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The Mining Fields of Moina, Mt. Claude, and Lorinna

BY

A. McINTOSH REID, Assistant Government Geologist

Issued under the authority of

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Minister for Mines for Tasmania

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[W. Castle Photo.

Photo. No. I.—MOINA SETTLEMENT.

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The Mining Fields of Moina, Mt. Claude, and Lorinna.

I.—INTRODUCTION.

(1)—Preliminary Statement.

The original purpose of this expedition was to make an examination of the tin, tungsten, molybdenum, and bismuth ore-deposits, and to report upon those unprospected areas which were considered likely to prove profitable sources of the ores of these metals; but, in compliance with the request of mine-owners and others interested in these districts, the scope of the investigation has been extended to include metallic mineral deposits other than those enumerated.

It is intended in this bulletin to present detailed information regarding the occurrence of the ores of tungsten, molybdenum, and bismuth, and to provide also particulars relating to the various methods of concentration that have proved applicable to the different types of ores. Investigations have been made to ascertain whether the amount of molybdenum present justifies the establishment of a customs concentrating plant for bismuth, tungsten, and molybdenum ores, with the addition of a special unit for the complete separation of the latter mineral.

All the mines and mining prospects in operation, and most of those temporarily abandoned, were visited; and a very careful examination was made of the geological features of the districts. Many new features have been revealed as the result of this examination, not only of purely scientific interest, but also having a decided economic bearing.

(2)—General Statement.

The work outlined in this report was carried out during the period extending from the 23rd June to the 3rd September, 1918. The writer was absent for eleven days, therefore the actual time spent in the field was two months.

The present report is designed to supplement that written by Mr. W. H. Twelvetrees [1] (now out of print), in which an adequate description is given of the general geological features of these districts. Since that publication was written a considerable amount of developmental work has been done, thereby providing much further material information relating to the ore-deposits. The writer desires to acknowledge the influence of the conclusions drawn by Mr. Twelvetrees, from whose report extracts have been made, and are included herein.

The geological map accompanying this bulletin includes a portion of the Mt. Pelion area to the southward. The Mt. Roland area, outside of these districts, but included in the region covered by this report, is not shown on the geological map.

This work was carried out with the aid of the mineral charts of the districts, drawn to a scale of 20 chains to 1 inch. Certain topographic features have been corrected, and other features not marked on the charts have been added.

The heights above sea-level have been calculated from aneroid readings based on the level of the railway-line at Sheffield.

For purpose of reference, the old numbers of forfeited mineral leases have been retained in this report, and appear on the geological map.

(3)—Acknowledgements.

The writer desires to express his appreciation of the courtesy and hospitality extended to him by many residents of the districts during his visit. The assistance rendered by Messrs. J. Craze, J. J. Andrew, A. Carlson, J. P. Kelly, and B. L. Thomas, of Round Hill; W. E. Hitchcock, F. Townsend, C. F. D. Adam, H. Lawson, A. Jubb, S. Goldsworthy, and B. Gurr, of Moina; and Syd. Reardon and G. Sloane, of Lorinna—greatly accelerated the work of this investigation.

The writer wishes also to gratefully acknowledge his indebtedness to Messrs. W. B. Cocker, J. J. Andrew, L. J. Smith, C. F. D. Adam, Syd. Reardon, and R. Magee for much valuable information received.

The writer was accompanied on this expedition by Messrs. R. Magee and Warwick Castle as field assistants.

(1) *Vide* W. H. Twelvetrees: Tas. Geo. Surv. Bull. No. 14, 1912.

It is a pleasure to acknowledge and to place on record the splendid and efficient services rendered by them.

(4)—Location and Area.

The Middlesex and Mt. Claude districts are situate in the southern part of the County of Devon, which occupies the north central part of Tasmania. The Forth River, which has a general meridional course, forms a rough geographical boundary between the two districts.

Mt. Claude district includes the silver-lead mines of Round Hill, the Tin Spur area two miles southward, and the gold-mining field of Lorinna. Middlesex district includes the rich tin, tungsten, bismuth, and molybdenite mines of Moina, the alluvial gold area of Bell Mount, and the Five-mile Rise, Stormont, and Black Bluff goldfields. Mt. Roland area, outside of these districts, but included in the region covered by this report, lies to the north-east, and adjoins Mt. Claude. The Mt. Pelion mining district, in which important wolfram discoveries have been made recently, lies immediately to the south. The main centre of population is Sheffield, a farming township of about 2000 people. In the region examined there are three small settlements, namely, Cethana, Lorinna, and Moina. Cethana is situate 13 miles in a southerly direction from Sheffield, and Lorinna lies 8 miles farther southward on the right bank of the Forth River. Moina lies on the west side of Forth River, and is 22½ miles distant by road from Sheffield.

The region examined is 9 miles wide east and west, and 9 miles long, and has an area of 81 square miles.

II.—LITERATURE.

The literature on the geology and ore-deposits in these districts is rather extensive. The earlier reports contain mainly descriptions of the mines in operation at the time, little attention having been given to areal geology.

The only large-scale map covering the whole of this region is that prepared by Mr. W. H. Twelvetrees, to accompany his very comprehensive report, issued as Bulletin No. 14 of the Tasmanian Geological Survey. Mr. G. A. Waller also prepared a very useful map of portion of the region covered by this report.

The following publications relate to the geology and mining industry of the Middlesex and Mt. Claude districts:—

1881. Thureau, G.: Report on the North-Western Mineral Deposits.

1893. Montgomery, A.: Report on the Mineral Discoveries in the Neighbourhood of Bell Mount.

1897. Smith, J. Harcourt: Report on the Shepherd and Murphy Tin Mine, Bell Mount.

1898. Smith, J. Harcourt: Report on the Bell Mount and Middlesex Tinfields

1901. Waller, G. A.: Report on the Mineral Districts of Bell Mount, Dove River, Five-mile Rise, &c.

1907. Twelvetrees, W. H.: Report on the Bell Mount and Middlesex District.

1913. Twelvetrees, W. H.: The Middlesex and Mt. Claude Mining Field (Tasmanian Geological Survey Bulletin No. 14).

1916. Hills, Loftus: Middlesex and Mt. Claude Districts—Mineral Resources No. 1, Part II. (Geol. Surv., Tas.).

G. Thureau, in his 1881 report, details the results of an examination of the galena mines on the northern slope of Mt. Roland and at Mt. Claude. The Mt. Claude Silver-Lead Company was then working the deposits which are now owned by the Round Hill Silver and Lead Mining Company, No Liability. It is pointed out that the ore occurs in irregular veins or stockworks, and that the proper way of mining it would be by open-face cuttings. Rich ores are stated to outcrop 130 feet above the lowest deposits worked at creek-level.

A. Montgomery, in 1893, visited the Mt. Claude mines, and his report covers the whole of the Middlesex district. He concluded from the number of discoveries already made that the field must be more than ordinarily rich in minerals, and that it was well worth attention.

J. Harcourt Smith, in 1897 and 1898, traversed the Mt. Claude and Middlesex districts, and described the workings on the various mining leases.

G. A. Waller's report, in 1901, dealt with Bell Mount, Dove River, and the Five-mile Rise, and was accompanied by a geological sketch plan of the Bell Mount mining district.

W. H. Twelvetrees, in 1907, described the ore-deposits of Bell Mount, Middlesex, and Dove River. The conclusion arrived at in that report was that the field, on the whole, would probably prove to be one with numerous small and rich lodes. In his later report (Geological Survey Bulletin No. 14), published in 1913, Mr. Twelvetrees exhaustively discusses the mode of occurrence of the ore-deposits, and predicts a prosperous future for the district as a source of tin, tungsten, and bismuth.

Loftus Hills, in his report on the mineral resources of these districts, gives statistical information on the tungsten and molybdenum production and deposits, and makes certain specific recommendations, with the object of stimulating mining activity and expediting production.

III.—HISTORY.

In the history of this mining division the earliest discovery of which there is definite record was made by the well-known explorer, the late James Smith, formerly of Hamilton-on-Forth. Early in the sixties, before his discovery of copper ore at Penguin and at Copper Creek, near Gunn's Plains, Mr. Smith traversed the Middlesex and Mt. Claude districts, proceeding *via* Castra and Black Bluff, and crossing the button-grass-covered plain south of Nietta, later named after him. During a few weeks' sojourn in the Lorinna area gold was discovered in the placer deposits near the present bridge, crossing the Forth River. After carrying out certain preliminary prospecting work, proving the extent of the deposit, Mr. Smith returned by the Forth Valley route to Hamilton. A few months later—this time accompanied by Joseph Raymond, James Fenton, and W. M. Crosby—he returned to Lorinna, and endeavoured to test the value of the gold-bearing ground by sinking a number of shafts through the wash. Although encouraging results were obtained from the top wash, this work was abandoned before reaching the bottom of the deposit, owing to the heavy influx of water.

Attention was then given to the valley of the Dove River, a tributary of the Forth, resulting in the discovery of a little gold, and a galena lode located south-west of the Devon Mine. On the return journey down the Forth Valley gold was discovered at Golden Point, near Geale's Bridge, and a galena lode at the confluence of Claude Creek and Forth River. The latter discovery is of some promise, but the lode remains undeveloped to this day.

Following the encouraging prospects obtained on the earlier expeditions, a number of explorers from time to time visited these almost inaccessible areas, but no discovery of value was made until the year 1878, when Weeks and T. Shepherd reported the presence of galena in the sandstone strata at Round Mountain, the western extremity of Mt. Claude Range. The Mt. Claude Silver-Lead Mining Company was organised in 1880 to exploit the ore-bodies disclosed by the prospecting operations of the discoverers. The operations of this company were not attended with success, and in the year 1884 the mine was abandoned. The further attention drawn to the district by the exploratory work of this company had its sequence

in the discovery of gold at Campbell's Reward Claim in 1885, by Alex. and Malcolm Campbell; followed in July, 1887, by J. Aylett's discovery of the Great Caledonian Gold Mine on Five-mile Rise. Within a very short space of time gold was located at a number of other places in the neighbourhood, and the Lorinna gold-mining boom set in. Milling plants were erected on the Devonian, Great Caledonian, and Golden Hill properties before developmental work had been advanced sufficiently to determine the value of the gold-bearing veins. Machinery was hauled up the old road from Sheffield over the top of Mt. Claude Range, thence over Oliver's Hill to Lorinna, and finally up the steep road over Five-mile Rise. The gradients of these roads are in places as much as 1 in 5, so some idea can be formed of the magnitude and expense of the undertaking. Surprisingly little development had been carried out, and even if the veins were extraordinarily rich near the surface, such expenditure was certainly not justified. After a short period of activity the district was again abandoned, save by a few prospectors. About this time, Malcolm Campbell found galena in the Dove River Valley at what is now known as the Devon Mine, which, at a later time, was operated with fair success.

In 1891 John Levings and Thomas Brennan discovered tinstone and wolfram on Dolcoath Hill, and were granted a reward claim. The Iris Tin Mine, in the following year, was located by M. Hearps; and in that year also Malcolm Campbell reported the presence of rich alluvial gold at Bell Mount. This latter discovery led to the influx of a large number of miners to the field, inaugurating an era of exploration and development, which gradually brought about the highly satisfactory condition of mining obtaining to-day. In 1893 those well-known prospectors, Thos. Shepherd and Thos. Murphy, who have played such an important part in the history of these fields, were successful in discovering bismuthinite, wolfram, and tinstone at the S. and M. Mine. This is usually referred to as the pioneer mine of the district, formerly known as the Shepherd and Murphy Mine, and long familiar to prospectors as the Bismuth Mine. The whole area occupied by the granitic rocks was carefully searched, and revealed many other important occurrences of wolfram, bismuthinite, and tinstone ore, the most important of which are now the All Nations and Tin Spur properties. Gold was located at Stormont, Black Bluff, and Bond Peak, but not in highly payable amounts. At this time the inaccessibility of the districts was the greatest obstacle to their advancement. Freights over the ill-formed, steeply-graded roads were excessively high. From Moina to Sheffield, 22½ miles, transport cost was at the rate of £7 10s. per ton; similar charges were made for haulage over the Mt. Claude-road, on the east side of Forth River. From Sheffield the ore was carted to Devonport, a distance of 21 miles, for shipment abroad. During the last decade the road from Sheffield *via* Wilmot has been remodelled, the Sheffield-Lorinna trunk road has been constructed, and the branch railway from Railton through Sheffield to Staverton has been completed, thus providing good transport facilities in accordance with the requirements of the districts. During this period also the districts have come into prominence as a source of bismuth, tungsten, tin, silver, and lead. Many new discoveries have been made, and most of these prospects have developed into payable mines. The most successful of the later prospectors are Warwick Castle, B. L. Thomas, and R. Magee.

IV.—PHYSIOGRAPHY.

(1)—Topography.

(*a*) *General Description.*

The topography of this region is directly related to the geology, since the highest and most conspicuous mountains are capped with erosion-resisting conglomerates, and the lesser eminences are occupied by hard tubicolar sandstones, grits, and conglomerates. Where the streams have cut through the superincumbent sediments, exposing the softer igneous formations below, the rate of erosion has been greatly increased. The underlying rock consists for the most part of decomposed schistose felspar-porphyry and quartz-porphyry (porphyroid) rocks, which offer little resistance to the corroding effect of flowing water.

The topography generally is one of high relief, brought about mainly by the erosive action of the fast-flowing Forth River and its numerous tributary streams. The inter-stream areas form part of a very extensive tableland, which has a slight northerly pitch towards the sea. In this region the surface of the tableland is occupied almost exclusively by tubicolar sandstones and conglomerates, but these rocks are covered in some places with a thin sheet of basaltic lava. Above this tableland prominent mountain peaks and ranges stand out in bold relief. The elevation of the Forth Valley is from 400 to 650 feet above sea-level, the tableland from 2300 to 2850 feet, and the mountain peaks rise about 1600 feet higher.

The present Forth River follows the course of a former Forth, which flowed over a more maturely dissected land surface. At Lorinna elevated terraces of the wider and older Forth are still visible above the road, and similar terraces of river gravels occur 500 feet above the river, near Wilmot Bridge. At this latter locality the terraces are separated by sheets of basalt, showing that the old Forth Valley in Teritary time was even then of considerable magnitude. Following the uplifts of the region in Late-Pleistocene and Recent time, the river gained renewed power, and soon carved its way through the loose wash, more gradually through the basaltic rock, and is now deeply entrenched within its former channel. Where the present river valleys are young and occupied by hard sandstones, conglomerates, or granitic rocks, the channels are very narrow (100 to 150 yards), with steep and in some places precipitous walls 100 to 200 feet high. The rivers are still far above the base-level of erosion, and are actively engaged deepening their present channels.

The valleys of the higher mountain areas have been occupied by local glaciers, some of which were of considerable extent. The Vale of Belvoir is a typical U-shaped valley, and the Forth has the appearance of one that has been greatly modified by glacial agency. It is probable that the complete dissection of the thick highly-resistant conglomerate strata, the remnants of which still occupy the higher mountain ranges, is largely due to the corroding effect of glaciers.

(*b*) *The Peneplain.*

The general character of the surface, as represented by the hill and plateau summits, is uniform throughout its entire extent. The country is a great uneven plain, which may be called a peneplain, but whether denuded by subaerial erosive agencies alone has not been determined.

The deep, sharply-incised valleys, carved by the numerous streams, give the country a decidedly hilly appearance, but its character as part of a great peneplain, when the landscape is viewed from any of the higher peaks as a vantage point, is at once recognised. Looking towards the horizon the level of the inter-stream areas appears remarkably uniform; but while this tableland seems very even, viewed from any one point of outlook, it is not horizontal. There is a slight pitch northward towards the sea, and southward the surface rises very gradually, until it finally merges into the great Central Plateau. The elevation of the tableland varies from 2300 feet above sea-level near Moina, to 2600 feet east of Lorinna, and 2850 feet at the top of Five-mile Rise. The rising slope southward thence becomes much less.

The dissection of the peneplain commenced in Teritary time prior to the eruption of the basalt, which partly filled the valleys and buried the leads. The present configuration has been brought about largely by the action of glaciers during Pleistocene time, and by the corroding effect of the waters of the Forth River and its numerous tributary streams.

(*c*) *The Mountains.*

The highest mountains in this area are Black Bluff, 4300 feet, and Mt. Roland, 4047 feet, above sea-level. The next in importance are Mt. Vandyck, Mt. Claude, Bond Peak, Round Mountain, Brazen Nose, Stormont, and Bell Mount, which range from 3500 feet

down to 2700 feet above sea-level. All of these (with the sole exception of Bell Mount, which consists entirely of porphyroid rock) are wholly or partly crowned with hard silicified conglomerates of the West Coast Range series. Mts. Roland, Claude, Vandyck, Brazen Nose, and Round Mountain have a deep covering of this conglomerate, which rests upon schistose igneous porphyroids. Stormont, Bond Peak, and Black Bluff partly consist of hard tubicolar sandstone and conglomerate. These rocks, composed almost entirely of silica, are only with difficulty decomposed and disintegrated, and form a strong protective covering to the soft igneous rocks which they overlie. The mountain range formed by Mts. Roland, Vandyck, and Claude rises abruptly from Sheffield Plain, which is 880 feet above sea-level. This plain is occupied almost wholly by Tertiary basalt, although river gravels of this age outcrop here and there. The slope of the mountain range is gradual, and not very steep over the portion occupied by porphyroid rocks, which are to some extent buried under a deep talus of conglomerate, but the hard, massive conglomerate strata of the upper portion form great escarpments hundreds of feet high. The disintegration of the soft basal rocks leads to the disruption of the overlying conglomerates, and avalanches of this rock are of common occurrence. It is noticeable that the steep bluffs all appear on the north-west to south-west fall. On Oliver's Hill the tubicolar conglomerates present an unbroken wall of rock over 100 feet high, facing south-west, with a deep talus of conglomerate boulders on the lower slope. The general direction of the higher ranges is from north to south, and the lesser ranges have a north-easterly trend.

Mountain-building in this region is due mainly to orogenic movement, but the general features have been modified to a great extent by the effects of long-continued erosion, both glacial and fluviatile.

(*d*) *Drainage.*

The Forth River, which receives the drainage of the whole area, and has been the major sculptor in determining the present configuration of the country, has its source in the central highlands. The source of one branch is at Lake Ayr, near Mt. Pelion West; another is at a small unnamed lake on the north-east side of Cradle Mountain. The narrow ridge connecting these mountains divides the headwaters of the Forth and Pieman Rivers, the latter flowing south-westward to the Pacific Ocean, while the former flows northward to Bass Strait. Similarly, the Vale River (another tributary of the Pieman) and the Lea River (one of the affluents of the Wilmot, which is the major tributary of the Forth) have their sources in the Vale of Belvoir, between Black Bluff Range and Bond Peak, and are divided by a narrow, low saddle. The main tributary streams of the Forth flow through Middlesex district on the west side of the parent stream, which is the geographical boundary between the two districts. The Forth River is remarkable for its great antiquity, and for the immensity of its valley, although the immediate channel is very narrow and precipitous.

The area here considered is drained by three streams on the west side, which ultimately junction to form the Wilmot River, the major tributary of the Forth. These streams, named in the order of their size, are Falls River, Lea River, and Iris River. Falls River flows into Lea River, the source of which is at Lake Lea, in the Vale of Belvoir. Iris River flows through Middlesex Plains estate, and, junctioning with the Lea River near Moina, forms Wilmot River. These streams flow north-eastward to the Forth, which has an almost perfectly straight meridional course. At the southern end of the region the Dove River (the source of which is on the northern fall of Cradle Mountain) and Campbell River (still farther south) flow north-eastward, and are important tributaries of the Forth. On the eastern side there are numerous affluents of the major stream, but most of them contain little water during the summer months, and have their source within the confines of the old valley. Dasher River rises at the township of Cethana, at the northern end of Mt. Claude district, and flows north-eastward to the Mersey River.

The fall of Forth River for the 15 miles of its course through the centre of this region is 320 feet, the average fall in this distance being 21 feet to the mile; thereafter the fall diminishes towards the sea. The stream at Sloane's Bridge, 15 miles south of Lorinna, is 1200 feet above sea-level, at Lorinna Bridge 650 feet, and at Wilmot Bridge 400 feet.

(2)—Relation of Topography to Mining.

(a) *Prospecting and Exploitation.*

It does not always follow that a district of high relief is of very great advantage to mining. That, in the main, the topographic features of the country within the confines of this region are of decided advantage is due, not only to the pronounced high relief, but also to the position of the ore-bodies in relation thereto. Since the uplift of the surface in Tertiary time, and the subsequent oscillations resulting in the further elevation of the country, the streams, having been given a greatly increased corroding power, carved deep narrow channels in the upland surface. The Forth River, as the parent stream, has been mainly instrumental in this work; but the tributary streams, themselves of considerable magnitude, have contributed largely to the dissection of the old plain. The streams, flowing across the strikes of the formations, have exposed numerous sections of the strata for examination, and have provided conditions for the easy exploitation of the ore-bodies contained in them. In only one instance—namely, at the S. and M. Mine—has it been found necessary to adopt the shaft method of exploitation; and, even in this case, the mine had been worked for many years by means of adits.

In effect, the topographic features of the district may be regarded as decidedly favourable to mining.

(b) *Water-supply and Power.*

The rainfall of this region is comparatively heavy, and is fairly evenly distributed throughout the year, but owing to the extremely high relief the water is quickly returned to the sea. The rivers rise and fall very rapidly, according to the condition of the weather, but the Forth River and its numerous tributaries, even in the summer months, carry considerable volumes of water, which can be utilised for the generation of power. The great obstacles to the more general utilisation of the available water-power are the difficulty in conservation and the heavy initial outlay required. In considering the question of water-power and supply it is well to bear in mind the fact that the initial cost is usually so great that the interest on the capital outlay would be sufficient to defray the running costs and upkeep of a modern suction producer-gas plant in localities where wood supplies are abundant. During the summer months those mining companies using water for power purposes find it necessary to put into commission the auxiliary producer-gas or the steam-driven machinery, kept on hand in case of emergency. Up to this time no attempt has been made to utilise the power of the larger streams owing to the very heavy initial outlay this would entail; but advantage is taken of the more easily accessible power available from the smaller streams. The Forth River and its larger tributaries could be utilised to supply sufficient power for all local requirements. There are few localities in this area where the conditions are suitable for the conservation of water.

(3)—METEOROLOGY.

The climate of the north central districts of Tasmania through the whole year is mild and delightful. There are no extremes of heat in summer and cold in winter, although snow falls on the highlands during July and August. This year snow fell at Cethana on July 8, 9, and 14, but melted very rapidly.

The mean annual precipitation recorded at Moina, in the central part of this region, at an elevation of 1950 feet above sea-level, is 70·70 inches; at Black Bluff, near the western boundary, at an elevation of 2400 feet, it is 82·32 inches; while that at Lorinna, to the south, at an elevation of 650 feet, is 68·65 inches. The maximum temperature recorded at Moina is 98·2 degrees Fahr.; the minimum temperature at the same place is 17·5 degrees Fah.; and the mean annual temperature since records have been made is 47·7 degrees Fahr. The prevailing wind is north-west. The severe frosts in these districts commence about May, and do not recur after October. No record is kept of the first and last killing frosts. The minimum temperature (17·5 degrees) was recorded on the 16th July, 1912; and, strangely, the maximum temperature (98·2 degrees) was recorded on the 2nd February in the same year. With this exception, there is no record of temperatures below 20 degrees Fahr. The readings have been taken in a thermometer screen placed 4 feet above the ground; the temperature of the air in contact with the ground would probably be from 4 to 10 degrees lower.

The annual precipitation of over 70 inches is spread over 148 wet days, not confined to any particular season, although more rain falls in the winter than in any other season. The months of July, August, and September, in particular, are characterised by rather boisterous climatic conditions. The settlements, Cethana, Lorinna, and Moina, are situate in well-sheltered positions in or near the river valleys.

The accompanying table, compiled from the monthly rain maps supplied by the Commonwealth Meteorologist, gives an idea of the distribution of the rainfall during the year.

Meteorology of the Rainfall during the Year.

Annual Rainfall (in Inches).

Station.	Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Black Bluff......	1910	?	?	?	?	13·74	17·89	6·00	16·75	11·21	7·25	6·09	9·08	—
	1911	2·89	6·73	7·20	7·74	4·97	6·93	8·08	4·21	5·72	5·49	2·96	12·40	75·32
	1912	4·55	9·60	5·82	6·22	5·65	10·12	11·36	11·33	6·22	8·99	10·13	6·12	96·11
	1913	3·50	2·03	5·66	1·93	2·54	10·21	8·23	16·08	9·61	4·92	11·72	4·83	81·26
Moina	1912	3·12	0·35	4·70	2·85	4·64	8·00	9·60	8·25	9·05	5·67	7·59	4·60	68·42
	1913	2·20	1·47	4·57	2·08	1·86	5·19	8·23	11·89	5·90	3·71	7·53	3·34	57·97
	1914	1·51	·41	3·12	10·38	5·49	3·60	4·77	3·11	2·66	·76	2·57	3·20	41·58
	1915	1·96	1·51	5·97	5·05	6·03	8·71	6·55	9·28	15·38	10·78	8·12	·58	79·92
	1916	6·33	3·11	1·75	8·98	5·15	8·95	6·28	9·26	4·03	10·32	5·11	13·85	83·12
	1917	2·12	5·16	6·22	1·42	10·91	11·82	13·64	6·20	11·46	8·40	11·65	1·79	90·29
Lorinna	1916	4·22	1·60	·95	8·62	4·24	7·40	5·19	11·83	3·72	7·98	4·18	12·59	72·52
	1917	1·66	4·38	4·75	1·25	9·44	9·61	12·93	5·87	10·16	7·96	8·09	2·03	78·13

(4)—Timber and Agriculture.

The valleys, hills, and parts of the mountain ranges are more or less covered by a good growth of trees of several species, the various eucalypti predominating; but clumps of celery-top pine, myrtle, and sassafras are found in parts of the region. The undergrowth is very thick in certain localities, and in those parts cleared of forest growth, bracken-fern and fire-weed completely obscure the surface and hinder prospecting. The most luxuriant growth is found on the country occupied by basalt, porphyroid rocks, and granite rocks; the sandstone and conglomerate country provides little nourishment for vegetation, and only heath and a few stunted eucalypti find subsistence thereon. The timber-covered slopes afford an abundant supply of wood for mining purposes, buildings, and for fuel. Several sawmills are in operation, and timber is exported in considerable quantity. Until recent years, owing to the inaccessibility of the area, the lack of transport facilities, and the cheapness of timber of this kind, valuable forests were systematically destroyed by selectors preparing their holdings for agricultural purposes.

In the district immediately to the south, parts of the higher mountain slopes are covered with King William pine, large quantities of which at one time were cut and floated down the Forth River to the coast. King William pine has the properties of lightness and toughness, by virtue of which it is well adapted for transportation by water, and can resist the buffetings of the water and rocks without suffering material injury. The objection raised against this means of transportation is that the logs would accumulate at the bridges and ultimately carry them away. It has been proposed to construct a by-wash at these points and conduct the logs past the bridges.

All of the land in this locality suitable for stock-raising and agriculture has been selected. The greatest progress has been made in the Lorinna area, where the farms are cleared of timber sufficiently to be cultivated. The country in the neighbourhood of Moina and Tin Spur is in the transition stage between stock-raising and agriculture. The process of preparing these heavily-wooded areas for cultivation is necessarily very slow. The first operation is that of clearing and burning off the undergrowth and the trees of small dimensions, followed by the sowing of grass seed. Cattle are then run on this partly-cleared country. It is usually necessary to burn off the second growth of scrub

a year or two later; this also completes the destruction of the standing timber, which in about five or six years is dry enough to burn freely.

The richest agricultural areas are those occupied by basaltic rocks, the disintegration of which results in the formation of the wonderfully fertile chocolate-coloured soils so highly developed in the neighbouring districts, Wilmot and Sheffield. These soils are especially suitable for the growth of potatoes and other root crops. Cereals grow in profusion; specimens of sparrow-bill oats over 5 feet tall were seen on S. Poynton's farm, south of Mt. Claude.

The porphyroid rocks disintegrate to a snuff-coloured soil of lesser fertility, but highly useful for grazing. The granite country is also of some value for this purpose.

V.—TRANSPORTATION AND COMMUNICATION.

These districts have for long been at a great disadvantage because of their remoteness from a railway. During the last decade they have been made more accessible by the construction of trunk roads and the branch railway from Railton through Sheffield to Staverton. Railton is a township on the North-Western Railway route, 15¼ miles by rail from Devonport. Sheffield is 8¼ miles from Railton, and Staverton is 14 miles. From the Moina area supplies are hauled 22½ miles to Sheffield. Round Hill and Tin Spur areas are only 8 and 10 miles respectively from Staverton terminus. Several surveys have been made with the object of continuing the construction of the railway to Wilmot, but the Forth Valley presented so many engineering difficulties that the project had to be abandoned. In 1899 Mr. Ross Reynolds, Assistant Engineer-in-Chief, carried out a useful exploration survey for a light railway from Sheffield through this region to Rosebery. A practicable route was found with sufficiently good grades for profitable traffic. A drawback is that west of the Middlesex Plains block, high country comes in for a few miles, rising to nearly 3000 feet at the 43-mile peg from Sheffield; and, in fact, from the Moina plateau to the south of Mayday Mountain the general elevation above sea-level does not fall below 2500 feet, which is a distinct handicap to a through line on this parallel. From the west side of Middlesex Plains block to the north end of Mt. Farrell is, however, only 32 miles

The best railway route—and one attended with few serious engineering difficulties—to serve mining, agricultural, and timber interests of these and the contiguous districts to the south, is that of the Forth Valley. This line would serve also as a great tourist route to the Central Highlands. and is the only natural route for the extension of the Staverton branch railway. If this alignment be chosen for the railway, good connecting wagon roads with easy grades can be cheaply constructed from Moina and other areas on the opposite side of the valley.

Ten years ago the only means of access to Lorinna was by the Mt. Claude-road. It is very difficult to understand why this route was selected in preference to that of the present highway. The road from Dasher Valley follows a steeply inclined ridge up to a narrow saddle between two

peaks of Mt. Claude Range, rising 1800 feet in 2½ miles, the heaviest gradient being as much as 1 in 5. The fall on the southern side is equally steep, thence it passes along the eastern flanks of Oliver's Hill down to Lorinna. At the time of the Lorinna gold-mining boom all supplies, including very heavy machinery, had to be hauled over the top of this mountain range. It is said that 36 bullocks were required to haul the big boiler erected at the Great Caledonian Mine.

The present Lorinna-Sheffield road is one of the few designed by an engineer, and although deviations were made from the original course to avoid a little heavy cutting, it is nevertheless a creditable job. There is one very steep pinch, namely, that leading up from Round Hill Mine, where the gradient is from 1 in 10 to 1 in 7. A number of branch roads lead off to selections on either side. The extension of this road to the Mt. Pelion wolfram mines is now under construction. Between Round Hill and Tin Spur the road follows a very steep sidelong, and is so narrow that it becomes dangerous for two vehicles to pass.

The main road to Moina falls, from Sheffield Plain to Wilmot Bridge, nearly 500 feet in 2 miles; thence rises, more or less gradually, up to Bell Mount, 1900 feet higher. This road branches off near Moina, and continues through Middlesex estate.

Many of the roads are constructed without regard to grade in a more or less direct line, in defiance of the topography, but some are adjusted to the topography of the country, and if widened in certain places and maintained in good order would be suitable for vehicles of all kinds.

VI.—GEOLOGY.

(1) Geological Map.

The geological map (Plate VIII.) accompanying this report includes the mineral districts of Mt. Claude and Middlesex and the northern portion of Mt. Pelion. The map shows the boundaries of the various sedimentary and igneous formations, and their position relative to one another. It has been considered advisable to separate the schistose porphyroids from the Dove River granites and granite-porphyries, as some doubt exists as to whether the latter are rightly included in the porphyroid group. A diabase dyke outcropping on Knowles' property, Sheffield-road, has been included with the porphyroids, but its boundary is shown to distinguish it from the unrelated felspar and quartz-felspar porphyry members. The clastic and pyroclastic sediments represented by bluish, black, grey, green, and purple coloured slates and crushed grits and fine-grained conglomerates, although classed with the porphyroids, are separately delineated on the map. The only other igneous rocks present are the widely-separated Devonian granites and Tertiary basalts.

The sedimentary rocks are sharply defined and do not require comment.

The map shows also the location of the mining properties, the positions of the more important lodes and faults, the directions of the strike and dip of the structurally important strata, and the general physical features of the region.

(2)—Geological Summary.

Sedimentary rocks are largely developed in this region, and consist for the most part of pre-Silurian conglomerates and sandstones of the West Coast Range series and tubicolar sandstones, grits, and conglomerates of the Middlesex series. These strata, of no great thickness, are slightly unconformable, and directly overlie felspar and quartz-porphyries and pyroclasitc sediments of the porphyroid series. These latter rocks underlie nearly the whole of the region, excepting the small areas occupied by the later intrusions of granite and granite-porphyry, and the Algonkian micaceous schists, which outcrop on the extreme southern part. The pyroclastic sediments are not very

extensive. They are exposed in the road-cutting northward of Round Mountain and again at Bell Mount. The original trend of the sandstones was almost east-west, but the granite intrusions have altered the strike of the strata, as exhibited in the anticlinal folds, to north-west.

In isolated areas, Silurian limestones, remnants of a much more extensive formation, occur overlying tubicolar sandstones.

The granitic rocks outcropping at Lorinna and in the Dove River Valley have been considered as belonging to the end term of the great porphyroid series of rocks so extensively developed in Tasmania. They have been more intensely altered than the Devonian granites of Moina, but they show, in parts, a remarkable resemblance, both in structure and composition, to these latter rocks.

Towards the central and south-central portions of these areas, granite and allied intrusives of Devonian age have arched up the overlying sedimentary rocks, and have assumed at the same time a strike and dip in conformity with that of the porphyroids through which they penetrated. The porphyry modification of the granite irruptives contains multitudes of tubicolar conglomerate and sandstone inclusions, the rounded siliceous pebbles being still easily distinguished. The quartz-porphyry has not penetrated the overlying tubicolar sandstones and conglomerates, the force of the intrusion having been spent on reaching these strata.

The tablelands of Moina, Wilmot, Lorinna, and Sheffield are covered in parts by remnants of basaltic lava sheets, agglomerates, and tuffs, the survival of an extensive eruption which took place in late Tertiary time.

The sides of the older valleys contain glacial deposits and the recent fluviatile gravels.

(3)—Sequence of the Sedimentary Rocks.

System.	Series.	Group or Formation.	Lithological Character.
Archæan	—	—	Not identified in Tasmania
Algonkian	Lower	Dove River	Crystalline schists
	unconformity		
Cambrian	Dundas	Round Hill	Slates and porphyroids
to	West Coast Range	Mt. Claude	Purple to reddish conglomerates
Ordovician	"Pipestem"	Middlesex	Tubicolar sandstones and conglomerates
Silurian	King River	Bell Mount	Clayey sandstones
	Mole Creek	Moina	Bluish-grey limestones
	unconformity		
Tertiary	Deep Lead	Forth River Moina	Stream-wash and sub-basaltic gravels
	unconformity		
Quaternary	Pleistocene	Black Bluff	Glacial drift and morainal material
	Recent	Forth and Wilmot Rivers	Alluvium and recent gravels

(4)—Sedimentary Rocks.

A.—Algonkian System.

The lowest and oldest rocks occurring in Tasmania are represented in the region covered by this report, and are considered to belong to the lower division of the Algonkian system. They consist of finely laminated micaceous

schists composed principally of quartz, biotite, and muscovite, and are regarded as being metamorphosed sediments derived from unknown Archæan formations. They are highly foliated, brown-coloured, medium to coarse grained rocks possessing well-developed crystalline texture. These rocks occur in the southern part of the region, and are exposed in the valley of the Forth River about a quarter of a mile south of its confluence with the Dove River.

These formations are correlated with the Ulverstone and Forth series. They underlie the whole of the strata from here to the shore-line on Bass Strait.

B.—Cambrian to Ordovician System.

(a) *Dundas Slate Group.*

In the road-cuttings about 1 mile northward of the Round Hill Mine hard fissile slates are exposed. They vary greatly in colour, from grey to green, brown, and bluish-black. The bedding-planes appear to be coincident with the present stratification lines. Interbedded with these slates are crushed grits and conglomerates, and also bands of schistose porphyritic igneous rock. The beds here have an average strike of north 60 degrees west, and dip north-westerly at 60 degrees.

Similar slates and crushed grits occur exposed on the roadside at Bell Mount. They possess a highly developed cleavage, and can be split with ease into thin slabs. The strike ranges from north 25 degrees to 47 degrees west, and the dip is north-easterly at angles of 82 to 85 degrees.

Slates and gritty quartzites, presumably of this series, are exposed in the valley of the Forth at Wilmot Bridge, where they strike north 60 degrees west, and dip south-westerly at 70 degrees.

The junction of these slates, both with the Mt. Claude conglomerate and with the tubicolar sandstone near Bell Mount, is unconformable and apparently faulted, but it has been definitely established that the slates are older than the other two groups.(2)

These slates, together with the associated igneous breccias and schistose porphyrites, belong to what is known in Tasmania as the porphyroid series.

(2) W. H. Twelvetrees: "The Middlesex and Mt. Claude Mining Field," Tas. Geol. Surv. Bull. No. 14, pp. 13-14.

(b) *West Coast Range Conglomerates.*

Capping Black Bluff, Stormont, and also the mountain range of which Mts. Roland, Vandyck, Claude, and Brazen Nose, and Round Mountain are the most prominent peaks, is a series of thickly bedded conglomerates and sandstones. These rocks form the crown of the West Coast Range whence their name is derived. The conglomerate is a quartzose rock of purple to reddish appearance, composed of quartz and quartzite pebbles with an occasional fragment of well-rounded quartzite schist, the whole set in a very hard siliceous matrix which constitutes only a small proportion of the mass. These stones have been derived from the Upper Algonkian quartzite beds. On Mt. Claude the lower members of the conglomerate contain much porphyroid rock (quartz-felspar-porphyry), some of these pebbles exceeding 2 feet in diameter. Grits, or coarse sandstones, as well as laminated argillaceous bands, alternate with the pebbly beds, but all combine to form one great series. Colouration by iron oxide is often very pronounced, and the rock becomes in places extremely hæmatitic. In some instances the hæmatite is found to have completely replaced the hard pebbles and the siliceous cementing material of the conglomerate, but such replacement is more commonly observed in the shale members of this formation.

The alternating sandstone and clay bands assist in determining the dip of the beds, but where they are absent it is often impossible to establish this, owing to the lack of visible bedding-planes in the massive conglomerate.

These conglomerate strata do not show much sign of intense rock-folding, and have resisted deformation. *En masse*, they have been only gently arched, but the sandstone members show numerous sharp anticlinal folds, and have been much tilted by vertical movements. Numerous faults have been observed in this formation at Mt. Claude, showing faulted junctions with other systems, rendering the question of relative age most difficult to determine from the exposures available here. It has faulted junctions with the porphyroids at Mt. Roland and Mt. Claude, and also with tubicolar sandstones at the latter locality. Such faulted junctions with the porphyroids have been observed also at Mt. Lyell and Mt. Farrell. These rocks are slightly unconformable with overlying tubicolar sandstones at Mt. Zeehan.

The age of this formation has been very difficult to determine, but within recent years its age-relationship to the porphyroids has been definitely established. During his examination of the Jukes-Darwin mining field, Loftus Hills([3]) discovered porphyroid pebbles in the basal members of this formation, and the writer on this expedition has been able to confirm the work of Mr. Hills by the discovery of multitudes of porphyroid pebbles in the conglomerate beds towards the summit of Mt. Claude. Some of the porphyroid boulders contained in the conglomerate are as much as 2 feet in length. Fossils are very rare in the strata of this system. In the conglomerates of Mt. Lyell and Sedgwick tubular casts have been found which are identical with those of the tubicolar sandstones so common in the Middlesex district.

The nature and form of the constituent pebbles of this conglomerate and the regularity of its linear extensions support the view that it was the resultant of wave-erosion, and is the survival of an ancient shore-line. These beds have been estimated to exceed 1500 feet in thickness on Mt. Roland.

(c) *Tubicolar Sandstone.*

The most conspicuous rocks in these districts are the tubicolar sandstones, grits, and conglomerates which immediately succeed the West Coast Range conglomerates and occupy the lesser eminences. The tubicolar casts occasionally met with in the older conglomerates are so abundant in these strata that they are considered a characteristic feature. These strata are found in all gradations, from fine-grained white sandstone, through grits, to white, evenly-graded, water-worn conglomerates. They differ considerably from those of the West Coast Range series, especially in the following particulars:—The younger rock is usually white, rarely pale pink, in colour; the sandstone member is much softer, excepting where it has come within the zone of metamorphism surrounding the intrusive granites; the pebbles are similar and much more uniform and worn; the proportion of matrix to pebbles is greater; in places it has the appearance of breccia made up of sub-angular, ill-assorted pebbles more closely packed than in the rock of normal type; it includes many yellowish-brown grey to green coloured bands of shale; and it often contains pebbles derived from the older formations.

The sandstone members are composed principally of grains of quartz, and very subordinately of grains of fel-

(3) *Vide* Loftus Hills: Tas. Geol. Surv. Bull No. 16.

spar which are much weathered. The sandstone is made up of sub-anglar to rounded particles cemented principally by siliceous material. Analysis shows the presence also of a little calcite. A common characteristic of the sandstone is its content of manganese minerals, which discolour the rock near the lodes from brick-red, almost black to light-green. The bedding-planes are 2 to 3 feet apart and are sharply defined.

The fineness of the grains, the almost total absence of minerals other than quartz, and the evenness as to size, all indicate a high degree of assortment found only in beds formed of materials that have been agitated for a considerable time. The true thickness of these beds has not been determined.

The individual beds of shale vary from a few inches up to 8 feet in thickness. In some beds the colour ranges from brown to black, in others from grey to green. Much of the shale, more especially the green bands, contains irregular streaks of white kaolin, which gives it a peculiar mottled appearance. These beds are evidently derived from disintegrated porphyroids. Some members are much warped, others are schistose, while still others have been transformed into fissile slates. The alternations of beds of shale and sandstone show that the shales were laid down in comparatively shallow waters.

The grit and conglomerate members are found at the base of this formation, and are from 60 to 100 feet thick. There are, however, bands from a few inches to several feet in thickness interbedded with the sandstones. At the very base of this formation the conglomerates are cemented by material derived from the porphyroids, but generally the matrix consists of silica with a very little calcite. The pebbles consist of white and (rarely) pink quartz. The lower portion of the conglomerate in particular contains well-rounded, evenly-sorted pebbles, indicating long-continued agitation in water. Loose, massive boulders of breccia, consisting of sub-angular pebbles and boulders of quartz finely cemented by siliceous material, are found at several points near Tin Spur. They evidently belong to the tubicolar sandstone formation, but they have not been observed *in situ*.

Excepting where they have been covered by basalt or have been broken by the effects of the granite intrusion and removed by erosion, these strata occupy almost the whole surface of the area. Like the West Coast Range conglomerate, they rest directly upon the porphyroids here,

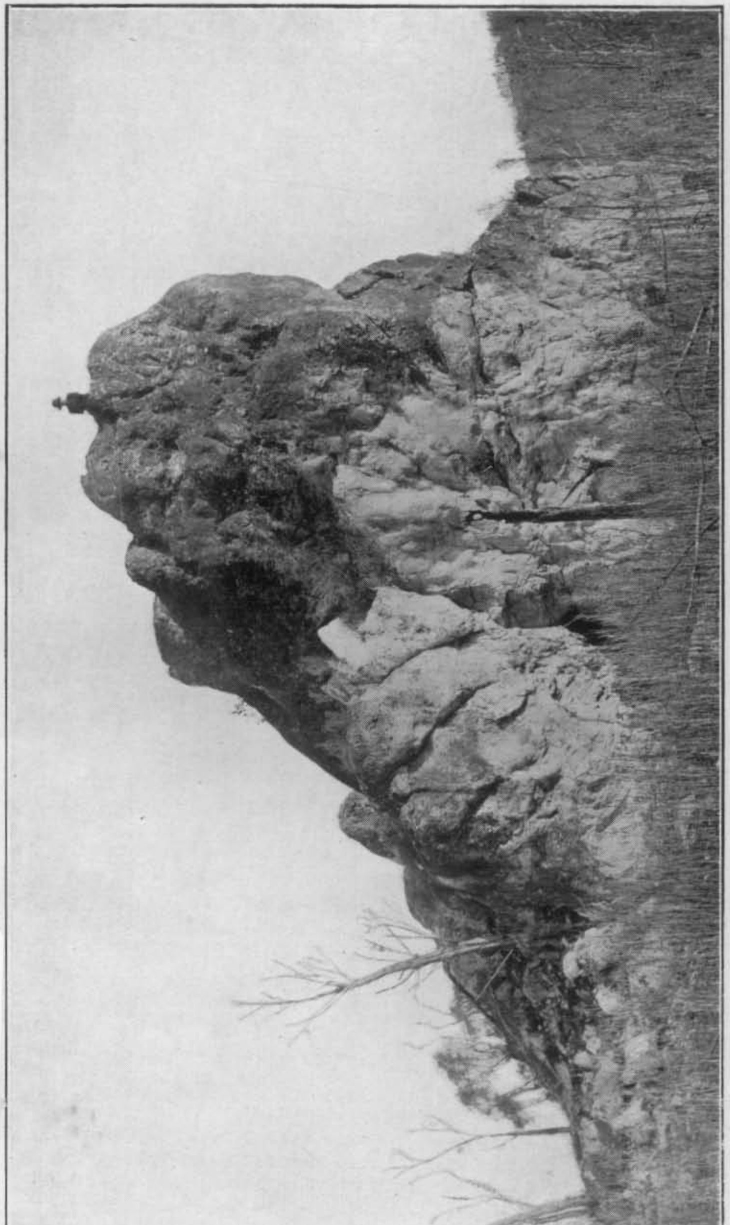


Photo. No. II.—TUBICOLAR SANDSTONE AND CONGLOMERATE CRAG NEAR BELL MOUNT. [W. Castle Photo

making their relationship to the older series very difficult to interpret. The order in which the beds are laid down is: conglomerate, grits, and sandstones, with lesser bands of grits and conglomerates interbedded therein.

