pounds; no inconsiderable sum for a small district in its early stages.

The development of the X River followed naturally on the progress of the Renison Bell field. Mr. T. Fox appears to have been the first to prove payable tin on the steep sides of the X River valley between the falls and the railway. Mr. T. Williams pushed further up the river and disclosed the rich outcrops of the X Proprietary, and the smaller creeks were then traced up and the Olympic and Athenic disclosed.

IV.—PHYSIOGRAPHY.

(1)—Geographical Position.

The area examined centres on Renison Bell station on the Emu Bay Railway, 79 miles from Burnie by rail, and nine miles from Zeehan, the railway forming approximately the western boundary.

The western coast line is 18 miles away in a direct line, while to the north about 4½ miles lies Rosebery, and to the east some 5 miles is the Hercules mine and its little township of Williamsford.

There is no road connection proper. A track runs along the west side of the railway, and at a point above where the railway passes through the tunnel, connects with a good road to Zeehan. It would be a most deserving work to continue this road along the east side of the railway to Renison Bell, and then extend it to connect with a road which comes south from Rosebery to the X River. There is no need to emphasise the isolation of the West Coast townships by neglecting to build roads.

From Renison Bell station a tramway known as the Boulder tram goes out along the east slope of the Dreadnought Hill, past the Dreadnought and Federal mines, to connect with the Boulder mine. A track also goes south along the west slope of the Dreadnought Hill, and extends further till it junctions with the N.E. Dundas 2-ft. railway from Zeehan to Williamsford at the Confidence Saddle. This railway forms approximately the southern boundary of the area, and is the outlet for that portion. Sundry other tracks exist here, but most of them are rapidly becoming overgrown; some have completely vanished since Mr. Ward's report.

At 73 miles on the Emu Bay railway the X River tramway goes off south and west for 2 miles. At the end of this a track goes south and connects with the Boulder tram, and so with Renison Bell. This track was surveyed and plotted on the plan, since it gives a good cross-section of the southern portion of the country examined.

(2)—Topography.

The area examined is bounded roughly by two well-marked divides, which isolate three small tributaries of the Pieman River. The northern divide is formed by a ridge of hills known as the Colebrook Range, which runs out north from the higher slopes of Mt. Read, and ends abruptly at the Colebrook Hill itself. Draining the west slope of this range comes the X River with small watershed, and its source only some 3 miles from the Pieman. West of this, with undulating ground between, comes the Ring River, the largest river of the three, which goes back to Mt. Read for the source of its waters.

The other or Confidence divide is formed by another range also springing from Mt. Read and going west across the Emu Bay Railway, which tunnels through it, into very broken country beyond. The Ring River drains the eastern portions of this divide, but coming west a spur shoots out north-west developing into Pine Hill, Commonwealth Hill, Renison Bell, and Dreadnought Hills. One side of these hills drains into the Ring River, the other into the Argent. The divide between the two rivers is very low at Renison Bell, and the railway slips over it there. The whole forms a rough quadrangle, with the Colebrook range as the eastern boundary, the Confidence range to the south, the Renison Bell spur on the west, and the fourth side closed in by the steep-cut valley of the Piemen River itself.

The undulating plain, densely covered with bush, which marks the valleys of the X River and the Ring River, can be classed as an off-shoot of the great peneplain which ranges at a height of from 200 to 500 feet along a large portion of the West Coast of Tasmania. Into it the present rivers have cut their gorges; out of it spring the bastions of the mountain ranges. To deal with the origin and cause of this peneplain is beyond the scope of this report. The steep narrow gorges of the rivers point to their comparative youth in geological time. The terraces and alluvial high up on the sides of some of the hills argue an uplift of the country in recent periods, but all the rivers that run into the western seas show drowned river valleys as direct evidence that the last movement was one of subsidence and submergence.

That glaciation has had a wide influence on the country is more evident in the mountains to the east than in the immediate vicinity. Cirques in the overhanging heights, large moraines, great scourings and striations on the rocks where the valleys narrow in, all these signs make clear that glaciers on no small scale covered the mountains from Mt. Murchison to Mt. Sorell. In many parts, notably at Farrell Siding, about 12 miles to the north, but in a lesser degree right up to the coast itself, erratics are found resting on the surface alluvial. At Renison Bell, both in the railway cuttings themselves, and also in the cuttings of the Boulder tram, there are alluvial deposits which present the characteristics of boulder clays, and are probably of glacier origin. It would seem that the period of glaciation coincided with a submergence of the coastal area to a depth of some 200-400 feet below present sea-level, followed by an uplift when the present river systems were developed, and succeeded finally by the subsidence which has drowned the present outlets of the coastal streams.

The contour of the surface does not seem to have been to any great extent affected by the geological structure. Similar rock formations are found in the lowest valleys and right on the summits of the hills. Surface decay under the influence of acid waters and heavy rainfall extends some distance down, but in a degree seems to attack the different rocks to an equal extent. It is noteworthy that a dyke of Mesozoic diabase, a rock which, as it occurs in Tasmania, is especially resistant to decay, gives here no prominent outcrop above the enclosing rocks, but maintains its level with them on hillside and plain alike.

In conclusion, it is necessary to emphasise the tremendous erosion that has taken place here in the past. There is no sign of Permo-Carboniferous or later formations so highly developed elsewhere in Tasmania. The Late Tertiary alluvial terraces rest directly upon Cambro-Ordovician slates.

(3)—Meteorology.

For rainfall records there are those at Zeehan, 9 miles south of Renison Bell, and about the same elevation, and Mt. Read, about 8 miles east at an elevation some 1500 feet higher. Rainfall on this coast increases rapidly with elevation, so that for each separate place the fall may vary within the limits of the two observation stations.

The following are the averages each month for the past five years from each station:—

	Mt. Read.	Zeehan.
January	8·64	6·73
February	3·23	2·59
March	7·39	5·92
April	14·41	10·45
May	14·23	9·11
June	11·19	8·11
July	10·97	8·33
August	13·99	11·19
September	15·34	10·87
October	11·60	8·69
November	16·36	10·52
December	8·85	6·36
Totals	136·20	98·87

The lowest fall for any one month was at Zeehan; 0·64 for February, 1912. The highest at Mt. Read; 27·95 for November, 1913.

From these figures it will be realised that the rainfall is heavy, and that a period of drought is seldom witnessed in this locality. At the same time the summer months from January to March may be extremely hot and the mountain streams dwindle down in a few days to mere trickles. Any supplies for mining purposes must be supplemented by conservation, or work will inevitably be stopped from lack of water.

Snow and hail fall occasionally, but quickly melt, except on the higher mountain ranges to the east. They are not a factor of any importance.

The country for the most part is covered by dense vegetation, both undergrowth and forest trees. Small belts of King William Pine are found on the hill tops, and Celery Pine and Blackwood are scattered sparsely through the bush. A patch of large gum timber covered the slope of the Dreadnought Hill above Renison Bell township, and other stunted gums show a regular partiality for the serpentine outcrops, but the larger timber is for the most part myrtle, timber which in itself makes a fine furniture and ornamental wood, but the trees are so faulty and so often decayed that it seldom pays to cut them. Much of the country has been fire-swept in the last few years and is gradually being cleared of scrub and roughly grassed.

Only very limited areas of button-grass occur, the chief ones being on a plain lying north of the Renison Bell township, and the other west of the X River, and on the south side of the railway.

(4)—Topography and Mining

The Commonwealth Hill is approximately 2100 feet above sea-level at its summit. The Confidence Saddle is 1500 feet. The Colebrook Hill on the northern divide is 1250. The Ring River is about 240 feet above sea-level below the railway bridge and 650 feet at Ringville. This gives a steep fall from the hill tops to the river-level of from 1000 to 1700 feet. The result of this has been to facilitate enormously the treatment of any alluvial or detrital material found covering the surface, and to make comparatively easy the proving of the ore-bodies by tunnels from the hillsides. After 17 years of work there is not one single shaft equipped with pumps or winding gear in the district. On the other hand the total of the tunnelling would need to be stated in miles.

(5)—Water Supply.

The steep slopes which render it easy to deal with the alluvial material when water is available, make that same water supply most precarious. It runs off too rapidly to endure for long when actual rain ceases. Races have been cut round the sides of the hills in many directions to provide water for the surface sluicing, and the two larger companies, the Renison Bell and the Dreadnought Boulder each have their power schemes to drive their batteries. The Renison Bell get their water from the Argent River, and have two dams, one built some years ago, and the other, owing to damage from flood, not yet completed. They convert the water power to electricty, and distribute to their battery by this means. The Boulder-Dreadnought Company drive their battery by Pelton wheel direct, and obtain their water by a race starting from the Great Northern Creek. They propose to instal a dam on this creek to conserve the water and equalise the flow. Both companies have trouble in dry weather, and it is difficult in this broken country to secure storage adequate for any considerable power. Another dam site is available on the Kapi Creek, a branch of the Argent River, but it is small for the heavy outlay which would be involved to utilise it to its utmost. The Ring River, with a fall of about 200 feet in a short distance, between Ringville and Star Creek, offers another source of power. There seemed some possibility of conservation around Ringville, but a fall of 200 feet is very low to carry the heavy cost of conservation. If the mines develop well, and the treatment of pyritic ore is contemplated on a large scale, it would probably be better for the district to draw on the supplies of power that are being now developed for the general benefit of the whole West Coast. It would provide a market for this power, and obviate those interruptions to the regular work in the summer months which are now a heavy burden on the profits.

V.—GENERAL GEOLOGY.

Summary.

The different formations that go to constitute the geology of the area examined are shown on the accompanying maps. To a large extent they explain themselves, but before dealing in detail with the individual formations, it will be of service to summarise briefly the main conclusions that have been adopted rather than established. So much of the ground is still hidden under the dense bush, there is so much yet to be discovered, not only here but throughout Tasmania, that it would be premature to regard any theory now put forward as other than provisional. The lack of finality that prevails is well instanced by the fact that the relationship between the Dundas slates, which extend over most of this area and other considerable areas in the neighbourhood, and the conglomerate which constitutes most of the West Coast mountains, is not yet established with certainty. Both are almost devoid of fossils, and though they approach in places, the contact is so intruded and compressed by other formations, such as those of the porphyroid group, that the salient features are concealed.

In this area we have first the main subdivision between igneous and sedimentary rocks. Even this division is not final, since the origin of some of the rocks classed as slates and clastoporphyroids is not certain. There is, however, no doubt as to the existence of large exposures of slates with occasional tuffs and fine conglomerates which have been classed as the Dundas slates and referred to Cambro-Ordovician times. Intrusive into these slates occurs a widespread igneous rock of basic constitution varying from gabbro to serpentine. This is regarded as the southern extension of a large serpentine formation which extends north of the Pieman River between its tributaries, the Wilson and Huskisson, for over 6 miles. It is not continuous in the area examined, but occurs in belts and patches of all dimensions. The outcrops are probably more extensive than appears on the plan, since the slates are taken as the predominating rock, and the unknown country is credited to them.

The second class of intrusive rocks are the quartz porphyries, probably to be linked up with the intrusions of

Devonian granite. The focus for them is at Pine Hill, and long dykes extend from the focus south-east and north-west. Minor dykes also occur, and it would appear that this quartz porphyry intrusion is subsequent to the basic intrusion and is responsible for the mineral elements.

In addition to the above, there are obscure occurrences of so-called porphyroid rocks. Some of these apparently were intrusive into the slates, some were probably formed from tuffs which were contemporaneous with the sedimentation of the slates. The occurrences are few and do not appear to be of economic importance; geologically they may ultimately prove of great value, but it is extremely difficult at present to see how to interpret them.

Finally, there is a diabase dyke which is classed with the Mesozoic diabase of Tasmania, and appears to have no connection with the ore bodies; and the various river terraces and recent alluvials which bring the record down to the present time. The immense geological gap between the Devonian age and the Tertiary alluvials, with only the single occurrence of a diabase dyke to represent all the vast intervening periods, marks out the West Coast as signal either for the slight sedimentation which took place in this corner of the world, or for intense denudation in subsequent times.

Taking the different formations into more detailed consideration we have the following subdivisions:—

A.—IGNEOUS ROCKS.

(1)—*The Porphyroid Group.*

Members of this group occur in two forms—(*a*) intrusive, and (*b*) as consolidated tuffs or fragmental effusive rocks, to which the name "clastoporphyroid" is given. This latter form will be considered together with the slates with which they are interbedded.

Form (*a*) is known to occur in two places. In the north-west corner of section 1273 there is a very small outcrop. The rock is dark greenish-grey in colour, weathering to a brown crust. Under the microscope phenocrysts of quartz and felspar are distinguished in a chloritised groundmass. The quartz has been much corroded by the enclosing magma, and the felspathic material is replaced by kaolin and chlorite. Ilmenite, converted into leucoxene, is abundant.

A similar type is present in a large mass on Section 2212M; but in this case the quartz is scanty, sporadic, and poorly developed. Felspar and leucoxene form the prominent minerals in this case.

The two rocks are closely related and both belong to the intrusive rocks which have been forced in to the enclosing slates, and from the nature of their occurrence must be later than the sedimentaries.

(2) *The Basic Group.*

This is by far the most prominent group of the igneous rocks that are found in this area, and in spite of the great local variation in the actual character of the rocks, they can with confidence be included in the one group. The one constant character is the consistent low percentage of silica, while the variation depends mainly on the proportion of the iron to the magnesian contents. In what may be regarded as the normal rock the ferromagnesian constituents, such as diallage, with nearly 30 per cent. of iron, or bronzite with 14 per cent., are fully developed in crystals up to three-quarters of an inch in diameter, while at the other extreme comes light green serpentine, the hydrous silicate of magnesia, with nearly all the iron withdrawn from its composition.

The predominance of the rocks is displayed clearly on the chart. They sweep round in a broad belt from the south-west corner at the Argent tunnel across the Ring River below Ringville almost to the railway. A parallel belt a little further west overlaps the first belt and carries the rocks right down to the railway just north of the X River siding. This constitutes the arc of a bow, and within the curve comes the main part of the field examined. When further it is realised that a broad serpentine formation stretches right across the opening of this curve a little further north beyond the Pieman River, it becomes apparent that the influence of this intrusion must be of far-reaching character.

Within the two main belts there are constant sporadic outcrops of the same rock, occurring both as patches and as dykes of greater or less extent. It is possible that some of the patches may be outcrops of the same dyke, and doubtless many more outcrops exist than are shown on the plan, but the heavy vegetation and the surface soil conceal these. Probably the most useful exposure is down the Ring River; a short distance below the influx of the Dolcoath Creek the gabbroid rocks come in, and a dyke about 100 feet wide runs nearly due north, and is crossed and recrossed by the twisting of the river channel. This gives fine exposures of the contact, and shows clearly the alteration that has taken place there. The main body is a coarsely crystalline rock which under the microscope shows augite and plagioclase felspar. The augite in places has altered to radiating tufts of actinolite, while the felspar has become saussuritised. Well-marked crystals of leucoxene, an altered product from ilmenite, also show in the sections. As the actual contact is approached the texture of the rock becomes finer, but under the microscope it still shows the same mineral constituents, though the leucoxene cannot be identified in the small dark particles of either ilmenite or magnetite. At the contact the exact line of demarcation is not apparent; the slates have been crushed and altered and hardened; in parts, local faulting and crumpling of the strata are very apparent; in most cases the cleavage planes are parallel to the contact, while in some cases the igneous rocks show partly developed cleavages parallel to those of the slate, pointing to the main crushing not being due to this intrusion, but subsequent to it.

With regard to the character of the rock in the other parts, it is difficult to give any general description. A complete gradation could be established from the true felspar-augite gabbro which occurs in the Ring River as described above, on X River tram, and in many other places, through the norites where the augite is replaced by hypersthene or bronzite, through the pyroxenites where the felspar has been crowded out, ultimately to the green serpentines with their hydrated silicates of magnesia and scattered chromite or magnetite. In addition, in many cases the pyroxene has been altered to amphibole yielding rocks, which can only be classed as gabbro-amphibolites.

The norite form is well instanced near the Emu Bay Railway, about a quarter of a mile south of the Argent tunnel, while the pyroxenite type also is developed near the south end of the same tunnel. In the rocks here the large crystals of altered pyroxene up to three-quarters of an inch in diameter are a marked feature, and give a very fine appearance to the rock. A banding structure is also apparent in the arrangement of these large crystals in the accompanying serpentine.

Another type is exposed in the large belt extending from Gormanston Creek across the Ring River, and swinging round across the X River to the Boulder tram track. On the west side of the river much of the rock is marked by the presence of abundant interstitial quartz; the rock is fine grained and almost falls among the diabases rather than the gabbros. Its close association with the gabbroid rocks leads to its classification with them.

The final type is the serpentine itself. This is developed at different points all though the field, and a curious feature in connection with it is the special bush of stunted gum timber that clothes these outcrops. Their outline can in certain cases be traced from the hillsides by this character of the bush. The more important occurrences are Serpentine Hill, which the Argent tunnel on the Emu Bay Railway pierces, a hill just east of the X tram siding, a hill on the south side of the railway about 1 mile west of the X River gorge, and a long ridge which forms the continuation of the large belt referred to above, which crosses the Ring River and swings round to cross the X River-Boulder tram track. This ridge for some distance each side of the track runs nearly north and south, and consists of serpentine.

The serpentine varies largely in character in different parts. In places it carries considerable iron in veins running through the rock. Signs of crushing are apparent in many instances but seem to be purely local, and due to the increase in the bulk of the rock as the process of hydration proceeded. Fragments some three inches in diameter show smooth polished surfaces on three sides as if they had been isolated in the crushing. In the crevices that have formed, picrolite or fibrous serpentine has been deposited, and in many places this in turn has been replaced by magnetite, until fibrous fragments up to 6 inches long and two or three inches in diameter, can be broken out, which show not only magnetisation, but well-developed polarity. The compass is no guide in the neighbourhood of the serpentine.

In addition to the picrolite, chrysotile or commerical asbestos seems invariably to accompany the serpentine, but so far its distribution seems to be too scanty to be of economic value. It is found near the track above the Argent tunnel, on the Serpentine Hill, just east of the X tram siding, and on the ridge that stands across the X River-Boulder tram track. From the last place a specimen with good fibre, three-quarters of an inch long, was secured, but the quantity seems scattered and limited.

A marked feature of the whole occurrence of these basic rocks is the difference of level at which they outcrop. They occur alike near the summits of the Commonwealth Hill to the west, and the Colebrook Hill to the east, and also in the bed of the Ring River some 1600 feet lower midway between. When the frequent isolated outcrops are considered in conjunction with the broad embracing belts, it almost forces the conclusion that a batholith of these basic rocks extends continuously beneath the surface, of which the projecting peaks and ridges only are at present exposed.

(3)—*The Acidic Group.*

This group includes an outcrop of considerable size, which constitutes the summit of Pine Hill on Section 5093 and the adjoining country, and certain quartz porphyry dykes, the more important of which radiate from the outcrop on the hill. The term "granite-porphyry" can be best applied to the typical development. The rock is essentially porphyritic where the large crystals consist mainly of quartz, and felspar, with some muscovite and biotite. The groundmass is a crystalline mixture of quartz and felspar, varying in texture from micro-granitic to cryptocrystalline when the rock approaches to a quartz-porphyry. A marked feature is the faint purple shade which occurs in much of the rock. This appears to be due mainly to the presence of tourmaline, which in parts replaces larger felspar crystals. This is especially evident in some specimens from the northern slope of Pine Hill, where the felspar crystals were over one inch long, and have been entirely replaced by fine crystals of tourmaline. A similar pseudomorphic structure is observed on the Stanley River field, where the change is advanced a stage further by cassiterite replacing the tourmaline.

In addition to the tourmaline, fluorite, sericite, cassiterite and pyrite occur in the rock.

From this main centre two well-defined dykes charted on the geological maps extend south-south-east and north-north-west. These dykes are composed of the quartz-porphyry variety of the granite porphyry. The longest one crosses over the Renison Bell Hill almost at its highest point, having a width there of about 30 feet, and can be traced in the creek near the north-eastern corner of Section 2765. An entirely similar dyke rock is visible in the creek bed near the northern boundary of Section 3240M, and is probably portion of the same dyke thrown off the line by faulting.

The other dyke runs about S. 35 E. from Pine Hill, and can be seen in several places along the track which lies below the North-East Dundas tram. It appears to end before the Great Northern Creek is reached. The dip of both these dykes seems to be nearly vertical.

A smaller occurrence is found near the boundary between the Montana Section 1342 and Duncombe and Maddox Section 1963. This has been well exposed by the surface workings; it is about 2 feet wide, bearing north-north-west, with steep dip to the north-east. The rock consists of quartz particles in a felspathic groundmass.

On the northern slope of the Pine Hill there has been a deep accumulation of detrital matter which conceals the rock formations below. There have clearly been several intrusions here, but it is impossible to trace out their separate relations.

(4)—*The Diabase Dyke.*

The later Mesozoic period in geology in Tasmania was characterised by a great intrusion of igneous rock into the coal measures and other strata that had been laid down in the earlier portion of the period. This rock now has been uncovered by denudation, and forms the surface of nearly one-third of the island, being markedly prominent on the Central Tiers, on the summit of Mt. Wellington near Hobart, at the Cataract Gorge in Launceston, and on various mountains in eastern and north-eastern Tasmania. It does not occur widely on the West Coast, but the summits of Mt. Dundas and Mt. Sedgwick are formed by it, and it occurs just north-east of Mt. Heemskirk.