Near to and south-west of Bell Mount, conglomerate and sandstone strata stand out in great precipitous crags nearly 100 feet above the surface. This bears away westward towards the angle formed by the confluence of the Iris and Lea Rivers, and eastward along the great fault line to Round Hill. The quartzite is pink in colour, and the conglomerate pebbles perfectly white, though an occasional pink pebble is found. The stone is identical with conglomerate on Hitchcock's and on Maddern's lot, west of the Iris, and in faulted junction with porphyroid south-east of the Iris Mine. In this latter locality the conglomerate pebbles are set in a matrix composed wholly of material derived from the porphyroids. On Lawson and Riley's 40-acre section, on the eastern fall of Dolcoath Hill, the conglomerate contains wolfram and tinstone, and rests directly upon granite and granite-porphyry. Here it stands up as a precipitous wall of rock 100 feet high. The sandstones and quartzites northward of the Squib and Narrawa Reward Mines contain multitudes of tubicolar casts, some of them exceeding 18 inches in length. On the east side of Forth River and the north side of the granite contact, similar white, evenly-assorted conglomerates are cut in the roadway. These are exposed to better advantage all the way up to the summit of Oliver's Hill, where they are found arranged in the form of enormous steps, tier above tier. The conglomerate stands up over 100 feet high, and presents a strikingly rugged appearance. It rests on purple to blackish-green schistose porphyroid rock.

On the fault line passing through Sections 7902-M and 7903-M an almost perfectly straight wall of rock 100 feet high extends south-eastward for nearly 1 mile.

These sandstone and conglomerate strata are the hosts of the economic minerals in these districts. On the south side of the All Nations Mine segregations and veins of quartz ramify through the conglomerate rock and enclose large crystals of wolframite; on the S. and M. property large boulders of conglomerate contain both tin and wolfram, and in many other localities where the lower strata are exposed they are found to contain metallic minerals. The richest lodes, however, have been found in the sandstones, though there is no reason why the underlying conglomerates should not be equally rich in metallic minerals. Near the granitic rocks the sandstones and conglomerates have been greatly altered. The change to quartzites and hard silicified conglomerates has been promoted by the granitic intrusion, and was characterised by the increased activity of the circulating aqueous solutions and gaseous emanations due to the influence of the heat given off during the cooling.

So far(4) no fossils have been recorded from these strata. The shells and other remains which have been collected from the Bell Mount diggings and the Five-mile Rise have evidently been derived from some other unidentified beds belonging to the Silurian system. The brachiopods which have been found on the Five-mile Rise and at Bell Mount diggings are contained in buff-coloured clayey sandstones, and suggest a rock of Silurian age.

Numerous indications of the existence of former organisms are seen in the curious cylindrical stems which traverse the tubicolar sandstone. These stems are tubular casts from a few inches up to 2 feet in length, giving a cross-section which is usually spherical but occasionally elliptical. Sometimes they are perfectly straight, but when any length is attained they are slightly curved. They always traverse the sandstone at right angles to the bedding-planes, but on the bedding-planes they ramify in all directions. Microscopical examination reveals no trace of organic structure in the filling material, which is composed exclusively of grains of quartz sand. The casts vary in size from ¼ to ⅜ inch in diameter. In addition to the tubicolar casts, some of the sandstone members contain myriads of casts of some other obscure organism. These are holes from 2 to 3 millimetres in diameter, commonly spherical but sometimes oval and elliptical. They do not penetrate the sandstone deeper than their diameter, but they are found at all points between bedding-planes.

The tubicolar casts are regarded as the filled burrows of some marine worm. The nearest allied form appears to be the pencil-like burrow of *Scolithus linearis* (Hall), found in the Upper Cambrian of North America.

These forms occur very abundantly at All Nations, Narrawa Reward, Stormont, Black Bluff, and the Five-mile Rise; also on Oliver's Hill, Round Hill, Tin Spur, and in many other localities.

(4) Since writing the above, Mr. S. Reardon, of Lorinna, discovered, in the end of the long crosscut at the Thistle Mine, fossil casts of *Rhynchonella borealis* in sandstone. Tubicolar casts in similar sandstones occur high up Five-mile Rise. If these rocks are identical, the age of the tubicolar sandstone would be advanced to Silurian.

C.—SILURIAN SYSTEM.

Isolated masses of bluish-grey limestone, remnants of an extensive formation, occur throughout these districts. Survivals of this formation are found at the S. and M. Mine, near Iris River bridge, on J. Smith's property between Moina and Bell Mount, on Robertson's and Hitchcock's selections near Iris River, at Bell Mount, and again north of the Narrawa Reward Mine; on the east side of Forth River in the Round Hill Mine; in the valleys of Claude and Tin Spur Creeks; and at several points at and near Lorinna. The unaltered rock is a light to dark bluish-grey sandstone, with a dense texture and massive habit. At the Iris Bridge its bearing is north-westerly, and its dip north 35 degrees east, at angles of from 25 to 28 degrees. It rests under the bridge conformably on white quartzite, which is exposed for 6 feet above water-level, and appears to be a band in the limestone, as the latter rock is again seen below it. In the long water-tunnel at the Round Hill Mine the last 150 feet is limestone, and an outcrop occurs on the banks of Claude Creek near the southern boundary of the Round Hill Extended Company's property. Limestone reappears at Lorinna on E. M. Bullock's land, south of the township boundary, and is below the alluvial on G. Sloane's land between the main-road and the Forth River below the bridge It here presents a cliff-face to the river, and strikes north 35 degrees west, with a north-easterly dip at an angle of 50 degrees. The limestone exposed on the road in E. M. Bullock's property is peculiarly structured, having a highly developed cleavage similar to that of slates. Calcite in parallel veinlets from ¼-inch to 2 inches wide, and also in large masses, occurs in its common rhombohedral habit. The strike here is north 37 degrees west, and the dip north-easterly at 60 degrees. A small creek near the road enters caves in the limestone, and does not emerge until within 3 chains of the river. At G. Sloane's farm also the creeks pass below the surface and emerge at the base of limestone cliffs near the river.

Metamorphosed limestones are represented by the curious garnetiferous rock at the S. and M. Mine, and the massive epidote rock in neighbouring localities. The limestone in Tin Spur Valley has been altered to epidote, garnet, and diopside by the action of solutions coming from the intrusive granite magma during its cooling and solidification. The distribution of the limestone in these districts denotes plainly the relation of its horizon to that of the pipestem sandstone. It clearly succeeds the latter in the S. and

M. Mine and at Lorinna. This sequence accords with that at Mt. Zeehan. At Tin Spur and the Round Hill Mine the faulting of the strata has apparently placed the limestone below the sandstone strata.

The unaltered limestones have a varying composition, some of them being exceptionally pure, while others contain a high percentage of material other than calcium carbonate. This rock is correlated with that occurring at Zeehan, Queenstown, Gunn's Plains, Melrose, Mole Creek, Winkleigh, and in the Jane, Gordon, Florentine, and Franklin valleys, and all are regarded as belonging to the Silurian system.

The following fossils have been recognised at Bell Mount in clayey sandstone:

Phacops or *Hausmannia*, *Rhynchonella borealis*, var. *schlotheimii*, orthis of the type of *Orthis calligramma*, and a monticuliporid coral. At the Iris Bridge the hydrozoan *Stromatopora* has been identified in the limestone. These fossils suggest a Silurian age.

D.—TERTIARY SYSTEM.

The deposits of this system in the districts under review appear everywhere to be associated with the basins of existing drainage channels; in other words, they are all made up of stream wash. High-level terraces of shingle and drift extend along the road near and at Lorinna. Sediments are found 300 to 400 feet above the bed of the Forth River, and indicate a great age for the present drainage system. A wide valley exists at Lorinna, and was evidently filled at one time with river deposits, the greater part of which was subsequently removed by erosive agencies following the elevation of the land surface.

On York's alluvial section (5470-M), on the west side of Forth River, is an old river terrace largely made up of well-rounded granite boulders and gravel. This wash contains payable tinstone. On the eastern side a terrace corresponding in all respects with that just described contains a little tinstone and wolfram. River drift and shingle in the valley near Wilmot Bridge, and at a height between 400 and 500 feet above the Forth, is overlain by Tertiary basalt. Similar occurrences have been noted in the valley of Dasher River, between the Sheffield basaltic plateau and the foot of Mt. Roland. Sub-basaltic gravels and drift, consisting of well-rounded quartz pebbles and containing tinstone, wolfram, and gold, are exposed at several points in the underground workings of the S. and M. Mine, and mark the course of an old Tertiary stream.

E.—QUATERNARY SYSTEM.

(*a*) *Pleistocene Series.*

Deposits of Pleistocene age are poorly represented in these districts. They consist chiefly of glacial drift, the remnants of moraines, in the valleys between the higher mountains. The glaciers were of the mountain type, and did not extend far from their source. Near Wilmot Bridge, Forth River, gravels of this age appear towards the floor of the valley.

(*b*) *Recent Series.*

Alluvium and recent gravels are found along the Forth River and its tributary streams. At Lorinna, Golden Point, Bell Mount, and Wilmot Bridge these sediments contain gold deposits, and at the latter locality they contain, in addition, a little tinstone and wolfram. At several other places in these districts there are gravels containing gold and other minerals of economic value, but they are nowhere extensive.

(5)—IGNEOUS ROCKS.

A.—PORPHYROID SERIES.

The several formations comprising the porphyroid series of rocks so abundantly developed in Tasmania are well represented in this region. The types developed here range from pyroclastic and fragmental rocks to felsites, diabase, porphyries, and granites. Variations in texture from felsites through felspar porphyries to quartz-porphyries show that these rocks are differentiation products of one magma. The diabase type appears to occur as an intrusive rock in the older schistose members of the porphyroids.

(*a*) *Quartz and Felspar Porphyries.*

The acidic members, quartz and felspar porphyries and felsites, are similar in composition, in that the dominant felspar component is albite, which with quartz is an essential constituent. Magnetite is an accessory component;

secondary minerals due to metamorphism are chlorite, epidote, pyrophyllite, calcite, actinolite, and sericite.

The prevailing colour, dark-green to greenish-grey, is due to the development of chlorite and pyrophyllite, the latter mineral being commonly noted in the schistose felspar porphyries. The calcite component is probably derived from hornblende, which was evidently an original constituent. Pyrophyllite has been produced by the action of carbonated waters on felspar, and is, therefore, more abundantly developed in felspathic porphyries. The grains of the component minerals are ordinarily of medium size, but they vary greatly from point to point. The quartz-phenocrysts of the quartz-porphyry have suffered corrosion to such an extent that the crystal outlines are quite obliterated, and they present a spheroidal or much embayed appearance. In some instances quartz-phenocrysts are entirely absent, and the rock takes the form of felspar porphyry. The phenocrysts are almost invariably arranged in parallel formation or flow alignment, indicating the volcanic origin of the rock.

A quartz-porphyry which outcrops on Thomas' road, shows the usual corroded crystals of quartz and decomposed porphyritic crystals of felspar and a ferromagnesian mineral in a holocrystalline quartzose groundmass. Other outcrops in this locality are on Oliver's Hill, and in the vicinity of Campbell's Reward Mine.

(*b*) *Diabase.*

An outcrop of diabase, which is believed to belong to the porphyroid series of rocks, occurs one mile north-east of Cethana in Dasher River valley. On E. L. Knowles' property a little work has been done on an asbestos formation in this rock.

It is a fairly fresh-looking rock, but under the microscope the mineral components are found greatly altered. Thus the plagioclase has become kaolinised and the hornblende partly altered to serpentine and epidote. The plagioclase shows broad lamellar twin structure, and is frequently idiomorphic. The hornblende is commonly found in allotriomorphic remnants, though idiomorphic crystals are not infrequent.

(*c*) *Granite.*

The granites outcropping near the point of confluence of the Dove and Forth Rivers are granular reddish rocks, consisting of pink orthoclase, quartz, and green chloritic pseudomorphs after biotite. Micropegmatitic or graphic structure is present. It has a red and green appearance, due to the felspar and chlorite. A good section of this rock is exposed in the tunnel at the Powerful Mine. Here it appears as a coarsely crystalline rock made up largely of spheroidal quartz phenocrysts, with biotite and felspar in subordinate amounts. The felspar, and in places the biotite components, have been greatly altered, but at certain points in the exposures here it presents the appearance of a fresh-looking normal biotite granite. Loose boulders of biotite granite are strewn over the surface on Sloane's farm, but only porphyritic varieties of this rock were found *in situ*. On the west side of the river at the Golden Cliff Mine similar granites occur. The dominant feature of this rock is its high content of quartz, which occurs in phenocrysts three-sixteenths to one-quarter of an inch in diameter.

There is a striking resemblance between these granites and quartz-porphyries and the stanniferous varieties, especially those occurring southward of Dolcoath Hill. Tinstone has been recovered from the quartz-porphyry sandstone junction on the Union Mine property, and also under smiliar conditions at Bond Peak. Again, tourmaline, a mineral almost invariably associated with tin deposits, has been repeatedly reported from this locality. The quartz-porphyry in junction with the tubicolar quartzites exposed in the main tunnel workings of the Union Mine has the usual large phenocrysts of quartz, but the spheroidal shape is destroyed, as if by sudden chilling, and the rock presents a hard, glassy appearance. At every point where this quartz-porphyry is exposed the surface rock has this peculiar chilled appearance. Inclusions of quartzite were not detected in the porphyry. Biotite granite and quartz-porphyry are exposed in the cuttings on the new road to Winspear's farm.

The granite porphyry of the Dove River at the Devon Mine is a hard siliceous rock, with a holocrystalline quartzo-felspathic groundmass, in which are porphyritic crystals of biotite and turbid felspar, and the usual crystals of quartz with rounded outlines. The felspar is too clouded with decomposition products to show twinning lines. The granite porphyry at the base of Bond Peak is essentially similar to that of the Dove River.

It has not been definitely determined whether these quartz-porphyries and biotite granites belong to the porphyroid series or to the later Devonian granites. Possibly they represent porphyroids resorbed by the later granitic magma, proof of which has been established regarding the similar rocks occurring northward. The only schistose porphyroid recognised in this locality is that cut in the shaft at the Caledonian Mine, possibly a remnant of unabsorbed material. These rocks have been tentatively grouped with the porphyroids.

B.—DEVONIAN GRANITE.

The granitic rocks which outcrop between Moina and Tin Spur and southward toward Five-mile Rise are parts of great masses of igneous magma which did not reach the surface, but cooled slowly underneath the cover of tubicolar sandstones and conglomerates. Subsequent uplift and denudation have exposed both the great bodies of igneous rock, and the sediments baked and altered by them in consequence of the heat given off during the cooling of the magma.

It is difficult to determine whether the granite intrusion is in the form of chonoliths or of a batholith. The term chonolith is used to designate large dyke-like intrusions which differ both in form and size from laccoliths and batholiths. The term batholith is applied to a vast irregular intrusive body having indefinite downward extension. In this locality the granite was intruded under no great depth of strata, but the surface area exposed by erosion is not great. These exposures are determined by the original irregularity of the upper surface of the granite. The nearest outcrops to that occupying the central portion of this region are those toward Mt. Pelion, 20 miles southward, and the quartz-porphyry at the northern end of Black Bluff, and at Loongana, 6 and 10 miles north-westward. On J. Leary's farm, Lower Melrose, multitudes of clear, white topaz stones are found in the thin basaltic soil, and at Barrington, a little farther southward, quartzites, apparently of the tubicolar type, outcrop above the basalt soil. This suggests the possibility of the occurrence here of tin and wolfram-bearing granites under the thin covering of basalt.

The normal rock is here a pink granite or biotite (magnesian mica) granite composed of felspar, mica, and quartz. The felspars are orthoclase and plagioclastic felspar in about equal proportions; the former is devoid of the

idiomorphism which characterises the plagioclase, and is often striped with perthitic intergrowths of albite. The plagioclase belongs to the orthoclase-andesine series. The mica is brown and dirty green in thin section, and a little fluorite is occasionally associated with it.

In general there is not much in either the mineralogical or chemical nature to distinguish this granite from the non-stanniferous Dove River varieties which are considered as belonging to the older porphyroid series.

The granite is traversed by numerous contraction fissures which trend north 55 degrees west, and dip south-west at angles of 40 to 50 degrees.

The acid dykes which accompany the granites may be divided for purposes of description into aplites, pegmatites, and quartz-porphyries. These metal-bearing granitic rocks occupy the northern end of the outcrop.

(a) *Aplite.*

A rock consisting essentially of quartz, orthoclase felspar, and muscovite mica occurs in the form of narrow, irregular dykes at the northern end of the granite stock. A variation from this type, consisting of quartz, bleached biotite, and potash felspars (orthoclase with microcline and microperthitic intergrowths), and an acid plagioclase (oligoclase), the latter in the isometric forms characteristic of aplite, is also common. The quartz is not interstitial, as in the normal granite, but in grains which frequently have outlines approaching crystal forms. Some of the larger grains give the rock a pseudoporphyritic appearance. Fluorite is usually present. The rock on the Princess section is an aplitic granite, and it is found also on Sayer's property and on the east side of the Forth River.

(b) *Pegmatite.*

The aplite of Dolcoath Hill and Tin Spur varies locally to pegmatitic phases, with also a tendency towards greisenisation. Pegmatites are particularly rich in pneumatolytic minerals, especially those containing fluorine and boron. On the Hidden Treasure and Premier properties the ore-bodies are contained in a peculiar pegmatitic rock composed of quartz, felspar, and massive muscovite or pinite. The felspar is almost completely kaolinised, and with the pinite indicates a considerable change from the original components of the rock. It is believed that the pinite is an alteration product of topaz, which was formed by the action of fluorine on felspar at the time of the intrusion of the acidic dykes.

Pegmatites are commonly the loci for cassiterite wolfram, bismuthinite, and molybdenite, and are especially prevalent at the northern end of the granite stock on both sides of the river.

(c) *Quartz-porphyries.*

Mineralogically, porphyries differ little from the parent granite, though pneumatolytic minerals are sometimes present. The greatest difference is in the structure of the rocks due to the conditions under which they were formed. In chemical composition the porphyries are much more acid than the neighbouring granite, but in other respects they are very similar to the more perfectly crystallised parent rock.

The rock commonly found bordering the granite is one made up of quartz-phenocrysts set in a quartzo-felspathic groundmass, the latter having become completely devitrified. On the northern and north-eastern limits this rock contains a large amount of magnetite.

An extensive belt of quartz-porphyry occurs between Dolcoath Hill and Five-mile Rise. It is exposed on both sides of Forth River, extending fully one mile in an east-west direction. Northward it gradually passes into granite, and is evidently caused by the quick marginal cooling of the granite mass. The great extent of the porphyry is explained by assuming that the present surface represents the top of the granite mass, and that the granite exists at no great depth below. Along the borders of the quartz-porphyry outcrop, sandstone and white conglomerate still remain overlying the porphyry, and the latter contains in its mass multitudes of well-rounded quartz pebbles and fragments of quartzite derived from the overlying tubicolar sandstones and conglomerates. At first sight this rock has the appearance of a conglomerate or breccia.

Farther eastward, where Forth River has cut deeply into this rock, it contains much actinolite and hornblende, and has generally a more basic character. Inclusions of quartzite, however, are not infrequently found in it. Quartz and felspar porphyries are exposed in the road-cutting south of the Premier Mine. One variety shows microscopically clusters of small crystals of biotite replac-

ing decomposed phenocrysts which have the outlines of felspar crystals. Tufted actinolite and epidote are occasional minerals. This rock passes into felspar porphyry containing hornblende. The disintegration of this rock produces a light-brown coloured, fertile soil, unlike that of the normal granite.

These apparently dissimilar rocks had a common origin, the difference in composition being due to the ready assimilation by the granitic magma of the porphyroid rock. The molten mass rose up to the tubicolar conglomerates and sandstones which directly overlie the porphyroids, but did not penetrate them, nor did it absorb any large amount of these rocks. The magma, being acidic, took up very little of the siliceous material, but near its surface it is preponderatingly quartzose, and in addition contains multitudes of unabsorbed quartz pebbles. The more basic igneous porphyroid rocks were assimilated readily, the resulting rock showing very little resemblance to the original magma represented by the biotite granite outcropping farther northward. Long narrow tongues of tubicolar conglomerate cemented by porphyroid, the remnants of unabsorbed material, occur in the centre of the intrusive mass. The evidence available here suggests an extensive assimilation of the invaded rock by the intrusive magma. Blocks of the invaded rocks loosened by this process sink into the fluid mass, and are gradually dissolved, and thus the composition of the magma is altered. The process of the assimilation of extraneous material by intrusive magmas is a theory having many advocates. R. A. Daly ([5]) has sought to explain the mechanism of igneous intrusions by a process which he calls "Magmatic stoping." He supposes that a batholithic magma eats its way up by solvent action on the invaded rocks.

(d) *Greisen.*

The greisen forms of granite, in which quartz is the substitute for felspar, and a white mica (lithia-bearing) is present in lieu of biotite, is illustrated by the rock in the adit of the Dolcoath Mine. Topaz is also associated with the rock here. Greisen is always an alteration product of granite, and in some form or another is an invariable companion of tin and wolfram deposits. This altera-

([5]) *Vide* F. W. Clarke: "Data of Geochemistry," United States Geol. Surv. Bull. No. 616, pp. 309-312.

tion is due to the action of mineralisers effecting a replacement of the alkalies, and the addition of silicia, cassiterite, alumina, fluorine-bearing minerals, &c. Greisenisation sometimes results in the almost complete silicification of the wall-rock of fissures.

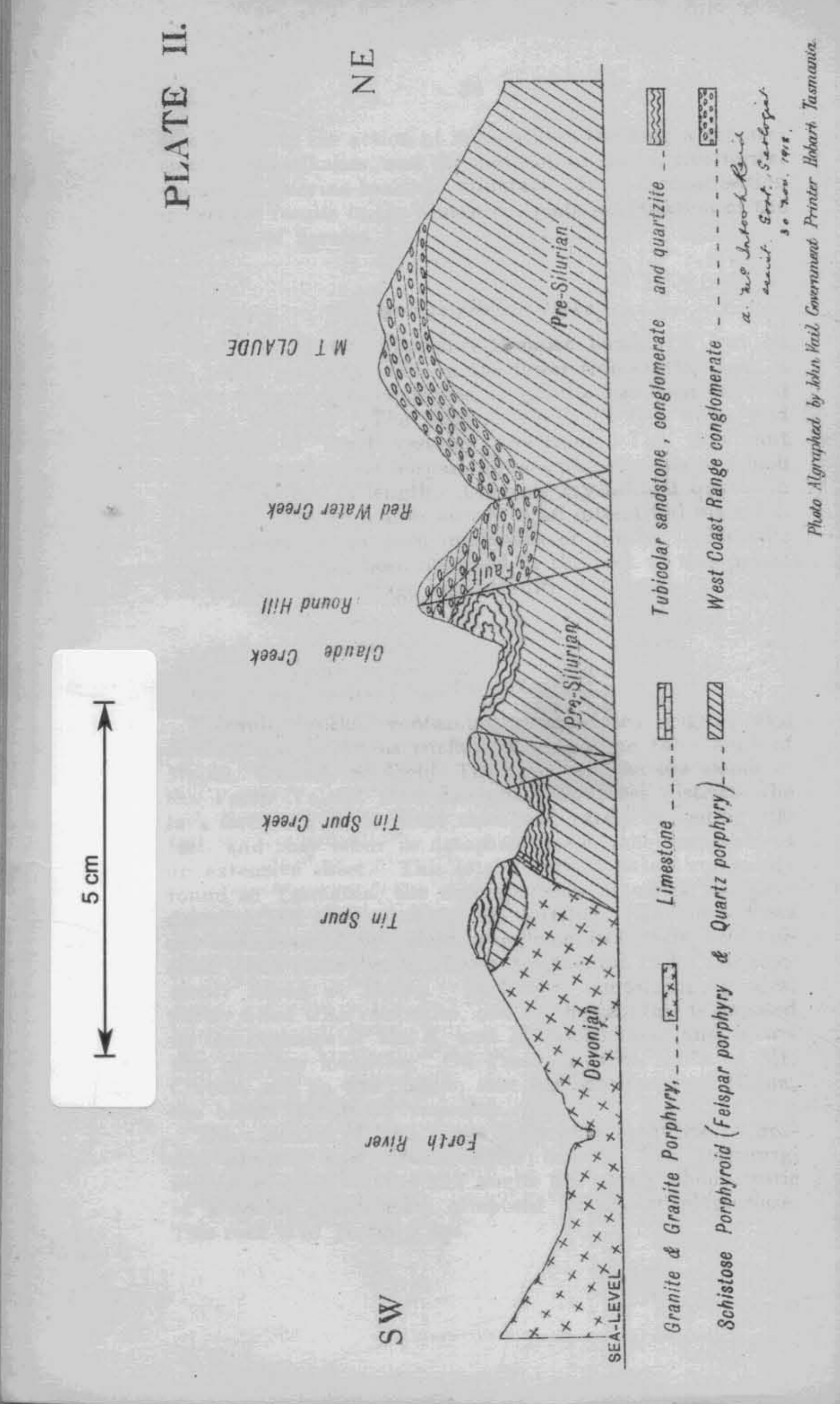
(e) *Quartz-felspar Dyke.*

Near the Hidden Treasure-Premier boundary, but on the latter property, and on the lower side of the road, a quartz-felspar dyke contained in granite has been exposed in two trenches. The dyke is 10 to 12 feet wide, and trends in a north-westerly direction. The dominant mineral is orthoclase felspar, idiomorphic crystals of which exceed 5 inches in length. Coarsely crystallised quartz in irregularly-shaped masses occurs as an interstitial material, accompanied by massive muscovite or pinite. Metallic minerals have not been observed in the rock at this point, but in the top cuttings bismuthinite is found.

C.—BASALT.

Volcanic rocks, containing plagioclase, augite, and olivine, are found as surface flows on the tablelands of Moina, Wilmot, Sheffield, Tin Spur, and on the slopes of the Forth Valley, near Lorinna. In these districts the lava flows are of no great thickness, rarely exceeding 100 feet, and they occur in detached masses, the remnants of an extensive sheet. This is the normal basalt commonly found in Tasmania, the decomposition of which has produced a soil celebrated for its fertility. The lava flows are accompanied by volcanic agglomerates, tuffs, and volcanic glass (tachylyte). These fragmental rocks are commonly found at Moina. Tachylyte containing geodes, partly filled with chabazite, one of the zeolites, is exposed in the cuttings of the S. and M. water-race, and occurs also in other localities. On Pinner's farm, south of Mt. Claude, and on the plateau east and south-east of Moina, the basalt is notably vesicular.

The varieties of lava range from pure tachylyte to normal olivine, and olivine-augite basalt. The ferromagnesian minerals olivine and augite are partly phenocrystic in a coarse groundmass composed largely of plagioclase. This rock is of Tertiary age.



(6)—Structural Geology.

The exact relationship of the several formations occurring in this region is very difficult to interpret. The base of them all is the porphyroid series upon which the West Coast Range conglomerates were laid down. These conglomerates, grits, and sandstones must have occupied the whole surface, as isolated masses of considerable proportions still occupy the summits of all the higher mountains. This formation, which on Mt. Roland is fully 1500 feet thick, is succeeded unconformably by the tubicolar conglomerates and sandstones which occupy all the lesser eminences. In this locality it is extremely difficult to determine the conditions under which these strata were laid down. It is probable, however, that during the interval between the laying down of the older conglomerates and the members of this formation, large portions of the former were removed by erosive agencies following diastrophic movements. The later conglomerates and sandstones were laid down on those portions of the porphyroid floor once occupied wholly by the older conglomerate. Apparently in this locality the tubicolar strata, at present from 100 to 300 feet thick, was never of any great thickness. Isolated masses of Silurian limestone, remnants of an extensive formation, occupy depressions on the surface and directly overlie the tubicolar sandstones. In some parts it appears as if the limestone was laid down on a surface possessing considerable topographic relief. Before the intrusion of the granite, the earlier Palæozoic rocks had been elevated. The action of the rock-deforming agencies connected with the intrusion and consolidation of the granite magma was less intense than that of the porphyroid diastrophism, but the local effect upon the overlying strata has been considerable. The irruption of the granite batholith is responsible for considerable faulting and for the sharp anticlinal folding of the tubicolar strata. Probably the present outcrops represent the most prominent points of the irregular surface of the batholith. It is considered that the granite magma absorbed the greater part of the underlying porphyroid and also small portions of the siliceous strata. Before the intrusion of the granite, the topographic relief, mainly due to differential erosion, was already considerable; but this was greatly intensified by faulting and folding directly following the irruption. Thrust faulting has played an important part in the deformation of the surface, and faults generally have influenced the present topography, although erosion has greatly modified the fault topography.

The most extensive fault is that sharply marked on the surface between the southern side of Bell Mount, Round Hill, and the southern side of Mt. Claude. Along this line are faulted junctions of porphyroid and older conglomerates, and older conglomerates and tubicolar sandstones. Here, also, limestones and sandstones are found transposed, while a few chains distant these rocks occur in correct relationship to one another. Erosion, working on the tilted fault slices, leaves linear ridges of hard tuibcolar strata, which near Bell Mount, stand up 100 feet above the surface. The older conglomerate in faulted junction with the porphyroid does not penetrate very deeply, as it is cut through by the Forth River and replaced by tubicolar strata. The porphyroids at the point of junction have been greatly eroded by Claude Creek, whose sharply-dissected valley is 500 feet deep. An overthrust fault is shown by the superimposition of the tubicolar sandstones and older conglomerates at Round Hill and Brazen Nose. South-eastward of Round Mountain high fault scarps are common features of the landscape. Similar structure exists on the Falls property and Oliver's Hill.

The width of strata affected by folding movements is not great. The deformed rocks are hard homogeneous quartzites with thin bands of shale interbedded therein. These comparatively thin strata thrust from the south-west found a massive buttress in the hard, unresisting conglomerate, and thus these folds were localised. Both rock flowage and fracture folding exist in these irregular anticlinoria.

Pre-mineral faulting on a small scale is a common feature of the lode fissures, in some cases they take the form of small step faults. The master planes of the granite trend in a direction north-west, which is also the direction the area is folded. These planes conform in strike and dip with that of the inclosing strata.

Later diastrophic movements have had little effect upon the geological structure of the area.

(7)—Contact Metamorphism.

The principal results of contact-metamorphism in these areas are those brought about by the intrusion of the granitic rocks. The granitic magma, coming into contact with sedimentary rocks, such as tubicolar sandstones and grits, and older igneous schistose rocks of the porphyroid group, creates a zone of contact-metamorphism around the intrusive mass. The accompanying gaseous and aqueous

solutions penetrate the adjacent rocks, and along the periphery of the magma a portion of the rock is more or less completely assimilated. The condition brought about by the action of the heated solutions permeating through the adjacent rock and circulating through cracks and fissures therein is called exomorphism, and results in the formation of contact-metamorphic rocks and ore-deposits. This alteration of the sedimentary and schistose igneous rocks by direct contact with the invading magma is called endomorphism.

Limestones have thus been converted into garnet, epidote, diopside, vesuvianite, and other lime-alumina silicates; and sandstones have been transformed into quartzites. Other examples of exomorphism are the formation and deposition of such minerals as felspar, muscovite, biotite, topaz, fluorspar, beryl, calcite, quartz, and many metallic minerals.

Endomorphic minerals occurring here are actinolite, epidote, quartz, and quartz-pyroxenite, the latter derived probably from sandstone, and occurring as a xenolith in the granitic mass.

(8)—Geological History.

A.—Pre-Cambrian Conditions.

The oldest rocks in the districts are the Pre-Cambrian mica schists outcropping near the confluence of the Dove and Forth Rivers. They represent the earliest formations found in Tasmania. The floor on which they rest has nowhere been observed, and the Archæan rocks from which these sediments have been derived have completely vanished. These rocks are believed to belong to the Lower Algonkian division of this system. They covered one-half of the present area of Tasmania from north to south, and from the western shores to as far east as Badger Head Range.

After these sediments had been laid down the country was elevated, the rocks were regionally metamorphosed, resulting in the development of schistose structure. The surface was then depressed below sea-level, and covered with the piles of Upper Algonkian sands, which were subjected to continued deformation, though far less intense than previously, and brought up to form land-surfaces, the waste of which was in its turn deposited on the floor of the Cambrian ocean. These Upper Algonkian sandstones are now represented by hard white quartzites.

B.—PALÆOZOIC CONDITIONS.

(a) *The Porphyroid Diastrophism.*

The time interval between the elevation of the Pre Cambrian strata and the deposition of the West Coast Range conglomerates was dominantly one of igneous activity and crustal movement. Sheets of lava and accumulations of fragmental volcanic ejectamenta are interbedded with sediments, while the plutonic phase in the igneous cycle is represented by intrusive acidic and basic members. The less resistant members of this series were made schistose by a second regional metamorphism, which is supposed to have taken place at the close of this epoch. The intensity of the metamorphism effected by crustal movement is shown in the highly developed schistosity possessed by the old quartz and felspar porphyries of Bell Mount, Mts. Claude and Roland, and the Forth Valley.

(b) *The Pre-Silurian Diastrophism.*

The land surface occupied by the porphyroid igneous rocks gradually subsided and the accumulation of littoral material commenced. These littoral deposits are represented by the heavy conglomerates and pink sandstones of Mts. Roland and Claude, Round Hill, Stormont, and Black Bluff. The pebbles composing them have been derived, in the main, from Upper Algonkian quartzites, although at their base they include water-worn pebbles and boulders of porphyroid. The rate of subsidence gradually diminished, the sandstone members were laid down, and there followed a short period of rest.

The land surface was again depressed, and the finer-grained tubicolar conglomerates, grits, and sandstones were deposited on the gradually subsiding shore-line. This series of rocks is slightly unconformable with the older conglomerates. The gradation between the conglomerate, grit, and sandstone members is almost insensible in general, although bands of shale are interlaminated with the sandstone and represent shallow-water conditions of deposition. These strata were also laid down on a porphyroid bottom, and thus they indicate the continued advancement of the strand-line. The materials of these rocks are similar in many respects to those of the older conglomerates, and they actually contain pebbles derived from these earlier formations.

There followed a sudden submergence of the area, and the calcareous sediments that formed the limestone were deposited on the ocean floor.

(c) *Devonian Diastrophism.*

Before the intrusion of the granite and the several kinds of rock that are believed to have been derived from the same magma, the earlier Palæozoic rocks had been elevated. The action of the rock-deforming agencies connected with the intrusion and consolidation of the granite magma was much less intense than that of the porphyroid diastrophism. The granite appears to have been intruded under no great weight of overlying sediments, and apparently did not penetrate the tubicolar sandstones.

The local effect of the intrusion is shown in the complete dislocation of the superincumbent strata; the dip and strike of the formations were changed, and the strata appear to have been pushed aside in all directions to make room for the invading magma. The irruption of the granite is responsible for considerable faulting and for the sharp anticlinal folding of the tubicolar strata.

C.—MESOZOIC CONDITIONS.

The land was again elevated at the early part of this era. Then came the intrusions of diabase in the forms of laccolites, dykes, and sills, and possibly some of the present outcrops represent lava flows. Mesozoic diabase occupies a considerable portion of adjacent areas, especially that immediately to the south, but it has not been identified in these districts. The intrusions were not related to the deposition of the ore in any respect.

D.—CAINOZOIC CONDITIONS.

Before the eruption of the basalt lava, a still further elevation of the land took place, and was immediately followed by a renewal of erosional activity. The volcanic activity succeeding these events was very extensive. Flows of basaltic lava, which still occupies a considerable portion of the higher river plateaux, choked the river channels, diverting the streams and completely burying the leads.

The effect of glacial action on the configuration of the country is more apparent in the higher mountain valleys. The Vale of Belvoir, between Black Bluff and Stormont and Bond Peak, is a typical U-shaped valley sculptured by glaciers.

The latest events include the successive slight uplifts within recent time.

VII.—ECONOMIC GEOLOGY.

(1)—Mineralogy of the Ore-deposits.

These districts are renowned for the great variety and abundance of well-developed minerals, many of which are present in such amount as to be of economic value. A list of the most important follows:—

Metallic Minerals.	*Rock-forming Minerals.*
Arsenopyrite	Actinolite
Asbestos	Beryl
Barytes	Biotite
Bismuth (native)	Calcite
Bismuthinite	Chabazite
Bismutite	Chlorite
Cassiterite	Diopside
Chalcopyrite	Epidote
Ferberite	Fluorspar
Ferritungstite	Garnet
Ferromanganese	Gilbertite
Galena	Hornblende
Gold	Ilmenite
Hæmatite	Laumontite
Hubnerite	Magnetite
Molybdenite	Muscovite
Molybdite	Orthoclase
Monazite	Pyroxene
Pyrite	Quartz
Scheelite	Topaz
Sphalerite	Tourmaline
Tungstite	Vesuvianite
Wad	
Wolfram	

A brief description of the most important of these minerals follows:—

Wolfram—tungstate of iron and manganese ($FeMnWO_4$): This mineral is the chief source of tungsten, and is divided on the basis of chemical composition into three sub-species: ferberite, hubnerite, and wolfram. Ferberite is an iron tungstate with theoretically 76·3 per cent. tungstic acid (WO_3) and 23·7 per cent. ferrous oxide. Hubnerite is a manganese tungstate with 76·6 per cent. WO_3 and 23·4 per cent. MnO. As these two substances

occur in mixtures in all proportions the name wolfram is generally used to cover them all.

The hardness of wolfram is 5 – 5·5, specific gravity 7·2 to 7·5, streak brownish-black to nearly black. It is weakly magnetic.

Wolfram crystallises in tabular forms of the monoclinic system; ferberite usually occurs in tiny crystals of chisel-shaped or spear-head form; and hubnerite is commonly in divergent groups of plates or needles. All varieties occur in granular form also, or in shapeless individuals embedded in gangue material. The colour is always dark, black and metallic in most cases; more commonly brown in hubnerite; shining black or with steely metallic lustre in ferberite. All varieties possess a single direction of very perfect cleavage, causing the mineral, when crushed, to break into thin flakes. The chief sources of wolfram in this region are the S. and M., All Nations, Squib, Princess, Lawson and Riley's, Iris, Premier, and Hidden Treasure Mines.

A complete analysis of a specimen of wolfram from the S. and M. Mine showed the following constitution:—

WO_3	75·3	per cent.
FeO	18·0	,,
MnO...	6·0	,,
SiO_2	0·8	,,
	100·1	

Ratio—FeO : MnO = 3 : 1.

Scheelite.—Scheelite is a tungstate of calcium ($CaWO_4$), containing when pure 80·6 per cent. WO_3 and 19·4 per cent. CaO. Scheelite is sometimes found in distinct crystals of tetragonal form; more often it is coarse or fine-granular, or the crystals are embedded in gangue material and have no distinctive shape. The colour is white or yellowish; the lustre is brilliant, with an oily appearance on fractured surfaces; and the cleavage is imperfect and parallel to the faces of the pyramid. The mineral is rather soft (H = 4·5 – 5), being easily scratched with a knife, and giving a white streak. The specific gravity is 6, considerably higher than that of most gangue minerals, and it is, therefore, easily separable therefrom by ordinary processes of concentration. It has been identified in the ore of the S. and M. Mine, but in quantity too small to be of economic importance.

Tungstite and Ferritungstite.—Tungstite is a hydrous oxide of tungsten; ferritungstite is a hydrous tungstate of iron: both are canary-yellow powders or scaly aggregates, which coat the tungsten ores or fill cracks in the gangue between them. These tungsten ochres, as they are generally called, are products of the slow oxidation of either scheelite or wolframite, and in some cases completely replace them, and are therefore always secondary minerals. They do not occur in sufficient quantities to become of economic importance.

Molybdenite—disulphide of molybdenum (MoS_2): Contains 59·95 per cent. of molybdenum and 40·05 per cent. of sulphur. It is a soft lead-grey mineral with a metallic lustre and greasy feel. It commonly occurs in flakes or scales having a highly developed basal cleavage, in this respect resembling some of the micas. Fine-granular and massive forms are also common. The mineral is sectile and flexible, and is so soft that it soils the fingers. Hardness is 1 to 1·5; specific gravity, 4·7 to 4·8.

The occurrence of molybdenite in these districts is perhaps the most important in Tasmania, and may prove to be of considerable value. The operations at the main level of the Squib Mine have developed a vein containing molybdenite from ¼ to ½ inch thick. Molybdenite occurs also in almost every mine in operation at or near the granite boss. The most prominent occurrences are at the Squib, S. and M., Hidden Treasure, Premier, and Princess Mines. It is usually found in pegmatite veins, contact veins, or in veins contained in metamorphic rocks near the granite.

Molybdite—hydrous ferric molybdate (FeO_3, $3MnO_3$, $7\frac{1}{2}H_2O$): Contains 39·63 per cent. of molybdenum. It is a lemon-yellow to greenish-yellow mineral, and usually occurs as an earthy powder or as incrustations. Molybdite is an alteration product of molybdenite, probably formed by the interaction of molybdic acid (liberated by the oxidation of the molybdenite) and limonite. Molybdite is often erroneously considered to have the composition of molybdic trioxide.(6) Molybdite is found accompanying molybdenite and wolfram in pegmatite veins at the Squib Mine and at the Hidden Treasure and Premier Mines. It occurs also in veins contained in the metamorphic quartzites and garnets at the S. and M. Mine.

(6) *Vide* F. W. Horton: "Molybdenum: Its Ores and Their Concentration," Bull. No. 111, U.S. Geol. Surv., 1916.

Bismuth.—Native bismuth occurs commonly at the All Nations Mine, large lumps having been recovered during the operation of sluicing the detrital material accumulated near the ore-body. At the S. and M. Mine it is also found accompanying cassiterite-wolfram in the ore-bodies.

It is a soft (H = 2 – 2·5), sectile, slightly brittle metal, having specific gravity of 9·7 to 9·8. The colour and streak are silver-white, with a reddish hue.

Bismuthinite—bismuth trisulphide, Bi_2S_3 = bismuth 81·2, sulphur 18·8 per cent. The hardness is 2, and the specific gravity 6·4 to 6·5. Lustre metallic, streak and colour lead-grey.

At the S. and M. Mine bismuthinite occurs both in massive form and in handsome specimens of acicular crystals with bright metallic lustre. Very fine specimens are obtained from the Princess Mine, where this mineral is a most important constituent of the ore. It occurs also in considerable quantity at the Squib and Premier Mines. Bismuthinite occurs sparingly in the galena-chalcopyrite ore of the Round Hill Mine.

Bismutite—a basic bismuth carbonate, $Bi_2O_3CO_2H_2O$. An alteration product of native bismuth or of bismuthinite, usually found as incrustations or as an earthy amorphous mass. Specific gravity, 6·9; colour, usually white, sometimes grey, yellow, or green. Commonly found in the upper portions of the lodes at the S. and M., Squib, All Nations, Princess, and Premier Mines.

Cassiterite—tinstone, SnO_2. Tin = 78·38, oxygen = 21·62. Cassiterite occurs commonly in these districts in lodes and placer deposits. It is a hard (H = 6 – 7), heavy mineral (S.G. = 6·4 – 7·1), usually of black or brown colour, rarely red, yellow, white, and grey. The mineral is coarsely crystallised in the S. and M. lodes, but is generally fine-grained at the Tin Spur. It is found in the form of sparable tin, and is frequently twinned, commonly in geniculate forms. It is closely associated with wolfram in the S. and M., All Nations, and Squib Mines. At the Falls and Morgan's Mines it occurs free from wolfram and bismuthinite, and is, therefore, more easily prepared in marketable condition. Placer deposits occur on the Iris and All Nations Sections and at Bell Mount gold diggings.

Monazite.—This mineral is a phosphate of cerium, lanthanum, and didymium, with variable proportions of thorium. Its specific gravity is 5, thus somewhat lower than that of cassiterite. Its colour is usually light-yellow to resinous, sometimes brown to reddish. The hardness ranges from 5 – 5·5. It is reported as having been found at the S. and M. and other mines in these districts. The value of monazite is proportional to the thorium content. No analysis has been made as to the contained thorium oxide (THO_2), but in other localities in Tasmania the thorium oxide in this ore has not been found exceeding 3 per cent., which is 2 per cent. below market requirements.

Arsenopyrite—sulpharsenide of iron, FeAsS = arsenic 46·0, sulphur 19·7, iron 34·3 = 100. The hardness is 5·5 to 6; specific gravity, 5·9 to 6·2. Colour, silver-white; streak, greyish-black; lustre, metallic. Occurs in greatest abundance at Narrawa Reward and Thistle Mines.

Chalcopyrite—copper pyrites, sulphide of copper and iron, $CuFeS_2$ = copper 34·5, iron 30·5, sulphur 35·0 = 100. Hardness is 3·5 – 4; specific gravity, 4·1 to 4·3; lustre, metallic; colour, brass-yellow; streak, greenish-black. A primary constituent, though in small amount, of wolfram lodes; a considerable quantity in Round Hill and Wilmot galena-chalcopyrite ores.

Gold—Au. Hardness is 2·5 to 3; specific gravity, 15·6 to 19·3, dependent upon the amount of silver present. Usually occurs in the native state.

At Campbell's Reward Mine (7), near Lorinna, the gold occurred in a very small vein or fracture plane in schistose felspar porphyry (porphyroid); the gold was faced on to the rock with a backing of decomposed felspar, and occurred in fern-like arborescent patches, occasionally altering to radiating masses, the whole presenting a very peculiar and unique appearance. Much of the separated metal had the appearance of irregularly chopped hair, each fragment as seen under the microscope being covered with extremely minute recurved barbs. Scattered throughout the mass were also flaky plates of extreme tenuity, the surface of these being covered with sub-crystalline reticulated impressions.

At Stormont a peculiar filiform variety of gold has been obtained in small seams traversing a siliceous rock. It is found here also as facings of gold between thin leaves of quartz.

At Bell Mount the coarse nuggety gold, found in the wash at Bell Creek and in the detrital material within 3 feet of the surface on West Spur, occurs in pieces up to

(7) *Vide* W. F. Petterd: "Minerals of Tasmania," 1910, p. 84."

22 oz. in weight. The larger nuggets are described as being flat in shape, with one side smooth and the other jagged.

Gold is commonly found in pyrite veins, and also in hæmatite. It is also a primary constituent of the wolfram veins and the galena-chalcopyrite lodes.

Galena—sulphide of lead, PbS = lead 86·6, sulphur 13·4 = 100. Hardness is 2·5 to 2·75; specific gravity, 7·4 to 7·6. Crystallises in isometric system, usually in cubes and octahedra. Very rich argentiferous galena occurs in the Round Hill, Round Hill Extended, Thistle, and Wilmot Mines. It is found also at Murphet's and Blythe's prospects in small quantities.

Sphalerite—zinc blende, ZnS. Zn = 67, S = 33 = 100. Hardness is 3·5 – 4; specific gravity, 3·9 – 4·1; colour, yellow to black. Commonly found associated with galena at Round Hill, Round Hill Extended, Thistle, and Wilmot Mines. A pitch-black ferriferous variety occurs, with wolfram and molybdenite, in quartz veins at the Squib Mine.

Pyrite—iron pyrites, FeS_2. Iron 46·6, sulphur 53·4 = 100. Isometric—the common forms are cube and pyritohedron. Pyrite is the most widely distributed of all minerals in these areas, and is especially common as a constituent of the lodes.

About 2 chains west of the No. 2 Tunnel entrance, Round Hill Mine, a band 6 inches wide, replacing shale, is exposed in the road-cutting. The occurrence here is in oolitic form, the small detached globules being about 1 millimetre long. The globules are usually elliptical or oval-shaped, and appear to be the filling of the cast of some obscure organism.

Hæmatite—Fe_2O_3 = iron 70·0, oxygen 30·0 = 100. Hæmatite is widely distributed throughout these districts. In some places it occurs in considerable masses, and is a replacement product after conglomerate and shale. At the Powerful and Union Mines the specularite variety is very common.

Wad.—A hydrous oxide of manganese occurring in amorphous or reniform masses, either earthy, compact, or as incrusting stains. Usually very soft and loosely aggregated. The colour is dull to bluish or brownish-black. It is very widely distributed, and is derived either from wolfram or the decomposition of other manganese-bearing minerals.

Ferro-manganese is a compound mixture of iron and manganese oxides. It is brownish-black to dull black in colour, and is fairly hard (about 6). The specific gravity ranges from 4 – 5. It is found in large quantities on Oliver's Hill, and in lesser amounts throughout the district. Considerable quantities are reported from the north end of Mt. Claude.

Ilmenite—$FeTiO_3$ = iron 36·8, titanium 31·6, oxygen 31·6 = 100. Hardness, 5 – 6; specific gravity, 4·5 – 5; colour, iron-black. It is found in considerable amount near to and on Tin Spur.

Asbestos.—True asbestos is a fibrous form of actinolite (hornblende). The occurrence of asbestos near Knowles' farm, with epidote, in diabase rock is not extensive, and is economically unimportant. A considerable amount of quartz is encased in this asbestos.

Barytes—heavy spar, $BaSO_4$. BaO = 65·7, SO_3 = 34·3 = 100. Commonly occurs in tabular form. Colour, white; also inclining to yellow, grey, blue, and brown. Very pure white barytes has been discovered in porphyroid at several points on the north-west and west sides of Round Mountain. It occurs also at Alma, near Wilmot.

Satin Spar—$CaCO_3$. A fine fibrous variety of calcite, with a silky lustre. It is a constituent of the lodes at the S. and M. Mine. The normal form of calcite is of common occurrence throughout the districts.

Fluorspar—calcium fluoride, CaF_2 = calcium 51·1, fluorine 48·9 = 100. Chlorine is sometimes present. Hardness is 4; specific gravity, 3·0 – 3·2. Colour, white, green, purple, blue, and more rarely brown and red. This mineral is very abundantly developed, and is contained in the lode material and in the pegmatitic granites.

Tourmaline is complex borosilicate of aluminium and other bases. Colour usually green, brown, or black. Specific gravity, 2·98 – 3·2. Hardness, 7 – 7·5. Tourmaline is rarely found here—near the granite contact it occurs sparingly in the form of thin laths in porphyroid rock.

Epidote—$HCa_2\ (Al,\ Fe)_3,\ Si_3O_{13}$. This mineral has ordinarily a peculiar yellowish-green colour seldom found in other minerals, but this colour passes into black and brown shades. It is abundantly developed in these districts associated with quartz in veins, and also as an alteration product of limestone in large rock-masses. It occurs in columnar aggregates, and is commonly divergent and even radiating.

Garnet occurs here in two recognisable forms, andradite ($Ca_3Fe_2Si_3O_{12}$) and grossularite ($Ca_3Al_2Si_3O_{12}$). This mineral, with vesuvianite, epidote, diopside, and other lime-silicates, is very abundantly developed from impure calcareous rocks by local igneous metamorphic processes. Some of the richest ore-bodies of the Moina area are encased in garnet rock. The grossularite variety is commonly found in almost perfectly formed dodecahedra.

Gilbertite.—A variety of muscovite mica, occurring as a common constituent of the tin-tungsten-bismuth ore-bodies. It might correctly be termed a hydrated muscovite, and thus comes near the substance which has been named margarodite. It has usually a pale-yellow to greenish colour, but is sometimes found silver-white with a glimmering lustre. It is very soft (H = 1) and light (specific gravity, 2·65 to 2·72).

At the S and M., Princess, Squib, and other mines it occurs massive, with a dense to crystalline structure, filling cavities between the wolfram and cassiterite. Well-crystallised pyrite and bismuthinite are found embedded in it, although the bismuthinite in acicular form is more commonly found filling cavities in the gilbertite. A second variety occurs at the S. and M. Mine in stellate or spherical forms, and also in tabular crystals. This variety is a little harder (H = 3) and heavier (S.G. = 2·82). This mineral is of secondary origin.

Topaz—$Al_2SiO_4F_2$, with part of the fluorine commonly replaced by hydroxyl. Specific gravity, 3·56; hardness, 8; colour, white, yellow, greenish, bluish, and reddish. Topaz alters easily by hydration and by the action of percolating alkaline solutions, and is transformed into compact muscovite. At the S. and M. Mine a pale-green mineral, decomposing to soft, massive, olive-green material, forms a fair proportion of the vein-matrix.(8) This mineral, examined under the microscope, was found to consist of small crystals of topaz embedded in a soft, pale-green cryptocrystalline mineral, which possesses the properties of the compact varieties of muscovite. Topaz is very abundantly developed at Moina and Tin Spur. It occurs in clear well-formed crystals as a constituent of the lodes at the S. and M., All Nations, Squib, Sayer's, Princess, Premier, Hidden Treasure, and Lawson and Riley's Mines. On the Hidden Treasure, Premier, Princess, and Sayer's Mines the topaz is a most common component of the pegmatite granites.

(8) *Vide* W. H. Twelvetrees: "The Middlesex and Mt. Claude Mining Field," Tas. Geol. Surv. Bull. No. 14, p. 36.

Laumontite—$H_4CaAl_2Si_4O_{14} + 2H_2O$. A salmon-coloured zeolite not uncommonly noted in metalliferous veins. It is a secondary product, probably of felspar. Specific gravity, 2·25 – 2·36; hardness, 3 – 3·5; streak, white. This mineral occurs in masses of radiating crystals up to 3 millimetres in length, and in strings and threads throughout the lode material at the S. and M. Mine.

Chabazite.—A hydrous silicate of aluminium, sodium, and calcium of variable composition. A white zeolite very commonly found filling geodes in basaltic glass, especially abundant near Moina. This mineral is of secondary origin and is easily decomposed.

Beryl—$Gl_3Al_2(SiO_3)_6$. Has been found in the S. and M. lodes, and is highly developed in the main vein of Sayer's Mine. Here it appears in the form of pale bluish-green prismatic crystals up to ½-inch in diameter and 3 or 4 inches long, and is associated with wolfram. Beryl is essentially a pegmatitic mineral.

Chlorite.—Under this general name considerable numbers of minerals are embraced which are closely related to the micas. Chlorites are always secondary minerals, and may be derived by hydrothermal alteration from any one of a number of minerals. The most prominent occurrence of chlorite in these districts is at the Falls Mine, in association with garnet, from which it has probably been derived.

Actinolite.—A calcium-magnesium-iron-silicate. This is a variety of hornblende. It is a dark-green mineral found most abundantly on the roadside 2 miles south of Tin Spur in the form of radiating, bladed crystals. Actinolite under favourable conditions alters to asbestos.

(2)—The Mineral Deposits.

(*a*) *Periods of Mineralisation.*

There are believed to be two widely separated periods of mineralisation represented in this region. That in which the later granite and its apophyses were intruded is considered to have been the period of more intense mineralisation, and the greater number of the ore-deposits described in this report owe their origin to the after-effects of this intrusion. These ore-deposits are believed to be of Devonian age.

But there is undoubted evidence of a much earlier epoch of mineralisation probably contemporaneous with the intrusive members of the porphyroid formations. The information relating thereto gathered here is confirmatory of that obtained in other localities where there is no apparent relationship to the deposits of Devonian time. Such occurrences are the deposits of barytes at Mt. Roland, Alma, Beulah, Mt. Block, and Pinnacles Hills; of chalcopyrite and pyrite at Mt. Claude, North Pieman, and in the vicinity of Mt. Farrell; of specularite at the Powerful and Union Mines in the southern part of this region; and of the gold-bearing formations at certain points in these districts, and at Minnow and Beulah.

Incidentally it is worthy of note that the most extensive deposits of chalcopyrite, pyrite, galena, sphalerite, and barytes in the State are contained in schistose members of the porphyroid formations.

It must not be inferred from the foregoing statment that many of the deposits of these minerals are genetically related to the porphyroids, for in most instances they merely provide suitable loci for ore-deposits which are known to be of Devonian age.

(*b*) *Kinds of Deposits.*

There are many quite distinct kinds of ore-deposits within the boundaries of these districts. Nearly all of them have, in a greater or lesser degree, a genetic relationship to the intrusive granite and granite-porphyry outcropping in the central part of this area. It has been decided to divide them into groups according to their mineral content, and to subdivide them according to the nature of their occurrence. Thus the deposits are grouped in the following manner:—

(1) Tin-Tungsten-Bismuth-Molybdenum Deposits:
- (*a*) Pegmatite veins.
- (*b*) Quartz veins.
- (*c*) Placer or alluvial deposits.

(2) Silver-Lead-Copper Deposits:
- (*a*) Fissure veins.
- (*b*) Disseminated deposits.

(3) Gold Deposits:
- (*a*) Pyritiferous veins.
- (*b*) Alluvial deposits.

(4) Barytes Deposits.

(5) Iron and Manganese Deposits.

(6) Asbestos Deposits.

(1) *Tin-Tungsten-Bismuth-Molybdenum Deposits.*—These metals are usually found in the same lode, and are genetically associated with the intrusive granite, but they occur in deposits of a wide range. Ores of these metals are contained in quartzites and garnet-epidote rocks within the zone of metamorphism, and also in the pegmatitic, aplitic, and greisen modifications of granite.

(*a*) Pegmatite veins contain many of the most important deposits in this area. They are coarsely crystallised granitic rocks, occuring in vein form, and are regarded as the last crystallisations of the granite magma. In addition to felspar, quartz, and muscovite, they contain here topaz, fluorspar, beryl, monazite, &c., in varying amounts. The pegmatitic material in liquid or in gaseous form has circulated through fractures in the granitic mass or into fissures in the quartzite, conglomerate, and garnet formations forming the cover into which the granite has intruded, and has deposited therein the metallic compounds held in solution. Pegmatite lodes occur on the Dolcoath, Sayer's, Squib, Princess, Premier, and Hidden Treasure properties.

(*b*) Quartz veins closely allied to pegmatites are perhaps the most important sources of the ores of these metals. They are sometimes found in the granite and granite-porphyry country rock, but more commonly they traverse quartzites and garnet rocks. The gangue is chiefly quartz, fluorspar, topaz, and gilbertite, with pyrite, chalcopyrite, calcite, arsenopyrite, and gold as common associates. The best examples of veins of this kind are found at the S. and M., All Nations, and Squib Mines.

(*c*) Alluvial Deposits.—Owing to the rugged nature of the country, the high gradients of the streams, and the narrow steep-walled valleys, the accumulations of alluvial material are not extensive. Most of the placer deposits operated here occur on the plateau high above the present drainage level. These deposits are made up of detrital material derived from the disintegration of surface outcrops, most of the tinstone and wolfram being set free. Wolfram is too soft and brittle to resist for long the abrasive action of transporting water, and is therefore not likely to be found in appreciable quantity in true placer deposits. The most notable deposits of this kind are on the Iris property, where wolfram, bismutite, and tinstone are recovered by sluicing; at the All Nations similar deposits occur, and are being profitably worked. Tinstone occurs with gold at Bell Mount. The bottom of the Forth Valley at Wilmot bridge is nearly ¼-mile wide, the rate of

flow of the water has become much less, and consequently conditions have been favourable for the accumulation of placer deposits. These prospects have been tested by means of shallow shafts, none of which, it is reported, reached bottom. It has not been possible to ascertain what values were obtained in these operations. The ores of economic value most likely to be found here are tinstone and gold, with only a little wolfram and bismuthinite. On York's section the remains of an old river terrace, 10 feet deep, carries payable tinstone. The deep leads of the S. and M. are not large, but portion of the wash could be operated profitably.

(2) *Silver-Lead-Copper Deposits.*—(*a*) Fissure Veins: Argentiferous galena-chalcopyrite ore occurs in veins and fractures in the anticlinal and synclinal folds at Round Hill, and at Wilmot Valley, near Bell Mount, and as cross-fractures in sandstone at the Thistle, Union, and other mines in the vicinity of Lorinna.

Some crystals of galena with octahedral habit have been found as mineral rarities in the S. and M. lodes.

The silver content of the lead ores in the district is variable. A range has been observed from ½-oz. to 10 oz. of silver per unit of lead, the higher ratios being yielded by ore verging on fahlore. The gold content ranges from a trace up to 25 dwt. per ton.

At the Round Hill Mine the copper content varies from a trace to 6 per cent.

(*b*) Disseminated Deposits: These consist of unimportant irregular deposits in schistose porphyroid. They are probably contemporaneous with the rock in which they are contained.

(3) *Gold Deposits.*—The most notable features of the gold-bearing deposits of the Middlesex and Mt. Claude districts are the very wide distribution and the extraordinary association of gold with ores which, although genetically related, have been deposited under entirely different conditions. For instance: gold occurs in wolfram-molybdenite-cassiterite-bismuthinite veins contained in garnet rock and quartzite at the S. and M. Mine; in similar veins contained in granite at the Squib Mine; at the Narrawa Reward it is a constituent of the galena-chalcopyrite-arsenopyrite lode occurring at the contact of quartz-porphyry and quartzite; at the Round Hill and Wilmot Mines this component is in such quantity that it adds appreciable value to the galena-chalcopyrite-siderite ore; gold occurs

also in the tubicolar sandstone and shale beds at the Golden Hill, Thistle, and other mines in their vicinity. The constant association of ferro-manganese ore with these deposits is another most striking feature.

(*a*) Pyritiferous Veins.—Much of the free gold met with throughout these districts is, in all probability, derived from the decomposition of sulphidic ores, particularly pyrites. Gold-bearing pyrites veins occur at the Devonport gold mines, the Lea River, and Golden Cliff Mines, near Black Bluff. Similar veins occur in several mines at Lorinna. At the Devonian Mine, vein gold occurs in kaolin. In each of the cases mentioned the pyrite was deposited later than the quartz upon which it is often found. Cellular quartz and friable sandstone have provided suitable loci for the deposition of gold-bearing pyrites. These pyritic veins are very small, rarely exceeding 6 inches in width.

Gold-and-silver-bearing wolfram veins are very commonly found here. This widespread association of tungsten with gold is remarkably evident, and is being emphasised as each wolfram discovery is made. The gold is almost invariably found as a primary mineral in wolfram veins, but there is indisputable evidence that the larger concentrations of gold in this region are the result of secondary enrichment. Thus the wire-like and dendritic forms occurring at Campbell's Reward and Stormont, the large nuggets found at Bell Mount, and the crystallised forms occasionally met with are the result of secondary deposition.

Genesis: An understanding of the genesis of the gold so widely distributed, and in some parts in comparatively large concentrations, is of the greatest importance in connection with the future development of the deposits. It is believed that the large concentrations, which are known to be of secondary origin, have been effected by the agency of solutions containing manganese. An explanation of the manner in which manganese assists the dissolution and re-deposition of gold is contained in the following paragraphs:—

([9]) Ferric iron, cupric copper, and manganitic manganese are present in many mineral waters, and under certain conditions any one of them will liberate chlorine from sodium chloride in acid solutions. Nascent chlorine dissolves gold. Each of these compounds will thus release chlorine at high temperatures, and at low temperatures in concentrated solutions. It has been proved that those auriferous deposits, the gangues of which contain manganese, show the effects of the solution and migration of gold more clearly than the non-manganiferous ores.

([9]) *Vide* W. H. Emmons: "Manganese and Gold Enrichment," Trans. Am. Inst. M.E., Nov., 1910.

Gold thus dissolved is precipitated by ferrous sulphate. It is therefore natural to suppose that gold in such solutions could not migrate far through rocks containing pyrite, since it would be quickly precipitated by the ferrous sulphate produced through the action of the air, oxidising waters, or the gold solution itself upon the pyrite. But the dioxide and higher oxides of manganese react immediately on ferrous sulphate, converting it to ferric sulphate, which is not a precipitant of gold. Consequently manganese is not only favourable to the solution of gold in cold, dilute mineral waters, but it also inhibits the precipitating action of ferrous salts, and thus permits the gold to travel further before final deposition.

These statements apply to the action of surface-waters descending through the upper parts of an auriferous ore-deposit, since such waters are cold, dilute, acid (*i.e.* oxidising) solutions. In deeper zones, where they attack other minerals, they lose acidity until the manganese compounds, stable under oxidising conditions, are precipitated together with the gold. Thus manganite, as well as limonite and kaolin, is frequently found in secondary gold ores.

Manganese acts as a catalyser, that is, it promotes the combination of gold and chlorine, but does not enter into the composition of the resulting compound. Catalysis can, perhaps, offer an explanation of the constant association of gold with tungsten ores. In almost every lode in this locality gold accompanies wolfram, and is a primary constituent. This association of gold with tungsten ores has been frequently observed in other countries, not only with wolfram, but also with scheelite.

(*b*) Alluvial Deposits.—All the main alluvial deposits, with the exception of the Bell Mount goldfield, which is discussed in another chapter, occur in the valley of the Forth River. The location of gold at Lorinna in the early sixties by the well-known explorer, the late James Smith, was the first record of the occurrence of metallic minerals in these districts. Futile attempts have been made from time to time to prospect the river-wash here, the last having been made five years ago by S. Bishop, who, encased in a diving suit, endeavoured to reach bottom. The object of this test was to determine whether the wash could be worked by means of a dredge. It was found that the boulders were far too heavy to allow of economical exploitation.

At Golden Point, two miles farther down the stream, very fair prospects were obtained, but many difficulties have been encountered in working the deposits here.

The Forth River Valley is so deep, and the sides so steep, that the catchment areas are only of very small size, and only remnants of the older terraces exist now on this steep-walled valley. Near Wilmot bridge the river widens and the gradient becomes much less, providing conditions under which alluvial material could accumulate. The wash is probably not more than 20 feet deep, and extends over only 40 acres, but this ground is worthy of careful investigation. The whole area could be bored with a hand-drilling plant, the only obstacle being the quantity of large boulders in the wash.

[(4) Barytes Deposits, (5) Iron and Manganese Deposits, and (6) Asbestos Deposit are described in a later chapter.]

(c) *Source of Mineralising Solutions.*

The close connection which exists between the tin-tungsten deposits and the granitic intrusives, and the relationship also of these deposits to those of other metals generally farther removed, but occurring within the zone of contact-metamorphism, point to the granite magma as the ultimate source of all the metals occurring in the vicinity. This granite magma was intruded into the overlying strata in two stages. The first part is that which now forms the bulk of the biotite granite and quartz-porphyry between Dolcoath Hill and Five-mile Rise. The magma left was considerably more acid in composition, and was intruded into the fissures in the partly cooled, older granite, and into the adjacent sedimentary rocks. This acid extract of the original magma was rich in mineralising gases and solutions. The extraction and collection of the lode minerals is attributed to the action of the fluxes and solvents which emanated from the granite magma. The process of formation of minerals by the reaction of gases and vapours upon one another is termed pneumatolysis, and that resulting from the solvent action

of liquids is termed hydatogenesis. The association of such minerals as cassiterite, wolfram, molybdenite, bismuthinite, topaz, fluorspar, &c., is indicative of the pneumatolytic or deep vein zone, and that of galena, chalcopyrite, sphalerite, &c., is generally considered as indicative of the hydatogenetic zone.

The foremost agent in the dissolution of tin, tungsten, boron, &c., is fluorine, which directly combines with these elements forming fluorides. Chlorine in the form of hydrochloric acid also plays an important part in the extraction of metallic elements from the magma, and their concentration in veins. Many of these mineralisers acted as catalysers, that is, they promoted combination, but did not necessarily enter into the composition of the resulting mineral. Catalytic action was largely responsible for the influence of such mineralisers as fluorides, chlorides, tungstates, borates, manganates, &c., in the formation of the deposits.

In addition to the mineralisers already mentioned, it is probable that sulphides, which are particularly abundant in this region, played a most important part as carriers of metallic minerals.

The mineralising gases and solutions attack the walls of the fissures, replacing the felspar constituent of the granite by fluorides, tin oxides, iron oxides, silica, and alumina, &c. Such action results in the formation of greisen, which for a few inches on both sides of the lodes occasionally carries wolfram, cassiterite, molybdenite, and bismuthinite.

These mineralising gases did not all remain in the later acidic magma until after the intrusion, but escaped, before the consolidation of the igneous mass, into the adjacent metamorphosed sediments. The greater portion of the tin, wolfram, bismuthinite, and molybdenite ores is consequently found filling fissures in these rocks. On the other hand, not all the magmas intruded in the fissures contained mineralising gases and solutions in quantity, so that many quartz veins occur which are almost unmineralised. Examples of this type of quartz vein are those occurring in quartz-porphyry on the Iris property.

(d) *Nature of the Ore-deposits.*

In these districts contact-metamorphic deposits are the most extensive. They consist of: (1) Quartz veins, carrying tin, tungsten, molybdenum, and bismuth ores, with the accessory minerals, gold, pyrite, arsenopyrite, sphalerite, chalcopyrite, and monazite in lesser amounts, and associated with fluorspar, topaz, beryl, laumontite, calcite, &c. (2) Galena-chalcopyrite ore-bodies contained in fractures in quartzite rock. (3) Gold-pyrite veins in sandstone. The deposits occur as fissure fillings, impregnations in quartzite, or as replacements, and all are contained in garnet rock or in quartzite, or in both.

The ores of tin, tungsten, bismuth, and molybdenum occur near the intrusive rock, and in some cases in the granite, while the greater part of the more soluble constituents, such as sulphides of iron, copper, lead, and zinc, remain in solution until a zone of lower temperature and pressure is reached. Here is a splendid illustration of the zonal distribution of ores. Cassiterite and wolfram occur also in pegmatitic veins, which are particularly rich in pneumatolytic minerals, especially those containing fluorine and boron. These minerals are also found in stockworks, which consists of masses of rock traversed by numbers of small veins. Such a group of fissures, with the intervening granite altered to greisen, and impregnated with ore, is that exposed in the open-cut workings of the Squib Mine. Although in general not a contact-metamorphic mineral, cassiterite occurs in far greater abundance associated with wolfram, molybdenite, and bismuthinite in quartz veins contained in garnet and quartzite rocks, very little having been found in the granite. At Tin Spur the tinstone occurs in soft, friable sandstone, and is free from wolfram, which is found in pegmatitic veins in the granite outcropping 10 chains southward. It is remarkable that the sandstones in which the tin ore is contained show very little alteration, while a few yards away from the lodes they have been transformed into hard, glassy quartzites, impregnated with pyrite.

Molybdenite, wolfram, and bismuthinite are found equally in igneous and metamorphosed sedimentary rocks, deposition being in the order named. Molybdenite occurs also scattered through the massive granite in joint planes and cracks, and at the point of contact between granite and the invaded rock. South of the Premier Mine it is found in porphyroid (felspar porphyry), near the point of contact with granite. Wolfram and bismuthinite and bismuth are almost invariably closely associated, having been deposited contemporaneously and under like conditions. It has been constantly observed that bismuth ores are more prominent near the surface, this component

of the lodes decreasing rapidly in amount from a depth of 100 feet. Inclusions of bismuthinite in quartz crystal are commonly noted; it is found also in garnet rock at the S. and M. Mine, some distance away from the lodes, and it is a constituent of the galena-chalcopyrite ore of the Round Hill Mines, thus showing a wide range of occurrence.

Fluorine in one form or another invariably accompanies tinstone and wolfram. It is usually found in the forms of flourspar and topaz, which occur here in great abundance as constituents of the lodes, and also of the pegmatitic rocks in which they are contained. Muscovite is remarkable by its absence, excepting where pneumatolytic action has taken place. The variety gilbertite, a secondary mineral, is a common constituent of the lodes, especially those contained in the metamorphic rocks A lithia-bearing mica (lepidolite) is found accompanying the ores in pegmatite veins.

The exact relationship of boron in the formation of tin deposits is not definitely established. In this locality, tourmaline, a boron mineral, and common associate of tin deposits, is not developed near the ore-bodies, but it occurs, although very sparingly, in the form of thin laths as an accessory component of the quartz-porphyry marginal rock. The absence of tourmaline is offset to some extent by the presence of boron-bearing vesuvianite in the metamorphosed limestone rock in considerable amount.

The major portion of the tinstone, wolfram, bismuthinite, and molybdenite components of the lodes occur on the walls, the central part being made up largely of quartz. These ores in their quartz matrix are found strongly adhering to the walls, showing that at the time of their deposition the temperature of the inclosing rock had been raised approximately equal to that of the ore-bearing solutions. The narrow veins carry considerably higher percentages than do the wide ones. The reason for this is that the solutions coming into contact with the slightly colder rock deposited their metallic contents first, and in the inverse order of their solubility.

In some instances there were two slightly separated periods of deposition, as evidenced by a second occurrence of ore separated from the first by almost barren quartz. Under normal conditions not all the metallic content was deposited at one time, for irregular masses of wolfram and bismuthinite occur toward the middle part of the lodes. There is a tendency towards the concentration of ore in shoots, separated by almost barren lode material. Such conditions have been observed at the All Nations Mine.

(e) *The Structure of the Lodes.*

In general, the lodes of the Middlesex and Mt. Claude districts are fissure veins. Those that are not simple fissure fillings have been formed partly by hydrothermal metasomatic replacement of the inclosing rock, and partly by deposition along the limbs and crowns of anticlinal folds. Although there is considerable variation in the type of fissure, the veins generally have a tabular form.

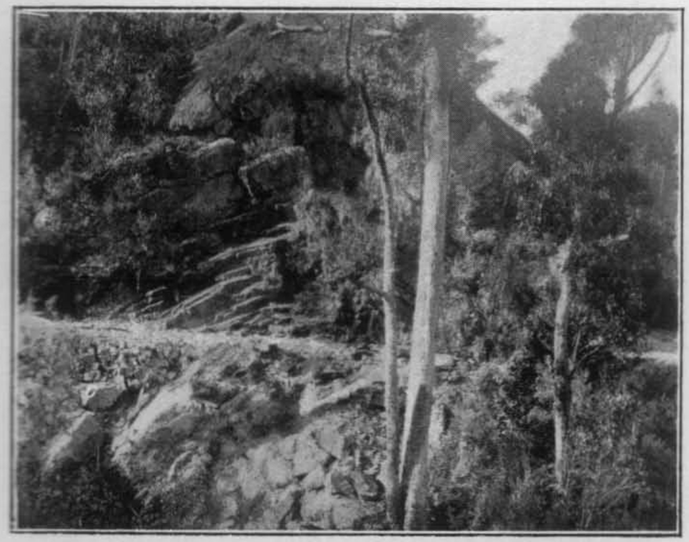
At Moina the fissures in the garnet and quartzite rocks are remarkably regular and continuous, although they split up in the quartzite in the east end. These parallel fissures are probably continuous also into the underlying granites, which cannot be far below. Near the west bank of Forth River, and at Tin Spur, they occur in granite, and represent contraction planes formed during the cooling and consolidation of the magma. These fissures, like those contained in the metamorphosed sedimentary rocks, are very narrow (from 3 inches to 2 feet wide), and are remarkably continuous. Faulting prior to ore-deposition is very common, especially in the fissures near Moina. At the S. and M. Mine step-faulting near the present surface is seen, and at the main and lowest levels faults showing both a lateral and vertical displacement are met with. The lodes of the All Nations Mine show similar faulting movements.

The sulphidic gold-bearing lodes at Five-mile Rise occur at or near the junction of quartzites and quartz-porphyries, and differ in this respect from most other lodes in these districts.

At the Round Hill and neighbouring mines the ores are contained in folded quartzites and shales. At the apices of the anticlines, where deposition has been greatest, they are sharply pointed and crushed, showing that the beds were incompetent to withstand the load without interior adjustment. Both flowage and fracture-folding effects are developed here. Evidence of flowage is apparent in the shale bands, and of fracture-folding in the more composite quartzite beds. Conditions were suitable here for the deposition of ore in the crushed shaly rock, while the quartzites provide space only between bulged bedding-planes. Pre-mineral faulting on a large scale is a particular feature of this locality.

[*A. M. Reid Photo.*

Photo. No. III.—Brazen Nose Mountain. West Coast Range Conglomerate Overlying Folded Tubicolar Sandstone.



[*A. M. Reid Photo.*

Photo. No. III.—Anticlinal Folding of Quartzite Strata, Round Hill Mine.

(*f*) *The Effects of Oxidation.*

The zone of oxidation of the lodes is so very shallow that in almost all cases unaltered sulphides are encountered within a few feet of the surface. The rate of oxidation does not greatly exceed that of erosion, and the alteration has only appreciably affected the ores near the surface. At the Five-mile Rise the ores in lodes contained between the dissimilar rocks, quartz-porphyry and sandstone, have become oxidised below the deepest level (150 feet). The oxidation of these gold-bearing sulphidic ores has brought about secondary enrichment near the surface.

In some cases the lodes are capped by limonite, due to the oxidation of pyrite and chalcopyrite, in others ferro-manganese oxides are more prominent. Other effects of oxidation are the decomposition of wolfram, resulting in the formation of tungstite and ferritungstite, and of bismuthinite, which has been transformed into bismutite. Molybdenite also has been affected, the resulting mineral, molybdite, being formed by the addition also of iron oxide, probably derived from limonite.

(*g*) *Selvage and Breccia.*

In nearly all the lodes selvage is developed on the walls to a greater or lesser extent, and is indicative of considerable movement along the fissure planes. It consists of finely-ground wall-rock, produced by differential movement of the walls on one another. This finely-ground material has suffered chemical change by the action of mineral-bearing waters circulating along the channel thus formed. In the galena lodes of the Round Hill area it carries in some places high values in silver and gold. This is remarkably evident in the Round Hill Mine, where galena ore near the walls and selvage on the walls contain up to 930 oz. of silver per ton. The selvage at the Round Hill Mine occurs also on flowage faults, and between the bedding-planes on fracture-folds.

Fissures in some instances show movement, both prior and subsequent to the introduction of the vein material. At the Round Hill Mine brecciated material, 3 to 10 feet thick, made up of well-rounded crushed particles of quartzite, occurs between the conglomerate and quartzite rock. This brecciated vein-material and wall-rock has been cemented by metallic sulphides. The faulted condition of the veins is common to all the ore-bodies, but is more highly developed at Moina. In the S. and M. Mine there has been movement both prior and subsequent to ore-deposition.

(h) Erosion of the Ore-bodies.

There has been relatively little erosion of the ore-bodies. This has been due in some measure to the protective capping of hard conglomerates (West Coast Range series) covering the porphyroid rocks containing the ore-bodies. But if, as is surmised, there was an earlier period of mineralisation contemporaneous with the porphyroids, these ore-bodies will have suffered the effects of erosion prior to the formation of the conglomerates. In those cases where the ores are contained in tubicolar sandstones and conglomerates, protection has been afforded to a certain extent by the basaltic covering, but these also must have been greatly reduced during the period extending from the time of their formation to the extrusion of the basalt. These sandstones and conglomerates are hard, highly-resistant rocks, and have been able to withstand the effects of erosion to a considerable extent. The full effects of this erosion are impossible of determination. The lodes contained in granite have suffered to the extent of the removal of the tubicolar strata, through which presumably they penetrated, and in a greater degree by the dissection of the granite rock in the valley of the Forth River. Generally, the present outcrop of the granite and quartz-porphyry may be regarded as the original crown of these intrusive rocks. Tubicolar sandstone and conglomerate in many places are still found overlying the granitic rocks, and the porphyry a little southward contains numerous fragments of conglomerate and sandstone embedded in its mass; so much so, that the weathered surface may be mistaken for that of a conglomerate or breccia. This shows that the porphyry has suffered very little denudation.

(i) Strikes and Dips.

The greater number of the fissures strike in a general direction parallel to the axes of the anticlinal folds in the sedimentary strata and those of the master-planes of the granite, but some contained in the garnet and quartzite metamorphic rocks do not conform to this rule. They strike due east and west, and dip south.

The general strike of the fissures and of the axes of the anticlines is 50 to 60 degrees west of north, and the dip is south-westerly, the angle of inclination being 30 to 45 degrees. The master-planes of the granite have a general trend in a direction north 55 degrees west; the dip is south-westward at 50 degrees. On the Princess property a vein in the granite courses nearly east and west, the tendency being a little north of west.

VIII.—MINE DEVELOPMENT.

Those responsible for the early development of many of the mines have failed to appreciate the peculiar structure of the geological formations encountered here, consequently many mining companies have little to show for the heavy expenditure incurred. In some instances companies were formed for the purpose of carrying out operations on sections which were pegged in alignment with ore-bodies existing on neighbouring properties, on the supposition that the ore-bodies would be continuous and pass into them. At the time of the gold-mining boom in this locality metallurgical plants for the treatment of the ores were erected before they were warranted by developed ore reserves. Plants were erected even on the supposition that the gold content and the size of the veins would increase with depth; in other cases this procedure was followed for purely speculative purposes. This policy, naturally, has had a ruinous effect on the mining industry, the direct result being the abandonment of the fields before extensive developmental work had been carried out. It is commonly, but erroneously, held that the installation of metallurgical plants during the early stages of development enables the company operating the mine to derive revenue from the ore recovered in the exploratory work, thereby increasing the amount of capital required to place the enterprise on a profitable footing. In addition to the outlay on machinery it is frequently the practice to erect extensive buildings preparatory to the greater exploitation of the ore-bodies before their value has been determined. An important advantage in applying all expenditures at the beginning of operations to exploration underground is that the mine may be abandoned at any stage of development without incurring undue loss. Except under unusual circumstances, mining development should always precede surface expenditure. Nowadays it is the object of all reputable mining engineers to eliminate, as far as possible, the element of chance from any mining undertaking, and consider the proposition from a purely business point of view.

(A)—Tin, Tungsten, Bismuth, and Molybdenum Mines.

(1)—*The S. and M. Syndicate Limited—Section* 3849-M, 397 *Acres.*

(*a*) Area, Situation, &c.

The lodes on this property were discovered in 1893 by Thos. Shepherd and Thos. Murphy, in honour of whom the original company operating here was named. This is usually regarded by prospectors and others as the pioneer mine of the district, and is referred to by residents generally as the "Bismuth Mine." This latter appellation has been applied in consequence of the predominance of bismuth ores in the upper workings. It is the largest mine in the district, and has been in continuous operation for many years.

The several sections comprising the holdings of this syndicate have now been consolidated into one lease of 397 acres, No. 3849-M, south of and adjoining the boundary of Moina township.

(*b*) Access.

Access is had from Sheffield by means of a well-formed public road, which junctions with that from Middlesex Estate just outside the northern boundary of Moina township. At Sheffield, which is 22½ miles distant, the road connects with the Staverton branch railway from Railton junction. The cost of transporting material over this hilly road is heavy; however, it is much less than that obtaining in 1898, when the carriage of ordinary mine supplies from Sheffield to the S. and M. Mine cost £7 per ton.

(*c*) General Features.

The property occupies high ground forming the eastern boundary of Iris Valley. In Tertiary time the Iris River must have been one, even then, of some magnitude, for deep leads have been discovered under the basaltic rocks covering a considerable portion of the surface. Cliffs of solid basalt occur in Bismuth Creek, on the road-side near the bridge, and apparently occupy portion of the deep lead exposed in the underground workings. This is 500 feet below the basalt-covered plateau between the Iris and Forth Rivers. The present channel of the Iris River, it is evident, closely follows the course of the old stream, but it has cut through the basalt obstruction, and is now deeply entrenched in the sedimentary rocks. From Iris River up to the S. and M. Mine the ground slopes very gently, but it increases rapidly from this point towards the east and south-east. About two-thirds of the surface is occupied by basaltic rocks or soils, while the greater part of the remaining portion consists of sedimentary strata, and, over a small area inside the eastern boundary, quartz-porphyry outcrops. In some places the basalt covering is very thin, only a few feet deep; in others it is fully 100 feet deep. On the plateau and the upper portions of the valley this rock is tuffaceous and glassy.

The older strata consist chiefly of tubicolar sandstone or quartzite and garnet rock. Both of these are metamorphic rocks, the former an alteration product of sandstone, and the latter of limestone. This metamorphism is due to the action of heated vapours arising from the granitic magma during the process of cooling and consolidation. The garnet rock consists chiefly of garnet, epidote, pyroxene, and magnetite, with vesuvianite, fluorite, and other compounds in subordinate amounts. In the mine the quartzite rock has an approximately north-south strike, and a dip from 30 to 45 degrees to the west, thus varying considerably from the general trend of the strata in the neighbourhood, which is from 40 to 60 degrees west of north. The garnet rock overlying the quartzite in the mine is largely made up of garnet and pyroxene. It is black through admixed magnetite, but at some distance from the lode it resumes its normal yellowish-brown colour. Similar rock occurs again west of the Iris River, up the hill, south-west from the bridge. Almost due west of the mine, on A. R. Robertson's block, the Iris River cuts through a large mass of epidote, which extends for ½-mile in a north-west-south-east direction. A similar rock outcrops on the main-road between Moina and Bell Mount, and due east of this towards the Narrawa Reward Mine another outcrop occurs. It is worthy of note that up to the present time no ore-bodies have been found in the epidote rock.

Between the Iris River and the mine, unaltered limestone occupies the surface. This is an extraordinary occurrence, for the effects of metamorphic action are apparent in the surrounding formations. A small area of garnet rock occurs east of Bismuth Creek, just opposite the entrance to No. 4 creek drive. Its course is north-west,

parallel to the fault-line, which extends south-eastward up Bismuth Creek Valley.

Near the south-east corner quartz-porphyry is exposed by the removal of the overlying tubicolar strata. About ½-mile southward of the mine, white kaolin (evidently derived from felspar-porphyry) is cut in the water-race. These are the only known outcrops, but it is certain that the granitic rocks extend westwards at no great depth underneath the sedimentary strata.

(*d*) The Ore-bodies.

At least seven mineral lodes traverse the lease, roughly parallel to one another, in an approximately east-west direction. The country-rock in which they are contained is quartzite in the eastern portion of the mine, and garnet-rock in the western. These lodes are essentially quartz-fillings of fissures traversing quartzite and garnet-rock alike in a direction roughly at right-angles to their strike. They are remarkable for their continuity, for their uniformity, and for their complexity of composition. Some of them have been proved to extend in a more or less straight line over 1200 feet; and at No. 3 Level, 300 feet below the surface, their size and value remain constant. Lodes 2, 4, and 6 are the most important, and have provided almost the whole of the crude ore sent to the concentrating plant. The mineral contents have not varied greatly with increased depth, excepting that bismuth ores are far more abundant near the surface. The ores do not occur in shoots, as in some of the neighbouring mines, but in blebs and bunches fairly evenly distributed in the quartz gangue material throughout the length and depth of the lodes; nor does the ore vary greatly with the size of the vein, for the larger portion occurs on or near the walls, and was deposited before the bulk of the gangue minerals. In general, the lodes have not sharply defined partings, but adhere strongly to the wall-rock, showing that it was intensely hot at the time of ore-deposition. Mineralisation of the wall-rock is not uncommon, and bismuthinite has been found a considerable distance therefrom. Selvage is seen only near the faults in the lodes, showing that movement took place subsequent as well as prior to ore-deposition. Faulting is common, but of only minor magnitude, and does not adversely affect the exploitation of the lodes. Both vertical and horizontal faulting have taken place, the dip being about

45 degrees north. Near the surface on No. 6 lode step-faulting has been observed. The displacements never exceed 10 feet, and the continuation of the lodes is picked up without difficulty. Faulting took place prior to ore-deposition, but in certain portions of the mine brecciation of the ore shows evidence of subsequent movement. In the garnet-rock the lodes are much more uniform than in the quartzite, and the richest bonanzas occur therein. In the latter rocks the lode splits up into a number of veinlets, enclosing horses of quartzite, and reunites further on. Comb structure is commonly noted, and cavities in the lodes show wonderful development of quartz crystal growth.

The dominant mineral components of economic value are wolfram, cassiterite, bismutite, and bismuthinite. They exist in the following proportions:—

Cassiterite, 20; wolfram, 12; bismuthinite, 3.

Others occurring in subordinate amounts are bismuth, molybdenite, scheelite, gold, chalcopyrite, pyrite, arsenopyrite, galena, monazite, and limonite. Accessory mineral constituents are quartz, topaz, massive muscovite (pinite), gilbertite, fluorspar, calcite, satin spar, beryl, and laumontite. Quartz is the predominant gangue mineral, followed by fluorspar, topaz, pinite, and beryl. These minerals are associated in a heterogeneous manner, and loosely aggregated, and in some cases highly developed.