A dyke of rock which in its microscopical features closely resembles this main body of diabase occurs on the west slope near the summit of the Dreadnought Hill. To the north it outcrops again beyond the button-grass plain near the north-west corner of section 3621. To the south it shows near the centre of the Montana section, past the old Boulder battery, and past the junction of Dolcoath and Gormanston Creeks as far as the hill slope east of Dolcoath Creek. It is composed of plagioclase felspar and augite, accompanied by biotite mica. The only feature in which it differs in any way from the typical diabase is in its resistance to weathering. The normal diabase weathers slowly, and the dykes usually stand out as prominent features. This dyke, though it passes through strata of varying hardness, has weathered equally with them, and has no assertive characteristics. From its close resemblance, both in ordinary features and under the microscope to authentic diabase dykes in other parts of Tasmania, it has been classed with these Mesozoic rocks, but it must be realised that there is a wide range in the characteristics both of the diabase rocks throughout the island, and also in the gabbroid rocks of this district. This dyke at its southern limits impinges on a gabbroid mass whose constituents of plagioclase felspar and augite are identical with those of diabase, though the general size and character of the crystals are not the same. It will be evident, though, that if a dyke emanated from this magma with these corresponding minerals, it would be reasonable to expect its form of crystallisation to be dominated by the dyke factors of the narrow intrusive sheet. The internal resemblance then of dykes of two widely different periods might be so close that there would be no means of distinguishing between them Possibly more evidence may be disclosed in due course, but for the present while the occurrence is classed with the Mesozoic diabase, the possibility of the close relationship to the gabbroid rocks must not be overlooked. In neither case is the dyke likely to have had any economic influence on the ore-bodies.

(5)—*The Relationship of the Igneous Rocks.*

The two groups classed under the heading of Porphyroids and Diabase stand apart; the porphyroids came long before, and the diabase long after the other basic and acidic groups, and no relationship can be traced between them. With the basic and acidic groups the position is different, but it is difficult to arrive at any finality. That the basic rock is subsequent to the Dundas slates is apparent, and also that the acidic rocks are subsequent to the basic. Further, the Dundas slates have been subjected to great crushing and folding strains by which their cleavages were developed, and there are signs, too, of frequent faulting throughout them. In the basic rocks the serpentines show local crush planes, but these almost certainly are due to the local increase of bulk due to hydrating action. The parts of these rocks less altered chemically appear also to have escaped the violent movements experienced by the sedimentary rocks, and this fact would seem to warrant allowing a considerable lapse of time after the slates were laid down before this intrusion took place. It seems probable that it was associated with the wide igneous action that has been relegated to the Devonian period.

Granting this assumption, the age of the acidic rocks has next to be determined. That they were subsequent to the basic rocks, and also to the slates is shown by the dykes that penetrate both these formations. What is not clear is whether they were just subsequent and virtually part of the same intrusion as the basic rocks, or whether they arose after a long period of inaction, and were independent in cause and origin.

It hardly seems possible to arrive at any definite conclusion on this point. Basic rocks are well-known to occur as aureoles at the margin of granitic *massifs* as the result of magmatic segregation on cooling, and such occurrences are found at the margin of the Heemskirk granite on the Trial Harbour-road. At the same time this is not the sole mode of origin of the basic intrusions, and there are no general grounds on which to deny them a separate corporate existence. In this case, too, the wide extent of the rock to the north where it must cover some 20 square miles of country seems to militate against any theory that subordinates this occurrence even to the large granitic masses that are exposed in the Meredith Range and on Mt. Heemskirk. The point is one mainly of academic interest, but the writer inclines to the theory that the basic intrusion was from a source independent of the acidic, and occurred so long previous to it, that the rocks had consolidated and cooled completely before the commencement of the acidic influx. That this influx was responsible for much of the serpentinization and conversion of pyroxene into amphibole in the basic rocks is extremely probable, but hardly helps in deciding the question raised above.

B.—THE SEDIMENTARY ROCKS.

(1) *The Dundas Slates.*

All of the mature sedimentary rocks of the North Dundas field have been placed under this group. They include not only slates and tuffs, but also the coarse-grained sediments, sandstones, grits, conglomerates, and even breccias, but the slates predominate so distinctly that this name has been adopted.

The only internal evidence of the age of the series is the discovery of some poorly-developed graptolites by T. S. Hall, recorded by him in the "Proceedings of the Royal Society of Tasmania. * On this evidence the formation would be classed as Early Palæozoic.

At the Leven River, on the North Coast of Tasmania, a slate formation occurs, which lithologically is similar to that at Dundas, and is also associated with the porphyroid group. Mr. Twelvetrees has obtained proof that these slates underlie the Silurian limestone of that district, and the general resemblance of the two formations has considerable weight in assigning the Dundas slates also to the same period, and regarding them as Upper Cambrian or more probably Lower Ordovician age; until further evidence is available they may be classed as Cambro-Ordovician.

The relationship of these slates to the schists and conglomerates which lie to the west has been dealt with by Loftus Hills in the Bulletins on the Read-Rosebery field(†), and he classes them as older than any of these other formations.

The slates themselves show almost unlimited variation in the different types of rock they present. On exposure, too, they weather and soften rapidly, masking their true nature. Only a general description can be given of the main features.

* Evidence of graptolites in Tasmania, by T. S. Hall. Pro. Roy. Soc. Tas., 1902, p. 16.

† Geological Survey Bulletins, Nos. 19 and 23.

The slates proper are green to purple in colour where fresh, but the weathered-surface may be brown to yellow, or white where silica predominates. The product of decomposition is a brown clay. The dip and strike vary largely, especially in the vicinity of the Renison Bell. Along the Renison Bell spur right over to the South Montana workings the predominant dip is at moderate angles to the north-east, the inclination of the rock showing a tendency to conform to the slope of the hill. This seems due in part to the development of beds of quartzite and breccia carrying considerable iron, to which the name "red rock" has been applied, which have proved more resistant to denudation, and thus brought it into relation with stratification.

The slates are seen in greatest regularity in the bed of the Ring River for about 1 mile above the railway bridge, and in the cuttings of the Emu Bay Railway either side of the bridge. The strike of the formation adheres very closely to a bearing about N. 25 W., and the dip is steep to the east. A marked feature in the railway cuttings near the bridge is the hard nodules, up to 1 or 2 feet in diameter, that show through the softer rock. These fragments appear to be normal argillaceous slates.

In a cutting about ¼-mile east of the bridge, a coarse-grained slate appears. This variety extends for about 100 feet, with bands of normal slate intervening in parts. It appears to be a fine-grained tuff, with particles of felspar predominating, but accompanied by quartz, the whole permeated by iron oxide. This series of tuffs is a marked feature in the Dundas slates. It is largely developed on the track up from Ringville to the Montezuma Falls, where the particles are larger, but of the same felspathic character, while a still coarser variety is exposed on the hillside just north of the South Montana workings.

Another occurrence is found just north of Pine Hill where it crosses the Penzance track nearly at right angles. In this case, though, the chief mineral is quartz, and under the microscope numerous rounded fragments of an igneous rock, constituted of glass, are revealed. These rock fragments, together with the fragments of quartz and oligoclase felspar, are set in a sericite-chlorite aggregate, and the whole constitutes a consolidated "tuff."

In places the slates give way to sandstones, and the texture of the sandstones increases in size till they become conglomerates. An instance of this is found near the western end of the Renison Bell cutting, where bands of white conglomerate show clearly in the face of the cutting and in the rocks above. This same rock or a parallel bed is also cut in the West River adit.

Reference was made above to the "red rock." This rock seems to overlie the normal slates and sandstones at the Renison Bell mine, and to be overlain itself by a coarse breccia which is exposed in several places in the area examined, notably at the old Boulder workings, and near Salmon's Lode at the X River, but is very largely developed in the area to the south-west between the N. E. Dundas tram and Dundas township. The red rock itself is a fine-grained sandstone, in which iron oxide has been developed in small blebs, giving it a mottled appearance and a red colour. The breccia is a coarse-grained rock, also coloured red by iron in the surface specimens, and carrying fragments and pebbles of quartz and slate up to and over 1 inch in diameter. Both rocks have been subjected to secondary alteration.

When the above rocks come in contact with the basic intrusives there is not much sign of alteration. A little local crushing and hardening shows at the contact itself, but the action does not extend far from the actual contact. When, however, mineralising action has taken place, there are no limits to the changes that have been produced either by the silicification or by definite replacement by the heavier minerals. This subject will be dealt with under the heading of Economic Geology.

C.—THE ALLUVIAL DEPOSITS.

Reference has already been made to these deposits in the chapter on the physiography. The largest development has taken place from the foot of the Dreadnought Hill to the north, where a plain of about 1 square mile in extent runs back almost to the railway line from the edge of the steep valleys of the Argent and Pieman Rivers. Sections of the material that compose it are given in the railway cuttings near Renison Bell, and also on the Boulder tram. These sections show the alluvium to be composed mostly of detrital fragments of slate, with some pebbles. The irregularity in the sizes of the fragments and of their distribution points to more than ordinary water deposition. Further, the very variable thickness of the alluvium which is evidenced in many places emphasises the irregularity of the rock surface below, and is against the theory that this is an old river valley gradually filled up to its present level by fluviatile deposits. It seems more probable that the glacial action from the mountains to the east extended to these limits, sheared down the projecting ridges of rocks, and in the intervening hollows deposited the debris and silt which are exposed to-day. It is not within the province of this report to go fully into this question, but the influence of the ice action on this coast must have been far-reaching, and its bearing in conjunction with the raising and lowering of the surface levels must be kept in view.

The economic contents of these beds are low. Chromite is always present, and colours of gold are frequently found with occasional colours of osmiridium.

Quite distinct from these deposits are the recent alluvial or detrital deposits of the creeks and hillsides. At the Dreadnought mine these deposits were being worked, and the material sent to the battery, where it rested on the older barren alluvium. Figures are not available as to the quantity of tin that has been won from these deposits in the district, but, although nowhere has any great extent been exposed in one single place, the material is so widespread and in some cases so rich, that the total output must have been large. These alluvials will be dealt with under the heading of Economic Geology.

Summary of Sequence of Geological Events.

(1) The Dundas slates were laid down in Cambro-Ordovician time on the mica schists of pre-Cambrian age, the depth at which they were deposited varying and tending to become shallow towards the end of the period. Volcanic outbursts were frequent during the period, and the volcanic ejectamenta aided in increasing the thickness of the strata by the interbedded tuffs.

(2) First Period of Igneous Activity.—The district shared but slightly in the intrusion of porphyroid rocks, which is an important geological factor to the east and north-east, and also in many other parts of the West Coast.

(3) Period of Metamorphism.—The strata were then exposed to widespread folding and crushing, which pro-

bably developed the slaty cleavage in the slates, and tilted the beds from the horizontal plane.

(4) Second Period of Sedimentation.—There are no signs of the Silurian strata so well-developed at Zeehan. Extensive beds of Silurian limestone exist to the north across the Pieman, and it is probable that these strata were laid down here as well, but have since been denuded.

(5)—Second Period of Igneous Activity.—In Devonian times there was first the intrusion of the basic rocks which cooled and consolidated, and subsequent to them, the intrusion of the acidic rocks which probably also brought the tin and other minerals, and caused much local alteration in the accompanying rocks as well.

(6) The invasion of the diabase came at the close of the Mesozoic age, a slender off-shoot from the great central plateau of the island.

(7) The development of the alluvials, with accompanying glacial action and alternate variation in the level of the land, must probably be placed either as Late Tertiary or Quaternary.

VI.—ECONOMIC GEOLOGY.

Accepting the above classification for the general geology of the district, the next, and from the ordinary aspect, the more important problem that is presented, turns on the introduction of the economic minerals into the rocks.

There can be no doubt that they came subsequent to the definite arrangement of the present relative positions of the rock masses, and there is also very strong evidence to associate them most closely with the intrusion of the acidic rocks. Moreover, the absence of evidence of lode crossing lode, or of any priority of deposition in the various occurrences points to all belonging to the same period, and as the products of the same causes.

Further, evidence is gradually accumulating which tends to allocate nearly, if not all, of our ore-occurrences to one period, that of the intrusion of the Devonian granite, with which it is believed the acidic rocks of this district are associated. The logical chain is not yet complete, and can only be outlined, but it commences with the undoubted association of the tin deposits of Heemskirk and Stanley River with the granite *massif*. The quartz-porphyry dykes at Bischoff link up the tin occurrences there with granite, which outcrops some five miles away, and is probably close at hand below. The stannite and cassiterite lodes of the Zeehan field connect the lead ores and tin occurrences there. The galena of the Tasman and Crown Lyell mine in Sedgwick Valley occurs almost contiguous to a body of bornite, similar to bornite found at the North Mount Lyell. The copper lodes of Mt. Read and Rosebery, with their complex zinc-lead associates, together with the low-grade copper ores in axinite gangue of the Colebrook, serve as another link to weld the chain into one continuous whole.

As a natural corollary to this, one would expect to find the ores of the other metals occurring associated with the tin on this field, and it will be shown below that this is a marked feature throughout.

Separate classification of the lodes is made difficult through the lack of definite lines of demarcation between them. For instance, a quartz-tourmaline lode system occurs, especially in the area around Pine Hill; while the pyritic bodies are especially developed in what has been classed as the inner quadrangle, which will include Renison Bell, Dreadnought-Boulder, and the contiguous mines; but in the northern section of the Renison, a pure quartz-tourmaline lode-rock is found, different in character to the type rock; while the lode at the X River mine, though probably a quartz-pyrites lode at depth, shows especially quartz and tourmaline near the surface. Nature's concentrators are no more pure and distinct than the products of the mills that man erects. At the same time certain distinctive features apply to separate lodes, and a provisional subdivision will be made, taking the more prominent examples from the property where they are best illustrated.

The following distinct classes are met with in sufficient frequency to be regarded as types:—

(1) Quartz Tourmaline Lodes.
(2) Quartz Lodes.
(3) Pyritic, including Pyrrhotite Lodes.
(4) Dolomitic Lodes.
(5) Other Forms of Lodes.

(1) *The Quartz Tourmaline Lodes* are especially developed in the vicinity of Pine Hill. They are closely paralleled by occurrences at Heemskirk and the Stanley River, where tourmalinisation has taken place over areas far larger than this. The lodes occur traversing both the quartz-porphyry and the slates, and vary from zones of country of considerable width merging into the surrounding rock, to thin radiating veins criss-crossing through the country through fairly regular jointings in the igneous rock.

It was this class of lode that was attacked by the Penzance Tin Mining Company. Both the lodes themselves and the impregnated country rock were dealt with, but the small dimensions of the actual lodes, and the low-grade of the bulk rock made the effort unprofitable.

Adopting the view that the lodes were formed at the period of acid intrusion, these lodes represent the simplest phase of lode formation, being the last stage in the consolidation of the magma.

(2) *The Quartz Lodes.*—Between some of the lodes that fall under this head, and the quartz tourmaline lodes, it is difficult to draw a clear distinction, though the differ-

ence in character shows up at once between two specimens from either source. The X River Proprietary lodes consist in parts of only quartz and tourmaline, and yet bear little resemblance to the Pine Hill lodes. In especial, the character of the quartz is coarser and more massive. The passage of the solutions through a considerable distance of slate country has had its effect upon the character of the deposition.

In the inner quadrangle, at the old Boulder workings a good instance of a quartz lode is given, and is shown on the photograph. The lode carries considerable pyrites and rich tin in parts—one sample gave 30 per cent.—but it is clearly a quartz lode. The quartz occurs as a coarsely crystalline aggregate, with the interstitial crevices completely filled with pyrites and marcasite. In structure it more resembles an igneous rock than a lode rock. The country rock is a grey, contorted slate, heavily charged with pyrites.

Leaving this occurrence for the time, there is yet another lode structure to be classed among the quartz lodes, which occurs frequently in this inner area. It is well-displayed close to the above quartz lode on the old Boulder workings; on the ground cleared on the Duncombe and Maddox section; on the South Montana workings; and on the North Montana workings, from the top of the ridge near the Montana track down into the Renison Bell Creek. These lodes appear to fill fault fissures, but the faulting in most cases seems to be local, and the lodes frequently taper out both vertically and horizontally within short distances. The North Montana instance seems to be the most marked; the exposure here is for a distance of 300 feet, and the friable lode material was sluiced out, and has left a clear fault plane, with strike about N. 70° W., and dip at 55° to N.E. The face exposed is 30 feet high. The lode consists of a friable quartz, carrying veinlets, and tracings of darker material throughout it, which appear to be due to inclusions of the surrounding slate. Even under the microscope it is not possible to resolve these into definite minerals. In parts, large fragments of slate are definitely enclosed, and the structure and character of these lodes will be dealt with again below.

(3) *Pyritic, including Pyrrhotite, Lodes.*—These lodes are the most marked feature of the district, and it was

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the gossan which capped them which led to its first development as a mining field. There is no abrupt break from the quartz lodes of the class above, with a certain proportion of pyrites to dense massive pyrrhotite, showing no quartz at all to the naked eye. The mode of occurrence varies also from what appear to be isolated masses of solid pyrrhotite, such as are seen in the Renison Bell railway cutting, to distinct lodes extending for a considerable distance, such as are shown in the Dreadnought lode system and the main Renison Bell lode. In some cases the walls are well-defined, in other cases the replacement of the country rock gradually grows less as distance increases from the main deposit. The country rock, though, in the vicinity of the pyrrhotite development always appears to carry a considerable proportion of pyrites. In some cases the pyritic formation is limited by an overlying band of country rock, and has the appearance of an interbedded structure, but this is the exception and not the rule. A greenish-coloured siliceous rock, very hard and flinty, frequently comes on the top of the pyrites, giving the appearance of a surface segregation of quartz from the main mass. In many instances a graphic structure is developed by the interlacing of quartz and pyrites crystals. This appears usually to occur when the form of pyrites is marcasite. The marcasite weathers very rapidly, and the grey-white residue is known locally as "ashes," and frequently carries considerable tin. In all cases, even of the densest pyrrhotite, there appears to be a skeleton of crystalline quartz. Where the proportion of this is high, and weathering has taken place, the quartz crystals form spiky bunches with regular sides and terminations to the crystals. It will be clear from this that the forms of pyritic occurrences are manifold, and a broad theory is required to embrace them all. Their origin will be dealt with after describing the other types.

(4) *Dolomitic Lodes.*—The difficulty of classification is shown again by this type of lode. It is especially developed in depth, and the chief examples come from the West River adit on the Renison Bell mine, and the bores on that same property. Again, at the cable workings on the Boulder mine, dolomite forms the footwall, while at Salmon's galena show and the west lode of the X Proprietary it is the prominent gangue rock. Pyrites is usually present with it, and it gives way readily to quartz in the same lode.

In the Renison Bell diamond drill bores, dolomite, usually carrying tin, is the common lode rock, and there is little doubt that its lesser frequency in the rocks nearer ... surface is largely due to its secondary removal by surface waters.

(5) *Other Forms of Lodes.*—Little more can be done in the space available than describe briefly such other lodes as are met with.

The main lode of the Renison Bell mine carries galena both in the railway cutting and along the footwall south of the cutting. In places it is fairly rich, and the ore has been mined out on tribute and sent away. As the south end of the lode is approached the galena merges into complex zinc lead ore with a faint purple tint, recalling the Rosebery type. The lead values, though, are too low. An analysis of a specimen from here gave:—

	Per cent.	
Tin	1·0	
Zinc	32·2	
Lead	2·4	
Silver		10 ozs.

Other examples of lead lodes are the dolomitic lodes on the X Proprietary and at Salmon's show, and a small lode on the west bank of the Ring River on section 3658. Also at No. 5 workings, east of the top workings on the Renison Bell, a galena lode, bearing S. 30° E., occurs in close conjunction with a large pyrrhotite outcrop, the structure of which is not clear. Dolomite also occurs here, and the galena generally seems associated with that mineral. Other minor occurrences of galena are comparatively frequent in the area, but have not yet assumed economic importance.