The presence of topaz, or altered topaz, is generally indicative of a high cassiterite and wolfram content. Cassiterite here is black in colour, and possesses a brilliant lustre. It is always coarsely crystallised, and fully 70 per cent. is contained free from adhering quartz in the finer broken material. Wolfram occurs usually as shapeless individuals embedded in the quartz gangue material, but also in large masses in the quartz and on the walls. Wolfram, with scheelite attached, has been found in No. 2 lode, contained in quartzite at a point 500 feet east from its junction with garnet. Scheelite has also been detected in the ore from No. 6 lode, and from the north-west branch lode at No. 3 adit level and No. 2 level. It is evident that it occurs here as an alteration product of wolfram. Its presence in increasing quantity is unlikely, and need not cause anxiety. Molybdenite is fairly abundant in portions of the No. 4 lode in close association with wolfram, while in other parts of the mine this mineral is not at all common. The bismuth content is greatest within 100 feet of the surface;

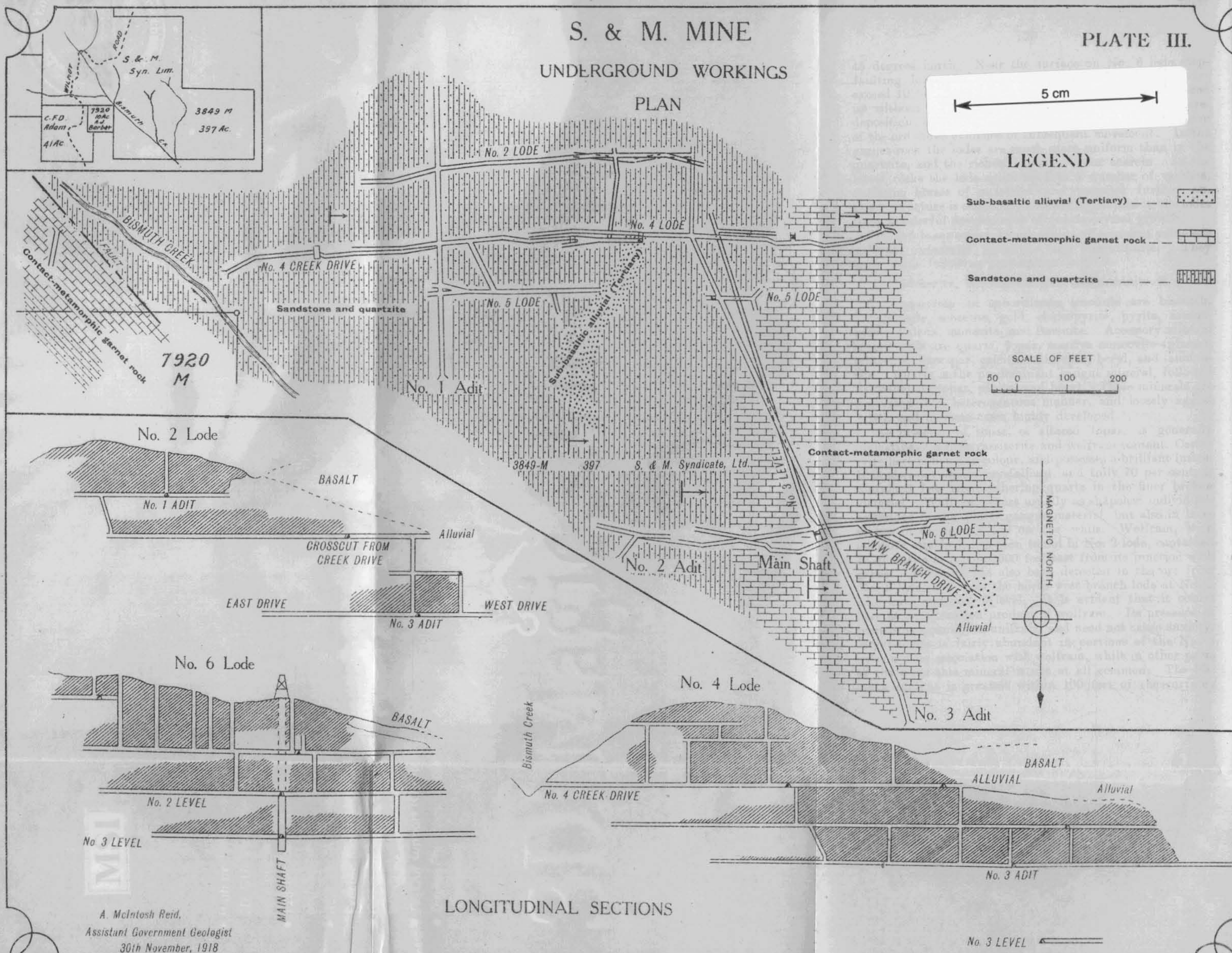


Photo Algraphed by John Vail Government Printer Hobart Tasmania.

below that depth bismuth and bismutite are rarely found, but bismuthinite is fairly abundant in the lodes, with the exception of No. 6, at all levels. It was deposited later than most of the minerals, and is commonly found in the acicular form filling cavities in gilbertite. Perfectly crystallised transparent quartz, enclosing bismuthinite, is not infrequently found, and specimens of pyrite encasing this mineral have been observed. The rest of the metallic minerals are not of much importance, occurring generally in insignificant quantity. Quartz, fluorspar, topaz, and massive muscovite (altered topaz) comprise the bulk of the ore-body, and were deposited early from solution; gilbertite followed with the later metallic minerals; and laumontite, a reddish zeolitic mineral, is considered to have been introduced into the lode-channels by infiltration from the basaltic covering. This mineral has filled every fracture and crevice in the lode material.

(e) Development.

The nature and extent of these ore-deposits have been investigated at a number of points on the surface by open-cuts and trenches, at a depth of 150 feet by long drives, and at 250 feet by a shaft. The underground works are very extensive, and have been the means of developing large quantities of rich ore, which has been profitably exploited for 12 years. Operations are now confined almost exclusively to lodes 2, 4, 6, and the north-west branch ore-body.

The natural conditions are not altogether favourable for economic development by means of tunnels, as the lay of the surface here is rather flat, and long crosscuts are necessary to intersect the ore-bodies. The No. 3 adit (which is the lowest level) is only 250 to 280 feet below the surface, where it intersects No. 2 lode at 1300 feet from the entrance.

It has been found convenient to operate below this level by means of a shaft (of three compartments, each 4 feet by 4 feet), connected with the surface. All future developmental work will be operated from this shaft.

No. 1 Adit.—This intersects No. 5, No. 4, and No. 2 lodes in their westerly extensions.

No. 5 Lode.—Divided lodes have been driven on 21 feet and 30 feet east, and at 44 feet west both branches unite and form one lode. The width of each vein before uniting was about 7 or 8 inches, and the combined width after junctioning was 15 to 20 inches. Above this length of driving the lode has been stoped to surface. It has been driven on for 200 feet west, averaging 10 inches in width, beyond the crosscut from the creek drive. In the face 4 or 5 inches of veinstuff is on the north side of drive, with another inch on the outside edge; on the south side is some micaceous veinstuff. The country-rock is still quartzite. All has been stoped out above, and alluvial wash is very close to this face. At about 90 feet west of the crosscut, and 40 feet above the level, alluvial drift was met with in the form of a terrace, 35 or 40 feet below the surface. This terrace is distinct from the main sub-basaltic valley-drift further west.

No. 4 lode has been driven on in this adit for 170 feet east and 170 feet west, and has been stoped out above this to surface.

No. 2 lode has been driven on east for 163 feet, and west for 63 feet. It has been worked out in stopes above the level, and runs out west into shallow ground. Eastwards it divided, and became irregular. Its aggregate width was from 8 to 10 inches. The values in concentrates are not so high from this lode as from some of the others, but it carries higher bismuth contents.

No. 4 Creek Drive.—No. 4 Lode.—The drive east starts on a branch vein, but at about 90 feet in, the main portion of the No. 4 lode is met with, which has been driven on to 800 feet, when alluvial wash appeared over the roof of the level. The wash dipped westwards gradually for 57 feet along the drive, until the whole face was in wash-dirt. The wash is of good quality, lying below layers of bedded quartz-topaz sand, which contains a little monazite. The wash is mainly tin-bearing, but bismuthinite, wolfram, and gold are present in small quantities. The sand itself is poor. Pieces of black coniferous timber lie in the wash. The workable gravel forms a bed 1 foot thick, above which is sandy drift of no value for 4 or 5 feet below the covering of basalt.

The lode has been stoped to the upper workings and surface for a length of over 400 feet, with an average width of 18 to 20 inches.

At 200 feet in, is a rise 110 feet to the surface, at the approach to the old intermediate level; and a small amount of stoping has been done round this rise on a narrow lode, and in hard ground.

East of Creek.—Some surface prospecting has been carried on recently on the east side of the creek opposite the entrance to No. 4 creek drive. Trenches have been opened in quartzite and lime-silicate rock, exposing veins which have a general north-westerly course. The band of lime-silicate rock is about 150 feet wide, and also strikes north-westerly. In one of the high-level trenches in the garnetiferous silicate rock is a small mica-quartz vein, near the apparent quartzite contact, carrying a little cassiterite, bismuthinite, and gold.

This contact-metamorphic rock is composed essentially of garnet and pyroxene with idocrase. The pyroxene is not hedenbergite. Its granular appearance in microscopic slides resembles the variety frequent in limestones, and known as "coccolite." The rock is greenish to pale-brown in hue, is tough and splintery, with a hornstone-like fracture. Its position at this spot (between bounding masses of quartzite) is difficult of explanation. It must owe its present position to faulting, but the latter cannot be connected yet with the fault system existing in the mine west of the creek. Veinlets of bismuthinite intersect the rock, but seem to be independent of a lode-channel, which it was hoped would be discovered by work on this patch of rock.

The veins met with so far, both in the garnetiferous rock and the adjoining quartzite, have not proved important. The occurrence of these veins and of splashes of bismuthinite in the lime-silicate rock seems to suggest that a larger lode exists somewhere in the vicinity, but the probabilities of finding it easily do not appear to be strong enough to warrant expenditure on intermittent prospecting work. If an adequate sum could be set apart for thoroughly exploring this mineralised block to the south-east up the hill, it might be good policy to carry on the work of searching in that direction. At present too little is known of the relations of this curious block of ground to the surrounding country to say much about its prospects. Although only a comparatively small shred of the lime-silicate rock may be preserved, the surrounding quartzite is always a good rock in which to prospect for mineral lodes.

High-Level Tunnel.—This is a shallow-level tunnel driven 100 feet westward on No. 2 lode from Bismuth Creek valley. The lode is of the quartz-vein type, 8 inches wide, carrying bismuthinite, bismutite, and wolfram, with also a little cassiterite, and is contained in quartzite rock. In driving this short distance, several bags of clean bismutite and bismuthinite were recovered from vughs in the lode, in value more than sufficient to pay the cost of the work. Faults showing both vertical and lateral displacements of 6 inches to 4 feet occur in two places.

This lode is exposed in the face of a quartzite cliff overlooking Bismuth Creek. At this point a fault of considerable magnitude (striking north-west) occurs, the full extent of which has not been determined. This fault-line is shown in the face of a deep cutting on Middlesex-road, where the quartzite, with irregular quartz veinlets, contains abundant pyrite and a little chalcopyrite and wolfram.

Three chains further northward, in another road-cutting, several veinlets filling cracks in the quartzite rock show facings of wolfram. The quartzite is very much silicified here, barren quartz veinlets ramifying through the country-rock. The veins strike north 45 degrees west, and dip south-west at an angle of 82 degrees.

On Barber's section (7926-M), in line with the supposed continuation of the S. and M. lodes, wolfram is found on the cleavage-planes and fractures of the sandstone, and a thin veinlet of almost clean wolfram has been exposed in the road-cutting.

No. 3 Adit (No. 1 Level).—This is a crosscut which has been driven a little east of south for a distance of 1300 feet, intersecting in its course four main lodes, Nos. 6, 5, 4, and 2.

No. 6 Lode.—This lode has given large quantities of ore, and has been driven upon east and west. The east drive is in 430 feet from the crosscut, and the lode is being stoped in this direction. Here, however, it is split and poor. The west drive is in 230 feet from the crosscut, and in the end the lode is split up and irregular. The backs at this point are so small that work has been relinquished in this direction.

At 130 feet in, the north-west branch lode, which is younger than the No. 6 lode, and crosses it, is intersected. It has been followed 200 feet, its limit in that direction, where it has been cut off by a bed of sub-basaltic alluvial, which shows in the leading stope a few feet back from the face, and shelves off to the west. Softened lime-silicate rock continues to the end, which is only 30 or 40 feet below the surface. This branch lode carried a high bismuth content, but the ores were frequently mixed with massive pyrite to an exceptional extent.

No. 5 Lode.—This has been cut in the No. 3 adit, and driven on easterly for 12 feet and westerly for 66 feet. Where it was intersected it was about 15 inches wide, but this proved to be a junction of veins which diverged in driving in both directions; and short crosscuts at the end of the west drive failed to locate anything further. Above the east drive a rise was put up through quartzite for 75 feet, and then for 43 feet through lime-silicate rock, when it encountered alluvial drift with 8 inches of mineral-bearing wash. A connecting winze was sunk from surface for 96 feet through decayed basalt.

No. 4 Lode.—This has been driven on east and west. It has been driven upon nearly 600 feet in an easterly direction, showing a vein 6 to 15 inches wide, containing a high content of cassiterite, wolfram, and bismuthinite. There is a large block of ground ready for stoping between this and the creek drive workings, 150 feet overhead. In the west drive the lode passed out of quartzite country into garnet-rock at 150 feet from the crosscut, and the latter rock continues as far as driven. In the face it is black, with much magnetite, and is banded with veins of felspar. At this point the lode is split up into a number of veinlets over a width of 5 feet. Bismuthinite is here found scattered through the garnet-rock, which dips west at an angle of 50 degrees.

No. 2 Lode.—This has been cut at 1215 feet from the entrance. It has been driven on 421 feet east and 160 feet west. Here it is 237 feet below the level of the upper workings on the same lode. The lode in the east drive up to 340 feet is barely payable, but the last 80 feet shows it 9 to 10 inches wide, and highly payable.

No. 2 Level.—The workings of No. 2 level, 75 feet below No. 3 adit (No. 1 level), are operated from the main shaft, which is sunk near No. 6 lode.

No. 6 Lode.—This is the only ore-body exploited at this level. It has been driven on 360 feet west and 325 feet east, and stoping has been carried two-thirds of the intervening height towards No. 1 level. In the east end the lode contained in quartzite is split up into two major veins and several interlocking veinlets. This lode has been observed at other levels to split up in the quartzite rock. Near the end molybdenite is abundant, and in the stopes overhead the lode is particularly rich in wolfram, molybdenite, and cassiterite. Towards the shaft the lode varies in size from 10 to 18 inches, and is particularly rich in wolfram. The richest bunches are usually found on the walls, and at the point of junction between the garnet-rock and quartzite a large bonanza occurs. The lode shows no displacement at the point of junction, but continues uninterruptedly. In the end of the west drive the lode is faulted to the south, the lateral displacement being 10 inches at the back of drive and 30 inches near the bottom. It is much smaller here, 4 to 8 inches wide, but up to this point the grade of material remains constant.

Near the entrance to north-west branch drive a small intersecting vein coming in from the south-west is particularly rich in bismuthinite. The north-west branch lode is 12 inches wide, and at 80 feet in, it splits into two veins, one 9 inches and the other 10 inches, both of which carry high-grade wolfram and bismuthinite. The lode here appears as a heterogeneous mass consisting of quartz, calcite, bismuthinite, wolfram, laumontite, and topaz, with gilbertite abundant on the walls. The garnet wall-rock is strongly impregnated with pyrite.

No. 3 Level.—This is the lowest working level in the mine—150 feet below No. 3 adit.

A large crosscut has been sent in southward from the shaft, cutting No. 6 lode at 10 feet, No. 5 at 500 feet, and No. 4 at 625 feet; and work is proceeding towards No. 2 lode.

No. 6 Lode.—A drive has been sent in 375 feet west and 250 feet east, showing ore of similar grade and character to that of the upper levels. Ninety feet westward of the shaft, the north-west branch lode has been intersected, and it has been followed for 380 feet, showing ore of very good grade up to 36 inches in width, the solid lode sampling ½ per cent. of tinstone-wolfram concentrate.

No. 5 Lode.—Very little work has been done on the lode at this level. It is about 6 inches wide, and carries ore of the usual grade.

No. 4 Lode.—Driving westerly on this lode is in progress at the present time. The face has been advanced to 120 feet from the crosscut on a lode 8 to 10 inches wide of average grade.

Alluvial Workings.—Up the hill south of the mine is some alluvial drift, which has been worked for tinstone. The surface drift consists of basaltic soil and rubble carrying a little stream tinstone. This layer is 15 feet in thickness; below it is a bedded stanniferous drift, 25 feet thick, dipping to the west and resting on quartzite. It was not payable, on the whole, but a layer of rubbly wash 8 inches to a foot immediately above the bedrock was payable. All this drift is a part of a sub-basaltic deposit, which has been broken up by the weathering and removal of the lava-sheet. Fragments of various drift-terraces have been found underground in the course of mining. These terraces contain gold, tinstone, and wolfram in payable amounts.

Large boulders of white hard conglomerate carrying cassiterite (tinstone), wolfram, and topaz occur on the bank near these alluvial workings. The conglomerate belongs to the tubicolar series, and has been removed downhill from its original position directly overlying the quartz-porphyry. This basal member very commonly contains cassiterite and wolfram at points in proximity to the lodes.

(*f*) Production and Ore Reserves.

At present development is well ahead of mining, and very large tonnages have been proved to exist. The reserves of ore actually opened up are sufficient to keep the milling plant in operation at the present rate of output for fully three years.

In mining the ore more than twice the quantity of wall-rock is broken with it, thereby diluting the material to this extent. Only coarse lumps of wall-rock are sorted out, the remainder, with the ore, going to the mill. Thus it will be seen that it is impossible to form an exact estimate of volume, and this applies also to the determination of the average value.

The S. and M. Mine has been a consistent producer during the past 12 years. The following particulars relating to the production of ore have been supplied by Mr. W. E. Hitchcock, manager for the syndicate:—

Details of Ore Milled and Products Obtained:

Crude Ore.	Firsts.	Seconds.	Slimes.	Picked Bismuth.	Picked Wolfram.	Total.
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
71,856·5	802·50	347·45	64·95	26·75	3·25	1244·90

The average grade of ore treated during the quarter ending 27th September, 1918, was 1·66 per cent. of concentrates (cassiterite, wolfram, and bismuthinite) of various grades.

The development footage to the 27th September, 1918, is 11,635 feet, and the total material milled is 71,856·5 tons, which gives 1 foot of development work for every 6·17 tons of crude ore raised.

(*g*) Water-supply.

The water-supply for power and dressing purposes is provided by a water-race, 5 miles 57½ chains, from a tributary of the Iris River. Of this, 4 miles 71½ chains are constructed; the balance of the old race has been regraded and enlarged. The face is 18 inches deep by 18 inches wide at the bottom, and is excavated in earth and rock in mainly basaltic country. This work was completed in 1907, and it furnishes a bountiful supply of water for nine months in the year; a short stoppage of milling operations is necessary only in very dry summers.

(*h*) Equipment.

Provision for operating from the main shaft is made by the installation of a first motion steam-driven winding engine. This plant is firmly set on a concrete foundation, and comfortably housed. The pumping-plant is an ingenious adaptation of an Evans force-pump, connected by rods to a crank-shaft at No. 3 Adit Level, and driven by means of a Pelton wheel.

Rock-drills have been installed in the mine and are used exclusively in the operations of tunnelling and stoping. The drills are worked by compressed air, delivered from air-compressors, driven by Pelton wheels, for nine or ten months of the year, and by an auxiliary steam-plant during the dry season.

The greatest material asset of the company is the milling plant, a full description of which is given in Geological Survey Bulletin, No. 14, pages 52-57.

Accommodation for a number of men is provided in well-appointed huts. Other buildings include manager's residence, mine offices, workshops, changing-house, and storerooms.

(*i*) Milling.

The separation of cassiterite, wolfram, bismuthinite, and bismutite from gangue material, such as quartz and calcite, is very easily accomplished, owing to the great differences in the specific gravities of the metallic minerals and

PLATE IV.

S. & M. MINE

FLOW SHEET, MILLING PLANT

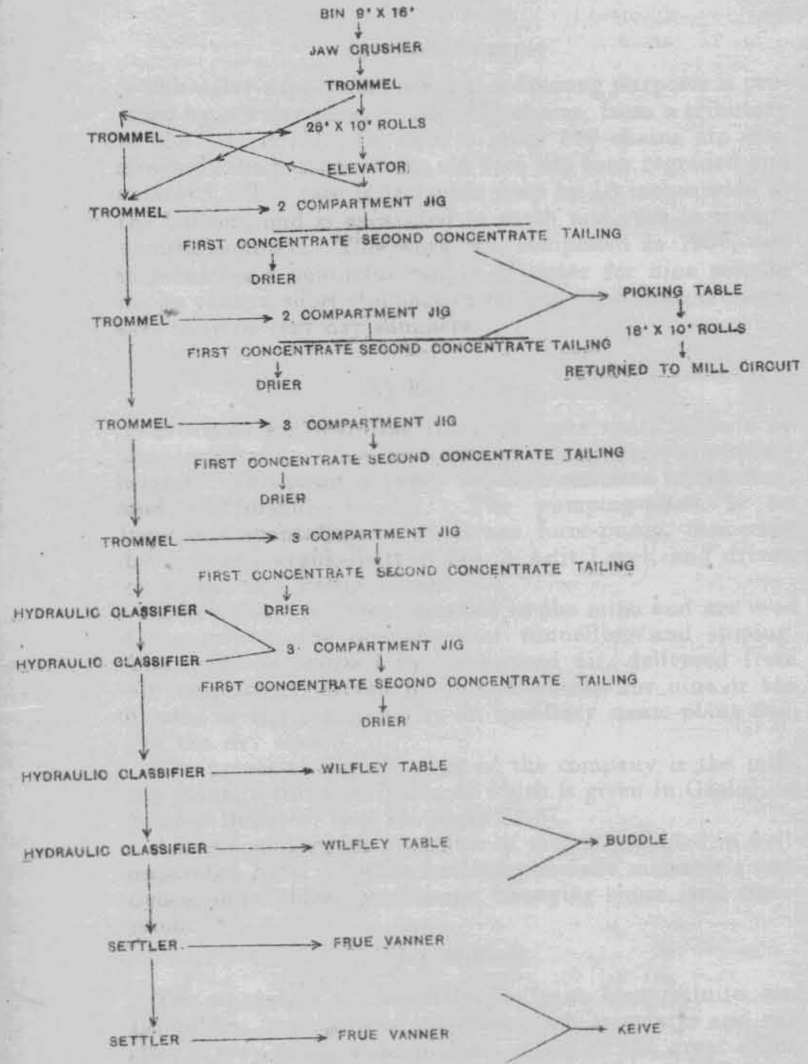


Photo Algraphed by John Vail. Government Printer Hobart Tasmania.

those composing the gangue. The object to be aimed at in the first process is to produce a concentrate as high in metallic content, and as free from gangue material, as is possible. The second process aims at the separation of the several metallic minerals forming the mixed concentrate of the first operation.

The first operation consists of the crushing of the ore-bearing material and its treatment by water concentrating machinery; the second is the further treatment of the concentrate in a magnetic separator plant. Full details of both processes are contained in Bulletin No. 14, pages 51-57.

Owing to their brittleness, due to perfect cleavage, wolfram and bismuthinite tend to form slime. On this account the concentrate from the vanners contains a greater proportion of wolfram than the coarser product from the jigs. Bismuthinite, in addition to its brittleness, is very soft, consequently the loss by water concentration is considerable. To obviate this recourse is had to hand-sorting in the mine.

The ore is easily crushed, and, being loosely compacted, the bulk of the economic minerals can be recovered without sliming. Sizing tests with the trommels show that not much over 1 per cent. consists of slimes. The first-grade concentrate contains 70 per cent. metallic minerals of value, and the second 40 per cent. It is proposed, when normal conditions obtain, to erect a new mill, and in this event, whilst the general scheme, as indicated by the flow-sheet, will be adhered to, several improvements will be introduced. These will include magnetic separation of magnetite from the concentrate.

The capacity of the mill is from 35 to 40 tons in eight hours.

(*j*) General Statement.

The indications of the potentialities of the S. and M. Mine are decidedly good. Perhaps the most striking features of the lodes are their uniformity in size and content, and their continuity in a linear direction. These veins will certainly be found to continue to great depths, and it may be safely anticipated that the metallic content will not vary greatly for several hundred feet.

The remoteness of the mine from transportation facilities, and the complexity of the ore, were causes which for a long time militated against its more successful operation, but the construction of roads and railways and the improvements effected in the method of magnetic separation have removed these obstacles. Another factor largely instrumental in bringing about the present condition of prosperity is the increased demand for these minerals, and the consequent higher prices obtained. It is the aim of the syndicate controlling this mine to operate it on purely business lines, proceeding cautiously with the present policy of development.

The mine is splendidly equipped, and is being worked in the most economical manner consistent with good mining practice.

(2)—*All Nations Wolfram Mine.*

(*a*) Area, Situation, &c.

The All Nations property now consists of the two mineral leases, 7100-M, of 55 acres, and 7198-M, of 10 acres. The larger section is bounded on the west by the S. and M. property and Section 8129-M, and lies near the summit of the interstream plateau, 2200 feet above sea-level. It is about 500 feet above Moina township. The main road from Wilmot to Middlesex passes a few chains westward of the property, but is connected thereto by means of Dolcoath branch road, which passes through the northern section.

Operations on a very small scale have been carried on here in a desultory manner for many years. The owners, like those of every other mine in the district, considered that it was rich enough to pay its way from the beginning of operations. There are certainly several very rich shoots of ore, which may be profitably exploited at shallow levels, even by means of the crude methods employed now, but ultimately it will be found necessary to provide sufficient capital for the development of the ore-bodies on a much larger scale.

(*b*) The Ore-bodies.

There are a number of lodes on this property, all of which are contained in tubicolar sandstone or conglomerate. They are of the quartz-vein type, from a few inches up to 2 feet wide, and remarkably persistent at the surface; the main lode, for instance, has been traced 1500 feet by surface trenching, and 900 feet by tunnelling. This lode is composed dominantly of quartz, with abundant wolfram embedded in the gangue material in shapeless masses and in divergent groups and isolated blades

implanted on and between the quartz crystals. The quartz occurs in crystals of great size and beauty; some pellucid, others white opaque, and smoky to black varieties are not uncommon. The vein material exhibits typical comb structure. Large vughs are frequently met with, some of them containing exceptionally rich ore. Native bismuth, bismutite, bismuthinite, molybdenite, gold, and pyrite are all present in the lode, some of them in such amount as to add considerably to the value of the material. A few flakes of molybdenite occur sporadically distributed, and native bismuth is occasionally found. One particularly interesting specimen obtained here shows a molybdenite enclave (½-inch thick) in bismuth, the surface of which is studded with flaky gold. It is noteworthy that pyrite invariably accompanies the molybdenite here. On the hanging-wall selvage from 1 to 3 inches wide contains carbonate of bismuth (bismutite) and gold. Good dish prospects of gold may be obtained from this selvage at any point. A sample of this material was found to contain:—

Bismuth...	4·8%
Gold	11 dwts. per ton.
Silver...	4 dwts. per ton.

A remarkable peculiarity of this ore-body is the absence of cassiterite. This is especially noticeable because the alluvial material a few yards below the main workings contains a considerable amount of this mineral, and undoubtedly a large proportion of the metallic content has been derived from the disintegration of the veinstone from the main ore-body. The origin of the cassiterite is to be found in the smaller veins farther southward.

The two minerals of economic importance in the main lode are wolfram and bismutite, which occur in the ratio of 12 to 1. The best part of this lode is comprised in a section about 400 feet in length, in which shoots or patches of ore occur at intervals; in fact, nearly all the ore shipped has been broken from this part of the lode. Like all wolfram lodes, the metallic content varies greatly from point to point; barren stretches, alternating with richer shoots, are the general rule.

The course of this main lode is north 65 degrees west, and the dip is southerly at a high angle.

In one of the trenches between the tunnel entrances, a quartz-wolfram vein, 3 inches wide, has been intersected. This vein, parallel to the main lode, has not been developed at all. South of the main lode, two veinlets, each 3 inches wide and 100 feet apart, have been traced on the surface over 200 feet by means of shallow trenches and pot-holes. They contain fair wolfram contents, and may prove to be profitable sources of this mineral at a deeper level.

Another outcrop, and one of much promise, occurs 200 feet up the hill to the south. It is a quartz-vein, 2 to 3 inches wide, carrying both wolfram and cassiterite. The strike, north 50 degress west, and the dip, 65 degrees south-westerly, of this vein vary greatly from those of the main lode system. This vein outcrops again several chains south-eastward on the summit of the hill in massive white conglomerate, in which it is very erratically distributed. The ore is scattered through the rock over a width of 8 feet as facings, and fillings of small cracks.

It has been considered that the lodes on this section, which have been traced westwards into the adjoining property, are identical with those operated by the S. and M. Syndicate. The line of the lodes, if constant, and allowing 130 feet horizontal deflection, due to their southerly underlay in a vertical height of 500 feet, would coincide with those on the S. and M. property. There is a difference in the bearings of the All Nations and the S. and M. lodes; the former trend from 25 degrees to 35 degrees north of west, and the latter are nearly east-west. This latter strike, however, has been influenced by the faulting movements which have disturbed the intervening country. For instance, the S. and M. lodes have been interrupted by a fault running parallel to Bismuth Creek, making it extremely difficult to pick up their continuation on the east side. Whether the All Nations lodes are the continuation of those on the S. and M. property or not is insignificant from the economic aspect, as it can have no direct bearing on their development and future exploration.

(c) Development.

Section 7100-M.—A considerable amount of developmental work, consisting of trenching and tunnelling at shallow levels, has been done during the past 15 years. The lode has been opened up eastward of the main workings by deep trenches, the most important being 12½ chains in length. Along the open-cut line three shafts have been sunk, 20 feet, 53 feet, and 66 feet from the surface respectively. The lode varies from 6 inches to 2 feet in width, and has been broken out along the open trench to a

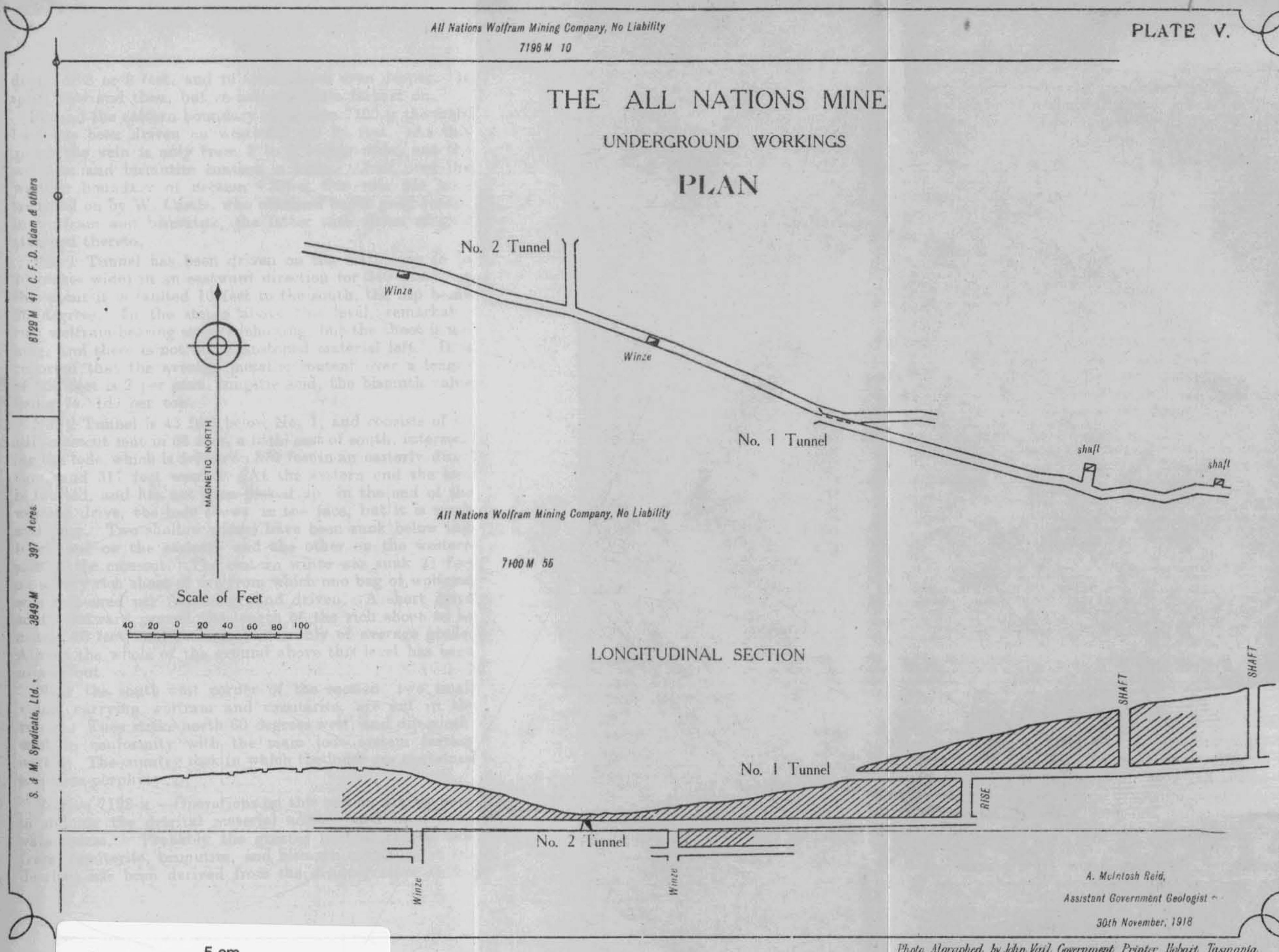


Photo Algraphed by John Vail Government Printer Hobart Tasmania.

depth of 8 or 9 feet, and in some places even deeper. It splits now and then, but re-unites a little farther on.

Beyond the eastern boundary of Section 7100-M the main lode has been driven on westward for 96 feet. At this point the vein is only from 2 to 3 inches wide, but the wolfram and bismutite content is high. Just over the western boundary of Section 7207-M this vein has been trenched on by W. Castle, who obtained fairly good results in wolfram and bismutite, the latter with flakes of gold attached thereto.

No. 1 Tunnel has been driven on the main lode (8 to 20 inches wide) in an eastward direction for 340 feet. At this point it is faulted 10 feet to the south, the dip being 35 degrees. In the stopes above this level, remarkably rich wolfram-bearing stone is showing, but the shoot is not long, and there is not much unstoped material left. It is reported that the average metallic content over a length of 250 feet is 2 per cent. tungstic acid, the bismuth value being 7s. 1d. per ton.

No. 2 Tunnel is 43 feet below No. 1, and consists of an adit-crosscut sent in 55 feet, a little east of south, intersecting the lode, which is driven on 370 feet in an easterly direction, and 317 feet westerly. At the eastern end the lode is faulted, and has not been picked up; in the end of the western drive, the lode shows in the face, but it is small and poor. Two shallow winzes have been sunk below this level, one on the eastern and the other on the western side of the crosscut. The eastern winze was sunk 21 feet on a very rich shoot of ore from which one bag of wolfram was recovered per foot of ground driven. A short drive south-eastward proved the length of the rich shoot to be nearly 40 feet, and underfoot it is only of average grade. Almost the whole of the ground above this level has been stoped out.

Near the south-west corner of the section two small veins, carrying wolfram and cassiterite, are cut in the trench. They strike north 60 degrees west, and dip south-west in conformity with the main lode system farther north. The country rock in which the lodes are contained is quartz-porphyry.

Section 7198-M.—Operations on this section are confined to sluicing the detrital material accumulated in a small watercourse, Probably the greater portion of the wolfram, cassiterite, bismutite, and bismuth contained in the detritus has been derived from the disintegration of the lodes occurring on the adjacent property, to the south. The main lode has provided a large part of this material, but it is peculiarly lacking in tinstone (cassiterite), which evidently had some other source.

The wash, from 3 to 8 feet deep, is largely made up of sandstone and conglomerate, with also a considerable amount of quartz-veinstone, and rests on a soft, argillaceous sandstone floor. Numerous pot-holes, cracks, and riffles in the sandstone bottom have provided suitable catchments in which the metallic minerals have been concentrated. The very rich ore-bearing material occurs in distinct leads, and also in thin bands. Wolfram predominates over the other metallic minerals, but tinstone and bismuthinite occur in appreciable quantity, and a little bismuth is also recovered. These ores occur usually in fairly coarse condition, and are therefore easily recovered by ordinary sluicing methods. Before operations in this detrital material were commenced, it was carefully tested by sinking a number of pits along the lead. The results of this work show the average length to be 400 feet, average depth 3½ feet, and width 75 feet—the area containing 4800 cubic yards of payable wash.

The estimated amount of the economic components calculated from the data collected is:—

Wolfram	10·98 lb. per cubic yard.
Cassiterite	0·83 lb. per cubic yd.
Bismuth...	0·5 per cent.

A recovery of 9 lb. per cubic yard was made from a paddock of ground selected as an average plot for testing.

On the eastern side of the present working-face, the bottom appears to be dipping in that direction, indicating another and lower run of wash. Power for breaking-down is provided by a dam supplying water under a head of 110 feet through a 1½-inch diameter nozzle.

On the northern end of this section there is a further accumulation of detritus, which at the boundary is 6 feet deep. The dimensions of the material available here for treatment have not been defined, but a considerable amount is known to exist. Lack of water is a great disadvantage in the sluicing of these surface deposits. This is especially felt in the northern workings where it has been found necessary to instal two 7-horsepower Sunshine oil-engines and force-pumps, one of which is employed in providing water under pressure to the nozzle, and the other for the purpose of returning the water from a settlement dam.

(*d*) Preparation of the Ore for Market.

A small percentage of the wolfram ore is sorted from the second-grade material in the mine stopes and bagged. The remainder, contained in the comminuted material and the loosely aggregated veinstone, is concentrated by sluicing and hand-jigging; the forkings, consisting of the coarser and harder material, are dumped. By this simple method of treatment the recovery of concentrated ore is equal to 2 per cent. of the crude material, and the forkings, of which there are now 560 cubic yards stacked, are estimated to contain 0·5 per cent. tungstic acid. The bismuth content is separated from the concentrate by sorting.

A small milling plant was erected, but it was destroyed by fire four years ago. This plant consisted of a small crusher, three two-compartment jigs, and two trommels, driven by a small portable engine.

The concentrate contains between 3 and 4 per cent. bismuth, and occasionally a little more, the recovery of which is worth the cost of separation. After treatment by the magnetic separator, the concentrates contain:—

Tungstic acid	72 to 73·8 per cent.
Bismuth	68 per cent.

This is a very high-grade product.

(*e*) Future Exploration and Development.

The reserves of rich ore above the present working level are now so low that production, even on the present small scale, will soon cease. A little further exploratory work could be carried out on the undeveloped parallel ore-bodies by advancing the crosscut southward, but it is problematical whether these lodes would be found rich enough to exploit by the crude methods employed at the present time. The continuation to this crosscut would intersect the lodes at depths varying from 80 to 120 feet, and would probably provide useful information affecting the design of future development, but on the whole it is not considered advisable to undertake the work at this stage. The mine openings are all at shallow levels, and are exploratory rather than developmental works.

Consideration should be given now to the preparation of plans for a much more extensive scheme of development. The greatest obstacles to the progress of the mine are the scarcity of water, due to its elevation, and the absence of facilities for adit-driving. In the design of future work three schemes are presented:

(1) Operation from a main shaft, to be sunk in a central position, commanding all the lodes.
(2) Driving eastward from the valley of Bismuth Creek.
(3) Driving on the lode from the upper part of Forth Valley.

(1) At present it is contemplated by the owners to adopt the shaft method of exploitation, which has certain definite advantages to recommend it. In the first place a shaft may be sunk either vertically or following the underlay of the vein at a point where rich ore is known to occur. It may be placed in a central position commanding all the lodes, thereby effecting a considerable saving in the cost of trucking. Another, and most important, advantage is that exploratory works may be carried into effect more expeditiously, and at a considerable saving in cost over the long tunnel method. In the event of the ore-bodies improving at deeper levels, and it is found advisable to operate by tunnel, the shaft would not only provide a second exit, but would be of distinct advantage in the ventilation of the mine. Disadvantages of the shaft method are the cost of haulage and drainage, and the cost of conveyance of the ore from the shaft to the mill site by aerial ropeway or self-acting ground tramway.

(2) A tunnel driven eastwards from Bismuth Creek, near No. 4 creek drive, would enter the All Nations property in 1500 feet, giving 200 feet of backs. If the continuation of the lode could be picked up here, and arrangements made with the leaseholders, the lode could be followed into the All Nations property, and explored all the way. A work of such magnitude at such a shallow depth is not regarded with much favour.

(3) A more feasible proposition is that suggested as the third scheme. The All Nations main lode has been traced into Section 7207-M, on the western slopes of Forth Valley. The slope increases rapidly as the descent is made toward Forth River, and, with a proportionate increase in distance, any desired depth for the proposed tunnel may be obtained. An advantage in this case is that the value of the lode material recovered in driving will greatly reduce the cost of the work. Suitable mill sites are available at many points below the proposed working level in the Forth Valley, and water could be easily conducted from Bull

Creek. This proposition is worthy of very careful consideration.

(*f*) Conclusion.

These ore-bodies possess the characteristics of all wolfram-bearing lodes in that the component ores are very unevenly distributed. In addition, the ores have the further irregularity of occurring in shoots separated by almost barren lode material. At a greater depth it is likely that the unprofitable sections of the lode will show an increase in the metallic content, more especially as regards cassiterite and wolfram, and it may be safely anticipated that these ores will extend into the underlying granitic rocks. As a general rule the linear extent of a lode may be taken as a measure of the depth it attains, but this does not imply the continuance of the metallic component, whose presence is governed by certain well-defined conditions.

The exploratory work has shown these lodes to be of remarkable continuity and regularity in size, and the quantity of ore contained in them provides sufficient justification for the adoption of a more comprehensive scheme of development and exploitation.

(3)—*Section* 7664-M, 10 *Acres (Lessees: J. Richards and W. Dunn).*

This is an alluvial claim, situate north and adjoining the All Nations Wolfram Company's lease, 7198-M.

At present operations are confined to sluicing the tinstone and wolfram-bearing detrital material, which is 3 to 8 feet deep, and ranges from 1 to 5 chains in width. The grade of the material varies from ½-oz. to 1 oz. of tinstone to the dish. Some of the tinstone recovered here is grey in colour, but generally it is black, and fairly coarse in texture. The wash is very fine, even puggy, with subangular to rounded pebbles, ranging from the size of peas up to 2-inch pieces, and occasionally large subangular boulders. This sandstone and conglomerate material rests on a soft bottom composed chiefly of tubicolar sandstone. There is no great extent of this material, the concentration of the metallic minerals having been effected by the small stream passing through the property from the All Nations Mine.

(4)—*Section* 8129-M, 41 *acres (Lessees: C. F. D. Adam and others).*

At one time this property was included in the holdings of the All Nations Wolfram Mining Company, No Liability. It lies north-west and adjoining Section 7100-M, on which the principal workings of that company are located. The main lode of the All Nations Mine, and those lying adjacent thereto, pass into this section near the south-east corner. It appears that the lode developed on this section is identical with the main lode of the adjoining property.

The main workings consist of a tunnel sent in 80 feet, from an approach trench 25 feet long, on a small siliceous vein carrying wolfram This vein, 2 to 4 inches wide, strikes 80 degrees east of south, and dips at a high angle southerly. It is composed chiefly of quartz and wolfram, with gilbertite, kaolin, and pyrite in lesser amounts. At the entrance to the tunnel, a veinlet, only 1 inch wide, is made up of about equal proportions of quartz and wolfram. It is accompanied farther in by two parallel veinlets, and loses its high percentage of wolfram, but near the end for several feet the wolfram content greatly increases. In the approach to the tunnel two small veins containing wolfram, tinstone, and bismutite occur, striking a little north of east. The rock in which the vein is contained is soft, unaltered sandstone. Westward of the tunnel the lode has been cut in several trenches, and in the cutting on Middlesex road. Near this point sandstone detritus, 6 feet deep, containing grey and black tinstone, has been successfully exploited by ground sluicing.

Near the north-west corner of the section, about 5 chains southward, a lode formation consisting mainly of ferro-manganese ore has ben cut in several trenches. In one or two places a narrow quartz vein, carrying wolfram and tinstone, occurs, but no further attempt has been made to determine its values. The strike, north 50 degrees west, carries it eastward of the main tunnel. East of the most northerly trench, and on the east side of the road, another vein carrying tinstone occurs in similar unaltered sandstone. Its course is a little north of west, and the dip is at a high angle southerly. Towards the eastern boundary of Section 7926-M, just below the road, two long trenches intersect a large ferro-manganese formation contained in sandstone rock. No other minerals have been detected in this ore-body.

It is apparent, from the unaltered condition of the sandstone country rock, that the upper part of the granitic intrusive rock is at a considerable depth below this point. The effect of the fracturing is less intense here, and deposition of the pneumatolytic minerals in the fissures will be found greater near the granite-sandstone contact, that is, at a lower elevation.

(5)—*H. Lawson and W. Riley's Mine: Sections* 7301-M, 5 *acres; and* 7207-M, 40 *acres.*

(*a*) Situation.

The properties are situate east of the All Nations Mine, near the summit of the plateau, between the Iris and Forth Rivers. They occupy the uppermost portion of the Forth Valley, which is here 1700 to 1800 feet deep. The slope of the surface increases greatly down to the eastern boundary, where it reaches its maximum, 40 degrees.

(*b*) Access.

Access to the upper section (7301-M) is had from Middlesex road by means of an unmetalled road half a mile long. The gradients are easy, and the foundation solid, so that, even in winter months, it never becomes impassable. The lower section is more conveniently reached by way of Dolcoath road, which also junctions with the main road to Middlesex. It is constructed along the sideling country just below the eastern boundary, and passes through the south-east corner.

(*c*) The Ore-bodies.

There are numbers of lodes on these sections, most of which are still in an undeveloped condition. The most important of the partially developed ore-bodies are those contained on the smaller section, but there are several others, outcropping on the larger property, which are likely to prove equally rich.

The dominant mineral component of these ore-bodies is wolfram. Tinstone, bismuthinite, and bismutite occur, but very sparingly distributed. Associated minerals are topaz, which is very abundantly developed, a little fluorspar, tourmaline, muscovite, and subordinate quantities of the commoner associated metallic sulphides, pyrite, and arsenopyrite. The wolfram component occurs in coarsely crystallised aggregates, in isolated blades, and irregular masses unevenly distributed through the quartz gangue. Comb structure is commonly noted in the lode material.

The lodes are quartz veins, 3 to 10 inches wide, contained in soft quartz-porphyry. The felspar component of the porphyry is almost completely kaolinised. On the larger section the ore-bodies pass up into the overlying conglomerates and sandstone.

At the present time developmental work is confined to the 5-acre section, on which two rich lodes, and one or two others of lesser import, have recently been discovered. These lodes have been opened up by means of two tunnels, the lower, or No. 2, tunnel being 30 feet below No. 1. This latter is an adit crosscut, 25 feet long, leading from an approach trench of 40 feet. No. 1 lode, 3 to 6 inches wide, is cut in the approach, and is exposed in a trench along its course for 100 feet. No. 2 lode is intersected at the end of the adit crosscut, whence it is driven on 50 feet north-westward, and 10 feet in the opposite direction. It is from 4 to 8 inches wide here, and it has a high wolfram content, and contains also a little cassiterite and bismutite. Topaz is a particularly abundant associate of the metallic minerals. These lodes are seen to greater advantage in the lower workings. The lower adit crosscut, approached by a long trench, intersects No. 1 lode at 80 feet, and No. 2 at 115 feet from the entrance. In addition to these lodes a small vein, 1 to 2 inches wide, composed of quartz-wolfram ore, is exposed in the sides of the approach trench. At this level No. 1 lode is 8 to 12 inches wide, and contains wolfram in highly payable amount. This ore-body has been driven on 60 feet eastward and 40 feet westward. No. 2 lode is similar in size, character, and content, and has been driven on 100 feet. No. 1 lode strikes 83 degrees west of north, and dips southerly; No. 2 strikes 40 degrees west of north, and has a south-westerly dip at a high angle. If these lodes continue on their present course they unite at some point to the southward. No. 2 lode has been traced downhill for over 500 feet by means of trenches along its course. In the 40-acre section it has been developed by means of two short tunnels. At this point it is similar in character to the occurrence in the main workings, but the lode here is only 4 inches wide, and the quartz-porphyry wall-rock is much harder.

About 100 feet northward, a parallel vein, 2 inches wide, shows a high wolfram and tinstone content in the

outcrop. Within a distance of 250 feet northward of the latter outcrop, three veins, varying in size from 1 to 2½ inches wide, and coursing, like the others, a little north of west, have been opened up in trenches. Still a little farther northward, at the foot of high cliffs of tubicolar conglomerate, another occurrence has been exposed. The conglomerate rock here has not been fractured, and contains a little wolfram only near the point of contact with the underlying quartz-porphyry. A fair amount of wolfram-bearing lode material, however, has been deposited as a horizontal ore-body between the conglomerate and porphyry.

Near the north-east corner of the section, at the point of contact between sandstone and quartz-porphyry, a tunnel has been driven 100 feet on a bearing 10 degrees south of west. At 80 feet from the entrance a drive has been sent in 20 feet on a bearing 25 degrees west of north. The tunnel and north drive are almost wholly contained in conglomerate, the porphyry coming in at 70 feet, and dipping 10 degrees eastward. The wolfram ore is very unevenly distributed through the unfractured conglomerate. Rich pockets and short, irregular veinlets are occasionally met with, but no defined ore-body exists. The fissure should be sought at a lower level in the quartz-porphyry. This lode is considered to be the eastern continuation of the main ore-body developed on the All Nations property.

Near the main workings the surface is occupied by detrital material, from 1 to 2 feet deep, composed principally of sandstone and conglomerate, which carries tinstone and wolfram in payable quantities. No attempt has been made to recover the ores from the detritus owing to the difficulty experienced in obtaining sufficient water for sluicing purposes.

(*d*) Future Development.

Up to the present time it has been possible to treat only the richest ore; the second-grade material, containing 2 to 3 per cent. tungstic acid, being dumped pending the erection of concentrating machinery. The first section of a miniature treatment plant, consisting of a 6" × 6" Dodge crusher and a double plunger-jig, to be driven by a 5-horsepower vertical steam-engine, is now being placed in position. It is considered that the profits accruing from the exploitation of the rich ore-bodies in the 5-acre section will be such as to provide ample funds for the exploration of the other lodes. If the preliminary exploratory work prove satisfactory, the plan of developing several lodes simultaneously could be adopted with advantage, thereby providing a number of working faces from which supplies of ore could be drawn sufficient to keep a large mill in constant operation. The mill site should be chosen so as to command the lodes as a whole. A central position, just above the Dolcoath road, seems admirably adapted for this purpose; and, in addition, there should be no difficulty in conducting the water required for ore-dressing to this point.

The lodes are so placed that all of them may be operated from the eastern fall of the hill. Another and very distinct advantage is that no cross-cutting is necessary—each lode may be driven on from the surface. The ore removed during the exploratory work can be treated, and the proceeds therefrom used in reducing the amount of capital required for development. There are no difficulties involved in the consideration of the planning of developmental work, methods or ore-treatment, transportation, timber and water supplies, &c., for here the conditions are ideal for economic mining.

The ore-bodies are remarkably continuous at the surface, and this may be taken as a measure of their persistence in depth.

Although the metallic content of these lodes is erratically distributed, it is not anticipated that the average grade will decrease greatly within 300 feet of the surface. It is impossible to state with any degree of certainty the future prospects of this mine, as it is now only in the earliest stage of development.

(6)—*Iris Mine: Section* 6981-M, 40 *Acres (Lessees: C. F. D. Adam, E. Davies, and R. T. Jubb).*

(*a*) Situation, &c.

Tinstone and wolfram were discovered on this property in 1892 by M. Hearps shortly after J. Levings and T. Brennan reported the occurrence of these minerals on what is now known as the Dolcoath Mine. This was one of the sections included in the holdings of the Iris Tin Mining Company, and was at a later time (1900) owned by the Tasmanian United Wolfram Company Limited. It is now being worked as an alluvial tin and wolfram sluicing claim by the present lessees.

It is situate 1 mile south-east of the S. and M. workings, and half a mile south of the All Nations Mine on the high plateau between the Iris and Forth Rivers. The surface slope of the plateau here is very gentle and towards the Forth River.

(*b*) Ore-deposits.

The greater part of the section is occupied by slightly decomposed quartz-porphyry, with a strip of tubicolar sandstone and conglomerate on the western side, and a thin basaltic covering on the southern portion. At the south-western border of the porphyry a soft laminated rock is exposed in the water-race, and appears to be an altered shale.

The workings are in the northern part of the section, and traverse it from west to east, the latter drainage being towards the south-east. It is difficult to determine the exact point of outlet of this lead, as the wash along the western border is apparently enclosed by a wall of solid rock.

These deposits are made up of detrital material derived from the disintegration of surface outcrops, most of the wolfram, bismutite, bismuthinite, and tinstone being set free.

Tinstone is the predominant mineral constituent of economic value: wolfram varies in quantity from one-fifth to nearly half the total metallic content, while bismuthinite and bismutite occur in subordinate amounts. The lodes from which the ores were derived were contained in quartz-porphyry and tubicolar sandstones and conglomerates. In the wash are numerous stones of white quartz-porphyry, containing combed vein quartz with wolfram, and sandstone and conglomerate specimen stones containing coarsely crystallised wolfram and tinstone are very commonly found. The richest tinstone-bearing detritus occurs near the north-west corner, where it becomes much shallower.

A few chains over the northern boundary, tinstone occurs in quartz-porphyry rock, and, with wolfram, in tubicolar conglomerates. The tinstone and wolfram ores are very little water-worn, the condition of the latter mineral, which is very brittle, showing that they have not been transported far from their source. Large numbers of topazes, some of them well crystallised and almost perfectly developed, are found associated with the metallic minerals, from which they are very difficult to separate by ordinary sluicing methods. A considerable portion of the wash is made up of white opaque quartz, derived from the barren veins commonly met with in the porphyry.

The width of the wash varies from 2 chains up to 7, but the depth of the metal-bearing portion is shallow (2 to 3 feet). This is overlain by almost barren material, which in some parts is 5 feet thick, and is stripped off before sluicing operations are commenced. At the present time the owners are treating the upper beds of wash discarded by tributers who were engaged here about 20 years ago. This material contains tinstone and wolfram in highly payable quantities.

The great difficulty encountered in the exploitation of these deposits is lack of water. During the rainy season surface-waters conducted to dams near the summit of the plateau provide sufficient to run on an average four hours per day, but work has to be suspended altogether from November to April. There is not sufficient ore remaining to warrant the construction of water-races from the nearest permanent creeks to augment the present supply.

(*c*) General Remarks.

The area of ground already sluiced over is extensive, but there remain quantities sufficient to provide employment for the owners for several years. It is estimated that the total quantity recovered from this section amounts to 200 tons. The present rate of output is 6 tons of tinstone-wolfram concentrate per annum, being the work of three men for eight months. After treatment in the magnetic separator plant in Launceston the tinstone concentrate contains on an average 73 per cent. tin, and the wolfram concentrate 73 to 74 per cent. tungstic acid. The bismuthinite and bismutite contents of the concentrate are picked out by hand before the mixed ore is shipped from the mine. Up to this time no mineral-bearing veins of any kind have been discovered as the result of the removal of the overburden, but the conditions are favourable for tinstone and wolfram lodes, and even yet something of value may be found before all the alluvial material is worked out.

(7)—*Dolcoath Section:* 5430-M, 79 *Acres.*

This was the first tinstone and wolfram discovery in the district. These minerals were located here in 1891 by J. Levings and T. Brennan, who later sold their mining rights to the Dolcoath Tin Mining Company. The operations of the company were not successful; the mine was abandoned, and it remained in that condition up to recent time. During the past five years a little further exploratory work has been done by prospectors, but without disclosing anything of economic importance.

This section occupies the summit and southern slopes of Dolcoath Hill, and lies south and adjoining Section 5221-M, one of the Squib properties.

The summit of the hill is composed of quartzite and sandstone belonging to the tubicolar series, containing numerous veinlets of quartz, in which a little wolfram occurs. Lower down in the southern part of the section, granite emerges from beneath the sedimentary rock. The marginal part of the granite is porphyritic, and extends westward as far as the Iris property. At this point the quartz-porphyry contains numerous inclusions of small, well-rounded quartz pebbles, derived from the younger conglomerates. The rock has a prevailingly greenish hue, differing greatly from the normal type exhibited by the granite-porphyries outcropping north-westward. This change has been brought about by the absorption and assimilation of sandstone, conglomerate, and the underlying porphyroids by the granitic magma. The ores are contained in greisenised granite, and consist of cassiterite and wolfram, with subordinate amounts of molybdenite, pyrite, and arsenopyrite. Topaz constantly accompanies the ores.

The work carried out by the Dolcoath Company many years ago disclosed the presence of tinstone (cassiterite) over a width of 100 feet, and blebs of that mineral were also found in the trenches and tunnels. The occurrence of tinstone in this granitoid rock is not in quantity sufficient to be of economic importance. Thick scrub and fallen trees completely obscure the surface, and many of the old workings are almost obliterated, and could not be examined.

An open-cut above the tunnel shows a vein of quartz bearing north-north-west, and dipping to the south. From this cut vughy quartz has been obtained, showing blades of wolfram and a little tinstone. On the west side of the tunnel entrance large boulders of conglomerate show facings of coarsely-crystallised tinstone. These boulders rest on granite-porphyry, whether in their original position or not cannot be determined. Probably it is a remnant of the old conglomerate covering, parts of which can still be seen outcropping boldly 10 chains uphill to the north-westward.

In the small creek 5 chains east-north-east from the tunnel are some alluvial workings in rubble wash up to 6 feet deep. It is reported that this ground contains tinstone in payable quantity.

A tunnel, in the south central portion of the property, has been sent in 48 feet in a direction north 12 degrees east, through greisen containing a good deal of topaz. At 36 feet from the entrance a drive has been sent in north 50 degrees west for 30 feet on a lode-formation which dips south-westerly at 46 degrees. The veins, contained in greisen, are very irregular in occurrence and size. They vary from 1 to 4 inches wide, and carry a little tin and wolfram and occasional blebs of molybdenite. Pyrite is very abundant, not only in the veins, but also in the topaz rock adjacent thereto. In the drive one inch of selvage shows on the footwall side. Mica (secondary) is especially abundant at this point. At the end of the crosscut the quartz-topaz-mica rock is heavily impregnated with pyrite, and contains also a little arsenopyrite.

The work already carried out is only of an exploratory character, and quite insufficient to determine the value of the known deposits. The first operation necessary is that of the removal of the thick undergrowth and the fallen trees. This will make possible a detailed inspection of the surface-rock for indications of other ore-bodies, and enable the prospector to further explore the known lodes

It is not anticipated that further developments will reveal increased tinstone values; but the conditions are certainly favourable for wolfram deposits, and the molybdenite and bismuthinite contents may increase in proportion.

(8)—*The Squib Mine (Lessee: B. J. Gurr).*

(*a*) Area, Situation, &c.

This property consists of Sections 6081-M, 10 acres; 5221-M, 50 acres; and 6075-M, 7 acres.

The mine, discovered in 1909 by Warwick Castle, is situate west and adjoining Sayer's, on the northern fall of Dolcoath Hill. It is connected by a short branch road with the main highway from Middlesex to Wilmot and Sheffield. Moina lies 1½ mile westwards.

(*b*) The Ore-bodies.

The ore consists dominantly of wolfram, with molybdenite, bismuthinite, and tinstone in lesser amounts. Accessory minerals present are gold, pyrite, chalcopyrite, sphalerite, and arsenopyrite; with also alteration products of the commoner constituents, molybdenite, bismutite, and tungstite. Associated minerals are topaz, fluorspar, beryl, monazite, and gilbertite. The gangue mineral is a white opaque quartz, and the smoky variety is commonly found in fine crystal development in cavernous portions of the lodes.

The order of deposition has been—tinstone, molybdenite, wolfram, wolfram-quartz and bismuthinite, quartz, chalcopyrite, pyrite, sphalerite, and arsenopyrite. Molydenite occurs also at a second stage after wolfram. Bismuthinite enclosed in quartz is commonly found. Gilbertite has been deposited on wolfram and molybdenite. The central part of the vein is occupied almost wholly by white opaque quartz, showing blebs of wolfram, molybdenite, pyrite, chalcopyrite, and sphalerite distributed sparsely through it. In different parts of the lodes the constitution varies; the wolfram content is fairly regular, but the other constituents are in certain parts abundant, while in others they are entirely absent. Gold is not abundant, though it is widely distributed. The pegmatitic veins of the open-cut workings contained in greisen carry gold.

Sandstone occupies the greater part of the sections, but this rock on and near the eastern boundary of Section 5221-M is intruded by the stock of granite. The veins traverse unbroken the granite and quartzite, with very little change either in size or content, although the richest ore appears to be contained in the quartz veins occurring in quartzite.

In the end of west drive, main level, molybdenite and wolfram are abundantly developed. It is noticeable that the sandstone here shows little alteration, while it is generally found in this mine that the molybdenite is more common in the hard quartzite. Here also pyrite and mica are abundant, both in the lode and in the wall-rock.

The ore-bodies strike about 40 degrees west of north, and dip south-westerly at angles ranging from 40 to 50 degrees

(c) Development.

Advantageous tunnel sites are afforded by the steep ridge, which wholly occupies the sections, and forms the base of the high Dolcoath Hill to the southward. Advantage has been taken of these facilities in adopting the open-cut and tunnelling systems of mining. Additional facilities for another adit exist, giving a further 150 feet of backs.

The principal developments consist of two levels—the open-cut and the main adit level (120 feet lower)—both of which are employed in the exploitation of the main lodes. The additional works consist of Truscott's (or No. 1) tunnel, Sparks' prospecting tunnel, and numerous shallow openings, such as trenches and potholes.

Open-cut Workings.—These workings, 40 feet by 30 feet by 25 feet deep, show a fine body of ore 20 feet wide, made up of greisen carrying 15 veinlets of quartz, bearing wolfram, bismuthinite, bismutite, and molbydenite. The veinlets vary in width from 1 to 5 inches, and are of such richness that, broken with the encasing greisen, the whole is said to be worth 20s. per ton. An adit, sent in underneath these workings (but only 15 feet below the present floor) has been used as a truck level. From this adit crosscut drives have been sent in easterly and westerly on the more important veins. In the end of the west drive on No. 3 vein the face is in quartzite, though the granite shows in the foot of the drive. The quartzite is very shallow, and dips north-westward. A vein of wolfram and bismuthinite-bearing quartz, 3 inches wide, shows in the face.

In the east drive the vein is 10 inches wide, and contains molybdenite, in addition to wolfram and bismuthinite. The molybdenite here is in appreciable amount. No. 4 vein is cut in the end of the crosscut about 50 feet south of No. 3, and has been driven on east and west for 60 feet. This lode is composed of quartz carrying wolfram and bismuthinite in fair amounts, and is contained in greisen, which also carries wolfram and bismuthinite 6 inches on either side. In each end of this drive the lode shows strongly.

Main, or No. 2, Tunnel.—These workings are the most extensive, and all ore-supplies are at present drawn from them. At 100 feet from the entrance the veins diverge a few feet, and then run parallel. The distance apart is too great to allow of the lodes being economically exploited by one drive. The drive on No. 1, or eastern, lode has

Plate VI.

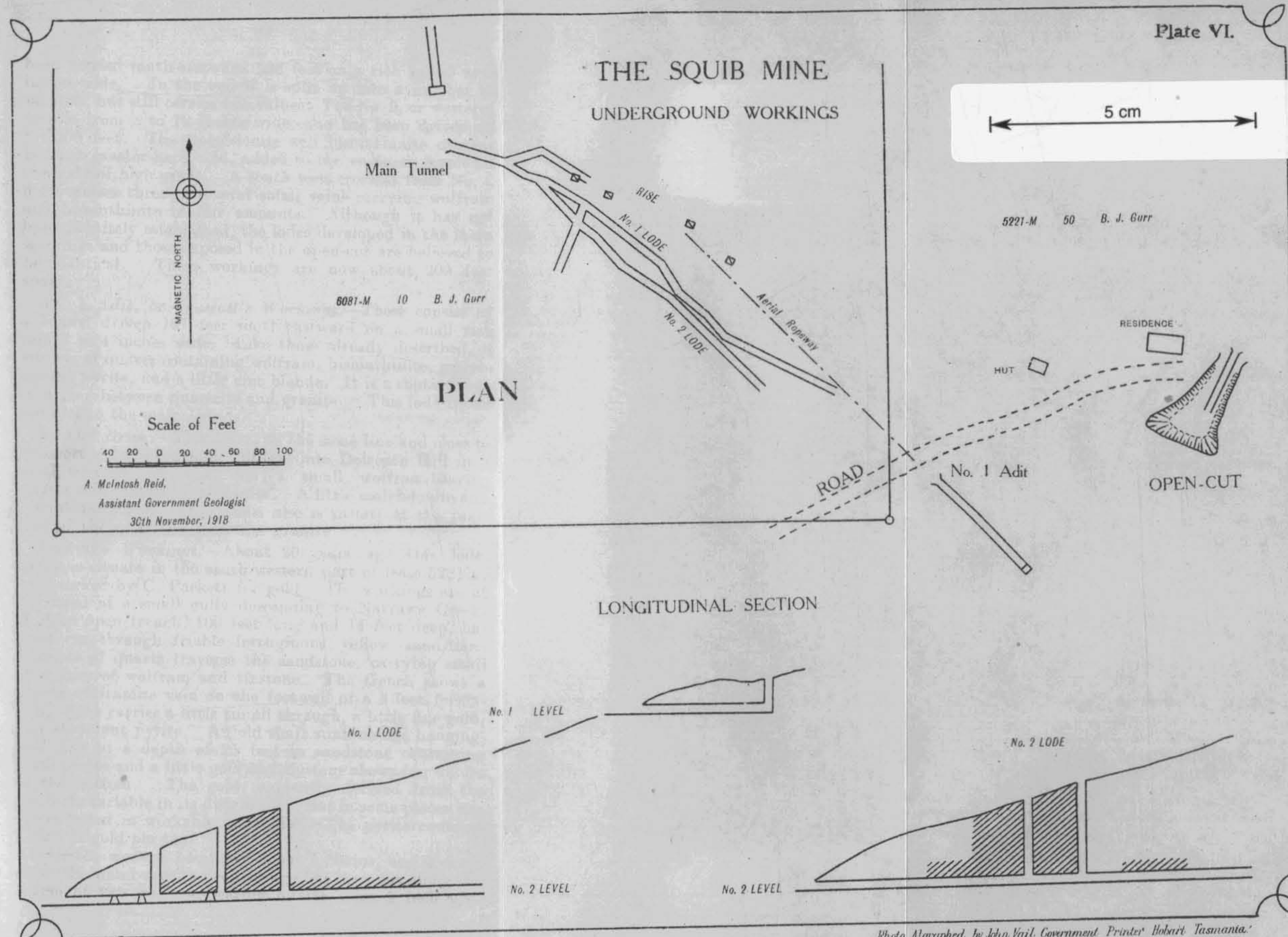


Photo Algraphed by John Vail Government Printer Hobart Tasmania.

been carried south-eastward 288 feet on a rich vein 3 to 8 inches wide. In the end it is split up into a number of veinlets, but still carries fair values. The No. 2, or western, vein is from 8 to 12 inches wide, and has been driven on for 258 feet. The molybdenite and bismuthinite content is much greater here, and, added to the wolfram, forms an ore-body of high grade. A south-west crosscut from No. 2 drive passes through several small veins carrying wolfram and bismuthinite in fair amounts. Although it has not been definitely established, the lodes developed in the main workings and those exposed in the open-cut are believed to be identical. These workings are now about 200 feet apart.

No. 1 Adit, or Truscott's Workings.—These consist of a tunnel driven 107 feet south-eastward on a small rich vein 2 to 4 inches wide. Like those already described, it consists of quartz containing wolfram, bismuthinite, molybdenite, pyrite, and a little zinc blende. It is a contact lode occurring between quartzite and granite. This lode is one parallel to the main lode.

Sparks' Drive.—This drive, on the same line and close to Truscott's, has been sent 150 feet into Dolcoath Hill in a south-westerly direction, on a small wolfram-bearing quartz vein contained in granite. A little molybdenite and bismuthinite also occur. This also is situate at the junction of the quartzite with the granite.

Packett's Workings.—About 20 years ago this lode, which is situate in the south-western part of lease 5221-M, was worked by C. Packett for gold. The workings are at the head of a small gully descending to Narrawa Creek. A deep open trench, 100 feet long and 14 feet deep, has been cut through friable ferruginous yellow sandstone. Veinlets of quartz traverse the sandstone, carrying small quantities of wolfram and tinstone. The trench shows a quartz-wolframite vein on the footwall of a 3-feet formation, which carries a little tin all through, a little fine gold, and abundant pyrite. An old shaft sunk on the hanging-wall side to a depth of 25 feet in sandstone containing much pyrite and a little gold and tinstone shows fair values in the bottom. The gold, evidently derived from the pyrite, is variable in its distribution, but in some places was concentrated in workable quantities. The pyrite contains 2 dwt. of gold per ton.

Over the western boundary about 5 chains, and 1 chain above the water-race, a deep trench has been cut along the course of two wolfram-bearing quartz veins 1 inch wide and parallel to one another. The trench is 270 feet long and 5 to 12 feet deep. At the north-west end of the trench pyrite shows strongly, and the soft clayey sandstone rock carries free gold, but not in payable amount.

Tinstone, wolfram, and bismuthinite have been recovered near the western boundary in the first creek met with above the mill.

The open-cut lodes are exposed in a deep open trench 4 chains further to the south-east. They are cut in another trench nearer the open-cut, showing a number of rich veins over a width of 30 feet.

Parallel veins occur higher up the hill southward, identical in all respects with these.

(*d*) Milling Plant.

The mine is equipped with a small concentrating plant driven by a 12-horsepower oil-engine.

From the main tunnel mouth the ore is delivered to the mill in trucks run on a self-acting inclined tramway.

The ore is conveyed to an 8-inch by 5-inch Blake crusher, thence passes to a coarse trommel ($\frac{1}{4}$-inch holes), the oversize from which passes to the rolls. The product from the rolls is sized in a second trommel, the oversize being returned and passed through the rolls again. The undersize from the first trommel, and that from the second, is conveyed to plunger jigs of two sizes—one $\frac{1}{4}$-inch, the other between $\frac{1}{8}$ and $\frac{1}{16}$ inch. Particles under $\frac{1}{16}$-inch pass to two Wilfley tables. The loss of wolfram and molybdenite is fairly heavy, the latter mineral especially being very difficult to save by this incomplete concentrating plant. In the jigs molybdenite concentrates can be brought to 25 per cent. ore, at which grade it is sold for further treatment. The wolfram concentrate contains 68 per cent. tungstic acid, with also from 3 to 4 per cent. bismuth. A little monazite is present, but the only economic ores besides the wolfram are bismutite, bismuthinite, and molybdenite.

Only the larger pieces of mullock broken with the ore are picked out; the grade then becomes greatly reduced, the proportion of mullock to ore being 2 to 1. From this crude material a recovery of 1 per cent. concentrate is made.

(*e*) General Remarks.

This mine has been in operation, and on a very small scale, since 1911. The improvements that have been effected

were accomplished with the aid of very little initial capital, the mine having been operated to such advantage that the costs of plant and development have been liquidated by the profits accruing from the sales of ore. Such results could have been obtained only from a rich lode operated under good mining conditions.

Mining development on this small scale has established the prospective value of the property, and has demonstrated that the ore-bodies can be profitably exploited.

Developments having reached this stage, the syndicate operating the mine is justified in adopting a more comprehensive scheme of mining and treatment.

(9)—*Section* 5499-M. 80 *Acres* (*Lessees: G. Pearse and others*).

(*a*) Introduction.

The ore-bodies exposed in this section were reported on first in 1913 by W. H. Twelvetrees, Government Geologist. Very little developmental work of note has been accomplished during the last six years. It will therefore be necessary here only to supplement the description already published, with mention of the works that have been carried out since.

(*b*) Situation, &c.

This mine, for long known as Sayer's show, is situate to the north-east of Dolcoath Hill, with its eastern boundary $\frac{1}{4}$-mile west of the Forth River. At its western boundary it is 1400 feet above the river, down to which the granite surface slopes very steeply. The section lies between the Squib Mine on the west, and the Princess on the east; and some of the ore-bodies developed on those sections pass into this property.

(*c*) Means of Access.

Sheffield, the principal town of the region, and the centre of a large agricultural settlement, lies 16 miles to the north-east. The Sheffield-Lorinna-road passes on the opposite side of the Forth River, one half-mile to the east, and the Sheffield-Middlesex-road passes $1\frac{1}{2}$ mile to the west. A small branch road leads down to the Squib Mine from Middlesex-road, whence a track leads through this property and the Princess to the cage, and, crossing Forth River, junctions with the Lorinna-road near Tin Spur. The ropeway carrying the cage has only recently been-re-erected by J. P. Kelly for the Department of Public Works. It is firmly fixed to anchor bolts cemented into granite rock, and may be tightened at will by means of strong union-screw bolts placed at one end. One obstacle to the more general use of this cage as a means of access from Lorinna-road is that it is placed near the foot of granite cliffs over 100 feet high. If the anchorage had been placed at the top of the cliffs all ordinary supplies for the neighbouring mines would have been brought by way of the Lorinna-road. The branch railway from Railton through Sheffield to Staverton terminus is only 11 miles distant, while the nearest railway-station (Sheffield) by way of the Middlesex-road is 23 miles.

(*d*) Ore-deposits.

The ore consists of wolfram, bismuthinite, cassiterite (tinstone) and molybdenite, occurring in pegmatitic veins, contained in aplitic and greisen modifications of granite. Wolfram is the predominant mineral, tinstone and bismuthinite occurring in small amounts, and in some parts of the lode being absent altogether. The wolfram content is variable, and occurs in its usual pockety manner. Associated minerals are fluorspar, beryl, topaz, and mica.

Several lodes exist on the lease. The principal one has been traced for 2000 feet in an east-west direction.

(*e*) Developments.

The principal developments consist of a number of shallow shafts and short, shallow tunnels, none of which has been advanced far enough to have determined the value of the deposits. In addition to these works, the lodes have been intersected at the surface by numerous trenches and open-cuts. All this work has been only of an exploratory character, but has been sufficient to supply information upon which permanent works may be designed. A description of this exploratory work follows:—

About 1 chain south of the northern boundary an underlay shaft (Bateman's) has been sunk to a depth of 36 feet on a pegmatitic vein composed of quartz and topaz, dipping at an inclination of 48 degrees in a direction 10 degrees west of south. At the surface the formation is 3 feet wide; at water-level the width has increased to 4 feet; and at the bottom it is said to be 5 feet or over.

The tinstone and wolfram contents at this point are poor. Thirty feet below the shaft an adit has been driven 35 feet southward, but not far enough to reach the lode. In the approach cutting to the tunnel a small quartz vein 3 inches wide was intersected, carrying mica and a good proportion of wolfram, and dipping steeply into the hill southwards. Twelve feet from the entrance a soft quartz felspathic formation, carrying a little wolfram, has been passed through. The country-rock is an aplite made up of felspar, quartz, and a little mica. The course of this lode-line is east-west.

Forty feet east of the shaft a trench (No. 4), 40 feet long, has exposed the main lode, containing black tin ore and wolframite in a quartz gangue, and also scattered through the altered granitic rock. The tin content is higher here than at the shaft. Trenches have been cut across the lode at intervals to within 4 chains of the eastern boundary, exposing the lode formation for a distance of 700 feet east of the shaft. No. 2 trench on this line, and about 500 feet from the shaft, shows a formation 3 feet wide, 1 foot of which carries some wolfram associated with coarse crystals of quartz.

No. 1 trench, 200 feet farther east, shows a similar hard igneous formation over 2 feet wide, containing fair wolfram values. Three veinlets exposed in this trench over a width of 6 or 7 feet carry wolfram. Within 100 feet of the shaft, on the west side, Nos. 5, 6, 7, and 8 trenches have been cut. No. 5 trench, 100 feet long, has not disclosed anything of importance; Nos. 6, 7, and 8 have been cut across the line of lode, exposing soft micaceous granitic rock, containing wolfram-bearing quartz veins. The formation is 3 feet wide, and radiating blades of wolfram are scattered through it. A vein of beryl, in crystals 3 to 4 inches in length, exists in No. 8 trench, and the same mineral persists to the shaft. The crystals are closely set in a more or less parallel direction at right angles to the vein. They have no terminations, and are commonly of a pale bluish-green tint, but some are brown-coloured. The prisms are vertically striated, and are from $\frac{1}{8}$ to $\frac{1}{2}$ inch in diameter. Entangled in this coarse aggregate of crystals is coarsely-crystallised wolfram. This is a typical pegmatite lode, traversing rocks which represent the aplitic and greisen modifications of granite. The 200-feet section of the lode between No. 4 trench and No. 9 is the best that has been uncovered on this line. The trenches farther west have not disclosed payable ore.

No. 9 trench is 59 feet west of the beryl trench, and shows the lode in the form of a quartz vein with beryl, and containing a fair quantity of wolfram. The formation is split into bands of 2 feet and 18 inches, with 4 feet of granite between.

No. 10 trench, 40 feet farther west, has passed through a 2-feet formation, consisting of greenish-yellow quartz-mica rock traversed by bands of hard ferruginous and siliceous stone without any visible sign of wolfram.

No. 11 trench, 350 feet still farther westward, has been cut through a soft, light-coloured greisenised rock, but does not show indications of a lode.

No. 12 is an open-cut, 25 feet by 8 feet by 10 feet deep, situate 80 feet farther west. It shows two veins containing a little wolfram, one 6 inches wide, the other 2½ inches, with 4 inches of greisen between, dipping south at 55 degrees.

No. 13 is a deep trench, 100 feet west of the preceding, cut into soft ground 15 feet deep, and showing the veins exposed in No. 12.

No. 14 is a small trench, 300 feet west of the above, but has not passed through the overburden.

No. 15 trench is 100 feet farther west. At the south end it has been deepened through 4 feet of red soil, and then into 7 feet of soft ferro-manganese ore, which still persists downward. The granite country has been left, and the manganese formation dipping north is overlaid by sandstone. Crossing the manganese formation is a quartz vein dipping southerly, 5 to 6 inches wide, carrying a little wolfram.

One hundred and fifty feet farther west a small trench (No. 16) has cut a 6-inch vein of clean quartz, containing a little coarse wolfram. Forty or fifty feet below this trench a crosscut adit (No. 2) has been driven 60 feet in a southerly direction. It passes first through dark manganese-stained quartzite, then through a manganese formation for 40 feet, which dips to the north at a low angle, and finally into bedded, dark quartzite. In the end of the tunnel is a small vein of quartz containing fluorspar, mica, and specularite.

It is not certain that all these trenches are on veins identical with the lode in the shaft. This applies more particularly to the veins cut west of No. 9 trench.

Between Bateman's shaft and the northern side-line of the property is a parallel lode, across which trench No. 3 has been cut, showing a quartz vein in altered granite country, with green and purplish fluorspar, pyrite, and a little wolfram. The occurrence is that of a 2-inch vein of quartz, carrying wolfram, which runs parallel with and 3 feet away from a 3-feet formation containing specks of molybdenite.

Southern Wolfram Lode.—South-west from Bateman's shaft is a wolfram lode exposed by a trench along its course up the steep hillside. The strike is north 55 degrees west, and the dip is south-westerly. The lowest opening on it is 100 feet above Sayer's Creek, and consists of a drive on its course for 30 feet. The lode-formation is still visible in the end of the drive, and comprises a series of irregular quartz-mica veins separated from one another by silicified and greisenised rock. The veins in this drive contain wolfram in large blades as the dominant mineral, with abundant pyrite and a little molybdenite, bismuthinite in acicular form, chalcopyrite, and purple fluorspar. The greisenisation effects are indicated by the abundant yellowish mica.

No. 1 trench is over the roof of this drive, and shows some stone with a little wolfram. This is over the point where the best ore was found in the drive.

No. 2 trench is about half a chain west of the preceding, and 20 feet above the drive. The capping has been stripped for 25 feet, showing the continuation of the lode composed of the same greisen vein-material with very little wolfram.

No. 3 trench, 90 feet farther up the hill, shows a little coarse wolfram in hard vein-quartz and silicified rock. Fluorspar and mica are associated with it.

No. 4 trench is 30 feet farther west, and 200 feet above the creek. The lode consists of vein-quartz and pink quartz greisen, containing a little coarse wolfram and bismuthinite.

Black's No. 1 Shaft.—This is an underlay shaft, 30 feet deep, sunk on the south lode 2 chains from the western boundary. A quartz vein, 6 inches to a foot wide, coursing north-west, and dipping south-west at 50 degrees, and containing tinstone and wolfram in payable amounts, has been followed down. The ore from the bottom of the shaft is composed of vughy quartz with dense pyrite, a little chalcopyrite, wolfram, and tinstone.

Black's No. 2 Shaft.—This is another underlay shaft sunk alongside the track, 5 chains from the western boundary. A dark-green micaceous greisen vein, containing much specularite and a little wolfram, has been followed down for 35 feet. The lode bears north-westerly, and dips to the south-west.

Black's No. 3 Shaft.—This is a vertical shaft, 40 feet deep, sunk on the opposite side of the track, 40 feet away from No. 2. The lode has not been intersected.

Large sloping surfaces of granite, with numerous wolfram and tinstone-bearing veinlets, rise to the south, and the sandstone country descends with a steep fall northward to Narrawa Creek.

Bateman's Lode.—This lode is 3½ chains north of, and parallel to, the South Lode, and contained in greisenised granite. The lode consists of a greisen formation 22 inches wide, with a vein of quartz on either side 3 and 5 inches wide. The outcrop carries large bunches of bladed wolfram, both in the greisen and the quartz veins. In this spur a number of small parallel wolfram-bearing veinlets occur. These have been exposed in a number of trenches.

A short tunnel just inside the northern boundary has been driven 40 feet on a bearing south 20 degrees west, sent in with the object of intersecting a wolfram-bearing quartz vein, 3 to 6 inches wide, developed by means of a small underlay shaft. The lode strikes north 30 degrees west, and dips south-westerly. Another remarkable development of manganese oxide occurs here, colouring a deep black the quartzite rock in which the lode occurs.

Povey's lode, just over the boundary, dips south-westward into this property, and has been traced south-eastward inside the boundary.

(*f*) General Remarks.

Sufficient exploratory work has been done on this property to form an idea of the extent and composition of the lodes. The many different works described above show that there are at least three lines of mineralisation which persist unbroken over distances ranging from 300 to nearly 1400 feet in length and 300 feet in depth. They show, also, that the metallic content is very unevenly distributed. In some places the minerals of economic importance have been found sufficiently concentrated to be profitably exploited. Some good coarse tinstone was found associated with the wolfram at and near Bateman's shaft, and a similar association may be discovered also in other parts of the property, but at present wolfram must be looked upon as the economic mineral. Bismuthinite is quite subordinate, but may prove in some shoots to be present in such amount as to add appreciably to the value of the ore. Molybdenite is present only in insignificant amount.

There is nothing unusual in this uneven distribution of ore, as these constituents commonly occur in patches and blebs and sometimes in alternate rich and poor shoots in the lodes. The time has arrived when development of a permanent character may be begun. The situation of the section in the valley of the Forth River affords most advantageous tunnel sites for the development and exploitation of the ore-deposits, which have a general trend at right angles to the valley. Tunnels may be commenced from the east side on each of the lodes, the " backs " increasing as the work is advanced westward; or crosscut adits may be sent in from the valley of Narrawa Creek. Experience gained at other mines in the district has shown that there is a tendency of the lodes to increase in width up to a certain point as developments are carried deeper. This fact offers some encouragement, as in working narrow veins of this kind the value of the ore is greatly reduced by the large amount of waste rock broken with it. It is necessary, in exploiting these thin veins to advantage, to have long working-faces opened up to provide for the employment of a considerable number of miners, thereby ensuring a large output.

In the event of this prospect developing sufficiently to warrant the erection of a milling plant, the most advantageous site may be found on the east side of the river. The conveyance of ore from the mine-openings to the mill would be effected by means of self-acting ropeways.

It is understood that the holders of the lease of this property have amalgamated their interests with those of the Princess Mine, and that an option for their purchase has been secured by a Melbourne firm, whose intention it is to provide sufficient capital to thoroughly develop the property.

(10)—7567-M, 10 *Acres (Lessees: Povey & Johnson).*

This property is situate north of and adjoining Sayer's. That part of it on the northern side of Narrawa Creek is occupied by a very steep hill, which falls away easterly to Forth River. The country-rock is sandstone of the tubicolar series, in some places indurated, in others soft and friable.

The developments consist of a crosscut adit, 25 feet long, sent in on a bearing 25 degrees west of south, from which the lode has been driven on 8 feet west and 55 feet east.

The entrance to this adit is on the south side of Narrawa Creek, less than a chain from the southern boundary, and as the dip of the lode is south at an inclination of 45 degrees, it at no great depth (about 50 feet) passes into Sayer's property. Near the lode the country-rock is a hard quartzite, stained a deep black colour by manganese oxides. This is a quartz lode, 3 to 8 inches wide, carrying a fair percentage of wolfram and a little molybdenite. Thin veinlets of black earthy manganese oxide (Wad) occur in the bedding-planes of the quartzite near the lode.

On the steep spur north of Narrawa Creek very thin veinlets of tinstone and wolfram occur in hard quartzite. These veins, which are worthy of attention, could be developed at small cost, by means of tunnels.

(11)—*Princess Mine*: 7855-M, 61 *Acres* (*E. Smith*).

The wolfram-bismuthinite deposits on this section were discovered in 1908 by Warwick Castle, and for some time were operated by him and J. Kenny on behalf of the original lessee, D. C. Urquhart, of Devonport. The property later came under the sole control of W. Castle, who profitably exploited the rich vein until the encasing granite rock became too hard to work by hand. Last year the section was secured by L. J. Smith on behalf of the present lessee, E. Smith, of Ulverstone.

(*a*) Situation, &c.

This section occupies the steep country between Sayer's Mine and the Forth River. The ground descends to the gorge in a series of rocky slopes, at inclinations varying from 30 degrees to 40 degrees, and is lightly covered with stringy-bark timber and bracken fern. The south-eastern corner of the property is on a cliff near the ropeway crossing Forth River, which at this point flows in a precipitous gorge 900 to 950 feet below Sayer's camp and 1800 to 1850 feet below the summit of Dolcoath Hill.

(*b*) Ore-bodies.

There are at least two well-defined veins of economic importance developed on this property. The main vein, 4 to 8 inches wide, consists of wolfram and bismuthinite set

in a quartz matrix; the order of deposition of these minerals being wolfram, wolfram-quartz, bismuthinite-quartz. Topaz and fluorspar are abundant constituents, not only of the vein-material, but also of the enclosing pegmatite rock. Bismutite (bismuth carbonate) is an abundant component, and tungstite and ferritungstite are commonly found as incrustations, especially in the oxidised portions of the ore-bodies.

At the open-cut workings casts of tabular and bladed crystals of wolfram are of very common occurrence in the siliceous gossan lode-material, the wolfram having been decomposed and leached out. The wolfram usually occurs in tabular forms, but also in chisel-shaped crystals and shapeless individuals embedded in the quartz gangue. Bismuthinite is a most important constituent of the ore, and occurs massive, in long bladed crystals, and in very delicate acicular forms. The country-rock is a fine-grained biotite granite traversed by aplitic and pegmatitic dykes, which contain the mineral veins. On the northern boundary and in the north-west angle of the section quartzite occupies the surface. This quartzite rock carries numerous wolfram-bearing veinlets, too small and scattered to be of economic value.

The strike of the main lode is north 50 degrees west, and the dip 45 degrees to the south-west; the second lode has an average trend of 10 degrees west of north, and dips at 60 degrees south-westerly. Sample of ore from tunnel showed the following content:—Bismuth, 2·86 per cent.; tungstic acid, 3·36 per cent.

(*c*) Developments.

The main lode is developed by means of a short tunnel leading from a long, deep trench. This tunnel is driven along the course of the lode about 70 feet in a north-westerly direction, exposing in the roof and in the end a narrow, though very rich, vein of bismuthinite and wolfram. Leading off the entrance of this tunnel a drive is sent in 20 feet on another vein 3 inches wide, coursing 10 degrees west of north. Further developments consist of a long, deep trench on the lode, from which a considerable quantity of marketable ore has been recovered, an open-cut 40 feet above tunnel-level, and a number of other trenches, which have proved the lode to be continuous right up to the western boundary. The open-cut, 20 feet long, 12 feet wide, and 12 feet deep, is the most important work carried out since the resumption of operations by the present lessee. These workings are wholly occupied by gossanous cellular silica, carrying variable amounts of wolfram and bismutite. Some of the specimen stone recovered shows clean wolfram, 2 inches wide, in short shoots, and generally it is massive and coarsely crystallised. A striking feature of the lode here and at points farther westward is the occurrence of almost perfectly developed crystals of smoky quartz of great size and beauty. Some of these specimens show crystals 6 inches long and enclosing metallic minerals. A shaft has been commenced from the open-cut to determine the continuity of the ore-body below the workings.

The ore-body, as exposed in the open-cut and in the several trenches westward, appears to be of far greater extent than it is in the tunnel and other lower workings; but this is only a local enlargement due to the lateral migration, and deposition of the mineral content, of the ore-bearing solutions at the point of junction of the granitic rock and the overlying tubicolar quartzites and conglomerates. The surface of the granite has been very little eroded, and occupies practically the same position it had at the time of its formation. In proof of this the trenches a few chains westward show still a thin cover of quartzite on the granite; and on this fall of Dolcoath Hill the junction of the tubicolar strata with the underlying granite is plainly noticeable, and shows a similar lateral extension of the lode material.

The exploratory work carried out proves the ore-body to extend almost right through the section, and shows the lode existing at a vertical height of 300 feet. Unusual facilities are provided for the economical exploitation of the ore-bodies by ordinary tunnelling methods of mining.

(*d*) Conclusion.

It has been shown that this vein is remarkably persistent on the surface, and that its vertical range has been proved for 300 feet. It has also been pointed out that, although the vein is very small (4 to 8 inches wide), its metallic content is high, and evenly distributed. But this lode cannot be exploited profitably without the aid of a milling plant to concentrate the metallic components, and as it is too small in itself to warrant the outlay required for this purpose, an amalgamation of interests with adjacent properties is recommended.

The site for the future milling plant should be chosen on the eastern bank of the Forth River, as the mine is easily accessible from Staverton railway terminus by the Lorinna-road. The ore from the working faces would be conducted to the mill by a self-acting aerial ropeway.

(12)—*Section* 5470-M, 80 *Acres*.

This is generally known as York's section, and is situate south and adjoining the Princess property, on the west bank of the Forth River. During the past 15 years this section (now vacant) has been leased from time to time, but very little work has been done.

Operations up to this time have been confined solely to the exploitation of the cassiterite and wolfram-bearing alluvial material, extending over the greater part of the section. Wash, 6 feet thick, lies below 5 feet of overburden, and rests on a body of kaolin (probably derived from the decomposition of felspar-porphyry), which exhibits peculiar surficial forms, due to the heat of the sun. Irregular circular fractures lend a shell-like appearance to the hardened clay. The wash is largely composed of water-worn granite pebbles and boulders, with quartz-porphyry, but very little quartz. There is no doubt that this is an old terrace of the Forth River, corresponding with that on the opposite side of the river.

The forkings comprise about 60 per cent. of the wash, so that prospects should show at least 3 lb. per cubic yard to make it payable. W. Castle, who tested this wash and worked the ground through which the second tributary of Dolcoath Creek flows, reports that the whole terrace can be profitably treated by sluicing. Dolcoath Creek, during the greater part of the year, carries sufficient water for all purposes.

Further east are creek workings on a granite bottom rising into the hill. A little wolfram ore is said to have been obtained from these workings; but the wash is not promising, though it may contain small quantities of wolfram and cassiterite. The section is almost wholly occupied by granite, and granite-porphyry and alluvial material. Towards the edge of the terrace, olivine basalt (probably a remnant of lava covering an old lead) occurs, but it is not extensive.

(13)—*Section* 7902-M, 40 *Acres* (*J. S. Morgan*).

(*a*) Situation, &c.

About 1½ mile south-west of Round Hill the road to Lorinna passes through this section, which lies north-west of the Falls Mine.

Tin ore was discovered here over 30 years ago by T. L. Johnson and his partner (Jordan). A company was organised in Launceston by F. G. Duff for the purpose of developing this ore-body, but the operations which followed were not productive of success. Seven years ago P. C. Ashworth and party of six men erected a small primitive concentrating plant in Tin Spur Creek Valley to treat the rich fine-grained tinstone exposed in trenches and shallow shafts along the southern side of the road. The machinery was quite unsuited to the purpose of recovering this fine-grained ore, and after running for two weeks operations ceased.