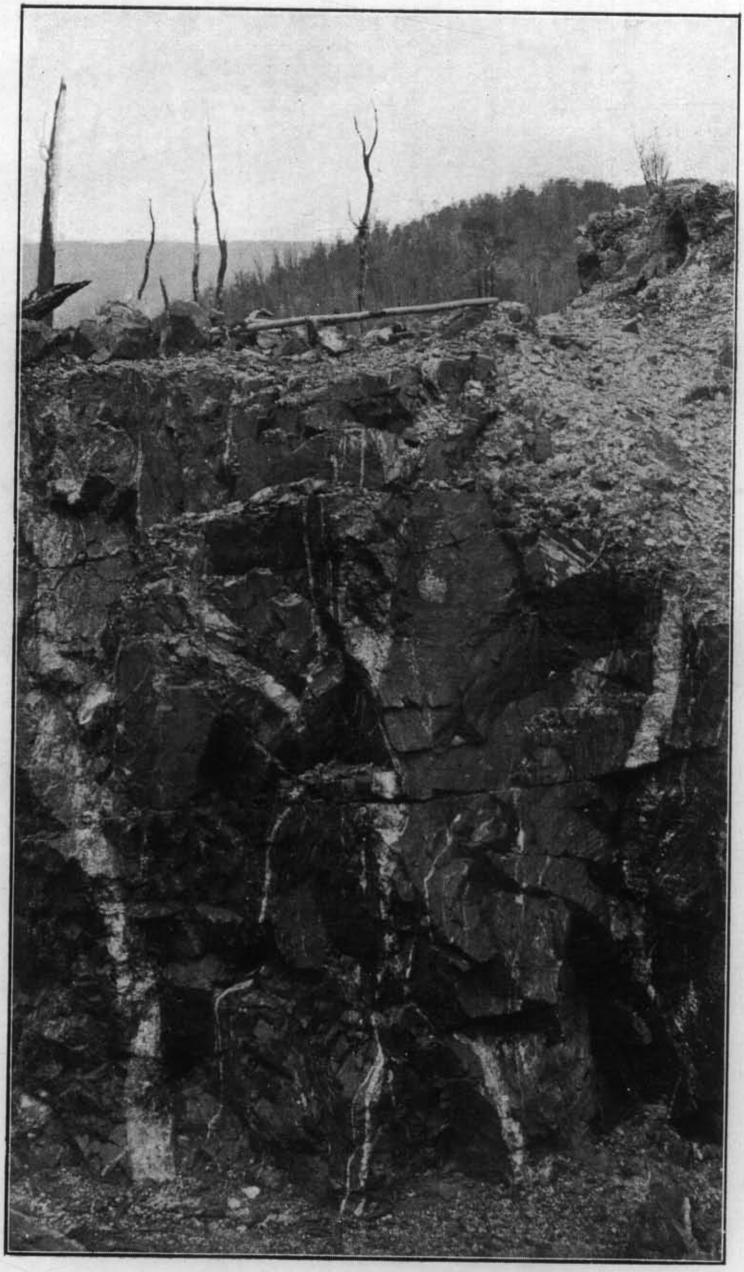
Of zinc lodes the best example is on P. Buchanan's property, on Section 774. There is a small quartz lode about 9 inches wide here with zinc, galena, and some tin; to the west of that is a large formation over 100 feet wide of greenish-grey rock, carrying zinc blende. This is associated with a garnet-actinolite vein carrying blende, which extends along the Gormanston Creek, crossing it at a narrow angle. The formation is so covered up by surface material that it is difficult to form a clear idea of its character or value. It is close to the quartz-porphyry contact, and may prove to be a contact deposit. The zinc values could probably be cheaply concentrated, and the formation may easily prove payable for this metal.

Axinite Veins.—Axinite is a borosilicate of lime and occurs in immense quantity on the Colebrook Hill, where it is the gangue of a very low-grade copper proposition. Veins of it occur in the vicinity of the garnet-actinolite vein referred to above, but the only occurrence of any size is just below the main Dolcoath workings on the hill-side south of Dolcoath Creek, which now are part of the Dreadnought-Boulder property. The vein is described in the account of the Dolcoath section later on.

Mode of Occurrence of Ore Deposits.

The key to the general principles by which the ore was introduced is probably to be found in certain special developments that occur in the slate rock. In the main body of the slates there is not evidence of *extensive* shattering and crushing. There was sufficient crushing to develop the slaty cleavage, and sufficient folding to bring into prominence the bedding planes, and produce jointing and folding planes in addition, but of complex plication and extreme contortion such as is seen in the conglomerate beds to the east, there is a complete absence in the main body of the Dundas slates. Further, the unbroken trend of both the quartz-porphyry and the diabase dykes points to the absence of large scale faulting during or subsequent to their intrusion.

When, however, these same slates are examined in detail, certain portions of them show very marked characteristics. The occurrences, too, are frequent throughout practically the whole of the inner quadrangle shown Plate I. Special instances may be mentioned, as above the west end of the railway cutting on the Renison Bell mine; on both the north and south workings of the Montana; on the Duncombe and Maddox workings, and especially along the extension of the Boulder tram, between the office and the mill of the company. In all these places, and in many others as well, a form of slate is met with that has been subjected to the severest crushing and contortion. It is composed, too, of two distinct materials; the one, fine-grained, slaty bands, in colour varying from light-grey through the various shades of grey to almost black; the other, white, of greater or less purity, extremely hard and composed of practically pure quartz. These white veins are marked either by the presence

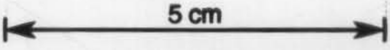


[J. B. Scott, Photo.

BOULDER T.M. CO.—OLD MILL WORKINGS.

BOULDER T.M. CO.

Photo Algraphed by John Vail Government Printer Hobart Tasmania



of pyrites or by the negative crystals since vacated by the pyrites. In some cases these bands are in parallel planes, but in most cases there is no limit to the curling and twisting and intertangling of the two bands, while the thickness of the alternation dwindles down to the thinnest of planes. The clue to the position is best shown at a face in the old Boulder workings above the old mill. A photograph is given of this face.* There is here a complete gradation from the definite fissure quartz-vein, some 6 inches wide, through all intervening forms to the thin paper-like sheets that interleave the slates. Further, a mass of secondary quartz in the bottom left-hand corner of the photograph shows the planes of the slate rock sweeping round the edges of the intrusion, showing clearly the simultaneous nature of the development of these planes. Pyrites, with rich tin-ore, shows in the main quartz veins, and is spread through the surrounding rock as well. The name "puckered slate" has been applied to this altered rock.

It is evident that there has been here an intrusion of quartz pyrites solutions under intense pressure, which, owing to some special conditions, could not develop for itself a main line of fissuring, but spread out, like a river passing through a swamp, till every plane and crevice was permeated, and a condition of flux created in the whole mass. The local pressure of the solutions themselves would then be sufficient to develop the puckering, and also to produce much of the faulting which in most cases seems to be quite local and limited. On these fault-planes the quartz is specially developed as mentioned above†, and any fault-plane might be a main channel for the solutions from their abyssmal source, but only actual exploration could determine the distinction between a local and a deep-seated fault.

A difficult question to decide is to what extent the action has been one of metasomatism or replacement, and to what extent purely intrusive. The clear lines of demarcation in most instances make it seem more probable that intrusion has been the main factor.

Pyrites accompanies these quartz intrusions, and quartz forms the skeleton of the pyrites formation, so that the relationship between the two forms is clearly very intimate. The place which offers the best opportunity to trace the

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* Page 29. † See also page 67.

origin of the pyrrhotite bodies is undoubtedly the Renison Bell mine, where the West River adit and the bore-holes do give some information as to the underlying strata.

There is on the Renison Bell mine a definite fault plane extending from the north workings across the river and the railway line, till it disappears on the hillside above. This has yielded ores not only of tin but of lead and zinc as well, and may be regarded as a definite fissure lode and as a source of mineralisation..

Where cut by the West River adit in two places its walls are not well defined, but it is represented by a belt of country-rock altered by the presence of quartz pyrites including pyrrhotite, dolomite, and cassiterite. There is not here the banding referred to in the puckered slates: replacement seems to have taken place.

In the same way, Bores 1 and 5, which cut this lode, give quartz, pyrrhotite, and dolomite as the main features.

It would appear that the solutions here too were forced up through the slates, but the pressure in the lower depths was so enormous that the development of definite fissures was restricted. As the superincumbent pressure lessened with lessening depth from the surface, opportunity for actual displacement and filling of the spaces formed would occur. The first opportunity would arise along the plane up which the solutions were rising: further, when once the start was made, even as in prizing the lid off a box, the displacement would become easier until certain limits were reached by the creation of new pressures. This would give us the larger pyritic ore-bodies which are found along a definite line in the upper portion of the Renison Bell Hill. The next opportunity for enlargement would undoubtedly arise between the strata. There is a certain lateral cohesion in the elements of a bedded structure, and the intrusion of liquid material will tend to bulge up the beds, as water will a sheet of ice, before causing fracture. It is such bulges as these which have given the flat pyrrhotite bodies, which seem to occur isolated on the field, while the pyrrhotite body at the east end of the Renison Bell cutting, with signs of the bulging showing in the slates above, probably belongs to the same class.

In this case, too, the part that replacement has played is difficult to determine. The physical action of intrusion and the chemical action of metasomatism are so closely involved that only in special cases is it possible to decide that one or the other has been absent. The bending and fracturing of the strata seem to point to intrusion as the

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main factor in the formation of the pyritic ore-bodies, but chemical action has undoubtedly accompanied it at the margins, and would probably assume more importance as the ore-bodies decrease in bulk and the surface comes to bear a higher proportion to their size.

The Dreadnought formation seems mainly to resemble the Big Blow lode of the Renison Bell. The lode channel here is clearly defined across almost the whole of the Dreadnought section and into the Federal section that adjoins it on the south. It is a fissure lode accompanied by faulting, and the footwall is well exposed for a height of 45 feet where the gossan ore has been removed at the main workings. While, though, the lode itself is well defined, there is irregularity in the development of the ore-bodies along its course. Following the principle referred to above that it is easier for the intruding elements to extend than to start a displacement of the country-rock, the ore has become localised at certain points on the fracture line. This is in keeping with what is seen on the other mines, but on this property the ore-bodies appear to have adhered more closely to the main line of fracture, and isolated or bedded ore occurrences have not been encountered. So far, only the gossan caps of the pyritic ores have been regarded as profitable. The pyritic ore-bodies below will in all probability be at least as frequent and as extensive as those which show on the line of outcrop, and with the plane of intrusion so well defined a systematic exploration for them will follow inevitably when the problem of their treatment is determined.

With regard to the dolomite, it is probable that this is due to the neighbourhood of the basic rocks. At the X River, near Fenton's section, there seems a clear tendency for the lodes to occur at the margin of the basic rocks, and steatite and dolomite are found as prominent constituents in the lodes. If the ore-bearing solutions passed either through, or, as is more probable, near the contact of the basic formation on their upward course, they would gather the magnesian element from them and probably leave silica in its place.

If the above theory is correct, the most favourable location for the ore-bodies would be in the vicinity of the puckered slates and of the broken country generally. The local developments or bulges would probably take place in what may be called a definite horizon of pressure which might well correspond now with a definite geological horizon. There is some sign of this, in that on the Renison

Bell, Central, and Montana sections the belt of red rock referred to above has been regarded as overlying and limiting the ore. If any more evidence accumulates on this point, the area now covered with red rock might well be examined by boring. The question of the character of the lodes in depth is to some extent affected, but apart from oxidisation concentration the contents of the lodes at depth on the Renison Bell appear to approach in tin—though not in sulphur—values the average contents of the bulges, so that this point is not vital. The general evidence seems to point to the tin contents maintaining themselves in depth on the main lines of the intrusive action.

Secondary Action.

By this term is understood the alteration caused to the ore-bodies, and especially to the distribution of the values in them by the action of meteoric influences, more especially to the physical and chemical action caused by the surface waters and the gases they contain.

(*a*) The simpler results of this action are the alluvial and detrital deposits, which have yielded a considerable tonnage of tin ore. The distinction between the two terms is mainly one of degree; alluvial applying to material which has been carried along a definite watercourse, and detritus to surface covering that not yet reached such channels.

The first work on the field was on the alluvial found in the gorges of the Dolcoath and Gormanston Creeks, and the latter creek was productive of some very large boulders of tin ore. The largest of these weighed 19 cwt., and has been preserved in the Tasmanian Museum, Hobart. It is estimated to carry 30 per cent. of tin. The boulders consist of quartz, tourmaline, and cassiterite, and appear to have come from a lode in slate country.

Most of the alluvial both here and in the other creeks has now been worked out, but Messrs. Maskell and Albury are still sluicing the detrital matter high up on the upper portions of Pine Hill.

The detrital matter proper was first attacked on the Renison Bell mine,and since then considerable areas have been also worked on the Montana, and Duncombe and Maddox leases. In some cases this ore which occurs associated with unaltered fragments of country-rock appears to have been set free by the weathering of pyrites, but in most cases it seems to be derived from the " puckered slates " and their accompanying quartz formations. Very fine tin seems to permeate these slates in very small quantity, and in the weathering of the surface this tin is set free and caught in the crevices of the surface rock. Wrong ideas of the value of the rock itself can be easily formed on account of this, and surface samples are misleading. The Boulder Company passed some of this detrital matter through fine screens before putting it into the battery, and it was found that only the very fine material was payable.

Some of this material was dealt with by simple sluicing, and doubtless a considerable proportion of the value was lost. The Montana Company is still working on this class of ore, but the crude detritus is carefully screened and the fine product passed over tables.

In the large alluvial plain deposits there is said to be a very small proportion of tin and some traces of gold and osmiridium. These are certainly too low grade for any of the present methods of treatment, but if very cheap power, as is quite possible, becomes available at Renison Bell, these deposits are deserving of careful examination.

Traces of gold and osmiridium occur in the other alluvials, both old and young. This is not surprising since gold is of very wide occurrence everywhere; a sample from the Olympic mine that was assayed for gold gave 1¼ dwts. Doubtless it is present in other ores as well. Osmiridium is found in considerable quantity in the creeks that drain the serpentine north of the Pieman, and its presence in the vicinity of the serpentine here is only to be expected. One creek coming into the Ring River from the north just above the junction with Dolcoath Creek is said to have yielded payable quantities in the past.

Chromite occurs commonly in the creeks, but not in commercial quantity.

(*b*) Secondary action in the ore-bodies. This is confined mainly to alterations in the pyritic constituents and the dolomite. In the quartz lodes and in the quartz bands in the puckered slates the crystal cavities remain which were occupied by the pyrites, but as a rule the mineral has been completely removed, and there is no residual oxide of iron. In the large outcrops of pyritic ore this is not the case. A gossan capping accompanies to greater or lesser extent all that extend to the surface, and was the first indication of the existence of ore.

The chief change is from the pyrrhotite to the hydrated iron oxide limonite. It is not clear whether there is an intermediate stage in which marcasite or white iron pyrites is produced with the limonite. Pyrrhotite with a formula of $Fe_{11}S_{12}$ carries a larger proportion of iron to the sulphur than marcasite with a formula of FeS_2. Hence the oxidation of some of the iron in pyrrhotite might yield products both of limonite and marcasite. Marcasite itself oxidises readily, so that where oxidation was free, such as at actual outcrops, this mineral would readily change to limonite, and limonite would be the sole representative. The actual occurrence of the marcasite bears this out. It is found usually at the margin of pyrrhotite bodies that have been covered up with surface soil or rock, which has been removed by sluicing or other work. In such cases oxidation must have gone on with limited supplies of oxygen. As soon as the mineral is uncovered it commences rapidly to decay, and in a short period the surface of the rock has crumbled away to the soft friable mass known locally as " ashes."

This residue is the representative of the quartz skeleton always found in the pyrrhotite. When this skeleton is abundant and the pyrite and its products are completely removed, it remains as an aggregate of acicular quartz crystals in which tin ore is sometimes visible. Where the quartz is less abundant, the whole mass crumbles away to the " ashes " referred to above.

Where, however, the limonite remains as the product of decomposition, the iron oxide and the quartz form a honeycomb mass, friable but tenacious, and with the tin constituent concealed by the dark substance of the iron.

The dolomite seems to be systematically removed from the surface zone and to leave little sign of its former presence. Though found occasionally in the surface workings it is not present in anything like the proportion in which it is met with underground. It is quite possible that in its removal it was a considerable factor in precipitating the limonite from acid iron sulphate solutions.

There is one important point on which no definite conclusion has been reached, and that is whether there is actual solution and reprecipitation of the tin oxide. It has become almost an axiom in mining geology that no secondary enrichment of tin ore takes place. It will be realised that it is practically impossible to bring actual proof as to whether certain particles of cassiterite have gained their present position by deposition from solutions emanating from a deep-seated source, or have been redissolved and precipitated from meteoric waters. The writer, in common with most of those familiar with this special field, holds that such precipitation has taken place, but the evidence is purely circumstantial.

(1) The average value of the contents of the gossan is far higher than that of the pyrrhotite ore-bodies, even after allowing for leaching out of a large proportion of the heavy sulphide contents. It has been observed by Mr. J. B. Scott, manager of the Renison Bell mine, that rich tin gossans abut frequently against dense, comparatively barren pyrrhotite. It seems either (*a*) that the presence of tin and the conditions that brought the tin tend to encourage secondary action; or (*b*) that secondary action has enriched the tin.

(2) A quite frequent occurrence is that of quartz crystals lining small vughs in the lodes. Considering the enormous pressure under which the ores were deposited, it seems inevitable that these same crystals are secondary. Accompanying them come crystals of cassiterite. It is difficult to see how these crystals can be of different origin from the quartz, or that they could be residual crystals of decay. The bright surfaces of the cassiterite crystals are against this view.

(3) There is no inherent reason why the solution of the tin should *not* take place. There appears to be a certain amount of tin sulphide or stannite in some of the ores, and this is readily soluble in acid solution. Further, the experiments of C. Doelter, referred to in Clarke's "Data of Geochemistry," page 684, show cassiterite is perceptibly soluble in water of 80° temperature, while J. H. Collins, in the Proceedings of the Institution of Mining and Metallurgy, Vol. XIII., page 485, establishes its solubility in hydrochloric and sulphuric acids. It is possible that the extreme fineness of the cassiterite in the pyrites on this field may be a local contributing factor.

That a certain physical enrichment is always taking place by the transfer and settlement of the fine particles of tin is certain, but actual solution, especially in conjunction with the quartz, also appears to be a considerable factor. The acid products of vegetable decomposition were at one time supposed to influence largely the solubility of quartz, but the more modern view* is that the alkalies are responsible for the solution of the quartz, and in all probability these also influence the solution of the cassiterite.

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* Clarke's Data of Geochemistry, p. 108.

Local Magnetic Variation.

Allusion has been made above to the fragments of magnetite showing polarity which are developed in the crevices of the serpentine. The whole mass of the serpentine is also magnetic, and compass bearings in the neighbourhood of these outcrops show a variation of 20 to 30 degrees along a line 300 feet long.

The pyrrhotite ore-bodies also are highly magnetic, and fragments show polarity, while in the immediate vicinity of them the compass shows complete demoralisation. In the theodolite traverse made to tie up the different workings in the inner quadrangle (Plate I.) the compass bearings were also taken at the various stations, and are shown on the plan. The work was preliminary only, but the results were interesting and tend to show the presence of magnetic bodies in parts of the field where they have not yet been located. If once the economic value of the pyrrhotite bodies is established, it is extremely probable that a magnetic survey with dip as well as horizontal needle will reveal many other ore-bodies at present concealed by surface rock.

Treatment Plants.

The question of the treatment of the ore will only be dealt with briefly in this bulletin. The reason for this is twofold—(1) To deal comprehensively with it would entail a very large number of assays, and such thorough analysis of many complex points as to constitute almost a separate bulletin. (2) The oxidised ores, unless unforeseen discoveries are made, are nearing exhaustion; and a review of past methods would serve little purpose.

Those who designed and controlled the mills know full well that the losses in the past have been heavy. Whether they could have been avoided economically, at less cost than the recovered values, is an open question. It is probable, though, that provision for settlement and retreatment of the slimes, such as obtains over large areas in Cornwall, would be profitable during the present high prices of the product.

In brief, the mills at present at work are as follows:—

Montana.—A small plant to treat detrital matter by screening and table-dressing. Motive-power, oil engine.

Central.—Ten-head battery, steam driven, followed by shaking tables.

Dreadnought-Boulder.—Ten-head battery, water driven, with grinding pans and shaking and rotary tables, and small Leggo furnace to roast concentrates for retreatment.

Renison Bell.—Twenty-head battery, driven by electricity produced by water-power, grinding pans and tables and Edwards furnace for roasting pyritic ores.

The salient point in regard to future treatment is that provision must be made for roasting the ore on a large scale, and it is very doubtful if any of the mills can be adapted for this. For the treatment of the roasted ore the machinery now employed can be utilised, but it will almost certainly need to be supplemented by settling and slimes plant on a scale that has not yet been contemplated on the field. The ore is bound to slime after roasting, and is now so valuable that a very small proportion will pay the expenses of separation and recovery.

Economic Future of the Field.

While a certain tonnage of gossan ore still remains at Renison Bell, and certain tonnages of oxidised quartz lode rock may be expected from both this portion of the field and from the X River portion as well, it is by now plainly evident that on the sulphidic ores must be based the permanent life of the district.

Unfortunately the larger companies, while treating the gossan ores, have not been in a position during their exhaustion either to develop the sulphide bodies so that a sound estimate of tonnages and values should be available, or to conduct experiments and instal plant to deal with these ores. The Renison Bell Company have made the best effort, and erected an Edwards furnace to roast their concentrates, but financial difficulty, unhappily, prevented a really effective test of this plant. It must be clearly understood that it is not sufficient to allow the money for installation of a furnace to deal with these ores: it is necessary to work out the process when the plant is installed—a new bat does not make a cricketer.

Such figures as could be secured as to the value of the sulphide ores generally are so incomplete that it is difficult to get a basis to work from. Samples of pyritic ores taken in the course of this work gave, by chemical analysis—

	Metallic Tin. Per cent.
X Falls: Three samples ... ... (average)	0·5
Boulder, Old Workings: Pyrrhotite...	0·20
Boulder, Dolcoath Workings: Selected pyrrhotite	5·3
Boulder, Dolcoath Workings: Pyrrhotite...	0·65
Federal: West trench	0·35
Montana South: Pyrrhotite	1·00
Ditto: Pyrites	0·4
Ditto ditto	0·61
Ditto ditto	0·51
Montana North: Pyrites	0·50
Renison Bell, No. 5 Tunnel	0·35
Ditto, Bore 1, 55 feet (average)	0·60
Ditto, ditto, 10 feet (average)...	1·35
Ditto, ditto, 15 feet (average)...	0·86

Bore 3 gave: 130 feet, average 0·3 per cent. tin oxide by vanning.