(*b*) The Ore-bodies.

The minerals, other than tinstone, contained in the ore-bodies vary in amount in the different lodes. The main lode in some parts contains pyrite and malachite in abundance, while a chain distant these minerals are not present in the ore. Neither wolfram nor bismuthinite has been detected in the lodes on this section. Gold is always present, and in the Star of Peace lode small rich pockets occur. Ilmenite in fine grains occurs in a small trench 2 chains east of main tunnel.

The lodes are contained in sandstone or quartzite at or near the junction with garnet-epidote rock. Sandstone overlies the garnet rock, into which the lodes have not yet been followed. The transposition of these rocks has been brought about by faulting movements, similar junctions being noticeable also at other points in this locality.

The main lode is that developed by Ashworth's workings, and it is the continuation of the Falls line. It occurs here under conditions almost identical with those at the Falls Mine, showing also a close mineralogical similarity. At Ashworth's workings the brown to black coloured, fine to medium grained tinstone occurs in payable amount over a width of 5 feet. Bulk samples of this soft tin-bearing sandstone showed by assay the presence of over 2 per cent. tin. The quantity of this high-grade ore available for treatment has not yet been determined.

At the surface the constitution of the lode varies greatly from point to point. In some places it is gossanous and pyritic, and in others there is an almost entire absence of pyrite. This lode has not been traced into the underlying garnet-rock. Its strike is 50 degrees west of north, and its dip 70 degrees south-westerly.

Below Gorey's tunnel a large gossanous formation is cut in the road, and outcrops continuously along the northern fall of the hill on the lower side of the road. This formation is composed of porous sandstone heavily impregnated with limonite. It contains a little tin and silver and a trace of gold.

The Star of Peace lode is on the northern side of the main gossanous formation, and is about 3 chains distant therefrom. Friable sandstone, carrying a little gold and tinstone, has been cut in the road bank and in two trenches farther down the hill. In each of these openings the metallic minerals, tinstone and gold, are found in amounts not sufficient to pay for exploitation. In this loosely aggregated sandstone formation quartz crystals of wonderful development and clearness occur in great abundance. This formation is stated to be tin-bearing over a width of 6 feet, but dish prospects are obtainable only from a narrow band 6 inches wide.

In Tin Spur Creek tubicolar quartzite, underlying garnet rock, carries abundant pyrite and a little chalcopyrite. This rock dips south-west at an inclination of 45 degrees. The garnet rock shows a peculiar surficial relief, due to unequal weathering. It contains much oxide of iron, some of it derived probably from its own decomposition, and it disintegrates to a yellowish-brown soil. This garnet rock contains a little tinstone and traces of bismuthinite; wolfram is not present.

On the north side of the creek trenches have been cut across a hæmatitic formation encased in sandstone. This formation does not contain minerals of economic importance.

Between the Star of Peace lode and the Falls Mine, a porphyry dyke intruding the tubicolar strata is exposed in the road-cutting. This is the continuation of the tinstone-bearing dyke recently discovered on the Falls Mine. The porphyry consists of a number of fracture-fillings, the smaller branching from the larger. They strike 30 degrees east of north, and dip in a north-westerly direction. Tests made of the limonite-bearing porphyry showed the presence of a little tin and silver. Interbedded with the sandstones here are light-green bands of shale. Hard quartzite, in which the tubicolar casts are still easily discernible, outcrops here, and extends through the Falls property on the east and through the remainder of this section on the west side. The original sandstone has been completely silicified and heavily impregnated with pyrite. A number of samples were taken and submitted to Mr. W. D. Reid, Government Assayer, for examination, who reported the contents as follow:—

Description of Ore.	Footage Sampled.	Locality—sample taken.	Tin.	Silver.	Gold.
	Feet.		Per Cent	Per Ton.	Per Ton
Soft siliceous sandstone	45	On road west of Ashworth's workings	0·90	...	...
Soft siliceous sandstone	100	On road west of Ashworth's workings	0·70	...	...
Gossanous silica	45	On road east of Ashworth's workings	0·45	...	...
Gossanous silica	45 to 75	Road east of Ashworth's workings	0·30	...	...
Gossanous sandstone	75 to 110	Road east of Ashworth's workings	0·16	...	...
Garnet-epidote rock	15	Road near Main tunnel	0·20	...	...
Garnet-epidote	10	Tin Spur Creek	0·37	...	...
Ironstone sandstone	5	Outcrop below road	0·18	...	...
Sandstone lode material	5	Ashworth's trench	2·70	...	...
Sandstone lode material	2	East side of Ashworth's	1·30	...	...
Sandstone	...	Duff's shaft, selected ore	2·20	...	...
Sandstone	...	Bulk sample from Duff's shaft	1·20	...	...
Sandstone detrital material	...	South-west corner of section	0·50	...	...
Gossanous sandstone	...	Outcrop below road	...	4 dwts. 15 grs.	Trace

(c) Developments.

The first improvements, carried out many years ago under the supervision of F. G. Duff, consist of—an underlay shaft, 50 feet deep, sunk in sandstone, at an inclination of 72 degrees to the south-west; Gorey's or main tunnel, driven 230 feet on a bearing south 22 degrees west, towards Duff's shaft; and west tunnel, near Ashworth's workings, driven 100 feet in a direction 40 degrees west of south. The latter works consist of a number of trenches cut by Joseph Drew nine years ago near the eastern boundary, and Ashworth's shafts and trenches on the main ore-body further westward. In addition to this work on the main lode, several trenches have been cut across the Star of Peace lode, and also across the garnet-epidote formation outcropping in Tin Spur Valley.

The main, or Gorey's, tunnel commences at a point 1 chain on the south side of the road and 8 chains eastward of Ashworth's workings. It was driven to cut the small tinstone veinlets exposed in Duff's shaft, but stopped short of the required distance. At the approach, and a few feet in from the entrance, a kaolin-gossanous formation is passed through. This formation, which is certainly worthy of attention, has not been carefully tested for tinstone. It appears to be on the line of the main lode traversing this and the Falls syndicate's property eastward. Beyond the lode-formation very hard quartzite (altered tubicolar sandstone) heavily impregnated with pyrite comes in, and continues for 190 feet, at which point it gives place to garnet rock. The garnet rock comes in at the foot of the drive, and gradually rises at an inclination of 14 degrees, until at 230 feet from the entrance it occupies the whole tunnel. At the junction of the quartzite and the garnet-rock a soft kaolin band, a little malachite, and a vein of pyrite 3 inches wide occur. In the face, pyrite, in the forms of pentagonal dodecahedra and cubes, occurs in solid veinlets from ½ to 1 inch thick. Sulphate of iron is found on the walls of the tunnel near the end.

Duff's shaft has been sunk southward of the main lode through sandstone impregnated with tinstone. The tinstone occurs in a highly crystallised form, and is found more commonly on the joints and bedding-planes of the rock. Close by tinstone is found also in the younger conglomerates.

Ashworth's workings are not extensive, but they show the richest ore exposed on this section. They consist of two vertical shafts, 30 feet apart, about 40 feet deep, and a shallow-level tunnel. The soft friable sandstone in which the fine-grained, brown to black tin oxide is contained dips south-westerly out of the shafts which bottom on hard quartzite.

South-eastward of these workings several small trenches, cut through sandstone and conglomerate detrital material, show fine prospects of tin oxide, most of which is found as facings on the joints of the sandstone. Farther towards the Falls Mine, on a north-south ridge, a deep trench, cut by J. Drew, through sandstone detritus exposes tinstone ore of fair value.

(*d*) General Remarks.

It is possible to recover a considerable amount of tinstone by ground-sluicing the detrital material, which covers a considerable portion of this property, but as so much of the tin ore is found adhering to the sandstone its complete separation could only be effected after crushing. The rich ore exposed in Ashworth's workings is made up in part of very fine material, most of which would be lost in treatment by sluicing methods. It appears, therefore, that concentrating machinery is necessary to effect the complete separation and recovery of the ore. This mine is too small in itself to warrant the erection of costly machinery, and in any case further exploratory work should precede any expenditure in this connection.

It is recommended, for the purpose of more economical exploitation, that the owners of this property amalgamate their interests with those of the Falls syndicate.

(14)—*Falls Mine: Section* 7903-M, 40 *Acres (Lessee: E. F. Blyth).*

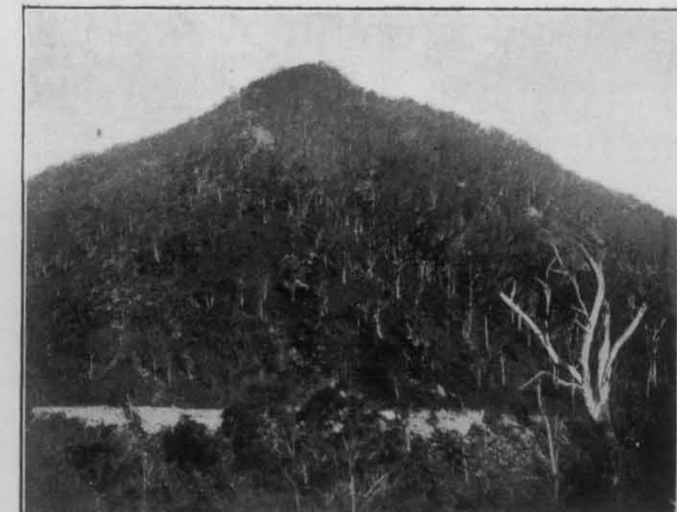
The tinstone lode on this section was discovered by R. Magee and B. L. Thomas nine months ago. The property is conveniently situated on the northern fall of Tin Spur, about 1 mile south-west from Round Hill. Lorinna-road to Sheffield passes through the section within 5 chains of the outcrop of the lode. Staverton railway terminus is 9 miles distant, and the township of Sheffield 16 miles.

(*a*) The Ore-bodies.

The main lode outcrops along the face of a steep hillside, and consists of gossanous material carrying tinstone in considerable quantity. The tinstone is fine to medium grained,

[*A. M. Reid Photo*

Photo. No. IV.—Fault Scarp, Falls Mine.



[*A. M. Reid Photo*

Photo. No. IV.—Tin Spur.

and well crystallised. It is commonly black in colour, though the fine material is of a prevalent brownish tone. The gossanous material in which the ore is contained is derived from the decomposition of porphyry, the limonite constituent being an alteration product of the pyrite introduced at the time the tinstone deposits were formed. A little development has been made by crosscutting the ore-body 25 feet and driving along its course south-easterly for 40 feet. These workings are at a very shallow level, and have not entered solid rock. The crosscut discloses gossanous material 15 feet wide resting on greyish porphyry, which greatly resembles sandstone at first sight. On the hanging-wall chloritic material occurs in cellular quartz, and the face shows much pyrite and quartz veinlets traversing the rock in all directions. The gossan contains a good deal of silica and undecomposed porphyry. This lode, evidently the south-eastern continuation of the porphyry dyke exposed in the road-cutting, has been traced over 100 feet on both sides of the tunnel opening.

About 5 chains south of the outcrop tubicolar conglomerates and sandstones, overlying porphyry rock, form a great escarpment over 100 feet high, and extend fully 1 mile south-eastward. This escarpment has been formed along a line of weakness due to extensive faulting. Other results of the faulting movements are the transposition of garnet and quartzite, and porphyroid and quartzite. At the faulted junctions of these rocks the tinstone ore-bodies have been formed. The greater part of the property is occupied by tubicolar sandstones and conglomerates, which are folded into a series of anticlines and synclines.

Two deep trenches sunk by W. Cook in angular to sub-angular detrital material at the southern boundary show fair tinstone prospects. The detritus is as much as 12 feet deep, and carries payable tin oxide in bands, and also a little gold. Rees Creek could be conducted by water-race to this point.

The flat ground in Tin Spur valley above the Falls was bored by P. Ashworth. It is reported that tin oxide was recovered from each bore-hole, but the quantities are unknown.

(*b*) Exploration.

The work at present in hand (the construction of a water-race from Tin Spur Creek to a point 60 feet above the workings, for the purpose of conducting the water required for sluicing operations) will soon be completed. It is intended to use this water for the purpose of the recovery of a large portion of the tinstone contained in the gossan, and by its removal ascertain the extent and nature of the undecomposed ore-body. This is regarded as a sound and cautious policy to follow.

The conditions for mining and treatment are unusually good, and exploratory work can be carried on at a minimum cost. The outlook is decidedly promising, and if the unaltered porphyry prove to be as rich as the outcrop a profitable future may be anticipated by the owners.

(15)—*The Premier Mine: Lease* 8070-M, 80 *Acres (Lessee: J. P. Kelly).*

(*a*) Situation, &c.

This property, until recently owned by J. S. McLean, is situate south of and adjoining the Hidden Treasure lease. The Lorinna-Sheffield-road passes through the western portion of the section.

(*b*) Ore-bodies.

The ore-bodies consist of mineral-bearing quartz veins contained in pegmatite, which is composed of quartz, felspar, and massive muscovite. They contain wolfram, molybdenite, and bismuthinite, accompanied by pyrite, chalcopyrite, and arsenopyrite. Accessory minerals are fluorspar, topaz, and muscovite. The granites here are traversed by numerous pegmatite dykes, all of which carry mineral-bearing veins.

No. 1 open-cut workings are situate 5 chains east of the road, and 200 feet higher up. The open-cut is 20 feet long, 6 to 10 feet wide, and in the end is 20 feet deep. The rock here is a pegmatite consisting essentially of coarsely crystallised quartz and felspar, the former predominating, with also pinite in subordinate amount. Variations occur in which the felspar component is insignificant, and the rock then greatly resembles greisen. In this rock, quartz veins carrying metallic minerals occur over a width of 4 feet. The quartz crystals, 2 to 3 inches long, occurring in cavities in the fissures exhibit typical comb structure. Wolfram is the dominant metallic mineral constituent, and is found embedded in the quartz or implanted on the quartz crystals and encased in very thin walls of silica. Bismuthinite, in acicular and massive forms, a little bismutite, and molybdenite are also present, but in subordinate quantities, and native bismuth is reported. The gold and silver con-

tent is small, but appears fairly constant. Pyrite in thin bands and in botryoidal form is fairly abundant, and chalcopyrite is met with in small quantity here and there. Green-coloured muscovite is found as a secondary mineral in the granite near the veins, and also implanted on quartz and wolfram.

No. 2 workings consist of an open-cut 15 feet long, from the end of which a tunnel has been driven 12 feet. It is situate 5 chains south-west of No. 2 workings. The lode is a fracture-filling, 4 to 6 inches wide, in pegmatite granite. Wolfram, bismuthinite, and molybdenite contained in a quartz gangue occur coarsely crystallised and highly developed. Molybdenite flakes 1 inch in diameter are commonly found, both in the lode and in the adjacent granite. At this point the granite contains a little biotite. Pyrite and green fluorspar are accessory lode minerals.

No. 4 Workings.—On the western side of the road, about 1 chain down the hill, and at a point a little south-westward of No. 1 workings, a number of small open-cuts have been put in on veins of bismuthinite-bearing quartz contained in pegmatite, made up chiefly of coarsely-crystallised felspar, quartz, and pinite. The bismuthinite occurs both in acicular and massive forms, sometimes in pieces sufficiently large to be separated by knapping. Pyrite and arsenopyrite accompany the bismuthinite, and secondary muscovite (green and black) and purple to green fluorspar are common accessory minerals. Molybdenite is also present. Neither wolfram nor cassiterite have been detected in this formation. The veins are from 3 to 8 inches wide, and from 2 to 4 feet apart. They strike 60 degrees west of north, and dip south-westerly at an inclination of 60 degrees. The top cut is about 10 feet square, and the lower 8 feet by 6 feet.

Samples from the several faces were found to contain—

	No. 1 Workings.	No. 2 Open-cut.	Drill-boring, No. 2 Open-cut.	No. 4 Open-cut Workings
Tungstic acid (WO_3)	Per cent. 0·58	Per cent. 2·8	Per cent. 0·4	Per cent. ...
Bismuth	Per cent. 0·13	...	...	4·21
Gold (per ton)	1 dwt. 7 gr.	...	...	...
Silver (per ton)	1 oz. 10 dwt.	...	...	...
Molybdenum	...	Nil	0·2	...

One chain past the first waterfall going south along the road a vein 2 feet wide carrying wolfram is exposed in the road-cutting. The rock in which it is contained is a coarsely crystallised granite consisting of pink orthoclase felspar, biotite, and quartz.

Besides these larger veins there are many rich veinlets traversing the pegmatite dykes.

(c) General Remarks.

The quantity of ore recovered from these workings is necessarily small, but it is reported that prospectors employing only crude methods of treatment exploited these ore-bodies successfully.

The geological conditions are decidedly favourable for ore-deposition. The pegmatite dykes containing so much topaz in their composition are natural *loci* for disseminated ores and mineral veins.

Every facility for economic mining is provided here, and, in addition, the property is easily accessible from Staverton and Sheffield.

Further developmental work, by driving along the course of the lodes, is required before consideration can be given to the question of the necessity for milling machinery.

(16)—*The Hidden Treasure Mine:* 6921-M, 70 *Acres* (*Lessee: J. S. McLean*).

(a) Situation, &c.

Wolfram has been known to occur on this property since the time of the discovery of cassiterite on Tin Spur, about 30 years ago. Very little work had been performed, however, until the present lessee took the property in hand in 1914.

Lorinna-road passes right through the section from north to south, the distance from Sheffield being 17 miles. It is bounded on the south by the Premier lease, on the west by the Forth River, and on the east by Lease 7870-M held in the name of E. F. Blyth.

(b) The Ore-bodies.

The chief economic component of the ore-bodies is wolfram; molybdenite and bismuthinte also occur in appreciable amount. Associated minerals are pyrite, chalcopyrite, fluorspar, topaz, and muscovite.

These minerals, set in a quartz matrix, are contained in veins 3 to 8 inches wide, encased in pegmatite. The pegmatite material, consisting of quartz, felspar, and pinite (a massive muscovite, and decomposition product of topaz), contains numbers of quartzose veins rich in wolfram, molybdenite, and bismuthinite, and the rock itself also carries blebs and pockets of these minerals. The pegmatitic material occurs in the form of irregular disconnected dykes, which range from a few feet to 50 feet in width.

(c) Developments.

Developmental work has been confined to a few small surface openings on the more important ore-bodies, showing results so encouraging that further work on a much larger scale is warranted.

Holroyd's cutting is a small opening 6 chains from the southern boundary sent in from road-level on a quartzose vein 10 to 12 inches wide, containing wolfram and molybdenite. The country rock is a pegmatite containing much pinite and unaltered topaz. This pegmatite dyke is of considerable extent, and contains appreciable amounts of coarsely crystallised wolfram and molybdenite, especially near the quartz veins. The decomposed material extends 12 chains up and down the hill. Below the road the detrital material derived from the decomposition of the pegmatite contains wolfram in payable quantity from the surface to a depth of 14 feet. The full extent of this detrital material has not been determined. Its removal and treatment by sluicing operations will not only be profitable in itself, but will be the means of uncovering the rich bands and veins from which the ore has been derived. The quartz vein contains 1 per cent. of tungstic acid and 0·15 per cent. molybdenum.

The main workings, consisting of an open-cut 30 feet long (from the end of which a tunnel is driven 16 feet), are situate 400 feet above the road on the hillside, 2 to 3 chains south of Section 7902-M. The lode, from 2 to 3 feet wide, consists of a quartz vein 8 inches thick contained in greisenised material 3 feet wide. In the tunnel face the lode is seen to carry wolfram and molybenite in blebs and pockets and irregular masses, and on the footwall a veinlet of molybdenite ½-inch thick. Pyrite occurs on the joint faces and scattered through the lode-material. Secondary muscovite is well developed in the vein, and is found also (though in a much lesser degree) in the granite wall-rock.

The trend of the lode is north-west, and the dip is south-westerly at an inclination of 60 degrees.

Fifty feet lower down the hill the vein outcrops again, and where exposed is seen to contain wolfram in fair quantity.

Samples of ore from the narrow vein exposed in the tunnel showed the following metallic content:—

Tungstic acid (WO_3)...	5·9	per cent.
Molybdenum (MO)	8·05	,,

Surface ore, 2 chains north and 50 feet below the tunnel:—

Tungstic acid	10·2	per cent.

Surface ore from parallel formation 1½ chain to the south and 40 feet higher than tunnel:—

Tungstic acid...	3·4	per cent.

These samples were taken from the clean vein-material, unmixed with wall-rock, a considerable amount of which will be broken with the vein-material in the exploitation of the lode, thereby rendering the average grade very much below that quoted here.

These small workings produced 30 cwt. of high-grade ore, containing over 20 per cent. tungstic acid.

There are several other parallel formations, none of which is at all developed, but they all have promise of becoming profitable sources of wolfram.

(*d*) General Remarks.

The pegmatitic detrital material already referred to as containing payable quantities of wolfram and molybdenite offers the greatest prospect for cheap and profitable exploitation. The only difficulty to be overcome is that of a sufficient water-supply for the operation of ground sluicing. Tin Spur Creek is the only permanent stream suitable for the purpose in the vicinity, but the larger portion of this water is used by the Falls Syndicate in operating their mine, and is therefore not available. As there is an abundant supply obtainable from several small creeks flowing through the property during the winter months, it seems advisable to confine operations on this property to the period covering the rainy season.

The several veins require more thorough development before an estimate can be made of their true value.

(17)—*Section* 7814-M, 80 *Acres (Lessees: B. L. Thomas and E. J. Rees).*

Situate near the summit of Oliver's Hill, at an elevation of 2330 feet above sea-level, and 1400 feet above Lorinna-road, the physical conditions are admirably suited for economic exploitation. The property at the present time is held under option for purchase by Messrs. D. Griffin and F. Richard, of Latrobe, who are exploring the lode by means of a crosscut adit, the entrance to which is 70 feet below the outcrop. On the surface the lode, 3 to 8 inches wide, is largely made up of gossanous material, the tin contents varying greatly from point to point. Rich specimen stone was obtained from the outcrop directly above the end of the adit, but the lode is patchy and in some places it is very small and barren. The vein is contained in hard mineralised quartzite, through which barren quartz veinlets ramify in all directions. Like so many similar occurrences in this locality, the veins are remarkably persistent in a linear direction. The dip is 52 degrees west of south.

The crosscut, sent in 72 feet in a direction north 70 degrees east, intersected the lode at 69 feet. From this point a south-east drive follows the course of the lode 40 feet. It is very poor at this level, and although a little gossan appears and a thin vein of quartz, the bulk of the formation consists of kaolin contained between sandstone walls. Facings of cassiterite on the sandstone occur in the crosscut. Pyrite is the most common metallic constituent of the lode-material. Developmental work here is very disappointing, and the results afford little encouragement for further exploration.

Gold up to 14 dwt. per ton is reported to have been recovered from shafts sunk on a ferro-manganese formation by T. Dawson and T. Terry about 28 years ago. These workings are situate near the south-east corner of the section. It is understood that the gold content of this ore-body, which extends into the neighbouring sections, is very irregularly distributed.

At the head of Rees Creek alluvial ground of small extent contains fair tin prospects.

An east-west lode-formation, about 7 chains north-west of the shafts sunk on the gold-bearing ferro-manganese ore, composed of yellowish shaly material, contains a little tinstone. A body of iron pyrites in sandstone occurs between the latter and Griffin's workings. These constitute the whole of the known mineral occurrences on the property, and while no payable ore-shoots have as yet been developed, they are worthy of continued attention.

(18)—*Section* 7869-M, 40 *Acres (Lessee: E. J. Rees).*

This is an undeveloped property, situate south and adjoining the Premier section. Granite occupies the greater part of the surface, which rises steeply towards the east from the banks of the Forth River. In the road-cutting near the centre of the section molybdenite veinlets on the walls of cracks in the granite are commonly noted.

One chain south from the northern boundary, near the north-east corner, a small cut has been put into decomposed granite containing wolfram. The lode-formation is about 5 feet wide, and consists of a number of mineralised contraction joints or fissures. One such fissure shows fairly good wolfram prospects, but the average content is low.

Just over the southern boundary of this section the granite-porphyroid contact-rock carries a fair amount of molybdenite. The contact-rock is a form of greisen consisting essentially of quartz and brown mica. It has been developed by means of a small open-cut sent in from road-level—this is known as Reardon's cut.

(19)—*Section* 7416-M, 30 *Acres (Lessee: E. F. Blyth).*

Situated south of the Falls Mine and east of the Premier, and near the granite contact with porphyroid and sandstone, this section is one which may be expected to contain ore-bodies. Up to this time no developmental work of any kind has been attempted. Samples of vein-material broken from an outcrop were found to contain—

Silver, 4 dwt. 11 gr. per ton.
Gold, 2 dwt. 17 gr. per ton.
Tin, 0·40 per cent.

On the northern part of the section tin oxide and gold have been recovered from detrital material. The surface is wholly occupied by sandstone.

These results are encouraging, and suggest that the property is worthy of a little more attention.

(20)—*Section* 7870-M *(E. F. Blyth).*

Lying between the Hidden Treasure section on the west and the Falls Mine on the east, this property offers considerable inducement to prospectors. The greater part of the surface is occupied by tubicolar conglomerates and sandstones. At the south-west corner the underlying porphyroid crops out, and at this angle of the section granite also is seen. A little tinstone shows as facings on the conglomerate at this point, and a little gold and tinstone have been recovered from the north-eastern part. Nothing of any appreciable value, however, has been discovered up to this time.

(21)—*Lease* 7892-M, 40 *Acres (Lessee: E. J. Rees).*

This property is situate north and adjoining Lease 7890-M, held in the name of E. F. Blyth, and occupies portion of the south-western slopes of Tin Spur.

Very little prospecting has as yet been done, and no openings of any kind have been made. At the time of the writer's visit, the survey of the boundaries had not been commenced, and therefore it was found difficult to fix the position of the prospects. Near the south central part of the section cassiterite (tinstone) occurs in small quartzose veins, 3 to 5 inches wide, contained in schistose porphyroid. Veinlets of quartz traverse the porphyroid in all directions, and cavities in them filled with highly-developed quartz crystals and muscovite mica are commonly noted. The tubicolar conglomerate directly overlying the porphyroid at the point of junction shows facings of cassiterite.

The very slight alteration of the porphyroid at the granite contact suggests a thinning-out of the granitic mass at this point. This is another instance of the general occurrence of tinstone outside the granite boundary.

No work at all has been done on these small veinlets. It is, therefore, impossible to form an opinion of their prospective value. A specimen broken from the outcrop contains 22·4 per cent. tin. This is no criterion of the true average value.

(22)—*Section* 1414-M, 40 *Acres.*

Situate north-west and adjoining Morgan's lease, No. 7902-M, and close to the Forth River, this section is on the Falls-Morgan line of lode. The surface is occupied by quartzites and garnet rocks, and granite passes through the south-west corner. The quartzite stands out prominently on the very sharp, narrow ridge trending diagonally across the section from the south-east to north-west; while the garnet rock occupies the valley floor of Tin Spur Creek and the northern slopes of the ridge.

The quartzites contain limonite and pyrite, this mineralisation increasing towards the north-west corner, where the rock assumes the form of gossanous sandstone. Near this point also magnetite appears at the surface as a massive, irregularly-shaped body filling fissures in a silicified sandstone.

Numbers of trenches have been cut across these formations occupying the apex of the ridge, but nothing of value has been revealed by this work. Farther down hill, near the river bank, the quartzites contain both molybdenite and wolfram as blebs and pockets irregularly distributed in quartz veinlets. At low-water wolfram can be detected in the quartzite rock occupying the river-bed opposite this point. Some very good specimen stone has been knapped off the rock projecting above the surface of the water, but these richer veinlets are very small.

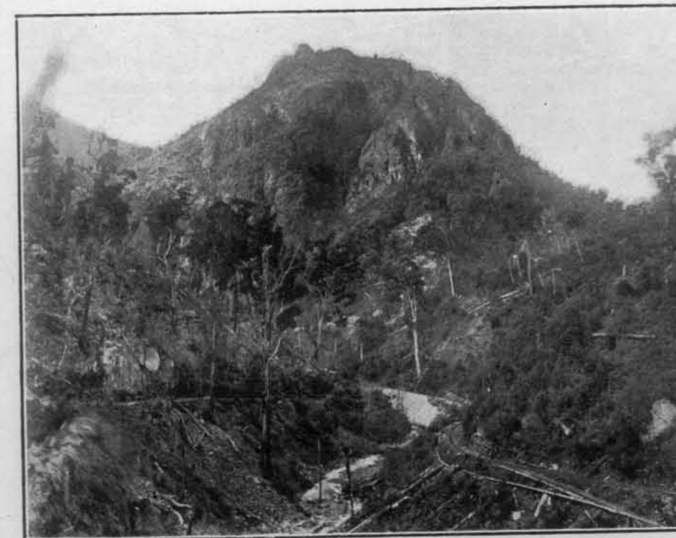
A little north of this pyritised garnet rock outcrops along the river bank, the mineralisation extending over a width exceeding 70 feet. The granites crop out 6 chains to the southward.

(B)—Silver-Lead Mines.

(1)—*Round Hill Mine.*

(*a*) Area, Situation, &c.

The Round Hill property now consists of consolidated lease No. 7478-M, of 182 acres. The mine, owned and operated by the Round Hill Silver and Lead Mining Company, No Liability, is situated at the foot of Round Mountain, near the western extremity of Mt. Claude Range. The district settlement, Cethana, lies 1½ mile northward, but the postal arrangements are conducted from the mine office, and many of the employees reside in the vicinity. The centre of population is Sheffield, a township of about 2000 people, which lies 15 miles northward. The nearest railway-station is at the terminus of the Staverton branch line, 8 miles distant. The Staverton branch railway, 14 miles in length, junctions with the North-Western Railway at Railton.



[*A. M. Reid Photo.*

Photo. No. V.—Round Mountain.

[*A. M. Reid Photo.*

Photo. No. V.—Entrance to No. 1 Tunnel, Round Hill Mine.

Galena was discovered here in 1878 by Weeks and Thos. Shepherd, well-known prospectors, who figure prominently in the early history of discovery of the northern mining division.

The mine since the inauguration of the original company has passed through many vicissitudes, and not until the advent of the present company has any degree of success been achieved. During the past 3½ years operations have been conducted under the supervision of Mr. John Craze.

(*b*) History.

The occurrence of silver-lead ore at Mt. Claude has been known for over 40 years, the discovery having been made by Weeks and Shepherd about the year 1878. In 1880 the Mt. Claude Silver-Lead Mining Company, under the legal managership of D. Burke, of Westbury, was organised, and developmental work was in progress in 1881. The first official record of the operations of this company is contained in the report of G. Thureau, a former Government Geologist, who visited the mine in 1881. The low-level exploratory adit had not then been started. The mine superintendent, James Hancock, shortly afterwards commenced the driving of this long adit. In 1885, G. Thureau wrote a further report on the mine, in which he referred to the company's workings on the east side of Claude Creek, at the base of Round Mountain, and others on the west side of the creek near the waterfall. The main adit had been driven at this time to 593 feet from the entrance. The company ceased driving the adit in 1884, and the mine was abandoned until 1890, when B. L. Thomas and Thos. Terry continued the exploratory work commenced by the original company. At this time the Maori Queen sections, and one of those included in the property of the present company, were secured by the Southern Cross Proprietary Silver Mining Company. Developmental work recommenced under the supervision of Geo. Hartrick, who continued the main adit to the boundary of the quartzite at 650 feet, where a strong stream of water marks the junction of the quartzite and limestone.

When A. Montgomery, Government Geologist, visited the mine in 1893, the Kentish Proprietary Silver Mining Company, No Liability, was carrying on mining operations, and had driven the adit in limestone to its present face, 802 from the entrance.

Work was again suspended till 1907, when investors from Devonport arranged for the flotation of the Round Hill Silver and Lead Mining Company, No Liability, which carried out a good deal of work, under the supervision of W. Watson and others, during the next six years, in the way of prospecting and opening up the property, providing concentrating appliances, &c. In 1912 the mine was let on tribute to a party of miners under the leadership of Geo. Gabbedy, who, continuing the No. 1 tunnel southward, encountered another ore-body, which produced large quantities of high-grade material.

In 1913 W. H. Twelvetrees, Government Geologist, visited the property, and in Bulletin No. 14 exhaustively discusses the peculiar geological formations in which the ore-bodies are contained. In addition a detailed description is given of the several workings. In 1915 the company was reconstructed for the purpose of raising sufficient additional capital to properly equip the mine and provide ample funds to allow of extensive developmental work being undertaken. During the past 3½ years, under the supervision of J. Craze, the mine has produced large quantities of high-grade galena ore. At the present time the outlook is more promising than at any period of its history.

(*c*) The Ore.

The ore consists dominantly of galena, with abundant chalcopyrite and a little pyrite, sphalerite and siderite as common associates. The only other minerals which can be seen in the hand specimen are a little bismuthinite, pinite, and quartz. Sphalerite is never abundant, and in many places cannot be detected in the ore. Siderite occurs rarely in small blebs distributed sporadically through the galena-chalcopyrite ore.

The galena-chalcopyrite ore in particular is especially rich, one parcel weighing several tons contained: 6 per cent. copper, 40 per cent. lead, 380 oz. silver, and over 1 oz. gold per ton. The average-grade galena ore contains 1¼ oz. of silver per unit of lead, with gold also in appreciable quantity. The south-eastern ore-body cut in the north-east crosscut from the end of the main tunnel shows galena-chalcopyrite ore of exceptional richness over a width of 16 feet and 80 feet in length. Specimens from this ore-body contained from 360 oz. to over 900 oz. of silver, and 14 dwt. of gold per ton. The concentrates from this lode are of much lower grade than the selected ore: 3 dwt. gold

and 181 oz. silver per ton and 62·4 per cent. lead. Near the surface the silver content is much less, but where chalcopyrite is an abundant constituent the ore is very rich in that metal. Bismuthinite, although present only in very small amount, always accompanies the rich silver-bearing ore. There is comparatively little vein-quartz in the ore-body; this is remarkable, as silicification of the wall-rock has been intense.

The galena occurs both fine-grained and coarsely crystallised. In the rich galena-chalcopyrite ore it occurs in streaks parallel to the walls of the fissure. Pyrite was deposited before the other metallic minerals filling the smaller cracks near the walls of the fracture and also on the walls and in the ore. The pyrite is not disseminated through the ore, but usually occurs as patches and in incomplete bands parallel to the walls. Chalcopyrite occurs in closely packed detached areas about ½-inch in diameter, surrounded by galena. In some places the pyrite and chalcopyrite are found only on the walls, in which case the galena is clean and also of high grade. Some of the massive clean galena contains blebs of pyrite in the centre of the mass. In general, the deposition of the metallic minerals has been contemporaneous.

Of the gangue minerals quartz is the most important, though never abundant. It is rarely crystallised, usually opaque, and full of inclusions of other minerals. Pinite occurs abundantly, especially where galena and chalcopyrite prevail, on the walls, and also throughout the ore. It was precipitated later than all the other minerals that are present.

Fine-grained ore is contained in the quartzite, which, before its transformation from sandstone, was porous and pervious to ore-bearing solutions. Infiltrating manganese oxides have coloured the quartzite in the ore-channel a deep brick-red, and also pale-green.

(*d*) The Structure of the Ore-bodies.

Mt. Claude, Round Mountain, and Brazen Nose form the western extremity of the range of mountains which includes Mts. Roland, Vandyke, and Gog. This range of mountains is occupied by heavy beds of West Coast Range conglomerates, which rest upon schistose porphyroid rocks. These porphyroid rocks are exposed both on the northern and southern sides of the mountain range, and in favourable places may be seen underlying the conglomerate half-way up the northern slopes. Included in this porphyroid group of rocks are various clastic and pyroclastic sediments represented by blue and green slates, crushed schistose grits, and felspathic schists outcropping near the southern part of Cethana settlement. The strike of these strata is north-westerly, and the dip is north-easterly. Southward and westward of the Mt. Claude Range the surface is occupied almost wholly by tubicolar sandstones and conglomerates. These strata, like the older conglomerates, have a more general east-west trend, with a tendency a little north-west.

Thrust-faulting has played an important part in the determination of the present topography, although erosion has masked the extent of the deformation. In this locality there are numerous fault-scarps and faulted junctions of dissimilar unconformable sediments, indicating dislocation of the strata on a very large scale. A faulted junction of slate and schist with the old conglomerates may be seen on the road ½-mile north of the Round Hill Mine. This line of fault extends for several miles westwards. A great conglomerate fault scarp stands up for ¼-mile east of Round Hill, forming the southern confine of Red Water Creek. Then there is the over-thrust fault of Round Hill, where the older conglomerates and the later tubicolar quartzites and conglomerates have been superimposed. These underlying, sharply-folded quartzites contain the main ore-bodies. At the apices of the anticlines, where deposition has been greatest, they are sharply-pointed and slightly crushed, showing that the beds were incompetent to stand the load without interior adjustment. There is evidence here of both flowage and fracture holding, but the general structure is more characteristic of the latter. The folds are of the "parallel" type, having the bedding-surfaces mutually parallel. The curvature of each bed is different, thus implying the gradual dying-out of folds and the differential slipping between the layers. The evidence of flowage is more apparent in the shale bands interbedded with the quartzite. The folds on these and other weaker layers are really "drag folds," due to differential movement between the controlling harder layers. This movement develops one set of shearing-planes parallel to the beds, and another at an angle less than 90 degrees to it. Fracture or joint cleavage forms along these planes.

The pitch of the axis of these folds is at an inclination of about 15 degrees in a direction north 55 degrees west. The

projection of the axis of the drag fold at the surface varies slightly in strike from the strike of the beds. The ore-bodies follow the pitch of the folds, and as they are brought down they are carried north-westward. The principal mineralisation has taken place at the apices of the anticlines, but solutions have migrated also along the bedding-planes. Deposition has taken place in the weaker beds, which have been affected by flowage, and are crushed at the apices of the anticlines. As these layers are rarely more than 20 feet thick, the depth of the ore-shoot is limited to this extent. The bulging of the beds on either side of the apices has provided space for the deposition of ore in rich clean bands. The lateral limit of the ore is about 12 feet on either side of the apices, or over a total width of about 24 feet. The ore-bodies are thus contained in shoots about 25 feet wide, 20 feet deep (measured at right-angles to the angle of pitch), and of (as yet) indeterminate length along the pitch. Mineralisation has also taken place, but to a minor extent, along cleavage-planes and joints in the rock. Parallel vertical fissures intersect the beds at the apices of the anticlines, providing one channel through which ore-bearing solutions circulated; but the main channel of access was along the flowage-planes of the crushed beds. The synclinal troughs, though seats of ore-deposition, do not carry ore-bodies of economic importance.

At the point of junction of the overlying conglomerate with the quartzite, friction breccia, from 3 to 13 feet thick, made up of rounded to sub-angular pieces of quartzite embedded in soft grey pug, may be seen. The breccia dips flatly to the north-eastward, and away from the ore-body, which nearly penetrates the conglomerate. This breccia actually lies on a curved fault, which will be found to straighten up as it is followed downward. The south-eastern ore-body, recently discovered, lies closer to the fault than any of those already exploited. There is good reason to expect other ore-bodies of equal magnitude to exist still further north-eastward of the most southern workings. The quartzites abutting against the hard resistant conglomerates will be found to have suffered far greater deformation at this point, and thereby have provided more favourable *loci* for ore-deposition.

As the ore-bodies in the main workings pitch north-westerly at 15 degrees they pass below the water-tunnel. It is probable that the several parallel ore-bodies occurring at the apices of parallel anticlinal folds are on or about the same level, and occur in the same weak strata, and, therefore, these also pass below the level of the tunnel. It is known that some of the ore-bodies occurring at a higher level are remnants of distinct deposits, the greater parts of which have been denuded.

There is no apparent dip of the anticlinal ore-bodies. This may be seen on referring to the plan of the mine workings, by the almost exact superposition of No. 2 tunnel in relation to No. 1.

There is evidence of the partial or complete replacement of certain narrow bands of shale occurring between thick hard layers of quartzite by galena-chalcopyrite ore. These shale bands are made up of pyroclastic material derived from felspathic porphyroid rocks. The felspathic nature of the original rock is indicated by the development of pinite in the ore-body.

(e) *Development.*

Developmental work commenced on this property about 40 years ago, and has been carried on intermittently up to the time of the reorganisation of the Round Hill S. and L. Mining Company three years ago. Since then exploration and development have been carried on vigorously, and in the most systematic manner. Developments consist of a number of tunnels, open-cuts, and trenches, all of which have been sent in at intervals along the valley of Claude Creek. These workings have established the existence of several lines of mineralisation parallel to one another in a belt of folded tubicolar quartzite 800 feet wide.

These mine-openings may be grouped for purposes of description into the western, central, and eastern workings.

Western Workings.—The western workings are about 1000 feet from the main tunnel, and appear to be on Sale's lode-line of ore-deposition. Most of the ore broken in these workings has been sent to the mill by means of an aerial ropeway. The open-cut, which is 58 feet wide and 50 feet long, has produced a large quantity of first and second grade material; but this appears to be the limit of the ore-body, as very little ore remains on the walls, and the exploratory work carried out in the tunnel, 20 feet below, has not revealed anything of value. The ore occurs here at the centre of an anticline, and consists of galena and zinc blende with much pyrite. On the legs of the folds the ore nearly cuts out, showing thin facings only of black sphalerite and parallel veinlets of pyrite on the bedding and cleavage planes. There must have been some material in the

rock replacable by the ore in solution, as the ore in places has the structure of the rock. Both cleavage and bedding planes far from the open-cut workings contain a good deal of pyrite. Infiltrating solutions have deposited fine grains of galena, pyrite, and zinc-blende in the porous sandstone, which here has a bluish hue. An upper, smaller open-cut, 25 feet higher, and directly adjacent to the lower one, shows a quarried face 35 feet wide. From a still higher cut of small size a little galena was recovered.

The adit, 20 feet below the main open-cut, known as No. 6, has been driven 100 feet along the anticline. Small galena veins traverse the rock in all directions, and over the back appeared in sufficient quantity to be stoped profitably. It is reported that rich ore was obtained from a shallow winze 90 feet from the entrance, but only traces of galena can be seen there now. At 40 feet from the entrance a crosscut 40 feet long has been sent in south-westerly. Above this crosscut a little ore has been stoped. During the period 1907-1908 over 67 tons of marketable ore were produced from these workings. The grade of the ore is much less than that of the eastern ore-bodies.

One hundred and fifty feet east from these workings is the No. 4 tunnel, which has been driven 45 feet southward, with the object of intersecting the supposed linear continuation of the western ore-body.

Central Workings.—The central workings consist of the water-tunnel, and No. 1 A tunnel, an open-cut, and a shallow shaft. No. 1 A tunnel and the adjacent surface workings are not important. They are exploratory works sent across a gossanous formation. A little ore was obtained near the surface. This is the trend line of the Falls lode.

The water-tunnel is now used as a reservoir for the supply of wash-water to the milling plant during the summer season, when the Claude Creek supply is insufficient. For this purpose the entrance has been boarded up, and therefore these workings could not be examined on this visit.

The entrance to the tunnel is from the southern bank of Claude Creek, at the level of the tramway connecting the No. 1, or main, tunnel workings with the milling plant. These workings are only a few feet below those of the No. 1 tunnel. The adit has been driven 800 feet in a southerly direction across the strike of the mineral belt. The average strike of the ore-bodies here is north 55 degrees west, so that the adit must intersect them. About 15 feet from the entrance, a vein of galena 1 inch thick appears, and is probably the upward continuation of the main fracture-plane, as it is on the strike of the main ore-bodies exposed in No. 1 tunnel. The main ore-bodies pitch below this adit. On this line of lode a rather strong formation is exposed in a small cutting sent into the hillside from the level of Claude Creek, and on the north side. The strike is 55 to 60 degrees west of north, and the dip 45 degrees south-west. The lode is composed of chalcopyrite and pyrite in shattered sandstone, and is 4 feet wide. This is doubtless the line of strike of the main lode-channel.

At 90 feet from the entrance to the water-tunnel a little work has been done on a mineralised formation 8 to 10 inches wide. This is probably the continuation of the outcrop below the boarding-house, and of the veins driven on from the creek between the main tunnel and Sale's workings.

At 170 feet in, Sale's line has been intersected and driven on west for 20 feet. The formation is 2 to 3 feet wide, with a little clean galena showing, but it pinches out in the end. The drive is on the regularly bedded south leg of an anticline. At about 400 feet in, the adit is below some shallow workings at the surface, which are in a gossanous formation connected with a water-channel, but nothing has been found in the tunnel below. This is the trend-line of the Falls lode. At 550 feet and 604 feet in this adit, veins are marked on the company's plan, but work has been discontinued so long that the walls of the drive are not in a condition suitable for examination. Between 600 and 650 feet the quartzite rock is hard and blocky; at 654 feet, or 148 feet from the end, a strong stream of water flows into the adit from a channel, which seems to mark the boundary between the quartzite and limestone. Calcareous rock is reported to have been met with after 500 feet, but this has not been confirmed. The limestone is a dark, bluish-grey, tough rock, and at the end of the adit appears to have a general tilt southerly. It is not exposed on the surface, its position in relation to the tubicolar sandstones being due to faulting.

The eastern workings comprise Nos. 1, 2, and 7 tunnels, where Claude Creek takes a bend to the south, and various cuts and drives on each side of the creek between the bridge and the falls.

During the past six years developmental work has been confined almost exclusively to Nos. 1 and 2 tunnels.