Bore 3 gave: 5 feet, average 0·8 per cent. tin oxide by vanning.

Bore 4 gave: 20 feet, average 0·5 per cent. tin oxide by vanning.

Bore 4 gave: 10 feet, average 0·5 per cent. tin oxide by vanning.

Bore 5 gave: 20 feet, average 0·6 per cent. tin oxide by vanning.

Bore 5 gave: 30 feet, average 0·5 per cent. tin oxide by vanning.

Bore 6 gave: 70 feet, average 0·62 per cent. tin oxide by vanning.

The vanning assays are far more reliable as guides, and as a general rule the chemical assay of metallic tin will yield on vanning the same percentage of tin oxide. This is in absence of stannite or other abnormalities.

The above data cannot safely be averaged up and used as a solid basis for engineering estimates. They are far too scanty and too scattered. They can only be employed to give a general idea of the problem to be faced if a close investigation is undertaken. On these lines it would appear that there is a large tonnage of pyritic and pyrrhotite ore

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available here in which the tin values range in the proximity of one-half per cent. of tin oxide. Allowing a good margin for freight and smelting costs and losses, this means, with metallic tin at £250, a contents value of about 15s. per ton.

Even with the considerable charges entailed by roasting and reconcentration, this figure, with the cheap power available at the mills, should leave a fair margin of profit; but there is very little margin if the grade falls off at all or the concentration losses prove heavy.

This makes it essential to consider the other contents of the ore that may have a marketable value. The lead and zinc associated with the tin are too limited to affect the problem. The iron will probably have a value some day, even as the iron of Spanish pyrites is used by British smelters, but for the present better ores are available and lying idle. The sulphur content holds out the best prospects of a helping hand.

There would be two forms of this in normal treatment: (1) Concentrates rich in pyrites from ore which carried, say, 10 per cent. pyrites and ½ per cent. tin oxide. This could be enriched to almost pure pyrites with, say, 4 per cent. tin oxide. (2) Dense pyrrhotite with about ½ per cent. tin oxide. This could not be enriched by simple cencentration.

Both materials could be used as a source of sulphuric acid. The first would be good quality, carrying probably over 40 per cent. sulphur. The second would carry only about 25 per cent., and has been regarded by no less an authority than Dr. Peters as valueless for the production of sulphuric acid. It is, however, used in Canada in special furnaces, and an account of its use is given in Bulletin No. 167 of the Canadian Department of Mines. The price varies very largely in Australia, being governed really by the cost of Spanish pyrites. In New York, in 1915, it was 7½d. per unit, equal to a price of 15s. 6d. per ton of 25 per cent. ore, or 25s. for 40 per cent. ore. In Australia prices were somewhat higher than this before the war, while at the present time no fixed basis of prices exists at all. It is evident, though, that we have here a substance which has a real commercial value if it can be utilised.

Its utilisation is not easy. The conversion to sulphuric acid is simple and straightforward, but the transport of sulphuric acid is almost impracticable, while the low contents of the pyrrhotite make the freight charges in this case also too heavy per unit of sulphur.

The main hope in the writer's opinion appears to be in the development of a chemical industry on the West Coast of Tasmania. The country is well adapted to this, chiefly from the cheap power that is now materialised; secondly from the abundant water; and thirdly from the absence of other industries that might be injured by the chemical wastes. Sulphuric acid is used largely in almost every such industry.

There is, further, the possibility of installing the modern method of manufacturing ammonia from nitrogen and hydrogen direct, and combining this with the sulphur from the ores to produce ammonium sulphate. This has a high manurial value.

It is impossible to go more fully into this question here. In brief, the conclusion arrived at is that it would not be feasible to gain a profitable return from the sulphur of the ores if that was the sole constituent; it will be difficult to gain adequate returns from the tin values by themselves. If by a stroke of genius these two values can be welded through the conjunction of cheap power into a surrendering to useful ends both these commerical constituents, then the immense supply of them which exists here may build up a mining enterprise second to none so far known in Tasmania.

VII.—THE MINING PROPERTIES.

(1)—The Renison Bell Prospecting and Mining Company, N.L.

The company holds a large consolidated lease, No. 5865, of 310 acres right at the township of Renison Bell itself. In addition, it holds three dam sites and water rights on the Argent River. It was the pioneer mine of the district; work of some importance having already been carried out in 1900; and has built two considerable dams on the Argent River with connecting water-race, a fine mill of 20-head of stamps, an Edwards furnace for roasting concentrates, and erected aerial and ground trams over various parts of the hillside to bring the ores to the battery. Stone to the amount of about 90,000 tons has been crushed, and 800 tons of tin oxide were recovered. Dividends have been paid to the amount of £7376. The mine was closed down at the time of this report, but the manager, Mr. J. B. Scott, was still in charge, and supplied full information as to the workings. That the mine has not been more successful is due, partly, to the limited amount of capital originally provided; this has caused the absorption of large sums in defraying the cost of the battery and general equipment, which sums would otherwise have gone to dividends, and shown a handsome return to shareholders; partly it is due to the character of the ore occurrences. The plant until recently contained no roaster, and was not equipped to deal with sulphide ores. The zone of oxidation all through the field goes to no great depth—often not 30 feet—before pyrites is encountered, and in consequence the oxidised ores were rapidly exhausted from the various occurrences as they were exposed. This involved fresh expense in developing and making accessible the fresh sources of supply. No blame attaches to the company, whose directors made every effort to attract large capital before they adventured on their own; rather they are to be commended for the confidence they showed in facing the risks they did, but this system which prevails also at the other large mine of the district can only be compared to the skimming of the cream off the ore deposits, and rendering even more difficult the dealing with the lower grade pyrites which rests beneath.

The workings, since the last report on this field, have increased so largely that a detailed description of them all is impossible. Only the more important can be closely dealt with, especially those which bear on the general character of the lodes.

Further, while the work done does certainly make clear some points which were in doubt before, it is not yet possible to establish any system which will connect and account for all the occurrences. In this and other properties adjoining, definite fracture lines with mineral fillings are apparent, but apart from these there seem to be ore-bodies quite isolated in the country rock, with nothing to indicate where they will be found or what will be their extent. This is referred to above in dealing generally with the economic geology*, but the point constantly recurs in the description of the details.

The general appearance of the property, and the location of the workings can be seen from the accompanying photograph and plans. The Emu Bay Railway and the Argent River, running about parallel, cut diagonally across the centre of the property. The northern workings stand out clearly in a quarry face of gossan, rising some 200 feet from the bank of the river itself. Beyond this, to the north, prospecting has revealed no considerable ore-bodies. From the river level at this point a long spur runs up in a south-east direction, and forms the backbone of the property. The major part of the ore came from the various workings on this spur, but the northern faces across the river gave the best returns, and formed the basis of the dividends paid out.

The railway cuts through the spur, and the sides of the cutting are over 20 feet high. This cutting gives the best cross-section of the ore occurrences seen in the district, more particularly since the first ore-body encountered affords a good example of the isolated bodies, while further on a well-defined fissure or fault-lode is also exposed.

The dense bush which covered the hillside 17 years ago is now nearly all removed. The quarries show up clearly, and the surface alluvial in many places has been sluiced away, exposing the barren rock beneath. Taking a broad view of the formation from high up the spur it is evident that a definite fault-plane or fissure-lode, with dip to the

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* Page 34.

east, extends from the gossan faces of the northern workings across the river, is a marked feature in the railway cutting, and shows plainly again on the western side of the ground sluiced for some distance up the hill from the railway. Its course so far has been clearly on a bearing about N. 50° W.; from this point on it is in doubt. To the west of its line come the gossan outcrops worked up the axis of the spur called the "Big Blow" lode system. To the east come some workings on the Central Sections, a well-marked outcrop on the Renison Bell ground, and then again some workings on the Montana ground. There are signs of cross-faulting, and it is an open question whether the lode has been deflected to the east or west, or whether it has been cut off altogether, and the supposed continuations are distinct occurrences. The writer's conclusion was that the throw of the fault was not great and that this main fissure passes on into the Central and Montana ground, ending in the confused country that there forms the divide between the Argent and the Ring River catchments. This will be called the Renison Bell main lode. The "Big Blow" lode-system is regarded either as an independent lode or possibly as a branch off the main lode. In the density and character of the pyrites it differs considerably from the main lode.

In addition to these well-defined lodes, there are the isolated occurrences cropping up in various places, which may be linked up ultimately into other connected lodes, but whose position now it does not seem possible to systematise.

Dealing in more detail with the main lode, it can be taken as starting from the northern workings. This does not mean that it ends here. On the contrary several trenches and tunnels have been put in further north. No. 7 tunnel, coming in from the western slope under a gossan outcrop, cuts a hematite formation showing smooth botryoidal fragments. Tin is said to occur here in the gossan, and to be associated with small veins of silica. Higher up the hill again a solid gossan outcrop is showing, which is regarded as the extension of the main lode. Still further north, big boulders of iron oxide show on the surface; and another siliceous outcrop is showing, said to carry 1 per cent. of tin. No. 5 tunnel comes in from the eastern slope for some 300 feet on a bearing S. 48° W. This cut an iron lode 3 feet wide, but no payable ore. All of this shows that there is no cessation or permanent break in the tin-bearing country, and that prospecting along the axis of the lodes may well be carried further north.

The northern workings are practically all in typical gossan and were quite extensive, since they are reported to have yielded 30,000 tons of ore. The bearing of the lode is about north-west, with dip to the north-east, lying between 60° and 70°. In the lower portions the footwall shows up clearly as a smooth outstanding surface, from which the gossan has come away cleanly. The hanging-wall is badly defined with layers of barren rock, and pockets and bunches of gossan penetrating behind and among them. The slate on the footwall is shattered and crushed into layers; that on the hanging-wall darker in colour, more massive and harder. In the upper portions it is the hanging-wall that is well-defined, and the footwall broken and irregular.

There are three main tunnels penetrating the ore-body at different levels, but only parts of the workings were accessible. The lowest tunnel practically at river level was blocked, but at this depth the lode is reported to be about 6 feet wide, and to consist mainly of quartz, carrying pyrites and tin up to 1¼ per cent. There seems little doubt here that the large gossan occurrence above represents the weathering of this lode. The country rock probably corresponded with that met with south of the river, and carried a large percentage of dolomite. The dissolution of this by the acid water from the pyrites would honeycomb the rock and allow even the physical transfer of the fine particles of tin which would be caught and retained by the iron oxide which replaced the carbonates. The hardness of the slate rock on the hanging-wall side is probably due also to the secondary silica deposited throughout it.

The lode shows in the river-bed as a quartz formation, and is then followed up the hillside by various workings. The first of these is known as the West River adit. This adit goes into the hillside on a bearing S. 43° E. At 100 feet a crosscut goes off north-east; at 150 feet one goes out a little south of west; while at 220 feet the drive itself turns north-east, becomes a crosscut for about 75 feet, and then follows the course of the lode for about 125 feet. At this point, when it is right below the railway line, crosscuts were put out east about 100 feet, and west about 25 feet. It will be seen from the plan that bore-hole No. 5 also penetrates this ground, and, in fact, explores it at a greater depth than the drive.

The drive itself for the first portion of its length is in footwall country below the lode. A marked feature is the regularity of the stratification, whether it be primary or secondary. The slates are divided into definite sheets of varying thickness from a few inches up to 1 foot or over. They have the appearance of true bedding-planes, and resemble the slates showing in the railway cutting above, to the west of ground intruded by the lodes.

In the north-east crosscuts, which cut the main lode—these characteristics change rapidly as the lode is approached. There is, however, in these workings not the same clear line of demarcation between lode and country rock that shows in the open quarries. The strata are broken up into irregular heads, and the slates outside the lode proper have been altered and indurated. The lode rock itself is composed of dolomite and quartz, and pyrites in varying quantities. In the No. 1 crosscut, which is nearer the surface, much of the pyrites has oxidised, while much of the dolomite has been dissolved, so the stone is honeycombed, and is red with the iron oxide. The stone from the deeper ground of No. 2 crosscut is only slightly altered, and is more compact and solid. A sample taken from the lode in No. 1 crosscut gave 0·35 per cent. metallic tin. One from the lode in No. 2 crosscut gave 0·60 per cent. Both these are payable, but only careful and systematic sampling, and some further work, could guarantee any definite tonnage.

No. 5 borehole, as seen from the plan, comes below these workings. The part that corresponds with the lode in the the tunnel is from 200 to 210 feet, the first 5 feet of which gave 1·65 per cent. of tin oxide by vanning, and the second 5 feet, 0·35per cent. Both these are payable, and these results from the deepest part of the mine give real encouragement.

Almost vertically above this adit, and about 50 feet below the railway line, No. 9 adit has been driven on a bearing S. 65° E. This extends right under and beyond the railway, and at the end a rise was put up, which connects with open-cut workings on the hillside. The first part of the adit goes through gossan for the most part, big vughs being also present. Further on dense pyritic ore was cut carrying good values up to 5 per cent. of tin. The rock is of a dense quartzitic nature, and marked by the presence of blende and traces of galena.

Above this tunnel the lode has been exposed by a small open-cut, which shows it some 10 feet wide, with slate walls dipping steeply to the east. Higher up again the railway cutting exposes the lode for a vertical height of about 22 feet. On the north side of the cutting the lode is associated with dark graphitic slates, permeated with pyrites, and crushed out of all semblance of regularity. On the southern or uphill side fragments of slate, with accompanying quartz and pyrites fill the lode fissure, while a small seam of galena can also be traced. The strike of the main lode here is S. 45° E.

Above the cutting a good deal of open-cut work has been carried on for some distance up the hillside, while the lode has also been worked by shallow tunnels. The geology here is complex. White sandstone and fine conglomerate rock show to the west, resting conformably on the slates. Tin-ore occurred in the surface drift here, and also in the rock. Considerable quantities of ore were won from this spot, which is really inside the footwall of the lode proper. Similarly on the hanging-wall side of the lode rich detrital and gossan material was taken to the battery, and a cutting has been made some 15 feet deep. The lode shows well in the south end of this cutting, but has been left, since not only is it of pyritic nature, but accompanying the pyrites is a quite considerable galena lode. This lode has been followed into the hill a little higher up and worked for its galena values. It is small, but well-defined, and is said to carry tin as well. Its occurrence caused some inconvenience and some anxiety to the company, since galena is a most unpleasant associate with cassiterite, but in this case the galena does not seem widely distributed, and it hardly seems likely that it will seriously affect the tin product. Up to this point the main lode has been exposed by surface and underground workings almost continuously. From now on the exposures are more broken, and it is not possible to write with the same confidence. The lode shows clearly up to and past the line connecting bores 4 and 3 on the plan. Where last exposed here it shows blue-grey shattered slates on the hanging-wall side, with dip N. 70° E. at 45°. On the west side the dip is flatter and the rock is more regular. The lode itself is about 3 feet wide, solid and massive, and in appearance the ore closely resembles the complex zinc-lead ores of the Rosebery district. By analysis it proved to be a zinc ore with 32·2 per cent. zinc; 2·4 per cent. lead; 1·0 per cent. tin; 10 ozs. silver. It would be of interest to know if tin has ever been found in the Rosebery ores.

Bore No. 3 is in the footwall country of the main lode and yielded from 5-135 feet an average of about ·5 per cent. of tin oxide by vanning from pyritic slate. It is difficult to link this up with the main lode.

Bore No. 4 gave low-grade returns from pyritic slate from 105-150 feet, and good returns from dolomite rock from 175-195 feet.

Bearing in mind the complexity of the formations here, it will be realised that one single lode cannot be expected to include them all. The most marked feature is a large surface of pyrite and pyrrhotite uncovered on the slope of the hill towards Renison Bell Creek. The footwall of this is not exposed, so that the true dip cannot be ascertained; the dip of the surface exposed is too flat to correspond with the main lode itself. It seems more probable that this is a detached ore-body, and not part of the lode itself. Similarly with bores 4 and 3, both of these cut good ore; the occurrences cannot be linked up together, and it is not easy to claim either definitely as part of the main lode.

If, however, it is correct to assume that the main lode continues across these broken portions, then probably bore 6, which cut 1·75 per cent. of ore from 15 to 60 feet, represents it. This is just at the southern limit of the pyrrhotite exposure. No. 6 adit also cut good ore under this same outcrop.

South of these workings the line of the lode passes across the corner of section 1215, owned by the Central T.M. Co., and then comes again into the Renison Bell ground. These workings on the Central can well be dealt with here. On the surface they appear as two circular pits, with well-defined footwall, dipping at an angle of about 50°. This corresponds in dip and bearing with the main lode. These pits represent the outcrops of gossan formations of quite large dimensions, which were tapped by adits driven on a bearing S. 30° W. from the side of the valley. Unfortunately the workings have been abandoned some time, and the chambers excavated are too much blocked and too dangerous for close inspection. This rendered it difficult to state the character of the lode here or its behaviour in depth. It was apparent, though, that the gossan continued to a greater depth than either along the other portions of the main lode, or at the Blow formations further west, which will be dealt with below. The adits, as far as they can be explored, reveal pyritic slates in the vicinity of the gossan, but no definite lode channel is exposed. The country rock here dips almost parallel to the hillside at an angle of about 30° in a general direction about N. 30° E. The dominant rock at the surface is the red rock referred to above and marked on the plan.*

Proceeding further south-east on the line of the lode, the Renison Bell ground is again entered in the vicinity of No. 8 adit. This adit goes in on a bearing S. 10° W. below a big gossan outcrop. It passes under this, and then into soft decomposed yellow slates, with dip to east, which grows flatter as the tunnel proceeds. Pyrite is showing on the tip, but the adit is partly blocked, and its source was not clear. Gossan is scattered all over the hill here, extending down to some workings just across the boundary, to be described as Hetherington's Workings. The impression here is that the tunnel has been driven too high up the hill, and is very possibly above the main lode if it continues here. With the isolated occurrences referred to above, as well as the definite lodes, it is quite possible to attack an off-shoot in place of the main body, and miss entirely the more valuable portion. There is evidence, both here and further south on the Central and Montana ground, of cross-faulting on E.-W. lines, but with this gossan showing at the surface, and the rich ore that is being worked lower down the hill by Hetherington's Tribute, there can be no doubt that this is a portion of the property deserving of closer attention than it has received in the past.

The question of the further extension of the main lode will be dealt with under the Montana sections.

There remain yet the "Big Blow" formation, and the isolated formations to be dealt with on the Renison Bell.

The "Big Blow" was one of the earliest discoveries on the property. A small bluff, some 15 feet high, com-

* Page 24.

posed of a limonite gossan, with skeleton of quartz, stood out well above the surrounding country. This in parts was very rich in tin, and the whole face on being systematically sampled gave an average of 3 per cent. tin, which was highly payable.

The first important work on the property consisted of tunnels and rises on this formation. These soon revealed the fact that the gossan outcrop was the oxidised capping of a large pyrrhotite formation, and it became clear that the soft gossanous material, from which the tin was easily won, very quickly in depth gave place to a dense pyritic rock, exceedingly hard and massive, with very irregular values, occurring so associated that special treatment was required to recover them. The result has been that both at this outcrop and at others disclosed on this same line up the hillside, only the oxidised ore has been dealt with, and the very large tonnage of unaltered stone still awaits treatment.

The occurrences at the "Big Blow" itself, and also above it further up the hill, are so similar that they may be dealt with together. As to their exact nature, in many respects they resemble the main lode, and it would appear that they are true lodes developed on a fault-line. The walls show very distinctly in several places—notably at the "Big Blow"—in one place the hanging-wall is very perfect, with smooth slickensides. At the hopper workings higher up the hill pebbles and fragments of slate show on the wall, with every appearance of a fault-filling. As in the case of the main lode at the river level, dolomite prevails here too, and the only marked distinction between the lodes lies in the large development of pyrrhotite in these upper workings. How extensive this is, or to what depth it reaches, is impossible to tell since the workings have penetrated to no great depth in the pyritic zone. The fault-plane probably extends deeply, but as there appears to be a break in the pyritic masses on the surface, so probably in vertical extent also, there will be a thinning-out of the lode material, and these bodies will show the lens-shaped structure so typical of the half-lodes, half-replacement ore-bodies prevalent on the West Coast.

With regard to the continuations of the lode, it is practically certain that the southern termination has not been reached. Gossan shows outcropping beyond the present limits, and though the gossan, where tested, did not yield tin, it is not only possible, but even probable on the evidence of the field, that at a shallow depth the tin values will come in. The present position is that the cost of opening up workings and connecting them by tram with the main haulage is so considerable that unless a large body of gossan is available, the dead work anticipates all the profits. If the pyrites could be treated, then the larger tonnage would render the dead work a less important factor.

With regard to the continuation north, it is evident from the plan that the Blow lode must either cease or pass into or through the main lode. The ground between the point to which the Blow lode can be clearly traced going north, and that to which the main lode can be closely followed coming south, amounts to about 100 feet in extent. In this area there is evidence of east-west faulting, while the rocks are shattered and twisted into every form of local strike and dip. This leaves the question of the linking up of the lodes a very open one, while at the same time it is not one of great economic import. The two lodes are both exposed, and their character revealed—both can be worked independently, and as the workings proceed the solving of the problem of their mutual relationship will give a special interest to work, whose main factor must lie in the actual profits that it yields.

The question of the value of the pyrrhotite ore in tin has not been ascertained. Surface sampling would be of little service, and no diamond-drill bore penetrates the ground here. It is known that the values are irregular and would bulk low, but the ground is very hard, and only a system of regular boring would give a clear idea of the average tin contents.

There remains to be considered the so-called "isolated bodies." Their occurrence has been dealt with in the section dealing with economic geology.* All that will be done here will be to describe a few typical examples. The best exposed of these is probably the so-called pyrrhotite lode in the east end of the railway cutting. The toe of the cutting on the south side shows, under 2 or 3 feet of detrital matter, slate country greatly broken and shattered, and carrying iron pyrites throughout it in small seams and in patches of considerable size. This extends

*Page 34.

for about 50 feet, and then a solid mass of pyrrhotite occurs about 25 feet long, and rising up 15 feet from the bottom of the cutting. Slate, broken and carrying quartz and pyrites, then comes from 15 feet up to the 90 feet mark, where a fault-plane, with slight dip to the east intervenes, and is followed by more regular and less mineralised strata. To the south, No. 5 adit and No. 1 bore show no continuation of any similar pyrrhotite body; to the north, No. 5 bore shows pyritic slate with tin, but no solid pyrrhotite. A drive in below the railway shows no downward continuation. This pyrrhotite mass stands as a massive kernel in the mineralised slate country, distinct from it, but with no clear source to explain its origin. The term floor can hardly be applied to it, since it has no apparent connection with any stratification: it is not a lode, though a fault-plane seems connected with it. It is rather a mineral cancer in the country rock, forming a localised mass of completely altered character, and incidentally carrying in this case quite a considerable proportion of tin. Specimens from the south side of the cutting have yielded over 20 per cent. of tin, while average samples over the whole width have given 3·8 per cent.

Instances of similar occurrences are plentiful on the field, though they vary in minor characteristics. No body was in unmineralised country, though they may possibly occur. They were regarded by Mr. Ward as floors, branching off from vertical feeders. They seem rather to be intrusive developments in a belt of country permeated with mineralised solutions. In such a case the intrusion would in many cases follow the bedding planes, and in consequence floors frequently occur, but in many other cases the principle does not apply, and no immediate reason for the shape or dimensions of the occurrences is revealed.

On the property, about 100 feet south of the cutting, a pyrites floor shows in a small face about 8 feet high. The pyrites is 2 feet thick, and is overlain by hard, flinty slate, 2 feet thick, with seams of quartz. Above this comes 1 foot of darker slate, with seams of pyrites, as well as of quartz, and above this 3 feet of grey twisted slates, altered and displaced by seams and patches of quartz.

The big pyrrhotite body near the main lode in the vicinity of No. 2 bore is probably an isolated body more or less conformable with the strata.

The next occurrence of importance is on the east fall of the main spur due east of the uppermost workings on the spur; a large pyritic and pyrrhotite body is exposed here by an open-cut, measuring about 70 feet square. Much of the pyrites has weathered to a black clay-like mass, with cubical crystals of pyrites studded through it. Dolomite is present as segregations, and in one place as a band 18 inches wide. A galena lode runs across the south-east corner of the exposure in a direction by magnetic compass S. 30° E. The whole pyrites mass goes under the slates at an angle of about 60°, while seams of pyrites spread up from below into the slates above. Work, as usual, was checked as the gossan was cleared away and only the pyritic ore remained, but the occurrence has all the appearance of an independent ore-body. The gossan was payable, and a rich seam of pyrites several inches wide was encountered below, and roughly parallel to the galena lode. The value of the main body of pyrites is unknown.

In addition to the above formations, all of which have been opened up to some considerable extent, there is the "western lode" on the west bank of the Porphyry Creek. This is a massive gossan outcrop, with main axis bearing north-west, and distinct from the other ore-bodies on the property. So far the values disclosed in it by a short tunnel and a little surface work have not been good enough to warrant deflecting more work in this direction, but with the erratic nature of the gossans so well established by now, a large body of this character well deserves closer investigation.

The above is a brief description of the ore occurrences on the Renison Bell property. Many points have of necessity been omitted, since the limits of the report require it. The detrital material which is now nearly exhausted, and the brief outline of the plant are dealt with with those of the other mines, and call for no separate mention here.

The ultimate future of the property rests on the treatment of the pyritic ore, and the economic limits in this respect are also considered generally above. The question arises though, specially with this property, as to which would be the best point of attack if the treatment question were satisfied. As a chief source of supply the main lode worked from the West river adit level seems to offer the best prospects; a steady tonnage would probably be secured from here, and the quantity of ore would be larger as the adit was pushed further into the hill.

For a further source, the south-east workings seem to offer the most promise. The pyrrhotite here gave good values at the surface. No. 6 tunnel disclosed some good ore, while No. 4 and No. 6 bores also passed through payable values. If ore from these localities can be made to yield a profit, the other sources of supply could also be brought in, and the life of the mine would be estimated at a span of many years.

(2)—Central Tin Mining Company.

This property comprises Section 1215—36 acres—charted in the name of A. W. Taylor. It embraces the lower portion of the valley of the Renison Bell Creek, and on both sides of the valley tunnels have been driven to intersect ore-bodies. Most of these workings have now been abandoned and access to them is dangerous.

The geology is difficult to interpret. The red rock slopes down with dip usually to north-east on the Renison Bell side of the valley. The same red rock shows on the east side of the valley, but the dip here seems in places to be north-west, and is much broken and disturbed. It would appear that there has been folding here with probably some local faulting, which has broken up the rocks on the western side of the creek and left the formations irregular there. Reference has been made to the diabase dyke which runs through the property, and to the fact that there is some doubt as to its geological position. If it belongs to the basic rocks, it might easily be a factor in this local dislocation. In any case there seems to be a definite line of lode occurrences on the east side of the creek, extending from the Renison Bell township nearly up to the southern boundary of the section near the dividing ridge. The occurrences, though, are irregular, both in continuity and in values. There is a bold gossan outcrop close to the track which is reported valueless. A considerable tonnage of gossan was won from some of the other faces along the line, but the quantities taken were not great before pyritic ore came in, the value of which was not ascertained. It seems possible that in some cases the dip of the lode is into the hill, and that the tunnels have not been pushed forward far enough to reach the ore. No work is at present being done on the east side of the creek.

On the west side of the creek, three tunnels have been driven almost vertically above each other to tap two lens-shaped developments of ore that occur on the line of the main lode of the Renison Bell mine. These tunnels pass through about 20 feet of red rock at the entrance, dipping nearly parallel to the hillside at about 25°. After that comes slate country. The ore was worked out by two large chambers, shown on the plan, and referred to above,* which have fallen in considerably. The openings are about 30 feet in diameter at the surface, with well-defined footwall dipping at about 50° N. 30° E. These workings yielded payable ore, but have now been abandoned.

Further south, and close to the western boundary come what are known as Hetherington's Workings. These are now being worked on tribute, and very good profits are being made by the tributers. The ore occurs at a peculiarly complex portion of the field. The Renison Bell main lode seems to have given out; the line of the well-defined quartz lode of the North Montana workings trends in this direction, but the intervening country is very broken, with cross-faults plainly showing, while other outcrops of pyritic ore occur sporadically around.

A long tunnel was driven here some years ago, but missed the ore, which was opened up by surface work. A branch tunnel has now been driven under the gossan, and rises put up to connect with the surface workings. Gossan extends up the hillside, above which has been proved to contain tin values. The whole formation rather has the aspect of the final phase of a flat-lying pyritic body, which has weathered *in situ* with a gradual concentration, mostly mechanical, towards the lower end where the tribute party is now working. Possibly there is a connection with the pyritic ore disclosed in Renison Bell No. 8 adit higher up the hill and a little further north, but on the whole the ore-body bears the aspect of an isolated body developed in the bedding planes with the covering beds completely removed. Needless to say the adjoining gossan on the Renison Bell property deserves the close examination which the manager is now preparing to give to it.

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(3)—Montana Tin Prospecting Syndicate, N.L.

This company holds one section, No. 1342M, 78 acres, and water-rights for 7 heads of water. The section lies between the Renison Bell and Dreadnought-Stebbins hills, and includes the dividing saddle between the Renison Bell Creek and the Montana branch of Dolcoath Creek. The water supply is drawn from the small creeks that drain the western slopes of the Commonwealth Hill, and is of necessity a rainy weather supply.

The workings are divided by the valley of the Montana Creek into northern and southern portions, and are shown on Plate I. of the attached plans. As usual the geology is very complex.

The work in the past has been confined almost entirely to dealing with the surface detrital matter. The natural concentration has been relied upon either by releasing the fine tin from the quartz, or by producing an enriched gossan from the pyritic bodies to yield a product with sufficient values to be treated by a small crushing and concentrating mill. The company purchased a fine battery plant, and have it on the ground by their old plant near their southern workings, but so far have not been able to erect it. The present mill on the northern fall of the saddle screens out the coarser detritus, which is stacked for later treatment, and then deals with the fine dirt on tables and strakes. This is far ahead of the older methods on this field, which relied on sluice-boxes, and serves its purpose well, but the era of surface workings, though it may be dragged out for some months or even some years by new discoveries on the property, is already largely a matter of the past, and for that reason less stress is laid on it in this report than on the prospects for the future. These can only be gauged from the ore deposits exposed by these same detrital works.

The chief exposures are as follows:—

(1) The North-West Workings, comprising three open-cuts near the mill.
(2) The Main Northern Workings.
(3) The Southern Workings.

(1) Of the North-West Workings the northernmost, close to the west boundary, seems to be a floor formation of pyrites dipping N. 45° E. at about 30°. The slates above show normal dip to the west, probably due to this

local intrusion. Residual quartz crystals show on the surface of the pyrites.

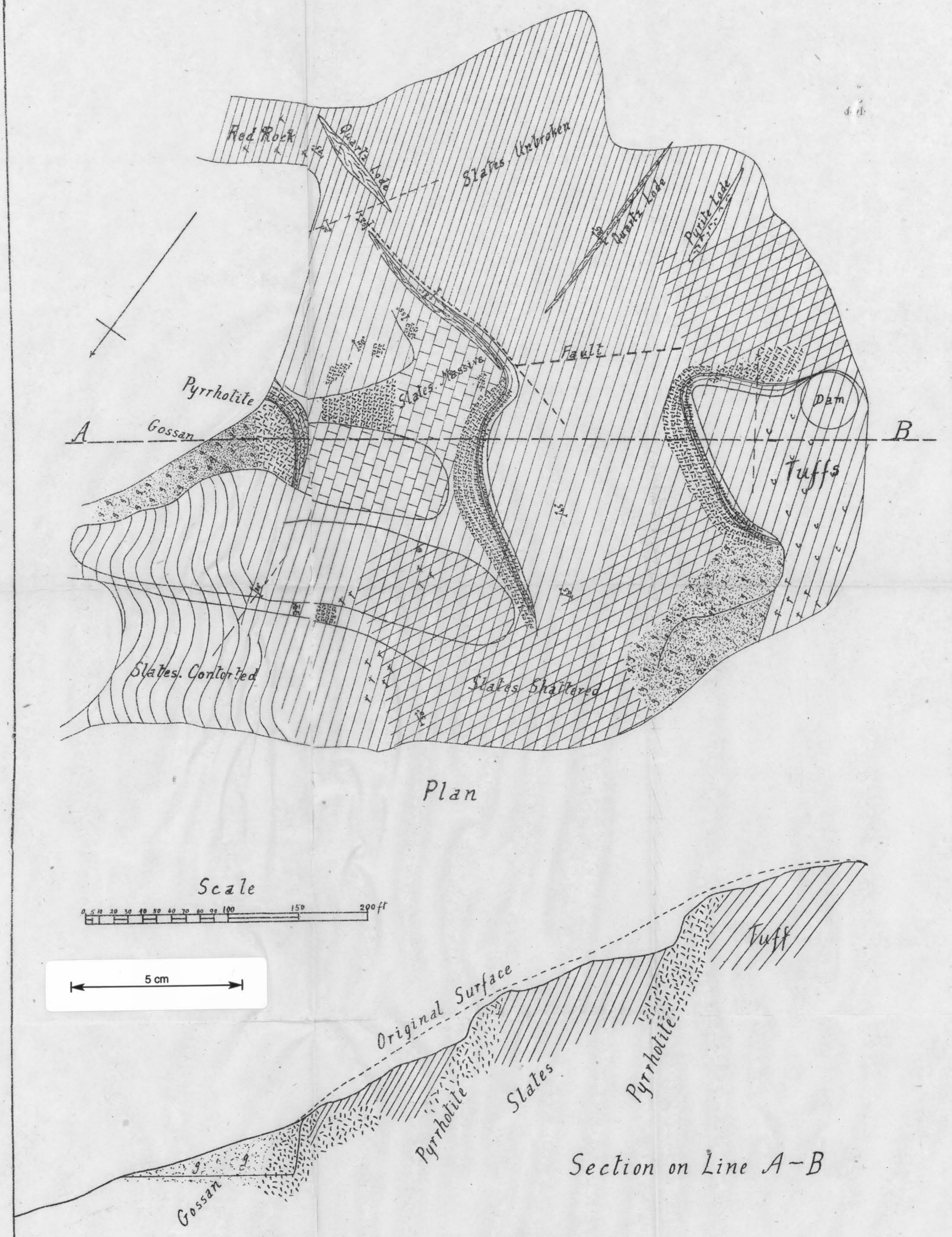
The next workings, a little further south show a distinct fault-fissure and accompanying lode which is developed with a bulge of pyrites near the centre. This seems to be mainly a quartz lode about 3 feet wide, with a dip of 75 degrees to the north. The surrounding strata are regular with flat dip to north-east.

The third workings, a little east of the above, are being drawn on now for supplies of ore. The geology here is obscure. There is evidence of quartz intrusion in puckered slates, and again in massive quartzite which overlies a big pyrites formation. The difficulty is to decide the line of intrusion. It seems to be on a fault-plane nearly east and west, with dip about 70° to the south. This is quite at variance with the usual trend of the lodes, but harmonises with the irregular character of the country rock in the neighbourhood. It is probably connected with the main fault of the northern workings. An old tunnel here appears to have passed through pyrites and ankerite, and is reported to have yielded ore worth ½ per cent.

(2) The Northern Workings.—These occur close to the track on the fall from the "Montana Saddle" down towards Renison Bell Creek.

The surface has been worked up here from a stretch about 250 feet wide, leaving little islands of hard, barren rock between, until the workings narrowed in to a cut some 12 feet wide alongside a large and well-defined fault-plane. This fault-plane is on a bearing N. 76° W., with a dip at 55° nearly due north. In the fault-plane is developed a typical quartz lode with green quartzitic rock, quartz-invaded slate, and some pyrites accompanying it. This lode is on a considerable scale, and with clear evidence of good detrital values, it deserves more attention before it is regarded as unprofitable.

In the eastern portion of the workings, two more fault-planes are clearly developed, with strike about N. 70° W. and dip nearly vertical. Between these two is a nearly horizontal bed of pyrites exposed in section by the workings. The slates above are shattered. This whole corner seems to have been a focus of intrusion, and is a favourable spot for underground prospecting.



Montana South Workings.
Geological Sketch

Hartwell Conder.
Dec 1917

Photo Algraphed by John Vail Government Printer Hobart Tasmania.

B3024

(3) The Southern Workings.—These were the most extensive, and a separate sketch has been prepared of them. The surface covering here has been almost completely removed over an area of about 4 acres on a steep hillside exposing the underlying rocks. A tunnel was also driven, but unfortunately this has been completely blocked.

The workings illustrate most of the features that occur on the field. The character of the country rock changes from regular, evenly bedded slates at the south end, to crushed and broken rock, with dip and bedding most irregular to the north. In the north-east corner folding has made the position even more complex. The red rock referred to above appears in the south-east corner, and also right up in the western limits. At this point it borders on a rock distinct in appearance from the clay slates of the southern parts, which under the microscope resolves itself into a crushed and altered tuff, which can best be ranked as clastoporphyroid. Further down the hillside, to the north, a tuff rock occurs, which has suffered far less alteration, and shows the coarse included fragments of a typical rock of this class.

The lode characterisations are also well illustrated. There are fault-lines, with little or no accompanying mineralisation; quartzitic lodes which may or may not also be fault-fissures; quartz-lodes, accompanying faulting; and large pyritic developments of massive pyrrhotite. The dimensions of these latter are shown by the cross-section, which does not, however, explain them. With the absence of the underground information which the tunnel would have yielded, it is very difficult to arrive at a satisfactory explanation. They may be distinct lenses or parallel lodes. They may be the same ore-body separated by a complex system of faults. On the whole it would seem that they are distinct lenses developed in another focus of intrusion, the evidence of which lies in the crushing and alteration of the slates to the north. The lodes probably extend vertically at least the same distance as their horizontal length, and may be succeeded then by mineralised country such as occurs in the Renison Bell lower workings. In any case a very large tonnage of pyrrhotite ore is already shown here in the faces exposed.

The valuation of the ore is only possible either by boring or driving through the ore-bodies. Some representative samples of the ore were taken, but no quantities can be based on these. The results were as follows:—

		Per cent.
(1) Quartz Lode	... ...	0·45 Metallic Tin—chemical assay.
(2) Pyrrhotite	... ...	1·00
(3) Pyrites	... ...	0·40
(4) Pyrites	... ...	0·61
(5) Pure Pyrite	... ...	0·51

There is danger in these surface samples from mechanical secondary enrichment, but they indicate the values to be expected.

In addition to this, some most interesting work was done on the pyrites from here by the Mt. Lyell Co., and the figures were supplied to me by the Montana manager, Mr. Cooper. They were as follows:—

Analyses of Montana Tin Pyrites Samples

No. 1, North End Robertson's Cut.

Sulphur. %	Tin as Sulphide. %	Tin as Oxide. %	Total Tin Contents. %	Copper. %	Antimony. %	Arsenic. %	Bismuth. %	Lead. %	Zinc. %
32·80	0·441	0·816	1·257	2·85	1·40	1·43	Trace	Nil	Nil
No. 2, Lower Face.									
35·88	0·284	0·135	0·419	0·20	0·42	0·18	Trace	Nil	Nil
No. 3, Top Face.									
29·17	0·094	0·204	0·298	0·08	0·49	0·21	0·48	Trace	Trace
No. 4, Tunnel Face.									
34·16	0·182	1·090	1·272	0·42	2·69	4·94	0·96	Trace	Trace

Melbourne H.O., 11th July, 1913.

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It is not clear where these samples came from, but they were chosen for their sulphur values, since it was sulphur that was required. One important point is the occurrence of tin as sulphide. It had been supposed that stannite did not occur on the field, but the difficulty of concentration in some cases where the chemical assay gave high results gave rise to doubt on this point, and these assays establish its presence. To confirm them, sample 2 above was assayed by Mr. Reid in the Geological Survey Laboratory, and yielded 0·10 per cent. of tin sulphide. A sample of pyrrhotite from the Renison Bell cutting gave 0·44 per cent. tin oxide and no tin sulphide. The bearing of the stannite on concentration, with or without roasting, requires investigation.

Duncombe & Maddox Section.

This section, numbered 1963-M, of 80 acres, is held in the name of Duncombe and Maddox. There is also a water-right drawing its supplies from the head of Dolcoath Creek.

No work is at present taking place on the section, but a considerable area has been exposed by the working of the surface detritus a few years ago. The workings are in the north-east corner of the section, close to the Montana boundary. The underground work comprises a tunnel about 80 feet long, and a rise to the surface from it. This tunnel was sampled by the writer in 1910 in 5-feet sections. In three sections it yielded as follows:—

(1) At the face: ·2 per cent. metallic tin, chemical assay.
(2) 30 feet from face: ·3 per cent.
(3) 63 feet from face: ·15 per cent.

A rise goes up from the tunnel, but no samples are available from here. At the surface much of the slate country is intruded with quartz and puckered slates, while what appears to be a definite fault or fissure lode crosses above the tunnel, bearing S. 5° W., with nearly vertical dip at 70 degrees to the east. It is up to 1 foot wide, filled with seams of quartz, with some accompanying tourmaline. Similar parallel seams run through the country over a width of some 10 feet, and veins show in the rock over a width of 50 feet. Very little pyrites shows in most of the rock.

A quartz porphyry dyke is a marked feature on this claim, and extends across the boundary into the Montana leases. It bears N.N.W., and dips steeply to the east. Its width is about 2 feet, and it has split in one place into two branches, which seem to reunite. A point of considerable interest is the fact that the dyke shows local crushing. This local crushing has been regarded in this report as due to the intrusion of the lode minerals. It seems here that the dyke action was antecedent to the crushing, though with a small dyke, such as this, cooling would be rapid and the priority might be very short.

The detrital material includes almost every variety of weathered and banded slates and quartz.

Some of the tin saved was coarse, but the majority seems to have been fairly fine. The tailings were stacked, and later on some of them were screened and treated by the Boulder Company. Only the very fine screenings were payable.

It seems clear in this case that the lodes centering round the fault fissure were the sources of the tin, and that natural concentration on weathering made the detritus payable. There is no need to suggest any actual solution and redeposition of the tin ore. The particles would cling to the irregular surface and sink in the crevices as the rock decayed, while their higher specific gravity would delay the progress of the larger fragments down the hillside. The slates are bedded somewhat flatly here, with general dip to the north-east. It was thought that an interbedded lode might be responsible for the ore, but the rise did not reveal this, while the values of tin found in the tunnel, low as they are, probably represent the veins that show on surface.

There is also a tunnel going into the hill on a course nearly due west, on the southern fall from these workings, but it does not appear to have revealed any ore.