No. 1 tunnel was commenced many years ago along the northern limb and crown of the most northerly anticline. This is now the main mine opening, through which all

material is drawn. It is 8 feet high (6 feet 6 inches clear of timber), 12 to 30 feet wide, and has been extended to nearly 800 feet in a southerly direction from the entrance. The tunnel is equipped with a steel-rail tramway of 2 feet-gauge, by which it is connected directly with the mill bins. Sidings are provided both inside and outside the mine. The ore and waste rock from the mine is conveyed by horse-traction in side-tip trucks (1 cubic yard capacity), four to a train. Stoping commenced at 57 feet from the entrance, where the first rich shoot of ore came in. About 25 feet width of ground has been taken out from tunnel-level and sent to the mill. This shoot is 75 feet long, measured along the tunnel, and has been stoped out 30 feet above this level, the width in the end being 25 feet. At 120 feet from the entrance the drive is 17 feet wide. The intervening ground has been almost completely stoped out from Gabbedy's workings. At 287 feet ore has been taken out over a width of 16 feet; another shoot of ore came in at 355 feet, and continued for 50 feet. This shoot, like the others, gradually rose from the tunnel-level, and was stoped out 30 feet up. Barren country comes in 25 feet north of No. 2 rise, and continues almost as far southward as No. 3 rise, which is being sent upward to connect with the intermediate level. Rich galena-chalcopyrite ore came in at this point, giving place to galena-pyrite ore as the drive is continued south-eastward. This is one of the longest shoots of ore in the mine, but is very irregular in metallic contents. It has been stoped out 25 feet wide, over 100 feet long, and about 30 feet high. At 545 feet from the tunnel entrance branch veins have been followed south-easterly 125 feet further, and in an easterly direction an "indicator" vein has been driven on 144 feet. About 80 feet from the point of junction of these drives a large quartz formation with 6 to 8 inches of clean high-grade galena came in, and continued for 20 feet. This vein, of exceptional richness, was limited to the height of the drive. In the roof a thin veinlet of galena shows, and appears also in the face of the drive a few feet further on. The lode-formation in the end of the drive is composed of brown and green stained quartz and quartzite, carrying irregular blebs and veinlets of galena. On the west wall fine-grained conglomerates or grits, very much silicified, occur. The quartz here contains gold in the proportion of 1½ dwt. per ton.

The east drive follows a galena indicator for 144 feet. This is the furthest point southward reached by the tunnel, and is some distance beyond the crown of Round Mountain.

From this most southern point a crosscut was sent in 43 feet in a north-easterly direction, intersecting a very strong and rich lode-formation from 13 to 16 feet wide. The work, which led to the discovery of this ore-body, was carried out subsequent to the visit of examination. The reasons for undertaking exploratory work in this direction have been outlined in an earlier paragraph. This lode has been driven on over 80 feet, and shows an average width of 16 feet. Selected pieces of galena from this lode contained silver at the rate of 360 to 930 oz. per ton.

No. 2 tunnel workings, 70 feet vertically above No. 1, consist of a long drive and various crosscuts and rises on the same ore-bodies developed in the main workings below. This drive commences also on the arch of an anticline, and as it continues south-eastward each succeeding ore-shoot is passed through. From this tunnel communication with the No. 1 and with the surface has been made by means of rises. West Coast Range conglomerate has been passed through, 70 feet above this level, in the rises communicating with the surface. Galena is contained in the overlying conglomerate at the point of junction. At the end of the tunnel, nearly 500 feet from the entrance, only a few veinlets of galena show in the quartzite rock. Nearly all of the ore above these workings has been stoped out.

The continuation of the anticline followed in the above workings has been developed on the opposite or west bank of the creek in No. 7 tunnel. A crosscut has been driven 67 feet in a south-westerly direction across a poor flat vein underlaying with the drive. In the magazine chamber, at the end of the crosscut, a lode has been cut with bands of galena up to 7 inches wide, which is the continuation of a 3-feet lode crossing the creek at the top of the small falls. This produced principally seconds, but had some clean ore, and seems to be the best part of this particular shoot. It pinches going east, but has been followed west in the 54-feet drive behind the magazine and stoped out.

Nearly 200 feet south of No. 2 adit, along the Lorinna-road, east of the creek, a dark belt of altered country about 100 feet wide is exposed in the road bank. It contains a formation of slate and quartzite 25 to 30 feet wide, slightly mineralised with galena and containing a considerable amount of pyrite. It forms an anticline, and its continuation probably passes through Sale's quarry on the western side of the creek. One band of shale 6 inches thick in this anticlinal fold is found to have been almost completely replaced by pyrite, which occurs in oolitic form

The small unattached globules are oval to elliptical in shape, and about 1 millimetre in diameter. They may represent the cast of some obscure organism.

The quarry is a small open-cut excavation about 140 feet above the creek, and about 20 feet wide, cutting obliquely across the bedding; the true width of the exposed beds being about 9 feet, of which 4 or 5 constitute the mineralised formation. In this are small veins of galena and pyrite, concordant with the bedding-planes for the most part, but also branching irregularly. A little fair-quality milling ore, with occasional clean galena, has been obtained here, but the face exposed at present does not look quite so good as the stone which has been broken out would indicate.

There is, however, here an undoubted line of ore-deposition, possibly of some value. This line of lode is probably indicated in the water-tunnel by the veinlet cut at 190 feet from the entrance.

On the Lorinna-road, 400 feet south of No. 2 tunnel, is a small drive 25 feet long, bearing 57 degrees east of south, into the hill in a synclinal trough between two arches. On the south wall are one or two clean galena-pyrite veins in a quartz gangue, but these seem to have pinched out in the end. On the west side of the creek, opposite this line and about a chain below the falls, a tunnel has been driven north of west for 30 feet under the third anticlinal arch, but no galena ore is visible. Lower down the creek, between Sale's lode-line and No. 1 tunnel, a small drive has been sent into the east bank on some veins of galena. A little fine-grained ore is showing inside the entrance, but the end seems to have verged slightly to the south of this. The formation exposed here, if prolonged westwards, would connect with one below the boarding-house.

About 3 chains south of the mill, on the east bank of Claude Creek, a chalcopyrite formation in shattered sandstone has been exposed by a small trench. The chalcopyrite, with pyrite and silica, occurs as disseminations and thin veinlets in the crushed part of an anticlinal fold, which is considered to be the northwestward extension of the anticline containing the main ore-bodies. The strike is 60 degrees west of north, and the limb on which the ore is found dips 45 degrees south-westward. The average content of the ore is equal to 1 per cent. copper.

In another bedding-plane, dipping 45 degrees north-east, a band of galena is exposed. This occurrence is just above the road opposite the copper prospect. Claude Creek, for some distance, flows along the axis of the main anticlinal fold, which appears here in a deep depression.

(*f*) Production and Ore Reserves.

No accurate statistics of the production of the mine are available prior to the commencement of operations by the present company, which was organised in 1907, and registered on the 26th July of that year. The earlier works of the company were confined mainly to exploration and development, and therefore it is only within recent years that production has been at all extensive. In 1908 and 1909 several parcels of ore, amounting to 67 tons 11 cwt., containing 29·1 oz. silver per ton and 48·3 per cent. lead, were broken at the western workings and shipped to smelters. Since then production has been entirely from the eastern workings.

Period of Production.	Net Dry Weight	Silver.	Lead.	Net Value at the Mine.
	Tons.	Oz.	Tons.	£ s. d.
1907 to March 31, 1918	2,913·6732	133,227·64	1592·328	30,320 5 10
April to September, 1918	234·1078	6,625·24	126·337	2,298 4 3
Total	3,147·7810	139,852·88	1718·665	32,618 10 1

Since September shipments totalling 120 tons have been made, but no returns are to hand. The average grade of the ore exported is equal to 41·25 oz. silver per ton, 54·69 per cent. lead; and is worth at the mine £10 7s. 3d. per ton. The ore has a fairly regular gold content, amounting to 2 dwt. per ton. In the statement of production and value mention was not made of 121 oz. of gold for which the company received payment. The Sulphide Corporation Ltd., to which the ore is sold, pays for gold only on those lots containing more than 2 dwt. per ton.

The extreme irregularity of the ore-bodies precludes even an approximate estimate of volume being arrived at. Prior to the recent development in the south-eastern portion of the main workings, the actual reserves of ore were sufficient only to keep the milling plant in operation for about five months. It is impossible to estimate, at this stage of development, the quantities added to reserves by the discovery of the south-east ore-body, but the indications are such that this may be regarded as the most important development in the history of the mine.

The critical worth, below which mining at a profit cannot be counted on under prevailing conditions, has been put at the low value of 10s. per ton for crude ore. In arriving at this figure allowance has not been made for interest on capital outlay, but all ordinary costs have been taken into account.

(*g*) Milling.

The following description of the milling plant and the method of operation employed at this mine is taken directly from particulars supplied by Mr. J. J. Andrew, assistant manager for the company:—

The mill is designed for the treatment of 60 tons of ore in eight hours. During the wet season (March-October) the milling plant is driven by two Pelton wheels operating under a head of 200 feet of water, which is conducted from Claude Creek to the mill by water-race and pipes.

One Pelton wheel is connected with the rock-breakers and rolls, the other with the jigs and concentrating tables, thus ensuring regular and steady running of the concentrating units. During the dry season (November to February inclusive) the milling machinery is driven by a National suction producer-gas engine of 90 h.p., the gas being produced from wood direct from a 100-h.p. Commonwealth gas plant.

Ore is delivered from the mine to the mill storage bins, which have a capacity of 80 tons, in side-tip trucks by horse traction.

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

(1) From the storage bins the ore gravitates to two automatic-feed tables or perforated shakers, holes 1½ inch in diameter, the oversize going to two rock-breakers (one of the Dodge, the other of the Blake type), set to crush 1½ inches; the undersize passing through the perforated shaker joins the product from the rock-breakers. First-grade lump ore passing over the automatic feeder is picked out and bagged.

(2) The product of the crusher, with the undersize from the perforated shaker, falls into a set of

coarse rolls, which reduces the size to ½-inch; and is then conveyed to a series of trommels, where it is sized.

(3) In the first series of revolving trommels the crushed material is separated into the following sizes: 13, 9, 5, 3, and 1½ millimetres, and thence conducted to five sets of jigs each of four compartments. The jig screens are 1½ millimetre larger than the corresponding trommel screen. The product of the first and second compartments is of marketable grade, that of the third and fourth being returned by elevator to the fine rolls.

(4) The finely crushed material is then conveyed to the second series of trommels, in which it is separated into four sizes by screens of 5, 3, and 1½ millimetres in diameter, thence passed to four jigs of corresponding sizes.

(5) The slimes passing through a spitzkasten are run on to four concentrating tables, two of the Wilfley and two of the Card type, the coarser product going over the former and the finer over the latter. The second-grade product of these tables is returned to the spitzkasten, and thence run on to the tables for further treatment.

(*h*) Equipment.

Provision has been made, by the installation of modern appliances and by the adoption of a well-devised scheme of operations, for the most economical exploitation of the ore-bodies. Surface expenditure has not been unduly heavy, and is sufficient for all requirements at this stage of development.

The most important material asset of the company is the milling plant already described in an earlier paragraph. The mine equipment consists of an Ingersoll compound air-compressor plant capable of supplying air up to 100 lb. pressure per square inch to ten rock-drills of the hammer type; a National suction-gas engine of 120 h.p., provided with gas from a 135-h.p. Commonwealth wood producer plant; and seven rock-drills, five of which are of the Denver Dreadnought water-drill type, and the remaining two are telescope hammer drills (Waugh's patent).

Accommodation for upwards of 40 men is provided in well-appointed commodious huts. Other buildings include

the mine office and assay office, workshops, and engine-houses.

(*i*) Water-supply.

This mine is favoured with a water-supply capable of providing power sufficient to drive the milling plant for eight months of the year. The supply is drawn from Claude Creek, and conducted to the milling plant by water-race and pipes. The water is brought along the hillside to a point 200 feet above the mill. The conditions for conservation are unfavourable, and there are no other permanent streams in the locality from which the present supply can be augmented.

(*j*) Exploration.

The ore-bodies of the Round Hill Mine present so many peculiarities in their mode of occurrence that the work of exploration and development has been attended with the greatest uncertainty. Their occurrence, at the apices of weak, sharply-folded beds between more composite layers of hard quartzite, limits their lateral and vertical extension proportionately to the depth of the weaker layers; and their pitch in the plane of the anticlinal axes renders their location at any particular elevation a matter of considerable difficulty. For instance, it is quite possible, by deviating slightly from the strike of the axes of the folds, to pass alongside the ore-shoots without receiving any indication of their presence, and in like manner, owing to their high angle of pitch, their location by crosscutting may prove extremely difficult. An aid to their location may be found in the distinction between competent and incompetent layers, the former being recognised by their homogeneity and the greater thickness of the layers; the incompetent beds containing the ore being made up of thinner and weaker layers, some of which are thin shale bands.

The ore-shoots operated from the main workings do not penetrate the overlying conglomerates, and therefore are not found outcropping at the surface.

Further exploration should be directed towards the north-east and also along the axes of the folds south-easterly. Less immediate work would be to crosscut south-westerly to intersect the parallel anticline. The information already gained will enable the company to select the most advantageous position for the shaft when sinking below the main level is decided upon. The extension of the crosscut north-eastward should enter schistose porphyroid country within 300 feet.

(k) Mining.

One of the most striking features of the later developmental work is the small extent that has not directly produced further additions to the reserves of ore. Such are not the results of chance, but of the close study of these peculiar geological formations. At the beginning of the present system of exploitation, it was the practice to stope out the barren ground lying between the tunnel roof and the ore, but as the shoot gradually rose higher and higher above the tunnel, the depth of barren country became too great to be economically romoved, in comparison with the advantage gained in working after the manner of ordinary stoping. In the strictest sense of the term stoping is carried on only in a minor degree. Owing to the shallow depth of the shoots, each stope is in reality a drive carried gradually upward along the pitch of the ore-body. Extraction cost is of necessity greater than that of mining an ordinary lode. The lateral spreading of the ore from the apices down the limbs of the anticlines, with a large proportion of barren material between, makes it necessary to take out very wide stopes in order to recover all of the ore. Some of the stopes are from 20 to 25 feet wide, thus adding considerably to the cost of extraction. This cost is greatly offset by the natural facilities provided in operating entirely by means of tunnels, and also by the adoption of the most economical methods of mining and treatment. The mine, of its kind, is one of the best equipped in the State, and reflects the greatest credit on the manager and his staff for the technical skill and judgment displayed by them.

(l) Origin of the Ore-deposits.

The origin of the ore-deposits is directly due to the heated aqueous solutions which accompanied the intrusion of the granitic rocks outcropping at Tin Spur, 1 mile distant to the south-west. The presence in the ore of bismuth, which is more characteristic of pneumatolytic conditions, shows that the temperature and pressure of the solutions were considerable at the time of the deposition of their mineral contents, and also that the solutions had not migrated far from their source. The presence also of so much copper and a little gold is indicative of the outer limits

of the deep pneumatolytic zone, but the predominance of the galena constituent shows that hydatogenic conditions prevailed. Pinite, a common component of the ore, is derived from the decomposition of topaz, which is also indicative of pneumatolytic conditions, and suggests the possibility of tin and tungsten ores being found at a deeper level.

(m) Conclusion.

At this stage of development a proper appreciation of the potentialities of this mine cannot be formed, as opinion based on the present conditions leads one only into the bounds of conjecture. The mine has little ore in reserve, save that inestimable quantity provided by the recently discovered ore-body now in process of development.

The geological conditions, certainly, are decidedly favourable for ore-deposition along the anticlinal folds, not only within the boundaries of this property, but also in their extension south-eastward to Brazen Nose Mountain. It is possible that the richest and most extensive ore-bodies are yet to be found, and these may be sought nearer the main fault-line to the east.

The outlook has never appeared so bright, and although the element of uncertainty is never absent from any mining enterprise, the company may look forward with assurance to a more prosperous future.

(2)—*Round Hill Extended Mine.*

(a) Situation, Area, &c.

The Round Hill Extended property now consists of Mineral Lease 7120-M, 75 acres; and Dam-site 1712-W, 5 acres. This mine, owned by the **Round Hill Extended Silver and Lead Mining Company, No Liability,** is situated south of and adjoining the Round Hill Company's property. The northern boundary passes a few chains south of the peak, and the north-east corner is on the saddle connecting Round Mountain and Brazen Nose. At one time this company leased Section 7137-M, of 39 acres, lying south-eastward, and adjoining the main section.

Galena ore was discovered here about 30 years ago at the time when developmental work was being actively prosecuted at the parent mine. The exploratory work undertaken by the original syndicate consisted only of surface trenching and tunnelling at shallow levels.

(*b*) Ore-bodies.

The predominant mineral constituents of the ore-bodies are galena and sphalerite (zinc-blende); accessory minerals are chalcopyrite and pyrite. Associated gangue minerals are quartz, calcite, and a little pinite. The silver content, 1 oz. per unit of lead, is fairly constant, while the amount of gold present is generally insignificant.

The country-rock in which the ores occur is a tubicolar quartzite with interbedded bands of shale. These rocks are folded into a series of sharp anticlines and synclines, parallel with those containing the ore-bodies of the Round Hill Mine. The structure of these formations is identical with that described in detail in the report on the Round Hill Mine.

(*c*) Development.

The ore-bodies have been exposed on the surface by a number of deep trenches, and have been developed by shallow-level tunnels. In addition to these works, deep-level crosscuts have been sent in to intersect the ore-bodies on the supposition that they continued vertically downward. The planning of developmental work has been based on the idea that these lode-formations are of the normal fissure-vein type. The failure in the appreciation of the peculiar structure of these formations has led to much useless expenditure and the suspension of operations by the company.

No. 3 *Tunnel*.—This tunnel, driven 81 feet on a bearing 35 degrees west of south, was the work of the original syndicate operating the mine about 30 years ago. The lode, striking north-westerly, and dipping at a low angle to the south-west, was intersected at 40 feet from the entrance. It is composed of galena and zinc-blende in about equal proportions, and contains also a considerable amount of pyrite and a little chalcopyrite. It occurs on the south-west limb of an anticlinal fold.

The tunnel is situated about 12 chains south-west of the north-east corner of the section.

Open-cut Workings.—These consist of a trench 30 feet long, 16 feet deep at the end, and 4 to 6 feet wide, situated 7 chains south-east of (and on the same fold as) No. 3 tunnel ore-body. The ore occurs in thin veinlets and irregular patches in a soft felspathic sandstone formation 6 feet wide. The galena and blende ore is of good second-grade quality, from which a fair proportion of first-grade may be selected.

The limonite capping of this ore-body has been traced 100 feet along the axis of the fold.

This is the most important ore-body exposed on the property, but it requires further development to determine its extent and value.

No. 2 tunnel workings are situated 60 feet east of, and 40 feet directly below, the open-cut. This tunnel has been sent in 125 feet on the bearing 52 degrees west of south through hard, folded quartzite. At 89 feet from the entrance mineralised country, containing much pyrite and a little galena on the south-west limb of the anticline, was intersected. These veins were driven on 44 feet in a north-westerly direction. Very little galena shows between the bedding-planes of the folded strata. The ore-body exposed on the surface, like all of those contained in these folded strata, pitches north-westerly at a flat angle; therefore these workings are too far south-eastward to intersect the soft beds in which the ore occurs. Large ore sheds and bins have been erected in preparation for a large output.

The No. 1, or main, tunnel entrance is 70 feet on the west side of Claude Creek, directly below No. 3 workings. The approach is in the face of a high cliff of almost horizontally-bedded quartzite. This crosscut, which is 179 feet below No. 3 tunnel, has been sent in 323 feet on the bearing 45 degrees west of south. In the first portion of the tunnel the country-rock is only gently arched; at 200 feet sharper anticlinal folds have been penetrated. Near the end quartz veins 6 inches thick occur on the bedding-planes, and they are found to contain blebs of galena, chalcopyrite, and pyrite. In the face quartz veins have traversed the rock in all directions, and the rock itself has undergone almost complete silicification. After blasting, gases are emitted from the rock, which swells and breaks in flakes as if under great compressive strain.

This tunnel was driven directly below No. 3 adit, with the object of cutting the ore-body exposed in those workngs at this lower level. The workings may be employed at some future time in developing the southern ore-body, which pitches at a very flat angle north-westward, but they are even too far below the level of this ore-body to be of much use. No. 3 ore-body is only the remnant of a more extensive formation, the northern portion of which has been completely removed by denudation.

There are indications of another ore-body 3 chains further westward. Gossan shows on the surface, and 4 feet of iron oxide silt has accumulated therefrom in a small depression in the hillside.

Near A. Carlson's house on this section, tinstone has been recovered from soft sandstone detrital material. The source of the tinstone has not been located; probably it will be found in soft, rubbly sandstone beds similar to those at Tin Spur.

(*d*) Planning of Mining Development.

The fall of the hill northward of the No. 3 tunnel is greater than the pitch of the ore-body, therefore the quantity of ore available from this source is very small. The southern shoot, on the other hand, has been little affected by denuding agencies, and presents many encouraging features. The shoot should be trenched on northward until the trench becomes too deep for economical work. This will give an idea of the course and pitch of the ore-body. Further exploration should be undertaken by sinking shallow shafts about 50 feet apart along the north-westward strike of the anticline. This would provide all the information necessary for the selection of site for a tunnel, by which means the ore-body can be exploited to the best advantage.

(3)—*Section* 7137-M, 39 *Acres*.

This section, now vacant, was at one time included in the holdings of the Round Hill Extended S. and L. Mg. Co. It is situate east and adjoining 7120-M. Near the boundary-line of these two sections several deep trenches have been cut across ferro-manganese formations, which appear to be on the main line of mineralisation. The most easterly trenches are in limestone rock containing a considerable amount of pyrite. This trenching, performed by Alfred Carlson, did not reveal ore-bodies of economic importance.

(4)—*Section* 7223-M, 40 *Acres*.

This section, now vacant, was leased two years ago by the Round Mountain Silver and Lead Mining Company. The workings are situate one half-mile east of, and 600 feet above, the Round Hill Mine. The surface is wholly occupied by heavy beds of conglomerate of the West Coast Range series. The ascent to the mine from Round Hill is very steep, and access is had by means of a narrow foot-track up the almost precipitous western side of the mountain.

The workings are on the south-east end of Round Mountain, and consist of a tunnel driven in hard conglomerate 200 feet on a bearing 40 degrees west of south. The conglomerate strata appear to lie almost horizontally here, the bedding-planes being fairly distinct and especially noticeable on the eastern side of Redwater Creek.

This work, it is understood, was carried out with the object of intersecting the Round Hill line of lode. It shows an absolute misconception of the structure of the geological formations by those responsible for the work. The Round Hill lode-line passes a considerable distance outside the western boundary of this property, and the ore-bodies are contained wholly in certain beds of the folded tubicolar quartzites at or near the faulted junction of these strata with the older conglomerates; therefore there is not the smallest possibility of discovering ore-bodies of value on this section.

(5)—*Section* 7138-M, 40 *Acres*.

This section is situate on the south-east fall of Brazen Nose Mountain, east and adjoining Section 7219-M. At the present time it is not held under lease.

A continuous and strong lode courses through this section in a direction 75 degrees west of north. The dip is northerly at a high angle. The lode is exposed in two deep trenches sent in north and south. Manganese-iron oxides, over a width of fully 10 feet, show in the trenches, and the sandstone in which they are contained is stained black by infiltrating solutions of this mineral over a considerable width on either side. The lode is 3 chains on the south side of, and is parallel to, Claude Creek.

(6)—*Section* 7219-M, 40 *Acres*.

A tunnel has been driven 100 feet from the southern bank of Claude Creek towards the lode outcropping on Section 7138-M. The tunnel, which has partly collapsed, was not carried forward far enough to intersect the lode.

(7)—*Section* 7195-M, 80 *Acres*.

At the point of confluence of Claude Creek with Forth River a lode, contained in schistose felspar porphyry (porphyroid), may be seen at low-water outcropping in the bed of the stream. The ore consists of narrow veinlets and blebs of galena and pyrite scattered through the porphyroid rock. A small trench has been sunk on the east bank of Forth River off the course of the lode, which strikes about 40 degrees east of south, following the course of Claude Creek for fully 60 feet before passing on the north side.

The galena and pyrite ore occur as replacements of the soluble constituents of the porphyroid rock.

(8)—*Section* 7205-M, 12 *Acres.*

This is a narrow section, now vacant, situated on the east bank of Forth River south of that just described. At a point 50 feet above the river, and 1 chain distant therefrom, a tunnel has been driven a few feet in a south-easterly direction along the axis of an anticlinal fold in quartzite rock. Pyrites and quartz veins show on the limbs of the folded rock between the hard layers. This is on the line of strata occurring at Round Hill.

(9)—*Section* 7118-M, 80 *Acres (Lessee: A. Carlson).*

This section is situate west and adjoining the Round Hill Mining Company's property.

The main fault-line passes through the northern portion of this property. There may be seen the faulted junction of West Coast Range conglomerate with porphyroid on one side and with tubicolar sandstones on the other. The Round Hill belt of folded strata passes through the section from east to west, but up to this time galena ore has not been discovered here. Perhaps one reason is that those ore-bodies occur at a lower horizon.

At the time of the gold-mining boom a considerable amount of surface prospecting was done. This work consists mainly of a number of trenches and short adits sent in from the north bank of Carlson Creek. These trenches in all cases exposed sandstone heavily charged with gossan, and in several the rock showed much pyrite from which the limonite has been derived. Great numbers of small quartz veinlets traverse this soft, friable sandstone in all directions, and some of them are reported to carry gold. It seems more likely that the pyrite is the source of the gold.

At the end of the ridge, near the point where the country falls sharply towards the river, numbers of pot-holes, trenches, and shafts have been sunk along the bank of Carlson Creek. Gold and tinstone have been recovered

from each of these, but not in payable quantities. The gold is fine-grained; the tinstone is brown-coloured and also fine-grained. The detrital material from which these minerals have been recovered is made up almost exclusively of soft sandstone.

(10)—*Wilmot Silver-Lead Mine: Section* 7153-M, 80 *Acres (Lessee: T. L. Johnson).*

This mine is situate on the east bank of Wilmot River, about a mile west of Bell Mount. Galena ore was discovered here in 1893, during the boom days of Bell Mount diggings, which lie one half-mile to the south-eastward.

No. 1 tunnel has been driven in a direction south 50 degrees east for 40 feet. This tunnel is about 100 feet below the summit of the hill. The country-rock is hard tubicolar quartzite, certain beds of which are traversed by irregular veinlets of galena. These mineralised layers occur on the limbs of an anticlinal fold, in exactly similar formations to those existing at Round Hill. The vein here is about 6 inches wide, and poor.

A small vein cut on the track 50 feet below the summit of the hill consists of pyrite contained in a quartz matrix. Similar formations are exposed in the cliff-face southward.

No. 2 tunnel is 75 feet below and 70 feet north of No. 1. This tunnel has been driven 70 feet east at an angle of about 40 degrees with the strike of the ore-body. The lode consists of brecciated quartz material, 2 feet thick, carrying galena-chalcopyrite ore of fair grade. The dip of the limb here is 45 degrees south-westerly, and the strike is north-west. The tunnel passes through the formation at the approach, and then follows along the very flat vein to the end. The brecciated material is composed of angular quartz embedded in black puggy material. It appears that this vein of ore occurs on a flowage fault, and therefore the apex of the anticline will be found at a higher elevation.

This and other small veins containing fairly clean galena-chalcopyrite ore are exposed in the face of the cliff above the tunnel.

Samples of ore from this mine were submitted to the Government Assayer, Mr. W. D. Reid, who reported the metallic contents as follows:—

	Lead. %	Copper. %	Silver. oz.	Gold. dwt.
Clean galena	73·5	—	58	trace
Galena-chalcopyrite ore	42·6	3·5	60	2

Future exploration should be designed according to the plan outlined in the report on the Round Hill Mine.

(11)—*Section* 7851-M, 40 *Acres (Lessee: E. F. Blyth).*

This section is situate on the north-west fall of Mt. Claude, about 1¼ mile south-east of the settlement of Cethana. The old road over the mountain passes through the eastern part of the section.

Five chains in a south-westerly direction from the north-east corner peg of the section, a lode-formation, composed mainly of massive and micaceous hæmatite (specularite), has been exposed in a shallow trench. The strike of the lode is north 40 degrees east, and the dip is south-easterly at an angle of 68 degrees. The whole section is occupied by schistose quartz-felspar porphyry (porphyroid), and the hæmatitic ore occurs as a replacement of the soluble constituents of this rock.

In Knowles' Creek, on the west side of the road, and about 7 chains south-west of the northern outcrop, a strong lode-formation, 8 feet wide, consisting of pyrite and hæmatite, with a little chalcopyrite and galena, has been uncovered by trenching up the bed of the creek. Apparently these are outcrops of the one lode.

In the bank of Knowles' Creek, 2 chains on the higher side of the road, a parallel lode, composed almost entirely of pyrite, has been uncovered in a deep trench. Traces of galena have been reported from this lode. This, like those already described, is a replacement deposit.

Very large loose boulders of conglomerate, largely made up of closely-packed quartz and quartzite pebbles, but containing also numerous pebbles of porphyroid schist, are strewn over the section. The porphyroid pebbles are coloured brick-red by infiltrating solutions containing hæmatite.

These lodes are massive, wide formations, and they may prove persistent in depth as well as length, but they are of such low grade as to be of no economic value. The outlook for this property is not encouraging.

(12)—*A. Carlson's Claim.*

This property, held under prospector's licence, is situate one half-mile north of Round Hill. On the north-eastern side of the road a gossanous quartz lode, containing much

pyrite and a little galena, occurs in schistose porphyroid country. The outcrop consists of loose gossan boulders capping a vein of quartz 8 inches wide. This lode is developed by means of a trench 60 feet long and 15 feet deep, and by a tunnel 30 feet long. The trend of the porphyroid is north-west, in conformity with that throughout the district.

(13)—*Mount Vandyke Prospect: Section* 7897-M, 40 *Acres (Lessee: A. C. Murfet); and Section* 7898-M, 40 *Acres (Lessee: J. Overton).*

These properties, situate at the foot of and on the north side of Mt. Vandyke, and 2½ miles north-east of Round Hill, are being explored under the direction of a Devonport syndicate. Prospectors operating here many years ago discovered galena, chalcopyrite, and pyrite in narrow veins in porphyroid rock, but failed to locate anything of value. Their work has been extended by further discoveries, though of an unimportant character, by the present lessees.

The ore-body consists of galena, chalcopyrite, and pyrite, and also a little covellite, disseminated through schistose felspar porphyry (porphyroid). This occurrence is in the nature of a metasomatic replacement of the soluble constituents (mainly calcite) of the encasing rock. In addition, there are one or two narrow quartz-calcite veins, which carry blebs and stringers of galena and chalcopyrite.

Developments consist of a deep cross-trench and one leading off it along the quartz-calcite vein; and a small tunnel driven 40 feet on a bearing 65 degrees west of south. The schistose prophyry passed through contains chalcopyrite and pyrite sparsely disseminated through the schistose rock. At the point of its intersection the lode is poor, but, according to reports received subsequently, a vein 6 inches wide, containing fair galena contents, has developed as the work was carried northward. Some of the ore is reported to carry 9 oz. silver and 1½ dwt. of gold per ton. These operations have been carried out on Lease 7897-M.

On Lease 7898-M a small tunnel has been driven 20 feet easterly on quartz-calcite veins contained in porphyroid schist. These veins are 6 to 8 inches wide, and carry blebs of galena.

These lodes are mainly disseminated deposits of such low grade as to be of no present economic value. The presence of fissures, however, in this zone of mineralisation suggests the possibility of richer concentrations existing in them.

(14)—*The Thistle Mine: Section* 7140-M, 40 *Acres (Lessee: G. M. Day).*

(*a*) Situation, &c.

This mine, originally worked for gold, was discovered by Alex. and Malcolm Campbell during the boom period, about 30 years ago. It is situate on the northern fall of the Five-mile Rise, three-quarters of a mile south-west from the Lorinna Bridge.

(*b*) The Ore-bodies.

The ore is composed of galena, zinc blende, arsenopyrite, and pyrite, with a subordinate amount of chalcopyrite. Silver and gold are also present. The silver content is in the proportion of half an ounce per unit of lead, and the gold is fairly constant at 2 dwt. per ton.

The minerals occur well crystallised and coarse-grained. Arsenopyrite usually occurs in distinct bands which abruptly give place to galena, though both minerals are found in parallel arrangement and also in intimate association. Sphalerite (zinc blende) occurs in bands with galena. Quartz is the gangue mineral, and in certain vughy places occurs in perfectly-developed crystals.

In the upper workings and at the outcrop gold is freely recovered from the crushed stone by panning. Stone from the tip, on being panned off, showed a tail of fine gold. The gold which led to these developments was found at the surface facing the stone, from which it was easily detached by washing. It is probable that the gold was contained originally in arsenopyrite and pyrite, arsenious oxide and limonite being commonly found in the upper workings.

The ores occur as fracture fillings, and, to a lesser extent, as disseminations in tubicolar sandstone or quartzite and shale, which has a north-easterly dip at an angle of 20 degrees. No. 1 lode bears 48 degrees west of north, No. 2 25 degrees west of north, No. 3 lode 50 degrees west of north; they all dip south-westerly at angles of 65 to 75 degrees.

Samples of the cleaner ore showed by assay the following contents:—

Description of Ore.	Lead.	Silver, per Ton.			Gold, per Ton.			Arsenic.
	Per cent.	oz.	dwt.	gr.	oz.	dwt.	gr.	Per cent.
Galena and pyrite	37·3	26	2	16	0	2	3	...
Galena	70·0	26	16	0	0	19	14	...
Galena-arsenopyrite	42·6	29	0	7	0	3	10	10·2

The lodes are very small. No. 1 and No. 2 are 2 inches in a formation 2 feet wide; No. 3 is 9 to 12 inches wide.

In a long trench up the hillside southward, another auriferous gossanous outcrop has been intersected, and may prove to be the capping of still another galena-bearing vein.

The fissures in which the ore occurs strike almost at right angles to that of the bedding-planes of the tubicolar sandstone strata. They are sharply defined and continuous, but the actual lineal extent has not been determined. It may be safely anticipated that the lodes persist in depth in proportion to the lineal extent.

(*c*) Development.

Developments consist of an old tunnel driven 30 years ago, another adit crosscut 30 feet lower, and a number of trenches and shallow shafts.

No. 1 *Tunnel.*—This is an adit crosscut sent in 42 feet from the entrance in a direction 50 degrees west of south. No. 2 lode is cut at the entrance to the tunnel, and No. 3 at the end of the crosscut, showing good second-grade galena and zinc blende. This vein is driven on 48 degrees west of north for 35 feet, then 53 degrees west of north for 55 feet. The ore did not continue northward, but the end shows much gossanous sandstone, which contains an appreciable quantity of gold. This ferruginous friable sandstone contains a white incrustation of arsenious oxide occurring as facings on joints and in caverns, with also crystallised quartz. Bands of shale occur interbedded with sandstone.

This tunnel has only 40 to 50 feet of backs.

No. 2 *Tunnel.*—This also is an adit-crosscut, commenced in 1916, and advanced to its present position this year. The crosscut, sent in on a bearing south 37 degrees west, intersects No. 1 lode at 12 feet and No. 2 at 75 feet from the tunnel opening. The crosscut is continued from No. 2 lode on a bearing south 43 degrees west, and intersects No. 3 lode at 63 feet, or 138 feet from the entrance.

On the eastern side No. 1 lode shows 2 inches of clean galena in a short cuddy; on the western side two veins of galena each 1 inch thick, separated by heavily mineralised sandstone 2 feet wide, occur. No. 2 lode is driven on south 25 degrees east for 40 feet. The ore shows well on the west side of the crosscut and also along the roof of the drive on the east side, the clean galena being 1 to 2 inches thick. In the east face, zinc blende, arsenopyrite, and pyrite are the dominant components of the ore. The lode-formation is 2 feet wide, and is encased between sharply-defined hard walls, which show much selvage and brecciated material.

In No. 3 lode, which dips here at 65 degrees south-westerly, the ore occurs in two parallel bands, in one of which arsenopyrite predominates, in the other galena. One to 2 inches of clean galena show in the roof of the crosscut. At the present time this lode is being driven on south-easterly, and shows in the face 9 inches of good-grade material.

This developmental work has produced 3 tons of first-grade ore and 30 tons of second-grade.

The greatest obstacle to the advancement of this mine is its remoteness from a railway. The ore is either packed or sledged to Lorinna-road, 1½ mile, whence it is carted 15 miles to Staverton railway terminus. The freight is a heavy charge against galena ore containing only from 25 to 35 ounces of silver per ton. At the present time the arsenopyrite content, if separated from the other components, is readily marketable; and this fact must be taken into consideration in the planning of a treatment plant. At this stage developments do not warrant any surface expenditure, and the lessee is advised to concentrate attention on exploratory works.

(C)—The Gold Mines.

(1)—*The Bell Mount Goldfield.*

(*a*) Introduction.

The origin of the gold found in the detrital material at Bell Mount diggings has for many years excited the interest of prospectors, mining engineers, and others. An endeavour

has been made in the following report to present a reliable statement of facts relating to the origin of the gold, and which, it is hoped, will be of considerable use in the future development and exploitation of the deposit. All the available evidence, gathered from the observations of earlier writers and from every other reliable source, in addition to that obtained during this visit, has been carefully investigated and sifted, and has produced sufficient data upon which a definite hypothesis may be advanced.

(*b*) Area, Situation, &c.

The Bell Mount gold diggings occupy an area of only 120 acres, and are situate at the southern side of Bell Mount, 1 mile north-westward of the township of Moina. Gold was discovered here by Malcolm Campbell in 1892, and during that and the following year more than 100 men were actively engaged on the field. Since then the diggings have lain more or less dormant, and are visited now only by itinerant prospectors. In the year 1901 the Bell Mount Hydraulic Gold Mining Company was formed with the object of handling the large quantity of comparatively low-grade alluvial ground which proved unpayable to exploit by ordinary sluicing methods. A water-race, 4½ miles in length, was constructed from the goldfield towards Iris River, but owing to the shortage of funds, although the work had been advanced within ½-mile of the objective, operations ceased.

(*c*) Description of the Field.

The diggings are confined to a shallow, rectangular-shaped basin, bounded on the north by Bell Mount and on the east, south, and west by small spurs, the summits of which are only from 60 to 80 feet above creek-level. The south and west spurs, separated by Bell Creek gorge, are composed of hard sandstone, and slope rather steeply towards the basin; on the north the ground rises gradually to the foot of Bell Mount, and on the east side the slope is very gentle up to the Wilmot-road, which follows the saddle dividing the watersheds of tributary streams of the Wilmot and Forth Rivers.

Several creeks flow through the deposit; the major stream, Bell Creek, after having received its tributaries, Bell, Poverty, Mosquito, and Basalt Creeks, passes at the south-west corner through a narrow gorge to join Wilmot River. The watershed of these creeks comprises the whole area of auriferous alluvial ground. Bell, Poverty, and Mosquito Creeks are separated by large mounds of detrital material, which, near the source of the creeks, are found to be unconnected with the ridges leading up to Bell Mount. These mounds are about 40 feet high, the upper portion being composed of fine drift, while the lower is made up of angular to sub-angular detrital material.

The wash is composed for the most part of angular to sub-angular fragments of tubicolar sandstones and conglomerate, with schistose porphyroid (felspar porphyry), basalt, vein-quartz, and quartz-epidote in lesser amounts. Ferro-manganese plates, from ¼-inch to 2 inches thick, are commonly found strewn over the surface and in the detrital material, especially on West Spur.

In the wash there are many well waterworn quartz and quartzite pebbles, derived probably from disintegrated conglomerate boulders, of which there are many of large size in this basin. Near Mosquito Creek, 10 chains north-eastward from the homestead, enormous boulders of tubicolar sandstone and conglomerate stand out prominently above the general level of the surface. Similar boulders are found in other parts of the field, and they are found a quarter of a mile eastward, on the other side of Wilmot-road, outcropping in the form of bold crags 70 to 80 feet above the general level. The sandstone of which they are partly composed is soft and friable, and is attached to conglomerate largely made up of sub-angular white pebbles of quartz, with an occasional well waterworn pink pebble, derived probably from the older conglomerates. This rock contains gold-bearing quartz veinlets, which are arranged in parallel formation.

The bedrock varies in character from point to point. At the northern end of the field it is a fossiliferous clayey sandstone, probably connected with the limestone beds reported as underlying the wash at the eastern part of the field. In Bell and Poverty Creeks it is blue slaty material, which, in turn, is underlain by tubicolar sandstone. This sandstone is seen outcropping at the confluence of Bell and Basalt Creeks, and dips north-eastward at 15 degrees. At Sykes' workings, near the southern end of the field, and again at the northern corner of the basin, sandstone and shale are the bedrocks.

The bluish-black puggy material of Bell and Poverty Creek diggings has been erroneously considered a false bottom. Holes have been sunk in it 16 feet deep without reaching the supposed true bottom. Although some doubt exists as to the nature of the black puggy material, it has the appearance of a clayey swamp deposit, but is probably an altered limestone. This pug contains a considerable amount of well-crystallised pyrite, occurring in perfectly-developed cubes and also in elongated forms. The pyrite is disseminated throughout the mass. Inasmuch as it concerns the gold-bearing wash, this puggy material may be considered as the bedrock upon which the wash is laid down.

(*d*) The Workings.

Bell Creek workings are the most extensive, being fully 20 chains in length and 4 chains in width. Here both the wash and the gold are coarser than elsewhere, and on the terraces on the eastern side of West Spur the gold is coarse and is found from the surface down. It is noteworthy that very little fine gold has been recovered from the latter workings, while at the foot of the spur in Bell Creek, only 5 chains distant, fine-grained gold predominates. Near the summit of West Spur 20 ounces of gold, in nuggets from ½ to 1½ ounces in weight, were recovered recently from a small "paddock" 20 feet square. These nuggets were obtained from sandstone and conglomerate detritus 1 to 2 feet deep, and appeared to follow a narrow tortuous course, suggesting that the rock from which they were liberated had been disintegrated *in situ*. In this vicinity a large sandstone boulder, which was split in two in order to facilitate removal, was found to encase a flat nugget of gold similar in appearance to the large nuggets found in the detrital material. The greater number of the large nuggets of gold have been recovered from detritus within 3 feet of the surface in the vicinity of West Spur and Bell Creek. The largest nugget weighed 22 ounces; several from 10 to 16 ounces, and many others of lesser weights were also obtained. The larger are described as being flat in shape, with one side smooth and the other jagged. Most of the coarse gold is angular, and is sometimes found adhering to quartz, though some waterworn gold has been obtained from pot-holes in or near the present creek-bed. From West Spur the depth of wash increases as Bell Creek is approached. A prospect taken from the deep wash (15 feet) of Bell Creek showed 20 colours of fine gold, with a little resinous and black tinstone.

Poverty Creek workings are not extensive, being only 15 chains long and 2 chains wide. It is reported that the wash, which is fine, has been sunk in for a depth of 35 feet without reaching bottom. This statement is entirely misleading, as the bottom of the gold-bearing detritus is at this point black pug and is not a false bottom. The depth of workable material is from 5 to 15 feet. The gold and the wash are finer, and not so rich as in Bell Creek. A little fine-grained tin accompanies the gold.

Mosquito Creek workings are confined to small "paddocks" of ground taken out at several points along the banks of the creek. The depth of wash varies greatly from point to point, ranging from 3 to 10 feet. A few prospects taken at the several workings showed the presence of a little fine gold and a considerable amount of tinstone. The tinstone is well-crystallised, grey to black in colour, and is much coarser than that found farther westward. The bed of the creek does not appear to have been worked throughout. A superficial deposit of ferro-manganese ore, specimens of which contain coarse gold, outcrops on the ridge between Mosquito and Poverty Creeks. This formation has been intersected by a long deep trench.

Prospecting work in search for the source of the gold has been confined mainly to the northern and north-western portion of the field. In this locality some work has been done on gossanous and siliceous outcrops.

The other workings of note are those situated on the south side of Bell Creek, and known as Sykes' workings. The wash varies greatly in depth and rests on slate and sandstone bedrock; the bottom is uneven and difficult to clean up. The wash is composed mainly of conglomerate and sandstone pebbles and boulders, and is much more waterworn than that in any other part of the field. The gold is very little worn, and is accompanied by fine-grained tin-oxide.

It should be mentioned that the fall of the black pug bottom is much the same as that of the existing creeks, so that it appears the concentration of the richest gold in a stratum 12 inches thick directly above the pug was effected in this manner.

(*e*) Production and Value.

No definite record has been kept of the production of gold from these workings, but it has been estimated that more than 4000 ounces have been recovered. The average value of the gold has been put at £3 17s. 6d. per ounce. During the boom period some of the working parties were very successful, but on the whole the field has not proved highly profitable.

(*f*) Origin of the Gold.

(1) It has been suggested that the sub-basaltic river gravels or deep-lead exposed at several points in the underground workings of the S. and M. Mine are connected in some way with the Bell Mount goldfield. The elevation of this old river-course at the S. and M. Mine is such that a stream flowing towards the field would have ample fall to arrive at the highest terrace. The old river-course trends in this direction, but is lost to view underneath the basalt cover near Bismuth Creek. Below Newman's house, half-way to the diggings, well waterworn gravels are exposed in a hillside cutting, and may have some connection with the deep-lead, but it is quite possible that these gravels belong to the Iris River recent series.

The deep-lead alluvial contains fair values in tinstone and gold, with also a little wolfram and bismuthinite. With the exception of the pebbles derived from the disintegration of conglomerate boulders, the so-called wash at the diggings is composed almost entirely of angular and sub-angular material. At Sykes' workings certainly the wash is more rounded than elsewhere, but it differs from the well-worn, evenly-sorted quartz gravels and drift of the S. and M. deep-lead.