There is also, near the southern boundary of the section where the Dolcoath Creek crosses the line, a lode occurrence containing quartz, siderite, pyrite, and blende; too little work has been done to estimate the value of this lode.

(4)—Dreadnought-Boulder Tin Mines Amalgamated, N.L.

(*a*) *Boulder Lease*, 4086, 160 *Acres*.

This consolidated lease includes two leases, of which the southern was originally known as the Dolcoath property. The workings in this part are still spoken of as the Dolcoath. The northern or original Boulder section will be dealt with first.

The general geology of the section presents no special features: the three main workings are located on either side and on the end of a spur running down south from Stebbins' Hill. The spur is composed of slates, which are much intruded by quartz and greatly puckered by the pressure accompanying the intrusion. The diabase dyke traverses the section, showing best in a small cutting a short distance south of the old mill, where it splits into two branches. The course of the dyke is somewhat curved, and it passes over the eastern boundary of the section. It is doubtful whether the occurrences here have any systematic or other connection with those of Duncombe and Maddox or the Montana. If there is any line of fracturing here, it would seem to be one which passes along the western side of Stebbins' and Dreadnought hills, but it is probably safer to regard the occurrences round here as belonging to a separate focus of intrusion.

Many of the old workings were inaccessible, and unfortunately there is no plan of the workings on the property, so that even their location on the attached plan is approximate. They will be briefly summarised:—

The most important is a long tunnel of 756 feet, driven from a point in Dolcoath Creek near the site of the present mill in a direction approximating to that of the northern side line of the section. Pyrites formations were cut at 85, 210, 267, and 464 feet; and 4 feet of pyrrhotite at 695 feet. No records of any values appear to be available.

A tunnel was driven for 236 feet from close to the junction of Gormanston Creek with Dolcoath Creek on a direction approximating to south-west. This was to prove at depth a lode which follows the course of Dolcoath Creek and shows as a vertical pyrrhotite and pyritic formation some 8 feet wide. This was reported on in 1895 by Mr. Montgomery, who states that it carries gold and silver. The lode is cut off by a fault just above the inflow of Gormanston Creek.

In neither of the above cases do systematic tests appear to have been carried out as to the tin contents of the sulphide ores. If the working of these low-grade ores is contemplated, a careful sampling of such exposures as these is one of the first steps to be undertaken.

The main workings on this section are comprised in three open-cuts, with associated tunnels, known as the Old Mill Workings, the Tram Workings, and the Cable Workings.

(1) The Old Mill Workings are situated on the hill behind the old mill. They comprise three open-cuts, which give probably the best illustration of the mode of occurrence of the ores that can be found on the field. There is also a tunnel driven for 178 feet below the workings, with a connecting rise to the first of them. This tunnel does not go far enough to prove any but the first occurrence of ore. This occurrence, now that the surface detritus has been worked away, shows as a vertical face of dense pyrrhotite, with hard greenish quartzite, to the thickness of about 2-4 feet overlying it. The face is 16 feet high in places, and there is a distinct steep line of demarcation between the pyrrhotite and the surrounding slates, which are bedded more or less horizontally. The slates are broken up in the vicinity of the ore-body. The tunnel below shows no solid mass of pyrrhotite, but from 122 to 130 feet a hard vein stuff with pyrites and other minerals. This may be the origin of the sulphide ore which developed in the bulge exposed in the cut above.

A little to the east of this, a narrow cut, some 10 feet wide, has been pushed in on the level till at the end a face of rock about 20 feet high is exposed. This face is shown in the accompanying photograph and sketch that illustrates the photograph.* It is the best example of the mode in which the quartz and pyrites invaded the slates, and twisted and turned them in every direction in the course of that intrusion. The mass of quartz, about 3 feet by 2 feet, in the right-hand bottom corner, has squeezed into the slates till the cleavage planes have been pushed round to roughly contour the intruded mass. Moreover, a fragment of the quartz vein, about 4 inches wide in the centre, yielded 30·3 per cent. of metallic tin, occurring in coarse particles in a granular aggregate of pyrites and quartz.

North of this again a cut goes in which skirts a pyrrhotite formation which seems to be dipping to the west. Here, as in the other parts, the workings have been directed to the gossans and detritus, and do not explore the pyritic ore. On the whole, there appears to be a line of lode here bearing approximately N.N.E., from which the big pyrrhotite face is an offshoot. There is clearly much irregular faulting, and no certainty can be assumed for behaviour in depth, but the tunnel should undoubtedly be pushed on under the rich quartzite veins, and there is a

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really good chance either of the rich veins of ore continuing down or, what is more probable, a wider dissemination of those veins with still sufficient values to yield payable ore.

(2) The Tram Workings.—These are on the backbone of the spur running down to Dolcoath Creek. A considerable tonnage of coarse detrital ore was won from here and sent to the battery, but the workings are not being drawn on at present. As far as one can judge, this ore was shed from a pyritic lode which dips into the hill at an angle of 40 degrees in a direction north-west. This angle of dip would leave a large accumulation of detrital material as the country weathered away. The lode appears to be at least 6 feet wide, and to be cut off by a cross-fault at the northern end. The detritus was shot down a pass to a level below, and a tunnel was started to come in under the pass and exploit the ground. This work was not completed, and probably a better location for exploring the lode would be to come in from farther west, as near as possible on the structure of the lode, with the object of picking up its extension. The slate country is much intruded and puckered at this point.

(3) The Cable Workings.—These workings are situated on the east slope of the same spur as the others, and are at present being used as a source of ore supplies. The workings are shown on the accompanying plan, but in spite of the amount of ground that has been opened up, it is not easy to determine the character of the occurrence. So much of the ore is heavy gossan, which coats everything it touches, that the strata are concealed and the character of the rock hidden. Where the surface workings at the top of the hill have exposed the slates, friable quartz and pyrites show with the gossan, and the formation appears to dip irregularly towards the east. In the tunnels below dolomite shows on the footwall in No. 1: the gossan zone is still strong, but pyrites comes in in places in dense masses in the footwall. Magnetite also occurs. At the northern end of the drive the lode-channel still continues of the same width, carrying gossan and magnetite, but the ore is poor in tin. In No. 2 tunnel, lower down the hill than No. 1, similar features show, but a sharp turn occurs at one point, which may be due to a cross-fault. Gossan and pyrites constitute the lode.

The work of the next few months should help to explain the position more. The gossan bodies are considerable in size, and since the outcrop of the lode follows the slope of the hill, the oxidised zone is drawn out and rendered more

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productive. Still, with the limits of the oxidised ore clearly drawing near, opportunity should be taken, while this work so near to the mill is proceeding, to test thoroughly the value of the pyrites associated with the gossan. If it appears payable, steps could be taken to deal with it. There should be a large tonnage of this ore comprised in the ore-bodies accessible by these tunnels above, but, in addition, the long tunnel referred to before cannot be far from the line of the lode if this preserves its easterly dip, and a little driving from the end of this tunnel would prove clearly what is happening in depth.

All these three occurrences are full of promise if proper means can be provided to deal with the sulphide ores.

(*b*) *The Dolcoath or Southern Portion of the Section.*

The general geology of this section comprises the Dundas slates, but a belt of gabbroid rock follows the course of Dead Man's Creek down to its junction with Gormanston Creek, crossing the section diagonally; and an outcrop of clastoporphyroid occurs in the south-east corner. In addition, what is probably a continuation of the quartz porphyry dyke prominent on Duncombe and Maddox section is exposed cutting the gabbro.

The chief workings are shown on the plan. After rising from the gully of Dolcoath Creek there is a small exposure of comparatively flat ground, along which passes the track to the Confidence Saddle. On the flat two small workings show. The first comprises an axinite lode about 1 to 3 feet wide, with steep dip, and bearing S. 19° E. This was trenched along for about 100 feet, and a small shaft then put down. The axinite is pink to grey in colour, honeycombed in parts, and accompanied by a green mineral which is probably tourmaline. This lode extends into the underground workings further up the hill.

A short distance east of these workings a small cut has been put in on a pyrites formation. Too little work has been done to make clear the character of the ore-body: the strata of the slate are confused, and the dip of the sulphide ore is doubtful. Some of it is dense pyrrhotite similar to the ore found higher up the hill. Arsenical pyrites is present here in considerable quantity, and is regarded as a first-rate indication of tin.

Higher up the hill occurs an open-cut with extensive tunnelling below it. These workings are the most important, and a considerable quantity of oxidised and detrital ore was trammed from here to the old Boulder battery. The open-cut comprises a large pyrrhotite body, the general course of which seems to be S. 17° W. At the end of the cut the exposed face, some 25 feet high, shows the slate contouring to some extent the pyrrhotite body, with signs of faulting as well. There is a shallow shaft sunk near the north end of the works, and right in the centre a pass down to the underground works below. A specimen from the pyrrhotite here yielded 0·65 per cent. metallic tin.

The workings below were extensive, but have largely fallen in, and are a chaos of mud and water and rotten timber. Over 330 feet of driving and crosscutting appear to have been done, two rises put through to the surface, and a small winze sunk for 6 feet. The axinite vein referred to above was encountered several times in the tunnel, and driven on for some distance. Massive pyrrhotite, and slate with pyrrhotite, were also encountered. Good ore is said to have occurred in several places, but it seems that here, too, the fact that appliances limited treatment to oxidised ores discounted all the work, and if careful samplings of the sulphide ores were made, they do not appear to be accessible. All these workings stand on a similar footing with most of the others of this district: zones of very great possibilities if a cheap method of handling the sulphide ores can be evolved.

Leaving these workings and going about S. 20° E. for 200 yards, a little cut only about 2 yards square shows on the hillside. The surface clay has fallen in and obscured the rock, but the cut was remarkable in that fragments of some of the best tin ore seen in the district were lying on the ground beside it. It occurred as dense black massive cassiterite in crystalline quartz, stained green in parts, possibly from tourmaline, and with soft yellowish residue in other places, probably due to the decay of arsenical pyrites. What the extent of this occurrence may be is quite unknown, and the man is dead who uncovered it; but the grade of the stone warrants prompt attention to discover its extent.

Further south-east from here, and across the gully of the Dead Man's Creek, a small tunnel about 25 feet long has been driven in the hillside. The slate is of a hard, black, cherty nature, probably due to the proximity of the gabbro, and in parts pyrites and gossan are showing. Much of the pyrites appeared to be mispickel (the arsenical variety), and a sample yielded 0·6 per cent. metallic tin. The extent or general average value of the occurrence is not known.

(c) Dreadnought Lease.

This consolidated section, No. 6964, of 226 acres, in the name of C. Brumby, comprises three sections, Nos. 2650. 2763, and 3370, of 78, 77, and 70 acres, with slightly different boundaries. It embraces the northern and eastern slopes of the Dreadnought Hill, and extends down almost to the Ring River.

As regards general geology, the area consists almost entirely of Dundas slates, usually of hard and flinty character. Near the eastern boundary there is an outcrop of gabbro, which seems to be a parallel formation to the belt that is exposed in the Ring River a little further east.

The diabase dyke referred to above crosses the south-west corner of the section near the summit of the Dreadnought Hill and on its western fall.

The ore-deposits occur on the eastern fall of the same hill, and extend right along its slopes past the dip that divides the hill from Stebbins' Hill into the ground of the Federal section.

In continuity of strike, and regularity of dip, and in the absence of what have been cited as isolated bodies, this formation approaches more closely to the recognised forms of fissure lodes. It possesses, though, the same irregularity in the filling of the fissure and in distribution of the values throughout it that may be regarded as characteristic of the whole field.

The workings are shown clearly on the accompanying plan. The first indication of the ore was in a gossan outcrop near the summit of the hill, and a tunnel was put in by the early prospectors to prove this gossan at depth. The miners then were in search of galena, and the presence of small percentages of tin were overlooked, until after many years Mr. H. E. Evenden made this clear. In places in the gossan, both at the surface and below ground, the ore is extremely rich, and the small crystals of cassiterite form the bulk of the rock, but these rich patches are exceptional, and the average grade of the ore that has been mined out would probably be below 1 per cent. of tinstone.

The main workings consisted first of an extension of the first or main adit to prove the extent of the ore. As further work was done, and fresh outcrops were revealed on the surface, the general line of the lode became apparent, and other adits were driven both north and south of the main adit to prove the continuity of the ore.

The largest body appeared to centre round the main adit, and this was attacked by open-cut, the ore being passed down to the level of the adit, trammed a short distance along the hillside, and then delivered by self-acter to the Boulder tram, and so to the Boulder mill. A large opening has been made by this action, which is 200 feet long, with footwall dipping at about 50° stripped clear, and standing up 45 feet high. At the bottom the cut is some 30 feet wide, and the openings of the old drives show as they penetrate further into the hillside. Even at this level the extent of the oxidation varies considerably and the workings have been held up in several places through striking pyritic patches. There is another rock of bluish colour, which appears to be a slate, altered by a certain amount of pyrites and possibly magnetite. This rock gives great trouble in the concentration, and is known locally by the expressive name of "blue ruin rock."

The supplies of oxidised ore have been nearly exhausted from this open-cut, and exploratory work is being directed towards other exposures of gossan further to the south, the size of which is still quite unknown. Work has at the same time been applied in the past to testing the main ore-body in depth, and a tunnel has been driven below the main adit, and is known as the Lower Tunnel. It has passed through massive green slates, occasionally hardened by quartz, and changing in places to a slate of red colour. The strike and dip are very indistinct. The lode is not well defined in the discoloured rock of the tunnel, and consists in part of decomposed slates with gossan, and in part of slate, with a certain amount of pyrites through it. A rise has been put up about 14 feet above the level on the lode. Two specimen samples were taken from here—one from the rock broken down from the rise gave 0·5 per cent.; one from the south side of the drive just past the rise gave 1·1 per cent. metallic tin. This last is good, but may not be representative of the whole lode, while the bugbear of the pyrites seems to be close at hand.

Of the other tunnels, the most important are Nos. 1 and 2 north. In each case a clear lode-channel is exposed, some 20 feet wide, in No. 1, consisting of soft decomposed slate and gossan. A sample from No. 1 gave 0·4 per cent. metallic tin, and a sample from the centre of the lode-formation in No. 2 gave 2·5 per cent. This is good, and the ore here deserves closer examination.

In the other northern tunnels the lode is not so well defined, and the country shows a curious change. The country-rock for some distance from the entrance is completely shattered, and in many places appears to consist of debris fragments in clayey matrix. It is not clear whether it is a shattered and decayed country-rock or actual secondary deposition, but the former seems more probable. The lode is ill-defined in the No. 3 north, but values were quite good here, going in places to over 2 per cent., and averaging 1 per cent. along 80 feet of driving; north of this, though, it is difficult to trace out the formation, and if it continues, it will probably be necessary to follow it at a greater depth than the present workings.

Going south the costean pits and the two tunnels have traced the lode right through to the Federal boundary, but do not suffice to give a clear idea as to the extent of the values or their continuity between the different exposures. All that can be said regarding this property—even now, after all the work that has been devoted to it—is that there is a definite lode of considerable width, and extending for a proved distance of close on 4000 feet feet. Portions of this lode have proved profitable on a large scale, with provision for the treatment of oxidised ores alone; other portions have shown tin contents which should leave a good profit even with the extra cost of treatment for sulphide ores. If the company can once start dealing profitably with this class of ore there seems no limit to the quantities that should be available. The present high price of tin may give them the opportunity to do this.

In addition to this main lode, another lode shows right up at the summit of the hill—in one place having a bearing about S. 20° E., and dip at 70° to the east. The country is broken and faulted, and the lode consists of quartz and gossan.

Below the Dreadnought Hill, in Isaacson's Creek, some alluvial work has yielded tin and a little gold, but the area was limited, and the ground was soon worked out.

Further south, on a small creek beyond the self-acter and near the Boulder tram, a creek was worked some years back for alluvial tin, and fair yields were obtained. At the time of this report beds of detritus below these workings were being attacked, and the material sent to the battery. These recent alluvials in some places here rest on the older alluvials, which may be of glacial origin, and the change in character is very marked, both in outward appearance and in the cessation of the values.

(5)—The Federal Tin Mines, No Liability.

This section is numbered 1273-M, 79 acres, in the name of A. S. Stebbins, whose name has also been given to the hill on which the property is placed. The Dundas slates occupy nearly all of the area, though the diabase dyke crosses the south-west corner of the section, while a small outcrop of porphyroid rocks shows near the north-west corner.

The economic importance of the section lies in the extension into it of the Dreadnought lode. The lode shows as a bold quartz outcrop on the east side, and not far from the top of Stebbins' Hill. A small tunnel, 27 feet long, was started here many years ago 150 feet below the summit of the hill, but it was not till about eight years ago that serious exploratory work in the chase of tin was undertaken. Since then two considerable drives, with 60 feet of vertical height between them, have been put in, with many crosscuts, as shown on the plan. The lode-formation is very irregular in structure and composition. Parts are dense quartz and other parts contain fragments of altered slate, while here and there are cellular patches of interlacing quartz crystals stained browned with limonite. The ore alternates with slate country-rock, and in places it is no easy matter to distinguish between the two.

The most promising feature in regard to this ore-body is that the lode is more consistent, and apparently of better value, in the lower than in the upper tunnel. A good deal of sampling has been done at various periods, but not sufficient figures are available to warrant any definite estimate of tonnages. Mr. J. B. Scott took a small number of samples to check some of the former results, and from these an average of ·75 per cent. of tin oxide was secured by vanning. It is evident that a large tonnage of ore exists here which could be worked cheaply by open-cut, and it is to be hoped that this tonnage will be available shortly for one of the batteries on the field.

In addition to these main workings there are outcrops of gossan round the edge of the hill above the cable workings of the Boulder lease which probably have close connection with the pyritic ore exposed across the boundary, and there is also a large pyritic body exposed by a trench not far above the Old Montana mill on Montana Creek. This occurrence has been referred to before. It may denote a separate line of lode intermediate between the Dreadnought and Montana groups. The tin contents here were low, being only 0·35 per cent. metallic tin.

(6)—Consolidated Lease 6836, 58 Acres, and Adjoining Ground.

This lease includes three leases formerly held by A. Kemp, and takes in the lower portion of Dolcoath Creek close up to its junction with the Ring River. The upper portion of the creek passes through solid slate, but for a short distance before the junction with the Ring a small alluvial flat occurs. This has been worked for tin, and a good yield was obtained, some of the potholes especially giving good returns and nuggets of considerable size being secured. The depth of the flat to the bottom of the gutter is from 10 to 15 feet. Much of the stone is clearly derived from the Pine Hill zone, but as the Ring River is approached quartzite and quartzitic schist pebbles also come in. On the north side of the creek a terrace exists which is now being sluiced by Mr. Kemp: it is about 25 to 30 feet above the creek. On the opposite side of the Ring River, and still higher above its level, wash of similar character is exposed on the hillside. It is evident that the Ring River has varied in its course in comparatively recent times, and the channel of the Dolcoath extended considerably further to the east. Whether subsequent river action left the bed of the creek untouched could only be found by detailed examination, but there is the possibility of an older channel remaining covered by more recent gravels.

On the east side of the Ring River, just north of this section, a 5-acre section was formerly held by M. Keys. A galena lode occurs on this property which strikes N. 11° W., with steep dip to the east. Some fair ore was secured, and in view of the rise in price of metals the occurrence deserves attention.

From a small creek which runs into the Ring a little further north, some tin ore was won. The wash included large blocks of conglomerate and many fragments of Pine Hill rocks. A small seam of pyrites and tin was found here, about 1 inch in width, but it could only be traced down for a few feet. There is an outcrop of gabbroid rock here, very soft and decomposed, and very complex in its relationship to the slate and to harder portions of similar rock.

(7)—Button Grass Plain, North of Renison Bell Township.

Allusion has been made to the older alluvials, and their origin discussed.* They constitute these plains, and their character is displayed in the railway cuttings. They appear, however, to tail off in depth as they run out into the plain, and the deposit is too shallow to prove attractive. Some tin occurs in the small creeks that drain the plain, and also in the later alluvial that comes in as the valley of the Argent River is approached, but nothing in sufficient quantity.

Three dredging claims were taken up here a good many years ago, but nothing was done with them.

(8)—Hawson & Finlayson's Section.

The western and southern boundaries of this section, 1290-m, 79 acres, adjoin the Renison Bell leases. The eastern portion of the section embraces the flat plain described above. The most important part is close to the western boundary on the northern side of the river. The boundary abuts on the northern workings of the Renison Bell, and portion of the gossan extended into this section and was worked and treated at the Central battery. The geological conditions are similar to those prevailing at the Renison Bell, and have been described above. Whether the Renison Bell main lode is the sole one here, and the gossans have their source from it, or whether there are other lodes, cannot be regarded as established. The section is right on the main lines of fissuring, and lode action has proceeded further north than the Argent River, so that every inducement offers for extending prospecting.

In addition to the above, a solid body of galena blende and pyrite occurs in the bed of the river. It is unlikely that this will prove profitable for its galena contents, but with the close association between these minerals and the tin ore in the Renison Bell main lode south of the river, a similar asssociation at this point is more than probable.

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(9)—Maskell & Albury, Section 5093m, 72 Acres, and Section 6860, 34 Acres.

These were the old Penzance sections, numbered 5093-m, 72 acres, and 5094-m, 59 acres, and were owned and developed by the Penzance Company. They have been forfeited and the battery removed and sold. Section 5093-m is held by Messrs. Maskell and Albury, who are working the alluvial on the northern fall of Pine Hill; and Section 5094 is chiefly embraced by 6860, of 34 acres, which has no tenant. The Penzance workings have fallen in, and Mr. Ward's report is largely drawn on for a description of these areas.