The almost entire absence of wolfram and bismuthinite from the wash is significant but inconclusive, as these minerals are too soft and brittle to resist for long the abrasive action of transporting water. Perhaps the strongest evidence against this origin is found in the physical condition of the gold. Almost invariably the coarser gold is jagged and flat-shaped. Probably part of the fine gold, with the tinstone, has been derived from lode-formations to the eastward. The fact that the tinstone grains increase in size and quantity as the south-eastern confines are approached lends colour to this supposition. Grey tinstone, which is found in the wash with the resinous and black varieties, is more commonly found in the vicinity of the All Nations Mine, to the south-eastward, than in any other part of the field.

(2) The nature of the large nuggets, flat on one side, ragged on the other, indicates that the gold has been deposited on the wall of small fractures. The gold possesses all the characters of a secondary mineral. Many large nuggets contain quartz which under the microscope is found to be made up of closely-packed grains. The gold has been deposited later than the quartz, occupying cavi-

ties and depressions therein. It will be noticed in every instance that the gold is attached to the quartz particles and is never contained in the quartz. Some ferro-manganese veinlets in the sandstone were found to contain gold. At the surface small bunches of rich manganiferous ore have also been found.

Deposits in which a secondary enrichment of gold is believed to have taken place are almost invariably manganiferous. Manganese, which is commonly distributed throughout the district, acts as a catalyser in the solution of gold. Catalysis can explain many of the peculiar occurrences of gold which have proved so difficult to understand. It is probable that the greater quantity of the gold distributed in this area has been derived from veinlets containing sulphidic minerals, and concentrated during the process of oxidation by the solution and precipitation of the gold in the presence of manganese. Certainly all the large concentrations of gold have been effected in this way. As the gold has not been transported far from its source it should not be difficult to locate the veinlets in the tubicolar sandstone. These veinlets, which are probably only from ½-inch to 2 inches wide, were composed of sulphidic minerals, pyrite predominating. Following the oxidation of the pyrite and associated sulphides, the gold was dissolved, carried in solution to a lower level of the same vein, and reprecipitated. Rapid erosion may remove the upper part of the deposit before it has been completely leached, and under favourable conditions the detrital material accumulated from the debris of the outcrop would, by the disintegration of the rock particles, set free some fine-grained gold.

Possibly some gold has been derived from sulphidic ores occurring in the mineral belt which contains the Wilmot ore-body, and which extends eastward towards Round Hill. In this event the solutions must have migrated some distance from their source.

Reviewing the evidence set forth in the foregoing pages, the conclusion is arrived at that the bulk of the gold has been concentrated from pyritic veins contained in sandstone near the present workings. The coarse gold is not placer gold, but occurs here in association with the alluvial by accident of position. The gold-bearing veins, therefore, may be looked for with equal likelihood of success outside the confines of the basin. The secondarily enriched veins will prove to be very narrow and irregular in value. Probably the unenriched material from which the gold has been concentrated will prove to be unpayable to exploit.

The richness of an alluvial deposit is not, of necessity, dependent upon the richness of the parent source.

The alluvium is not likely to prove payable even if worked on a large scale and in the most systematic manner. The greatest obstacle to the successful exploitation of this low-grade material is the lack of a sufficient water-supply and the difficulty found in conducting it to a point at a suitable elevation above the deposit.

The amount of gold obtainable from this small area is remarkable, and certainly warrants the further attention of prospectors in an endeavour to locate the secondarily enriched veins from which the coarse gold has been derived.

(2)—*Narrawa Reward Claim: Section* 35-93G, 20 *Acres.*

(*a*) Situation, &c.

This is a gold reward claim discovered in the early nineties, and developed to some extent by a Launceston company. The mine has been abandoned for many years, very little having been done since the cessation of operations by the original company. At the present time the workings are almost impassable owing to the partial collapse of the roof and walls, and also because of the accumulation of hydrous oxide of iron sediment.

The section is situate north-west of and adjoining the Squib lease (5221-M), and about 2 miles eastward of Moina. Access is had from Moina by means of a narrow, fairly well-graded road, which passes within 10 chains of the workings.

(*b*) Ore-body.

The lode consists of arsenopyrite, pyrite, chalcopyrite, and galena, disseminated through hard grey quartzite. The metallic components are contained in the quartzite in about equal proportion, and occur in an extremely fine state of division. It is considered that the porosity of the quartzite was brought about by the action of the heat emanating from the granitic magma. The impregnated quartzite shows no defined boundary on the south-west side, but it is probably connected with the Squib system of veins. This seems the more likely since a narrow quartz vein containing wolfram and topaz in association with secondary muscovite and kaolin occurs near the porphyry footwall. Some of the sulphidic ore is auriferous and argentiferous, selected pieces assaying 4 dwt. gold and 3 oz. silver per ton. This is essentially a contact deposit between quartzite and quartz-felspar porphyry, which latter appears more like the granitic type (represented by that outcropping on the Squib property) than that of the porphyroid exposed near Bell Mount. The channel of access for the mineralising solutions was evidently on the porphyry footwall, for here are found the secondary minerals, and also a more intense alteration of the rock. The porphyry rock on the footwall is very smooth and sharply defined. The lode dips south-westerly at a very high angle, and strikes north 70 degrees west.

About 2 chains south of the creek, opposite these workings, a narrow vein of molybdenite, ¼-inch thick, and contained in quartzite, has been uncovered.

(*c*) Development.

Although this lode was discovered during the boom days many years ago, very little development has been accomplished. The workings consist of a tunnel 155 feet in length, driven on the course of the lode, from which crosscuts have been sent in south-westwards. The lode outcrops in the face of a steep hill about 50 feet north of Narrawa Creek, and is so placed that exploration can be carried on at a minimum cost. At 90 feet from the entrance a short crosscut has been put in south-westwards for 20 feet through highly mineralised quartzite; at 130 feet another crosscut 40 feet long has been sent in through similar mineralised country. Hard dense quartzite containing a considerable amount of sulphidic ores shows in the faces of the crosscuts.

The outlook for improvement is not very promising, and the ore is of such low grade that it would be unpayable to exploit under existing conditions.

(3)—*Five-mile Rise Goldfield.*

This field extends up the hill on the western side of the Forth Valley from the Lorinna bridge. The track which passes through the field is the old road cut by the Van Diemen's Land Company to Middlesex Plains, and thence to Surrey Hills.

Five-mile Rise country consists of beds of tubicolar sandstone, with alternating bands of shale. The general strike of these beds is north-easterly, and the dip north-westerly. A few hundred yards south of the track up the hill they

are interrupted by an east-west belt of granite and granite-porphyry, which occupies the country between the pipe-stem strata and the Pre-Cambrian mica schists, further south. The tubicolar forms are very plentiful on the Five-mile Rise, and *Rhynchonella borealis* fossil casts have been recovered from this strata, notably from the end of the lower crosscut at the Thistle Mine.

All the old mines in this area are abandoned, with the sole exception of the Thistle, which is now worked for its lead ore. Those mines worked by means of shafts were inaccessible, therefore the reports on them are incomplete. The richest underground occurrences have been, not in quartz, but in sandy pug, probably altered shale bands. Most of the gold in the superficial occurrences of this field has been derived from the decomposition of auriferous sulphidic ores, notably galena, zinc blende, arsenopyrite, and pyrite. Oxidation has extended to greater depths here than in other parts of the district, leaving the gold in the free condition down to water-level, although traces remain in all the lodes of their original sulphidic nature.

It is noteworthy that all of the occurrences are at or near the sandstone-quartz-porphyry junction. These lodes will never prove of value for their gold content alone, and although it is anticipated that the proportion of gold will decrease with depth, it will probably be in sufficient amount to add appreciable value to the sulphidic ores.

(4)—*The Union Mine.*

This property, consisting of two sections each of 10 acres, and which are now vacant, is situate 2 miles south-west of Lorinna, on the north side of Five-mile Rise-road. Gold was discovered here nearly 30 years ago, the surface prospect being so rich that a company was organised to develop the lode.

A shaft 105 feet deep was sunk in tubicolar sandstone country, and a drive was sent in 11 feet westward intersecting the lode at the junction of quartz-porphyry and tubicolar sandstone. G. Sloane and party sank another shaft 25 feet deep at a point 30 feet away from the main shaft on a rubbly sandstone formation containing free gold and cerussite (carbonate of lead). This rubbly material is the insoluble portion of a sulphidic lode, the metallic components having been oxidised and leached out.

After having been abandoned for many years, the adit-crosscut commenced by the original company was continued two years ago by E. C. James. This tunnel, which is 100 feet lower than the collar of the main shaft, has been advanced to 264 feet on a bearing 72 degrees west of south.

This adit-crosscut is contained in quartzite for 204 feet, and the remaining 60 feet it is contained in quartz-porphyry. At the point of junction of these rocks, the lode has been intersected, exposing a formation 18 to 20 inches wide, composed of quartz containing galena, zinc blende, and much pyrites. Chlorite is developed on the walls, probably through alteration of biotite.

The gold and silver content of this ore has been determined by the Government Assayer, W. D. Reid, who reports—

	Per Ton.
Gold	3 dwt.
Silver...	7 dwt. 4 gr.

The strike of the lode here is 17 degrees west of north, and the dip is at a very high angle; the tendency appears to be towards the east. This is the downward continuation of the rubbly quartz formation sunk on from the surface, but the course of the tunnel is such that the lode is cut 100 feet further to the south-east.

At the end of the tunnel a wide specularite formation contained in quartz-porphyry has been passed through. This occurrence is similar to those others occurring in this area described in other parts of the report. The specularite appears to partly replace the porphyroid, and is partly contained in fractures in the rock. The specularite is almost barren of economic minerals.

Ten chains north-westerly from the main shaft and on the same lode is McLean's shaft, sunk on the underlay to 30 feet. Fair returns of gold were obtained at surface from auriferous quartz gossan, but the prospects became poorer in going down. The formation has a rubbly appearance, and contains carbonate of lead, and is therefore similar to the upper portion of the lode exposed in the main shaft. From the lode material on the tip fair prospects of very fine gold were obtained by panning.

Nearly all the creeks in the neighbourhood have been worked for gold. These include Sunday, Union, Dooley, and Main creeks, from which a considerable amount of gold has been recovered. On the bank of Dooley Creek a shaft was sunk 30 feet deep through angular sandstone and quartz detrital material, carrying gold throughout, but not in payable quantity. An appreciable amount of tinstone

is contained in this detrital material, and is recovered with the gold by sluicing.

The quartz-porphyry, on the wall of which the lode occurs, has a peculiar mottled and glassy appearance. The phenocrysts of quartz are unusually large, and have the rounded corroded outlines so common to this rock. In almost all respects this rock exactly resembles the quartz-porphyry outcropping between the Iris Mine and Bull Creek, and at this point it has the appearance of being intrusive into the overlying tubicolar sandstones, which dip very flatly towards the north.

This lode, like several others in this area, will probably develop into a sulphidic ore-body, with a preponderance of galena and pyrite. Oxidation by meteoric waters has extended to a greater depth here owing to the perviousness of the lode-material and the occurrence at the contact of two dissimilar rocks.

Every facility is provided here for economic mining, and this lode could be tested with very little expense. The first work should be a drive on the lode northward to connect with the main shaft.

This is one of the most promising lodes in the Five-mile Rise area, but it is not anticipated that it will prove payable for its gold content. Below the zone of oxidation the proportion of base metals may show a considerable increase in the constitution of the ore, so great that the ore-body may be profitably exploited. This could be determined by sinking a winze on the lode from the main tunnel.

(5)—*Golden Cliff Mine*

This mine is appropriately named from its position at the base of a high sandstone cliff, from which the surface slopes very steeply to the bank of Forth River, 500 feet below. The section on which the mine is situate lies half-a mile south-west of Lorinna bridge. It is easily accessible now by Winspear's-road, which passes within a few yards of the mine workings and connects with Five-mile Rise-road near the bridge over Forth River. By road the works are 53 chains from the point of junction with Five-mile Rise-road.

The discovery was made 30 years ago by Joby Thomas, who uncovered a small vein 3 to 4 inches wide, containing quartz studded with gold. Near the surface this vein was very rich, the concentration being due to secondary enrichment. The gold is not contained in the quartz, but occurs on the walls of cavities and in the interstices between the fractured quartz particles, and implanted on drusy crystals.

The "carriers" of the gold are pyrite and arsenopyrite, of which the lode is partly composed below the zone of oxidation. Manganese oxide in the form of ferro-manganese ore is found also in association with this deposit. This is a fissure-vein striking 20 degrees west of north, and dipping at 40 degrees south-westward, showing typical comb structure of the quartz-filling.

The junction of the granite with the sandstone strata occurs at the mine, the lower workings of which are wholly in granite rock.

Developments consist of an open-cut 30 feet deep, 30 feet long, and 4 feet wide, from the floor of which a shaft has been sunk connecting with a tunnel driven 60 feet on the vein 40 feet below. Further work consists of a tunnel 100 feet lower down the hill.

A narrow quartz vein still shows in the face of the open-cut, and in the end of the tunnel it is seen only 1 inch wide contained in a band of clayey shale. Some fair-quality stone was obtained from the vein in the broken country, which was met with in the first part of the tunnel, when it was being driven in 1901. A sample taken at that time contained 1 oz. 7 dwt. 11 gr. gold per ton.

The lower tunnel has been driven 120 feet, and a crosscut put out west for 40 feet. From a short drive off this crosscut a rise has been put up in search of the lode. The location of the tunnel was evidently determined by alignment with the outcrop, allowance not having been made for the flat underlay of the lode south-westward. The junction of the biotite granite with the sedimentary strata has not been reached, but evidently must occur between the upper and lower drives. The lode will probably be found at this level at the point of junction between these rocks. At a lower elevation it will prove to be a sulphidic lode.

Not one of the lodes in this district has been explored below the limit of oxidation by meteoric waters.

(6)—*The Great Caledonian Mine.*

This mine, discovered in 1887 by J. Aylett, is situate near the summit of Five-mile Rise, 2145 feet above the Forth River at Lorinna Bridge.

The surface stone at this mine was so rich that a 15-heads stamp battery, with accessory equipment for the recovery of gold, was installed before any considerable reserves of ore had been developed. The cost of transporting the heavy machinery over the steep mountain roads—the only means of access at that time—was enormous. That there was no justification for this expenditure was proved by the failure of the trial crushings a few months later. A crushing or two is said to have returned 12 dwt. per ton, but after a little work mining operations ceased. The battery was eventually removed, and a fire wrecked the remaining surface installations.

There is no official record extant of the underground workings of this mine. In 1894 A. Montgomery, Government Geologist, visited the mine shortly after the cessation of operations by the company. The following notes are taken from his report:—

> "On surface the lode appears as a small, rather irregular, vein of ferruginous rubbly quartz and sandstone, not unlike that at the Thistle Mine. The stuff raised from the deeper levels also does not appear to have been well-defined quartz, but only iron-stained, partly silicified country-rock."
>
> "Some 15 chains or so south of the Great Caledonian workings there are two small shafts sunk on what is known as Johnson's reef, which is a vein 4 to 12 inches in width of iron pyrites, said to be gold-bearing. The outcrop is largely composed of dense hæmatite. The vein seems somewhat irregular, and very little has been done beyond cutting it in the two small shafts. The lode must be near the contact of the granite and sandstone, the country-rock enclosing it being decomposed granite."

The following information relating to the mining developments has been supplied by G. Sloane, of Lorinna:—

> "The main shaft was sunk 50 feet vertically; a crosscut was sent in 60 feet westward, and from the end a winze was sunk 50 feet."

It appears that the shaft passed through the sandstone into quartz-porphyry, for the mullock-tip is largely made up of this material.

This will probably prove to be another lode at the junction of granite or quartz-porphyry with the sandstone strata.

(7)—*Powerful Mine (S. Reardon and G. M. Day).*

(*a*) Situation, &c.

This prospect is situate 2 miles south of Lorinna, on the east side of the Forth, near its confluence with Dove River. The workings are located close to the new road to Mt. Pelion, the tunnel entrance being actually at the roadside. The lodes discovered on this property have been developed by Syd. Reardon, assisted by a local syndicate.

(*b*) Ore-bodies.

This is a quartz-specularite lode, containing small quantities of gold and silver and also traces of zinc. Some of the quartz is white and glassy, and in the form of small irregularly-shaped pebbles. The quartz is surrounded by pyrite and specularite, the latter in many instances enclosing the pyrite. It appears that the pyrite and specularite in some cases have replaced the felspar and mica components of the coarsely crystalline granite in which the lode occurs, but vein-quartz is also present. In some places the quartz is brecciated, in others it is banded, and is also cavernous. The lode outcrops strongly on the surface, and trends north-westward towards the Union Mine, where similar formations exist. The dip of the lode is at a high angle south-westward.

The granite and granite-porphyry country-rocks are regarded as being plutonic members of the porphyroid suite of igneous rocks of such widespread occurrence in Tasmania.

Copper, gold, and silver-lead ores are found in members of this series, and tinstone has been found in association with them at Bond Peak and Five-mile Rise. The genetic relationship of these ores with the porphyroids has not been definitely established. The country-rock may be described as a coarsely granular granite, composed of salmon-coloured to bright pink felspar, quartz, and altered biotite. The felspar has become almost completely kaolinised and the biotite has been altered to a yellowish-brown mica or to greenish chloritic material. The quartz has the usual rounded and embayed outlines, and occurs in particles from ¼ to ½ inch in diameter. This is a normal biotite granite. In parts of the tunnel workings the granite appears remarkably fresh and hard, the felspar component only showing alteration. It greatly resembles the Devonian biotite granites.

(*c*) Developments.

The work carried out on this property consists of a number of deep cuttings and trenches across the lode over a distance of 6 chains, and an adit-crosscut driven from road-level 100 feet in a south-easterly direction. The several workings have shown the lode to be from 8 to 14 feet wide.

(*d*) General Remarks.

This occurrence is believed to belong to a period of mineralisation anterior to the Devonian and probably contemporaneous with the porphyroids in which it is contained. This being so, it is considered that the upper portions of the lode have been removed by denudation, the present surface representing the deep auriferous pyrite zone.

Owing to the preponderance of specularite, the ore is unsuitable for pyrite production, and could not be profitably exploited, even if transport facilities were provided for the district.

The results of developmental work are regarded as unsatisfactory.

(8)—*Sloane's Prospect.*

In the township of Lorinna, 10 chains west of G. Sloane's house, a tunnel has been driven 30 feet on a specular iron formation contained in quartz-porphyry. The specularite is attached to quartz, and is said to be gold-bearing. The vein varies from 6 to 8 inches in width, and the massive specularite component from 2 to 3 inches. Near this point large boulders of fresh-looking biotite granite are strewn over the surface.

(D)—Barytes Mine.

This prospect is situate 20 chains east of Blackwood Creek, on Paradise Range, the northern foothill country of Mt. Roland. Claude-road settlement lies 2 miles to the south-west, and Sheffield township is 6 miles by road to the north-west. The Sheffield-Paradise-road is only 7 chains away from the outcrop of the lode. The outcrop of the lode occurs on the west fall, but near the summit of a steep hill, which is wholly occupied by porphyroid schist.

The barytes is almost pure white in colour, though in parts there is a slight brownish discolouration. Tests made of the ore show that it contains very little impurity. An almost inappreciable amount of iron oxide, with a little silica, have been detected.

The ore occurs in bands up to 1 foot thick in a lode-formation 5 to 6 feet wide. The trend of the formation is north-westerly.

Very little developmental work has been carried out; therefore it is impossible to estimate the value of the prospect. Two or three trenches, now full of water, constitute the whole of the improvements.

It is reported that another barytes outcrop has been discovered at the base of Mt. Roland, half a mile to the south-west. This is undeveloped, and appears to be a parallel lode.

There are at hand here all the facilities required for cheap production. The lode may be operated by tunnelling; there is an abundance of mining timber; and it is easily accessible; therefore it should be possible to deliver the ore at the market at a very cheap rate.

(E)—Manganese Prospects.

(1)—*Mt. Claude Deposit.*

The first of these is situate north of Knowles' farm, on the east side of Sheffield-Lorinna-road. It consists of an outcrop of ferro-manganese ore of considerable extent, but the exact dimensions are difficult to determine. The central part of the formation is composed of hard clean ore; the lateral portions consist of impregnated sandstone of no value. It is conveniently situated as regards transport facilities, the Sheffield-road being only 20 chains distant.

(2)—*Tin Spur Deposit.*

This formation outcrops 4 chains westward of the south-eastern corner peg of Mineral Lease No. 7125-M, near the summit of Tin Spur. The outcrop trends south-easterly for 9 chains, at which point it is covered by detrital material. It appears to be a fairly pure ferro-manganese ore-body for 20 feet in width, with impregnated sandstone on either side. This is evidently the continuation of the manganese ore-body, worked for its gold content by means of shafts, on Thomas and Rees' section. It shows also on Lease 7861-M, and no doubt the whole area in which the gold occurs contains ferro-manganese ore to a greater or lesser extent.

Selected pieces of this ore contained—

	Per cent.
Iron oxide	22
Manganese oxide	68

Every facility exists for cheap production. The ore-body may be exploited by open-cut, and delivered direct into carts. A connection can be made with the main-road by constructing a branch road 20 chains in length. The prospect is 10 miles from Staverton railway-station.

Deposits of manganese oxides of lesser extent occur in other parts of these districts, but none of them is of economic importance. Even those described are not rich deposits, and a closer examination, after a little development, may prove the richer ore to be only of small extent.

(F)—Hæmatite Prospect.

On the summit of the saddle over which the Mt. Claude-road passes towards Lorinna, two shallow shafts have been sunk on a hæmatite formation, which it is reported carries gold. The shafts are one half-chain west of the road, one just over the summit on the southern fall of the mountain. A considerable amount of ferro-manganese ore is associated with the hæmatite, and both occur as replacements of shale bands in the conglomerate. Hæmatitic and manganitic infiltrations extend also into the sandstones and conglomerates.

It is difficult to determine the exact size of the massive material, but it must be 3 to 4 feet in width and 5 chains in length. This prospect is not considered to be of economic importance.

(G)—Asbestos Deposit.

This consists of irregularly-shaped masses in an altered diabase rock exposed on E. L. Knowles' farm, 1 mile north-east of Cethana. The asbestos is of the hornblende type, white in colour, and it contains siliceous and other impurities. The fibre is short and brittle. Epidote and quartz occur in veins in considerable amount, and are scattered through the asbestos in an irregular manner. This deposit is of no economic value.

IX.—THE CONCENTRATION OF MOLYBDENUM ORES.

(1)—Outline of the Processes.

Methods of concentration that have been used with success with molybdenite ores may be grouped under three general heads, as follows:—(1) Rolling and Screening Processes; (2) Electrostatic Methods; (3) Flotation Processes.(10)

(1)—*Rolling and Screening Processes.*

A considerable proportion of the molybdenite in some ores in which the mineral occurs as large flakes or crystal aggregates may be recovered by crushing the ore in rolls, and then screening the crushed material. The success of the process depends entirely upon flattening the molybdenite masses into flakes, the maximum diameters of which are in excess of those of the particles of gangue material. Usually before the ore is screened it is passed through a series of rolls to break the gangue into small particles. The material passing through the first screen is again crushed in rolls and screened, and the process repeated as many times as may appear to be advantageous. Naturally the loss in this process of treatment is considerable. It is, however, of considerable value in the preliminary treatment to remove the coarser and heavier masses of molybdenite from ores in which the mineral occurs in fairly large flakes. Ores containing much mica are, of course, unsuited to this method.

(2)—*Electrostatic Processes.*

Molybdenite, in common with many other minerals, such as chalcopyrite, pyrite, and pyrrhotite, is a good conductor of electricity, as compared with quartz, felspar, and most other silicates, calcite, &c., which are poor conductors. Hence it may be separated from a majority of the gangue materials by electrostatic processes. The principle on which these processes are based is that two bodies charged with electricity of similar sign repel each other, but when charged with electricity of opposite signs they attract each

(10) These notes are largely drawn from the work of Fred. W. Horton: United States Geol. Surv. Bull. No. 111.

other. When minerals that are good conductors of electricity come in contact with a charged body or an electrical field, they almost instantly attain an electrical equilibrium with that body or field and are repelled; whereas, as regards poor conductors, the time necessary for equilibrium to be reached is so appreciable that, if the contact is of short duration, the repelling force is negligible.

(3)—*Flotation Processes.*

Like many other metallic sulphides, molybdenite has the property of not being wetted readily by water, and, when dry and in small particles, of floating on a water surface. Moreover, like most other sulphides, it is easily wetted by oils. Further, in a pulp of crushed ore and water, oils have a preferential wetting action for particles of molybdenite, as against particles of gangue minerals such as quartz, and this selective wetting action is decidedly increased if the water is slightly acidified.

Particles of molybdenite so wetted with oil are covered with a buoyant water-repelling coating that materially assists their flotation. In many processes the area of the effective surface of flotation is increased by the liberation of bubbles of gas or air in the liquid, the surface of each bubble acting in the same way as the horizontal surface of a liquid at rest. These bubbles may be of air, produced by violent agitation of the pulp, or of carbonic-acid gas, formed by the action of sulphuric acid on limestone, or in some other way.

One of the processes most generally used, especially in Norway, is the Elmore vacuum flotation system. The method adopted there is as follows:—

The ore from the mine is first crushed in Blake type rock-breakers, then passed through a ball mill. After the requisite sizing and return of the oversize to the ball mill, the ore passes on to the Elmore units. Mica and chalcopyrite are the impurities which cause most trouble. Where these do not occur in undue proportion a good extraction is obtained, and the concentrate runs from 75 to 80 per cent. molybdenite (MoS_2), and in exceptional cases as high as 94 per cent.

No description of any particular process is attempted here, as there are many published works giving detailed information for the guidance of mining engineers.

(2)—Removal of Metallic Sulphides from the Concentrate.

When the molybdenite concentrate contains other metallic sulphides, such as pyrite, pyrrhotite, and chalcopyrite, considerable difficulty is experienced in effecting their separation. The presence of pyrite and pyrrhotite is not detrimental, except that they act as diluents, but if the concentrate contain more than 2 per cent. of chalcopyrite this impurity is so injurious that the concentrate is unsaleable. If the pyrite and chalcopyrite are slightly roasted, they become magnetic, and may be removed by means of a magnetic separator. Through the formation of a coating of oxide on the surface of each particle, the pyrite and chalcopyrite in the ore are readily wetted, and sink if the material is subjected to flotation. Another method for separating chalcopyrite, which takes advantage of the oxidation of the surface of the particles at ordinary temperatures, is as follows:—After grinding the ore to 40 mesh it is dampened and dried. Under thes conditions 90 per cent. of the MoS_2 will float, and practically every particle of the chalcopyrite will sink.

X.—UTILIZATION.

(1)—Tungsten.

Tungsten is a brilliant white metal which can be rolled into sheets and drawn into wire of great strength, and can be welded at a red heat. A few years ago its most valuable properties had not been recognised; now it has become an indispensable material in many branches of industry. The metal alloys with steel and other metals in all proportions, and gives to steel, when present in amounts from 2 to 8 per cent., valuable properties of high hardness combined with toughness and great tensile strength. In larger proportions up to 15 per cent. it gives to steel the remarkable character of self-hardening, by virtue of which it retains its hardness and temper at great temperatures. This property permits tungsten-steel tools in lathes, &c., to be run at a high speed and for long periods without losing their cutting edges.

Tungsten is one of the very heavy metals, having a specific gravity of 18·8. It is very hard, and it is the most infusible of all metals, the melting-point being about 3080° C. By virtue of this property it is now employed in the manufacture of incandescent electric lamps. The tungsten filament has the advantage over the ordinary carbon filament of yielding a much whiter light and a greater efficiency.

Considerable quantities of tungsten are consumed in the manufacture of tungstates, which are used as a mordant in dyeing, in giving weight to silk goods, and in rendering cotton fabrics fire-proof.

(2)—Molybdenum.

Molybdenum is a white metal with a silvery lustre: it is as malleable as iron: its specific gravity is 9·01.

Nearly 90 per cent. of the molybdenum output is consumed in the manufacture of alloy steels, to which, in conjunction with chromium, tungsten, nickel, manganese, vanadium, and cobalt, it imparts many extraordinary properties. It is considered that, like tungsten, molybdenum assists in producing hardness by helping to retain the carbon in solid solution. These steels are put to many uses, and since the commencement of the war the demand for them has increased enormously, resulting in the present abnormal condition of the market. They are used especially for crank-shaft and propeller-shaft forgings, guns of large bore, armour plate, rifle barrels, high-pressure boiler plate, permanent magnets, wire for filament supports in incandescent electric lamps, various electrical devices, self-hardening high-speed tools; and molybdenum is also used in dentistry. Molybdenum has a number of other uses, such as the manufacture of chemical reagents, disinfectants, glazes, dyes, &c.

(3)—Bismuth.

Bismuth is white with a red tinge, very brittle, and melts at 264° C.

Its principal use is as an alloy; its alloys melt at low temperature and expand on cooling. Alloys of bismuth, lead, and tin fuse at very low temperatures—from 100° C. down to 60° C. The alloys are used for making safety-plugs for boilers, for which purpose they are not absolutely trustworthy, and for automatic fire-plugs in buildings.

Bismuth is extensively used also in medicine, in cosmetics, &c.

XI.—MARKETING.

Molybdenite products are invariably purchased on the basis of their molybdenum content, reckoned as MoS_2. One part by weight of MoS_2 is equivalent to 0·6 part of Mo, and, inversely, one part by weight of Mo is equivalent to 1·67 parts of MoS_2. Quotations are usually made on a sliding scale to cover various grades of material. Specifications usually state the minimum percentage of MoS_2 in the ore that is acceptable to the purchaser, and the maximum percentage of objectionable elements, such as copper, tungsten, bismuth, and arsenic, that will be allowed. Copper is particularly undesirable. Up to 1914 it was difficult to sell MoS_2 concentrate containing less than 80 per cent. MoS_2, but ore concentrated to 25 per cent. is readily saleable now to owners of treatment plants.

The British Government has established maximum prices at which ores of tungsten and molybdenum may be sold. For molybdenum ore this price is £5 per unit of MoS_2 in ore of 85 per cent. and over, and for tungsten ore it is 52s. 6d. per unit of tungstic acid (WO_3) in ores of 65 per cent. and over, at Sydney or Melbourne, ex rail or ship. A penalty of 3d. per unit is made for wolfram containing between 60 and 65 per cent. WO_3; for each unit below 60, down to 55 per cent., the penalty is 6d. per unit. Up to 1 per cent. impurity is allowed. There is no fixed price below 85 per cent. for molybdenite, but probably a penalty of 5s. per unit under the standard price will be made down to 80 per cent.

In 1917 the price of bismuth in the United States of America was 12s. 6d. to 13s. 6d. per lb. The local price of bismuthinite (Bi_2S_3) was 7s. 6d. per lb. for 80 per cent. bismuth. At the present time bismuth (100 per cent.) is worth £784 per ton, or £7·84 per unit.

The average price of tin this month is £317 7s. 9d. per ton. The value of manganese ore in London on the 3rd May, 1918, was 3s. 6d. per unit, equal to £10 10s. per ton of 60 per cent. ore.

The "unit" as used in ore trade means 1 per cent. of a net ton of 2240 lb. of ore, or 22·4 lb. Thus tungsten ore quoted at "50s. per unit of tungstic acid (WO_3)" means 50s. for each 1 per cent. (or 22·4 lb.) of WO_3 contained in the ore. Suppose it contains 70 per cent. (or 70 units) WO_3, the price of a ton of ore is then 50s. × 70 = £175.

XII.—THE OUTLOOK FOR MOLYBDENUM PRODUCTION.

At present molybdenite is produced at the Squib Mine only, but low-grade material is known to occur on several other mining prospects which would be payable at present prices if a suitable plant were erected for their treatment. If several active producers were present in the field, a small customs concentrator attached to one of the large milling plants could be kept in constant operation. At this stage it is rather early to consider the erection of a flotation unit, but if good results follow the developmental work in progress on the several mines, the installation of such a plant would be the means of adding appreciable value to the ores. Much of the success of such an undertaking is directly dependent upon the market value of the ore. Molybdenum may be expected to retain its comparative value with that of tungsten, as its effective ratio in the manufacture of special steels is 1:2, or one part of molybdenum has an effect equivalent to two parts of tungsten in its uses for steel-hardening purposes. It may be said that the present prices are wholly abnormal, and companies should, therefore, be prepared for the slight decline that is sure to follow the cessation of hostilities in Europe. It is not anticipated that the decline will materially affect Australian producers, as the fixed price is much below that paid in the open market. It appears reasonable to expect that one result of the great war industry will be that the new and extended uses found for molybdenum will involve even a greater demand after the war. It may be anticipated that this extra demand will have the effect of maintaining fairly high prices.

XIII.—CONCLUSION.

Mining in these districts is in a particularly flourishing condition. This is due principally to the great demand for metals and consequent high prices occasioned by the war. None of the mines is very large, and the aggregate output is not great, but all of those that have reached the producing stage are being exploited profitably. The S. and M. is still the premier mine of the Moina area, and is a regular producer of tungsten, tin, and bismuth ores. Work at the All Nations is confined to the shallow-level tunnels, but it is contemplated by the management to make provision for its more extensive development by the sinking of a main shaft and making that the centre of operations. Reasonable expenditure in this connection is certainly warranted by the results already obtained. The Squib Mine has joined the list of regular producers, and although operated on a very small scale, a profit is being made. The latest discovery of importance in this area is that of Lawson and Riley's show, which has a very promising appearance, and may develop into one of the leading mines. The Princess and Pearce's (Sayer's) properties are now held under option by a Melbourne syndicate, which is carrying out preliminary exploratory works in preparation for more extensive development later on. On the east side of Forth River a number of prospective mines have come into prominence during the past year. The most important of these are: The Falls, Morgan's, Hidden Treasure, Premier, and Rees and Thomas' prospects, all of which are now receiving attention.

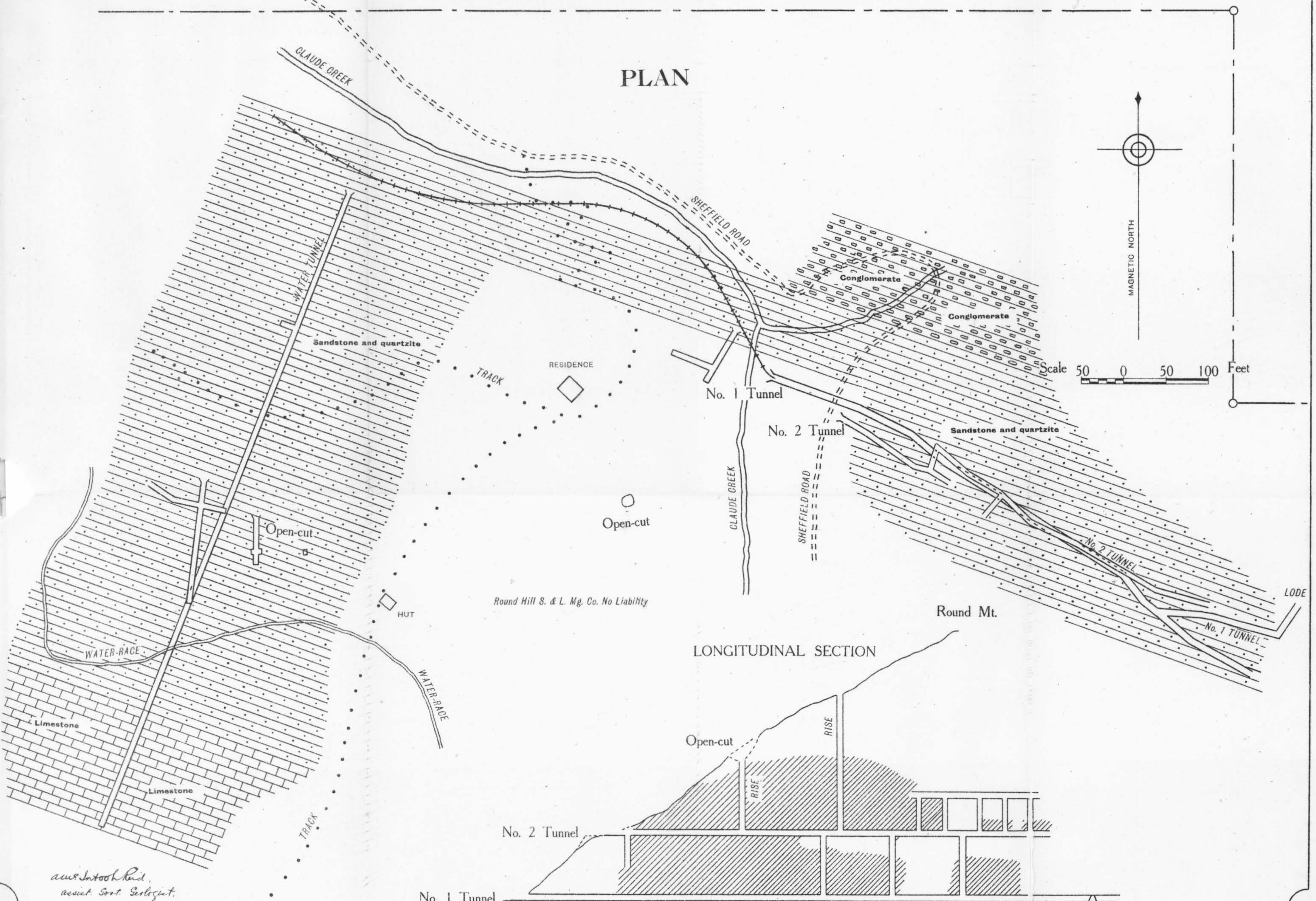
Only four silver-lead mines are in operation, and of these the Round Hill alone is producing on a large scale. The new discovery in the south-eastern end of the main workings is developing remarkably well, and promises to place the enterprise on a highly profitable footing. At the Round Hill Extended a start is about to be made on the exploitation of the lodes outcropping at surface. The Thistle Mine, near Lorinna, is opening up fairly well as exploratory work is being carried forward. Perhaps the greatest obstacle to progress is its remoteness from a railway. The only other galena mine in operation is that at the foot of Mt. Vandyke, operated by a Devonport syndicate. This prospect is only in the first stages of development.

The outlook for the districts as a whole is one full of promise. Although the first discoveries date back to 1878, many of the important developments have been made recently, and there are many unexplored areas worthy of the attention of prospectors.

A. McINTOSH REID.
Assistant Government Geologist.

Launceston, 22nd January, 1919.

SKETCH OF THE GEOLOGY OF THE ROUND HILL MINE



a. McIntosh Reid,
Assist. Govt. Geologist.
30 Nov. 1918.

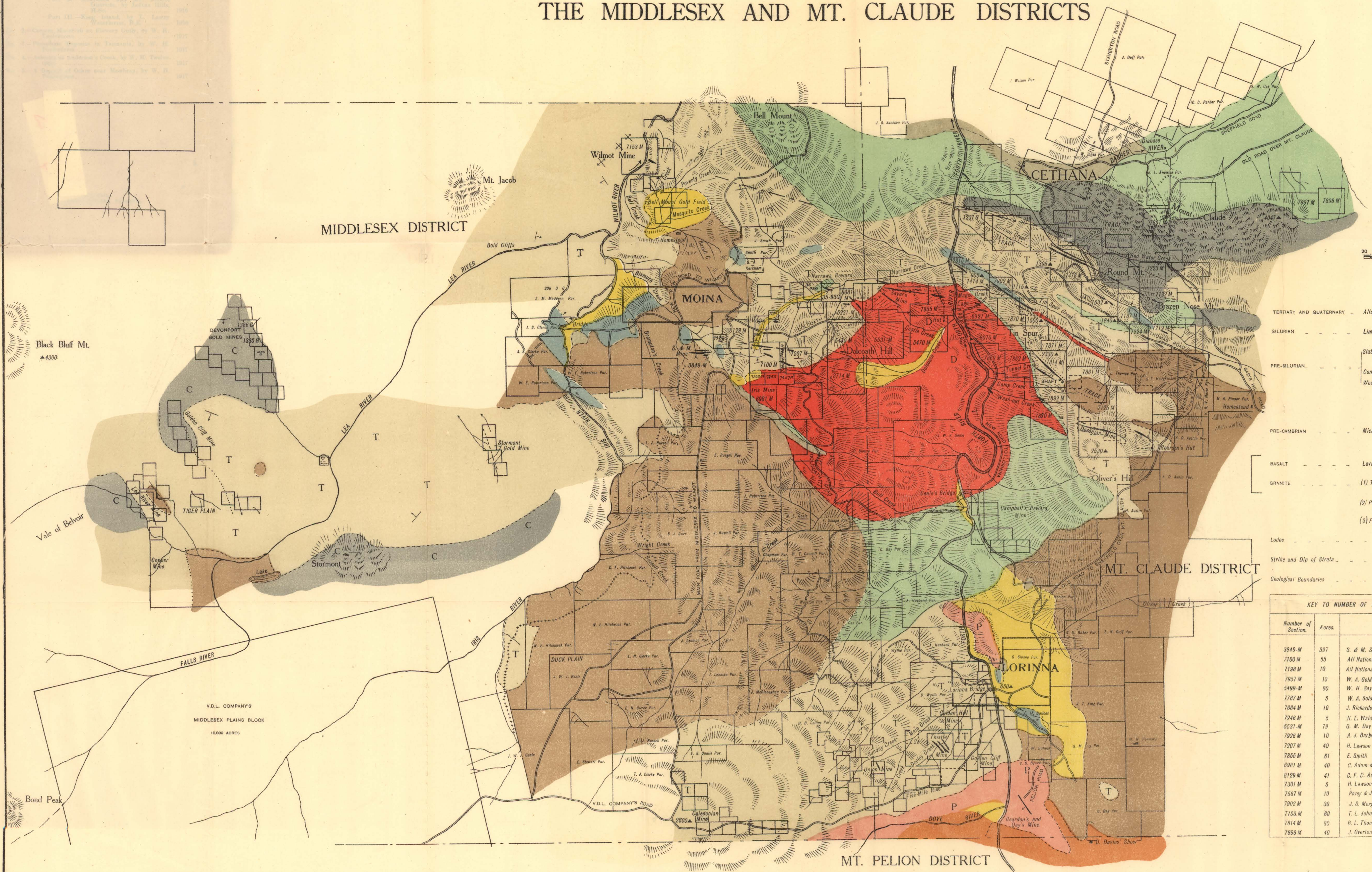
Photo Lithographed by John Vail Government Printer Hobart Tasmania.

Plate VIII.

GEOLOGICAL SKETCH MAP

OF

THE MIDDLESEX AND MT. CLAUDE DISTRICTS



LEGEND

SEDIMENTARY

TERTIARY AND QUATERNARY	*Alluvial*	(yellow)
SILURIAN	*Limestone*	(blue)
PRE-SILURIAN	*Slates, Conglomerates and Grits (Porphyroids)*	(grey-green)
	Conglomerate and Tubicolar Sandstone	T
	West Coast Conglomerate	C

CRYSTALLINE SCHISTS

PRE-CAMBRIAN	*Micaceous Schists*	(orange)

IGNEOUS

BASALT	*Lava and Tuffs of Tertiary Age*	(brown)
GRANITE	*(1) Tin-and Tungsten-bearing Granite, Granite-Porphyry and Greisen of Devonian Age*	D
	(2) Pre-Silurian?Granite & Granite-Porphyry	P
	(3) Felsite, Keratophyre (Porphyroids)	(green)

Lodes

Strike and Dip of Strata

Geological Boundaries

KEY TO NUMBER OF MINERAL SECTIONS

Number of Section.	Acres.	Lessee.
3849-M	397	S. & M. Syndicate, Ltd.
7100 M	55	All Nations Wolfram Mining Company
7193 M	10	All Nations Wolfram Mining Company, No L
7957 M	10	W. A. Goldsworthy
5499-M	80	W. H. Sayer & Others
7787 M	5	W. A. Goldsworthy
7664 M	10	J. Richards & W. Dunn
7246 M	5	H. E. Walduck
5531-M	79	G. M. Day
7926 M	10	A. J. Barber
7207 M	40	H. Lawson & W. Riley
7855 M	61	E. Smith
6981 M	40	C. Adam & others
8129 M	41	C. F. D. Adam & others
7301 M	5	H. Lawson & W. Riley
7567 M	10	Povey & Johnson
7902 M	30	J. S. Morgan
7153 M	80	T. L. Johnson
7814 M	80	B. L. Thomas & E. J. Rees
7898 M	40	J. Overton

KEY TO NUMBER OF MINERAL SECTIONS

Number of Section.	Acres.	Lessee.
7478 M	182	Round Hill S. & L. Mg. Co. No Li
7120 M	75	Round Hill Extd. S. & L. Mg. Co.
6081-M	10	B. J. Gurr
8070 M	80	J. P. Kelly
5221-M	50	B. J. Gurr
7416 M	30	E. F. Blyth
7903 M	40	E. F. Blyth
7869 M	40	E. J. Rees
7861 M	80	E. J. Rees
7851 M	40	E. F. Blyth
7871 M	16	E. F. Blyth
7870 M	40	E. F. Blyth
1385 G	10	J. T. Smith
1386 G	10	J. T. Smith
7862 M	40	E. J. Rees
7892 M	40	E. J. Rees
1231 G	39	P. Hartnett
8008 M	7	A. G. Holroyd
6075-M	7	B. J. Gurr
7897 M	40	A. C. Murfet

A. McIntosh Reid,
Assist. Govt. Geologist.
30 Nov. 1918.

Photo Algraphed by John Vail, Government Printer, Hobart, Tasmania.