The geology turns on the outcrop of quartz porphyry, which constitutes the prominent landmark of Pine Hill, once densely covered with King William pine timber, but now swept bare by bush fires. The summit of Pine Hill is a little due south of the centre of Section 5093. On the other section the basic rocks outcrop as they sweep round from the south here in a broad belt to cross the Ring River. The character of the quartz porphyry outcrop is concealed considerably by the detritus on the northern slope of the hill, but various exposures show that it alternates here with the slates in a series of dykes. It would seem that the hill itself is in the nature of a boss with radiating dykes.

The principal ore occurrences are in the Pine Hill section, and the Penzance workings were on the southern fall of the saddle between Pine Hill and Commonwealth Hill and close up to the level of the saddle. The country-rock here is quartz porphyry carrying a considerable quantity of tourmaline. The workings, which comprise several levels, appear to have been driven on a quartz tourmaline vein carrying good ore; from these veins, several of which have been exposed on the property, branch veins run off into the adjoining country-rock, and it seems that this reticulated rock was also mined out and sent to the battery in the head valley of the Argent Creek below. The small rich vein did not yield sufficient tonnage, and the adjoining country was too low-grade to be profitable, and the whole undertaking failed. No records seem to be available, and no plans of the workings, which is greatly to be regretted, as with the rising price of tin the failure of yesterday might easily be converted into the success of to-morrow.

In addition to this work a considerable amount of exploration was done on the northern slope of Pine Hill, and not far below its crest. A rich vein was exposed here, with strike S. 42° W., and dip probably 50 degrees to the south-east. The country-rock is mostly indurated slate, carrying veins of quartz and tourmaline.

Two tunnels were driven, the upper one of which drove through the slate country into solid quartz porphyry at 60 feet. The lower tunnel, 156 feet north of the upper, and 96 feet below it, cut some gossanous ore near the entrance, and then went through 64 feet of soft decomposed slate, when it came into hard slate with quartz and tourmaline. This slate is characteristic of this locality, showing in sundry trenches and other exposures.

The north-eastern portion of this section is of special interest, since the large Gormanston boulders are supposed to have been derived from it. So far their sources have not been located. It is possible that they were derived from a rich bulge in a quartz tourmaline vein of limited vertical extent, and that the whole vein has been denuded away. The size of the boulders is, however, against this view, and it is probable that some day their source will be disclosed. The writer's inclination would favour the slate country near the contact of quartz porphyry and gabbroid rocks.

On the eastern section the only workings are near the boundary between the two sections. A tunnel was driven 245 feet on a bearing N. 85° W., at a level of 35 feet below the lower tunnel referred to above. Slate country, indurated in many places, was passed through, with pyrites in parts and some tourmaline. The end of the tunnel is in dense quartz porphyry.

There is no doubt as to the richness of many of the veins of quartz tourmaline which penetrate both the slate and the massive quartz porphyry itself. They have, though, in cases of mining and treatment, to carry the whole burden of the cost, and in addition they come and go irregularly, so that the burden of locating their occurrence, as it alternates with barren rock, also falls upon their values. This is a heavy handicap, and will easily explain the failure of the Penzance Company, who do not seem to have realised the treacherous nature of these occurrences. Whether the final word has been said here, appears to be very doubtful. With the present high price of tin it seems quite possible that a miniature plant, run by working men on carefully-picked ore, might easily earn a a handsome profit, and possibly lead to work on a larger scale, as the true character of the occurrences was gradually understood.

(10)—Sections 3495 and 822-m.

Section 3495, south-west of Maskell's section, carries a large gossan outcrop which was prospected by a tunnel 161 feet long. Finality was not reached as to the nature or value of the ore-body.

Section 822 affords a fine exposure of veined quartz porphyry, and a contact between the quartz porphyry and the slate country with ore-bearing veins penetrating each. The softer slate was sluiced away here, and yielded good tin, but the massive rock remains to be tested.

(11)—Sections 774-m and 3657-m.

These two sections embrace the ground on the lower northern fall from Pine Hill. A portion is held by P. Buchanan under miner's right. The chief interest here is a large lode of actinolite referred to earlier in this report.* Garnet and axinite are associated with it, but it also carries a considerable quantity of zinc blende. A specimen of this was taken, and yielded 9·7 per cent. of zinc. The specimen was not picked in any way for its zinc contents, and this result was surprisingly high. The lode is a very large formation, and if values even considerably less than this occur throughout it, concentration would yield a product that would leave a handsome profit. It is to be hoped that attention will be paid to these possibilities, and the lode be sampled thoroughly to decide what its true value is.

It was close to this lode that the big Gormanston boulders were discovered. Their source would be higher up the hill, and was referred to in the notes on Section 6860.

(12)—Section 7075.

This section includes the Ring River in its eastern portion and a small eastern tributary known as Star Creek. Some tin and gold and osmiridium were won from shallow alluvial workings on this creek.

In addition, a lode has been disclosed right at the water's edge in the Ring River. Its main contents are zinc blende and galena associated with pyrites. These lead-zinc veins are more largely developed in the X River portion of the field than in the Renison Bell part, and this one does not appear to promise any considerable supplies of ore: it is of

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interest, though, as accentuating again the close relationship between the ore occurrences of every class of mineral on the West Coast.

(13)—Sections 4569-m, 76 Acres, and 4663-m, 40 Acres.

These sections embrace the country between Pine Hill and the Confidence Saddle. The northern section is comprised of gabbro and the southern of slate country. In the northern there is a promising vein of gabbro rock itself—a rather unusual occurrence—not far from the quartz porphyry contact. Crystalline tin occurs in a matrix of quartz tourmaline. A tunnel was driven 40 feet close to the oucrop.

In the southern section a tunnel was driven for 96 feet in slate country, but beyond some veins of quartz and pyrites no lode structure seems to have been cut.

(14)—Section 6710-m, 80 Acres.

This section was held formerly in the names of Karlsen and Riley, and a considerable amount of exploratory work was done on it by the Montana Company of Zeehan. Unfortunately the workings are now nearly all blocked, and the scrub has grown up so dense that it is impossible to gain any clear idea of the objective of the work. A good track runs down to the property from the Confidence Saddle, and good tin is reported to have occurred, but all is now abandoned and drifting back to primeval bush.

The country-rock shows well on the track to the property, and consists of gabbro altered in places to massive serpentine. Where the lode occurs there is a bold outcrop of limonite with chalcedonised slate, hard and compact. Trenching has been done in the surface, but this is overgrown, and at least four tunnels were driven in the hillside. The entrance of these tunnels is in yellow clay, which may be the result of decomposition of either the igneous or the slate rocks. One tunnel certainly seems to have been in slate country, though the gabbro belt should include all these workings. Quartz with pyrites and gossan shows on the tip here, and a lode of some description has certainly been cut. The occurrence might be of considerable value geologically, whatever be its economic features, since both the slates and the tin ore seem to be out of place here, but until the old workings are opened up and the young scrub cut down, any proper examination is not feasible.

(15)—The X Proprietary Syndicate.

This property consisted formerly of six separate sections—4973, 4974, 5003, 5004, 5013, and 5014, aggregating 381 acres. These have now been consolidated into two large sections—6219, of 264 acres; and 6218, of 115 acres.

The general geology has been already described. The Dundas slates on these sections vary considerably in colour, texture, and general character. Stretching out from the belt that skirts the Colebrook Range the gabbroid rocks invade the northern parts of the sections, and also occur in isolated patches through the southern and western parts. It is quite possible that these occurrences are of larger extent than shown on the plan, since much of the section is covered with dense bush, and so far the unknown portions have been credited to the slates.

The characteristics of the lode-formation conform in the main to the usual type of the district. The basis of the lode-matter is quartz. The quartz has intruded the slates, and is present in every degree—from massive fragments, several feet across, down to minute veinlets crisscrossing through a slate matrix; further, in many places the slates have been shattered, and the fragments disunited and enveloped by the intrusive quartz. Associated with the quartz are tourmaline and pyrites; this latter yielding the larger proportion in the deeper workings, while the cavities and the residual iron oxide bear witness to its original presence nearer the surface. Cassiterite accompanies the other minerals, being especially prominent in the more oxidised ores, and from its close association with the quartz and tourmaline leaving quite unsolved the question of any priority of origin in these separate minerals. The small hollows and cavities are lined with quartz crystals, both coarse and fine, which give every indication of being the result of secondary crytallisation as the removal of the pyrites gave space for their formation; in parts crystalline cassiterite takes the place of the quartz.

The same irregularity which characterises the more pyritic occurrences of Renison Bell is repeated in the more quartzose lodes of the X River. Either from the absence of main fissuring in the country-rock and a widespread weakening of the slate-rock as a whole from the manifold points of intrusion throughout it, the quartz-formations do not take on the features of definite lodes, but tend rather to develop into a succession of irregular foci, where the country-rock has been permeated to a greater or lesser extent, while between the foci the connecting links may be so slender as to be unrecognisable in ordinary mining. Since, in addition, the occurrence of the cassiterite is also irregular in the quartz, the difficulties of systematic work in proving ore reserves becomes apparent.

This is well exemplified at the X Proprietary, where further work is still required to develop the fate of the property. Under the rich tinstone exposed in the trenches referred to above a tunnel, known as No. 1, was driven 220 feet. Several small branches go off it; a rise has been put through to the surface; a winze sunk for 36 feet, and a drive put out S. 69° W. for 70 feet from the bottom of this winze.

The results have been puzzling. From the surface exposures in the trenches above it would appear that the trend of the lode is, roughly, north and south. The tunnel was driven on a bearing about N. 70° W. to serve as a crosscut to the lode-formation. Great as is the irregularity both above and below ground, it seems undoubted that the general course of the lode occurrence is parallel to that of the tunnel, and not across it. Further, there is a tendency for the quartz to widen out in horizontal floors and terminate abruptly beneath these. Possibly this may be due to faulting, but it has not that appearance. The consequence is that although the lode was cut and driven on in the tunnel, and although some rich ore was encountered (which remains in evidence on a heap outside), while the whole mass of the quartz yielded payable assays, yet it is still necessary to carry out further work here to prove the *quantity* of ore available for battery treatment.

The lines that work should proceed on cannot be laid down definitely; so much depends upon the information gained as progress is made. It would seem, though, that the general trend of the lodes here in a W.N.W. direction is established. This is borne out by a drive off the main tunnel near the entrance on what is known as Bakhap's lode. This lode is supposed to be parallel to the main lode, and a formation cut in the No. 2 tunnel north is taken as its continuation. If this view is correct, then an effort should be made to trace the main lode further into the hill by extending the No. 1 tunnel. There are signs which make it appear possible that the tunnel has left the lode on its south side, where the quartz ends; but in any case, breaks in the continuity are inevitable in lodes of this character, and the best method to pick them up is to drive ahead and then crosscut. The exceeding richness of the concentrations of ore when they do occur fully warrants this action, while the values here in lodes of this character are so far superior to any disclosed elsewhere on this property that this would seem the vital quarter.

The other work already done in this vicinity comprises a short tunnel known as the Magazine tunnel, and a long tunnel (No. 2) extending for 400 feet. Both these are about 350 feet north of No. 1 tunnel, No. 2 being below the Magazine tunnel. At 360 feet in No 2 tunnel a quartz lode was cut carrying low values in tin, which is considered to be an extension of Bakhap's lode, referred to above, as cut near the entrance of No. 1 tunnel.

Leaving this occurrence there is a branch creek, known as Roberts' Creek, running about north-east, which joins the X River near the north of the main workings. On the spur which forms the north-west side of the small valley this creek has made occurs a quartz-formation, which has been explored by sundry trenches and three tunnels over a distance of some 900 feet. No records were available as to the value of the stone exposed by these workings, but in appearance it was not promising. It consisted of quartz with pyrites and tourmaline associated often with black altered slate. The extent is ill-defined in the trenches, and the tunnels have not disclosed any large body of stone. In No. 2 tunnel the lode is 2 feet wide, and bears about east-north-east, with dip to the north. The tunnel follows it for about 15 feet, and then leaves it on the north side. In No. 3, or the southernmost tunnel, the quartz shows in a flat floor, recalling similar occurrences at the main workings, while the quartz here also shows similar characteristics.

The slate country-rock here is distinct in several features from that encountered in the main workings. It is of coarser texture, more resembling a grit, and small specks or segregations (probably of iron oxide) show in portions of it. At the northern end the gabbroid rocks occur in the creek close at hand, and it is possible that this is due to secondary alteration caused by the igneous intrusion.

In addition to the above workings isolated trenches have been put in to uncover several promising occurrences. The first of these is close to the northern boundary. A small creek, known locally as Brampton's, crosses the boundary on a northerly course here. The bottom of the creek is composed of yellow to grey slate considerably decomposed, and several small quartz lodes are noticeable, with strike about N. 25° W., and steep dip. A small branch creek comes in with steep fall from the west near the boundary, and close to this is the north-west trench. The formation is about a chain wide, and bears approximately north and south. It is composed of quartz with iron oxide and fragments of included slate alternating with grey-to-green slate country-rock. The whole is said to carry $\frac{1}{4}$ per cent. tin, and to extend north as far as Section 7484, now being worked by J. S. Fenton.

South again of the main workings, the south trench has been put in on a lode-formation about 16 feet wide. The characteristics are the same—quartz and slate alternating with intermediate bands, in which the quartz encloses fragments of shattered slate. Traces of tourmaline show, and iron oxide is also present. This outcrop is well deserving of more work.

Proceeding west from the main workings a lode-formation shows distinctly about half-way across the section. This is well deserving of work. Beyond this point, and approaching the western boundary, an interesting lode has been disclosed. It has been exposed by cleaning up the bottom of the creek, and by a parallel trench known as Salmon's, about a chain further north. It appears to occur at the contact of the gabbroid rocks and the slates, though the gabbroid rocks are so broken and altered—in parts even to steatite—that it is hard to define their boundaries. The course of the lode is approximately S. 20° W., with dip 70° to east, and the igneous rock forms the eastern wall. The lode itself is about 2 feet wide, and consists of quartz and dolomite gangue, with galena and blende and occasional trace of copper pyrites. On the western side is a distinct band of crystalline quartz about 4 inches wide. Beyond this come yellow slates, so much decomposed that their classification with the Dundas slates may be regarded as provisional only.

The whole occurrence is promising, and deserves further exploitation. On the Zeehan field it would certainly have been attacked as soon as discovered, but its isolation here and the difficulty of access militate against it. There is, though, a very similar occurrence (to be described later) not far away to the south-west, and it is quite possible that the two may be linked up and good ore disclosed in the intervening country.

The property is centrally situated, with the geological conditions throughout favourable for ore-deposition, with good alluvial in the creeks and lodes outcropping, which in places have yielded phenomenally rich ore. The chronic irregularity of the occurrence of tin values renders more work necessary to prove reliable tonnages, but the present condition of the mine fully justifies and warrants confident hopes of a successful issue. The work should be concentrated on the known occurrences, and radiate from these as far as possible.

(16)—Section 5816 (South-west of X Proprietary).

On this section a lode occurs on the slope of the hill-side above the Colebrook Rivulet. The lode is about 1 foot wide, bearing N. 40° E., with nearly vertical dips. The lode-channel is filled partly with crystalline quartz, enfolding slaty fragments almost wholly silicified to a hard mass. On the north-west side of the lode the country-rock is the dark massive conglomerate or breccia which occurs in several places in the Dundas slates. It appears to extend here for about a chain in width. In close association with it is a tuffaceous rock with decomposing felspathic particles and considerable iron oxide (probably hematite), which is supplemented by pyrites in the unweathered fragments. The lode does not appear to carry more than traces of copper pyrites and galena, and probably will not prove of economic value, but it shows that the mineralising action has extended to this portion of the field.

(17)—The Olympic Prospecting Association.

This section (4943) of 80 acres lies due east of the X Proprietary on the steep slope of the hillside which forms the western slope of the Colebrook Range. Geologically it is cut off from the Proprietary ground by the belt of gabbroid and serpentine rocks, which here runs parallel to the hills almost due north and south.

The main access to the section is by a branch track which connects with the Colebrook-Rosebery track on the top of the range, but there is a rough path from the X River tram up a creek known as Fenton's, which finally ties up with the wider track which comes down to the mine from above.

The character of the country-rock is, as usual, difficult to determine. It has the appearance at the upper portion of the workings of a hard green siliceous slate. In the bed of the creek below the mine, white mica with small felspathic particles is showing in the rock, and it resembles more closely the rocks which occur in the Dundas series, and which have been classed as tuffs. In the lower tunnel of the Olympic there are again signs of these tuffaceous rocks, and possibly the ill-defined siliceous rocks of the surface may be the altered product of this same type.

The lode itself outcropped at the surface and was benched into by an open-cut from the side of the hill, giving a face about 15 feet high and 20 feet long. The lode was then followed with a drive on a course about N. 15° W. for a short distance. The lode dips at about 80° to the east.

The lode itself is formed of quartz honeycombed by the decay of the pyrites which once filled the cavities. This has left a residue of iron oxide in the cavities themselves and a lining of brown oxide on the walls, which is replaced by crystals of cassiterite to greater or less extent, according to the richness of the ore. Where the lode was best, the cassiterite formed almost a solid vein from 3 to 9 inches wide, so pure that it was broken out and bagged up at once for despatch to the smelters.

About 80 feet below these workings the lower tunnel has been driven on a course N. 85° E. to cut the lode. The drive extends for 258 feet in altered slate country. Not far from the entrance a soft decomposed band of rock was passed through, which is supposed to be a lode-channel. At about 180 feet the lode worked above is encountered; it is small, but well defined, and is said to carry 2 per cent. of tin. At about 250 feet another lode was met with of larger dimensions, and this has been driven on north and south, the south drive being 100 feet long with several crosscuts off from it. A rise has also been put up for 50 feet carrying lode-matter to within about 10 feet of the top. The country-rock on the west side of this lode is much broken, and quite irregular. When the lode is passed the dip bcomes more consistent, and the limit of much of the disturbance seems to have been defined by the lode. The lode itself varies largely in character and dimensions. In the main it consists of gossan associated with a hard siliceous groundmass, which has the appearance of being recemented fragments. If this is correct, it would confirm the view that the lode marks the limits of a fracture zone. The lode here is evidently low-grade; its definite value could only be determined by careful sampling and assaying throughout the whole of the workings.

At a point a short distance north of these workings, and about 100 feet lower down, a long tunnel has been driven for 534 feet to cut the lode-formations at a greater depth. Beyond some promising veins of gossan this tunnel does not appear to have disclosed anything of value. In regard to both this tunnel, and to some extent to the tunnel above, there seems to have been the same tendency met with frequently in this district—to go too far from the known occurrences with the exploratory workings. The lode at the outcrop was so rich that every effort should have been made to trace it out to its ultimate limits. It should have been followed down as far as possible with a winze, and then risen on to connect from the lower tunnel. This connection even now has not been carried through, and it well deserves the first attention, both from the chance of finding further enrichments and from the information it may afford in laying-out further work.

(18)—Section 6217, 203 Acres.

This section adjoins the Olympic on the east, and was formerly held by the Athenic Prospecting Association as a consolidated lease. It includes the upper portion of the steep western slope on which the Olympic lies, and also the crown of the range above. In the northern portion a deep gully cuts into the hill in an easterly direction, and gives a means of attacking the lode formations by tunnels from a depth.

The main workings have been devoted to proving a large outcrop which occurs close to the boundary between this section and the Olympic, and is in fact trenched across on the Olympic side of the boundary. The outcrop is some 30 feet wide and bears about N. 10° W. The trench gives a face some 10 feet high and shows a fault-plane dipping at about 45 degrees to the east, while the general dip of the gossanous lode appears to be to the west, and to be stopped by the fault. With indications such as these at the surface—even if they be purely local—the risk of tunnelling from a distance to cut the lode at depth becomes apparent, and in fact two long tunnels put in from the gully referred to above have proved resultless, and the section has now been surrendered. This outcrop is regarded as the terminal one of a series on approximately the same line running right across the section and rising with the hill. It will be clear that if this fault cuts off the lode there might easily be a considerable tonnage of ore at the shallow depths and yet the lode not be discoverable at depth. If these gossans carry a payable quantity of tin—and only careful sampling can decide that point—then a less ambitious examination of these surface outrcops is well warranted, and might even lead to tracing out the problem at a greater depth.

In the north-east corner of Subsection 5156 another lode occurs which is over 5 feet wide and carried a narrow band of rich tin ore. This outcrop may be traced across the ridge and as far as the eastern slope of the Colebrook Hill. The strike is N. 33° W., and the dip nearly vertical. Some work has been done on this discovery, but so far it has not lived up to its early promise.

(19)—Sections South of the Olympic.

Only two sections are now held in the wide stretch of country, some 2 miles long, between the Olympic section and the old township of Ringville. These are charted in the name of F. A. Burns, and are now numbered 6373, 78 acres, and 7401, 80 acres. On these sections some old workings exist on some gossan outcrops, and a little irregular prospecting is still carried on, but the bush here is almost impenetrable, and so far no discovery has been made which appears likely to develop into a mine. Geologically the conditions here seem as favourable as in the other parts of the area examined: the basic intrusions, whose association with the ore here is so constant as to appear inevitably more than accidental, still continue into the dark slates which outcrop around Ringville; the creeks still carry fine alluvial tin and the gossan outcrops recur. The main obstacle is the dense bush that blankets everything and renders the task of prospecting so slow and tedious that men turn inevitably to more favoured spots.

(20)—X Falls Section.

This section lies north of the X Proprietary, and is numbered 6493, 51 acres.

Not far from the southern boundary a gossan formation shows on the hillside above the X River, and right down at the river itself a lode is disclosed running at an acute angle with the river and crossing from the western to the eastern bank. The bearing of the lode is N. 30° W., and the dip about 53 degrees to the north-east. It consists of bands of quartz and slate with pyrites in larger amount in the quartz and more sparingly in the slate. The width is ill-defined, since it is difficult to distinguish between the slate bands and the country walls. Samples taken from here gave 0·7 per cent., 0·25 per cent., and 0·60 per cent. of metallic tin. The river turns here to the west, and 100 feet further on drops about 20 feet over the falls from which the section takes its name. Just below these falls a tunnel has been put in on a bearing about N. 57° E. to cut the lode described above. This tunnel is 80 feet long, and has not reached the line of the lode, though a small pyritic lode was cut on the way. This is another instance of a too ambitious scheme. With half the money that was expended on this tunnel the lode could have been benched out on each side of the river, and a better idea of its value obtained even than if it had been cut by the expensive tunnel. As it is, with the present high price of tin (£240), one-half per cent. means a contents value of 24s. per ton, and this lode fully deserves opening up to see if the values obtained from surface samples are consistent through it.

It is doubtful whether this occurrence is connected with the outcrops on the west side of Roberts' Creek, trenched on by the X Proprietary as reported above. The bearings do not fit in too well, and it would be better to leave this point open until further work has been done.

On this section other lodes have been exposed; and higher up the hill, on the north side of the river from the falls, a small tunnel has been driven on a line N. 36° E. for about 20 feet. It passes through shattered graphitic slates with considerable pyrites, and is said to have carried a little tin.

Another wide lode formation shows on the southern side of the spur down which the short cut to the railway at the gorge passes from the X tram. The Falls lode, however, seems the most promising, and the first work should be concentrated upon it.

(21)—Fenton's.

North and west of the X Falls section comes a 40-acre section, 7484, taken up in the name of J. S. Fenton. This section was the objective of some prospecting work done about 18 years ago, when the Emu Bay Railway was being constructed. A small syndicate opened up a lode in search of galena about 3 chains back from the railway, just south of the X River. The workings now show a small quartz lode with arsenical pyrites. As in so many other instances on this field, the occurrence of tin was completely overlooked, and the syndicate's operations soon ceased.

In 1911 the existence of tin ore was discovered by Mr. Fox, and a considerable amount of work was done in exploring the extent and value of the deposit. The results were not very encouraging, and the section was surrendered. It was then taken up by J. S. Fenton, who is at present doing further work upon it.

The X River runs nearly due north at this point, and about 400 feet south of the railway a small creek runs down very steeply to join it from the western side. This creek was worked for its alluvial, and at a point about 300 feet from the river and nearly 150 feet above it a lode formation was cut. The lode bears about N. 5° W., dipping at 70 degrees to the east. The country-rock is soft and greasy to the touch, and proved to be mainly steatite. The lode is about 2 feet 6 inches wide, composed of quartz and steatite with pyrites disseminated through it. The steatite carries about $\frac{1}{4}$ per cent. of metallic tin, while the lode material yielded nearly 1 per cent. The lode is disclosed for nearly 100 feet, and it is said that 6 tons of tin were recovered from the clay filling on the hanging-wall of the lode; also that the lode formation itself is some 60 feet wide, with recurring seams of quartz in the soft matrix.

Down the hill, about 100 feet below and about 100 feet to the north, a long tunnel has been put in for over 250 feet to test this formation at depth. This was not accessible, but bands of gossan, quartz, and pyrites are said to have been encountered. The pyrites consisted largely of the arsenical form with which the tin ore is most frequently found on this field. No assays were available, and with the undeveloped state of the lode no safe deduction can be drawn from the above examination; but both the size and character of the lode formation fully warrant a very careful and systematic testing and sampling to make sure that a good property has not been overlooked here. Even if the values were poor in the tunnel, a formation like this should not be discarded until the lode has been driven on for some distance. It is established that the occurrence of the tin is patchy, and the tunnel might easily have cut the lode in a blank portion and brought about a premature condemnation.

A little to the north of these workings a tiny creek is crossed which yielded a little alluvial; and then right at the railway come the present workings of J. S. Fenton. There is a little flat on the west side of the X River which was formed by the excavation of the rock to make the embankment over the river. A vertical face, some 20 feet high, of hard massive quartzose rock, ends the flat, and into this, on a bearing S. 71° W., a tunnel has been driven for 66 feet. This was driven to cut a gossan lode showing on the surface further north, from which some very good oxidised ore has been won. The tunnel passed through varied rock—hard green slaty rock alternating with gossan and soft slates with seams of quartz in places—and has just reached the lode, which is of a soft clayey character, with green quartzitic fragments and some pyrites. A specimen of the harder fragments yielded 0·4 per cent. of tin.

The lode has a bearing of about N. 10° W., and dips steeply to the east. It has been traced and partly worked by shallow tunnels for about 150 feet to the north of and above the tunnel, which will give about 15 or 20 feet more of backs. In these shallow workings the ore is of the usual gossan character, with dolomite in places and with the tin contents sometimes rich enough for the ore to be bagged and sent direct to the smelter. Other of the ore has been sent to Renison Bell and treated there in the Central battery.

To the west of this lode 100 feet and higher up the hillside another lode shows which formed the objective of the original syndicate. This bears about N. 30° W., dipping steeply to the east, and is about 2 feet wide. Insufficient work has been done to reveal its main features, but it seems to be a quartz arsenical pyrites lode, while some of the specimens have very good tin showing through them.

The three lodes disclosed here—and probably there are more—seem certainly to belong to the same system, and will probably prove to be connected one with the other. The presence of the magnesian silicate, steatite, and also of the magnesian carbonate, dolomite, points again to the association, direct or indirect, of the tin occurrences with the basic rocks so prevalent here, and also helps to link this cassiterite mispickel lode with the galena blende pyrites lode in the X River sections.

Leaving these workings and following the railway in a direction N.N.W. for about 600 feet, a quartzitic outcrop is seen just above the western bank. No work had been done on it, but a fragment broken off was very rich, carrying at least 30 per cent. of cassiterite, and the outcrop should be further explored.

Beyond this, about 200 feet, and drawing near to the boundary of the section, a small cutting occurs with banks about 12 feet high. This is composed of slate rock, much altered and permeated with gossan.

The basic igneous rocks outcrop a short distance to the north-west, and in all probability lie close at hand here under the detrital covering. The alteration in the slates is due to their vicinity, and has proceeded so far that in some cases it is doubtful whether the rocks are not themselves of igneous origin. The gossan is partly formed of quartz, and a specimen taken from here gave 1·5 per cent. of metallic tin. The existence of tin at this spot was discovered some six years ago, and a tunnel was driven from below the railway to intersect the lode at a depth of about 60 feet. The tunnel is 121 feet long, the first part being in ordinary slate rock. At about 100 feet from the entrance a lode formation is crossed about 12 feet wide, carrying quartz and gossan: a specimen yielded 0·4 per cent. of metallic tin. The end of the tunnel is in a soft green-mottled rock, which under the microscope proved to be of igneous origin and a member of the gabbroid series.

Apparently the values in the lode were not considered good enough when the tunnel was driven, and possibly the tin contents were hard to save, but even if the specimen taken was above the average value—and no discrimination was possible—the finding of tin at all was quite sufficient to encourage driving on the formation with every hope of encountering local enrichments. It is not possible to advise whether this formation too will link up with the others on this lease, but it appears probable that all of them skirt a margin of igneous rock here, and that the contact line runs almost parallel to the railway until it twists round to cross the X River gorge.

(22)—Other Occurrences.

The descriptions given above do not pretend to include all the known occurrences of the district. The whole area is strongly mineralised throughout, and a catalogue of all the small lodes discovered, more or less opened up and then abandoned, would take too much space and become too monotonous. The typical occurrences have been dealt with and those which seem to have real possibilities if a revival of prospecting occurs. The rest of the known lodes are, as far as possible, shown on the accompanying plans.

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VIII.—CONCLUSION.

Of the mines that have not yet reached the stage of production or concentration, such as the X Proprietary, Fenton's, the Olympic, and others, no more can be said than that they occur in a district which has been proved so favourable for tin deposition that the only question in regard to them is the extent and value of the occurrences. This is not a matter of geology, but of prospecting and mining, and it is needless to say that the outlooks warrant this, and work may at any time lead to the disclosure of such quantities of ore as will place the properties on a solid basis.

The problem of the producing mines (mainly those included in the large scale plan) is different. These mines, even if the Federal property is made available for one of the present crushing-plants, are nearing the exhaustion of their oxidised ores, and their success in the past has been so limited in extent and in returns to the shareholders that their prospects are small of securing capital adequate to deal with the very large tonnage of low-grade sulphide ores which certainly exists. The writer in the past has always deprecated the undertaking by the State of speculative mining work. There is sufficient unwise expenditure on mining even when those responsible have to stand the brunt themselves. To make available the resources of the State is to invite the easy spending of the money where the promise of success is wholly inadequate to the risk involved. Where, though, large tonnages of ore are proved to exist, and it becomes a problem of treatment rather than of mining; where, too, the companies concerned have done their part manfully in trying to bring their properties to success, and yet find the problem too great for their resources—it would seem within the scope of the Government to step in and assist.

The most hopeful path by which success can be reached is by the utilisation of the sulphur contents of the ores, which are now wasted at extra cost, to provide sulphuric acid; then to combine this sulphuric acid with ammonia produced by cheap power from the atmosphere to yield the final commercial product of ammonium sulphate. This leaves the tin oxide in the roasted ore available for the ordinary method of water-concentration.

The manner in which this aid should be rendered is on the following lines:—

(1) The further investigation of the pyritic and pyrrhotite ore-bodies. As mentioned above, the companies had no means of dealing with this variety of ore, and their explorations have usually ceased when it was encountered. This work would consist of tunnelling, rising, and boring through these bodies. By opening up some of the older workings and systematically sampling, valuable information could be secured. This would establish the basic value of the ore.

(2) An enquiry into the cost of a sulphuric acid plant and the possibility of utilising the sulphide ores for this work.

(3) Laboratory and bulk tests—(*a*) of the concentration results of pyritic ore; and (*b*) of the recovery of the tin contents from the roasted concentrates or crude ore.

(4) An enquiry into the systematic production of ammonia from the atmosphere, and an analysis of the costs of the process if transferred to the West Coast.

(5) An enquiry into the consumption of ammonium sulphate in Australia, and the standard price in other parts of the world under normal conditions.

(6) A final estimate of the complete cost of the plant required to carry through the whole of the above process.

It would be necessary to come to some agreement with the companies that hold the leases, and such agreement should be based on a return of a proportion of the profits to the companies after payment of all expenses and interest. A royalty basis would not be fair to the Government.

That is the most practical scheme I can suggest to save this district from the annihilation that threatens it as soon as the limited quantities of oxidised ore are exhausted. It is based on the utilisation on the spot of sulphuric acid, to be produced from the tin-bearing sulphide ores, and quite possibly other and better outlets for this chemical may be discovered as investigation proceeds; if so, they can be adopted in preference to the ammonium sulphate.

As a further recommendation, the need of road communication between Renison Bell, Rosebery, and Zeehan has already been referred to. This can well be claimed as a right, rather than a concession, by these districts; their isolation is quite unwarranted.

As to the ultimate future of the district, there can be little doubt. The world, within the next 50 years, is bound

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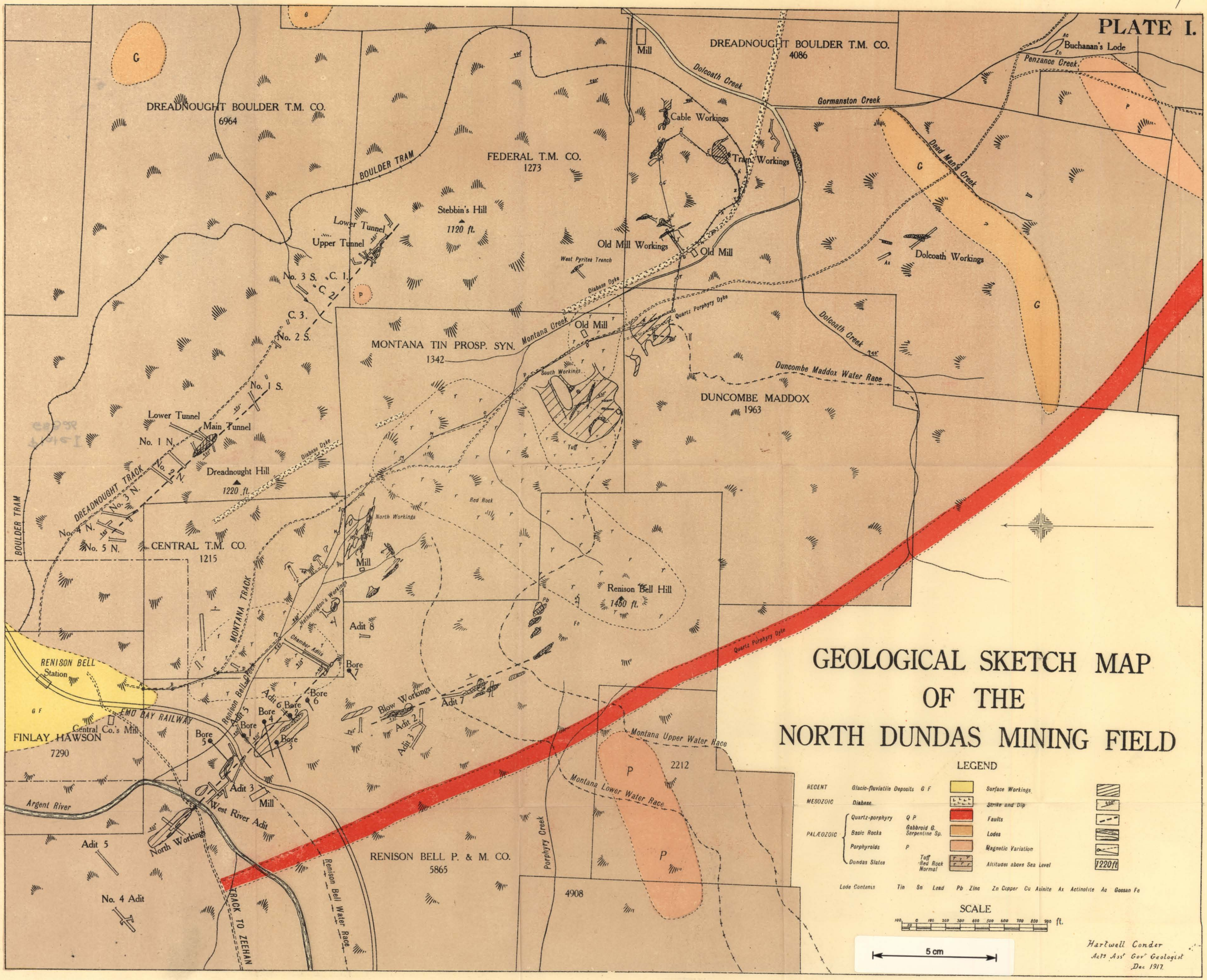
to require the natural resources it contains. For the present, though, with adverse conditions of climate and isolation, the district needs a helping hand, and it would seem to be within the province of the Government to extend that hand.

There is one point which has interested the writer for a considerable time. There is a large area of tin-bearing country here which has been subjected to heavy denudation. The tin won from the detritus or scanty alluvial cannot account for one tithe of the ore which must have been set free by this denudation. The problem is to account for the balance. That it has not remained in the rivers, such as the Argent and Ring, is due to the comparatively steep fall and sudden flooding of these rivers; light and heavy sands alike would be swept out of them. The Pieman in that case would receive the ore. The Pieman, too, has a rocky bed, covered in places with shingle. It floods heavily, and during the floods the whole mass moves forward with the water. Towards the mouth there are some 12 miles of tidal water caused by the subsidence of the whole coast line. The tin from the catchment area probably now rests either in the crevices of the rock bottom of the river or between the sands which constitute the Pieman bar. Some day, as the supplies of tin grow less and the world's demand more exigent, it may prove worth while to follow up this chase.

Finally, I must convey my appreciation of the assistance I received from all those in charge of the properties included in this report. The management of the properties they control has been one long struggle against the adverse conditions of low-grade and irregular ore-bodies. The information they have accumulated regarding both the occurrences and the treatment of these ores is a most valuable asset. It was freely placed at my disposal, and if a broad scheme of treatment is adopted in the district the ready co-operation of those who have done so much work here in the past will be the first essential towards success.

HARTWELL CONDER, M.A.,
Acting Assistant Government Geologist.

Launceston, 31st January, 1918.



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GEOLOGICAL SKETCH MAP OF THE NORTH DUNDAS MINING FIELD

LEGEND

PALÆOZOIC:
- Quartz-porphyry — Q P
- Basic Rocks — Gabbroid G. Serpentine Sp.
- Porphyroids — P
- Dundas Slates — Tuff, Red Rock, Normal

MESOZOIC Diabase

RECENT Glacio-fluviatile Deposits G F

Tunnels

Surface Workings

Strike and Dip

Faults

Lodes

Altitudes above Sea Level — 1220 ft.

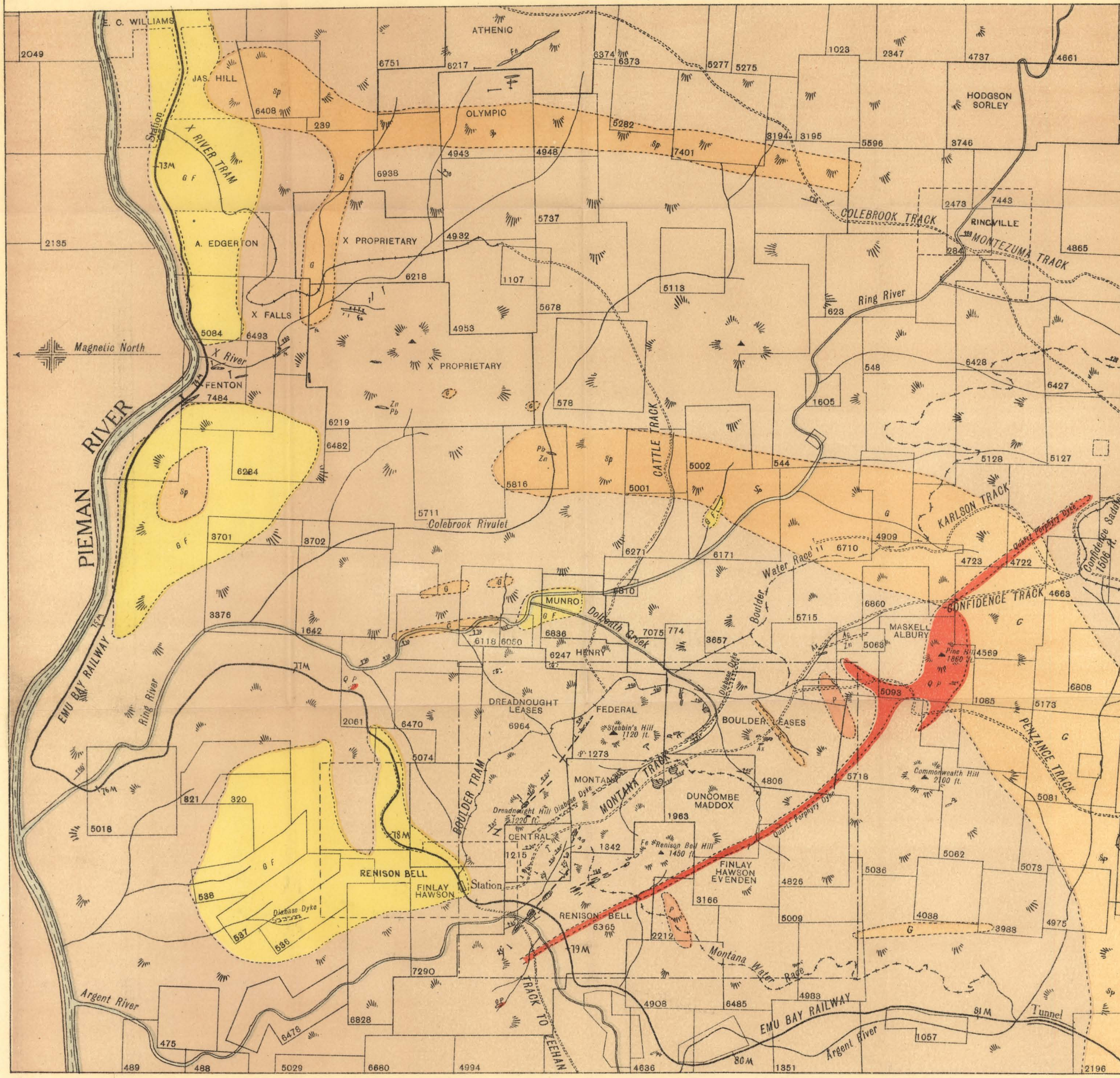
Lode Contents: Tin Sn, Lead Pb, Zinc Zn, Copper Cu, Axinite Ax, Actinolite Ac, Gossan Fe

SCALE

1000 0 1000 2000 3000 4000 5000 ft.

Hartwell Conder
Actg. Asst. Govt. Geologist
Dec 1917

PLATE II.



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