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The Middlesex and Mount Claude Mining Field

BY

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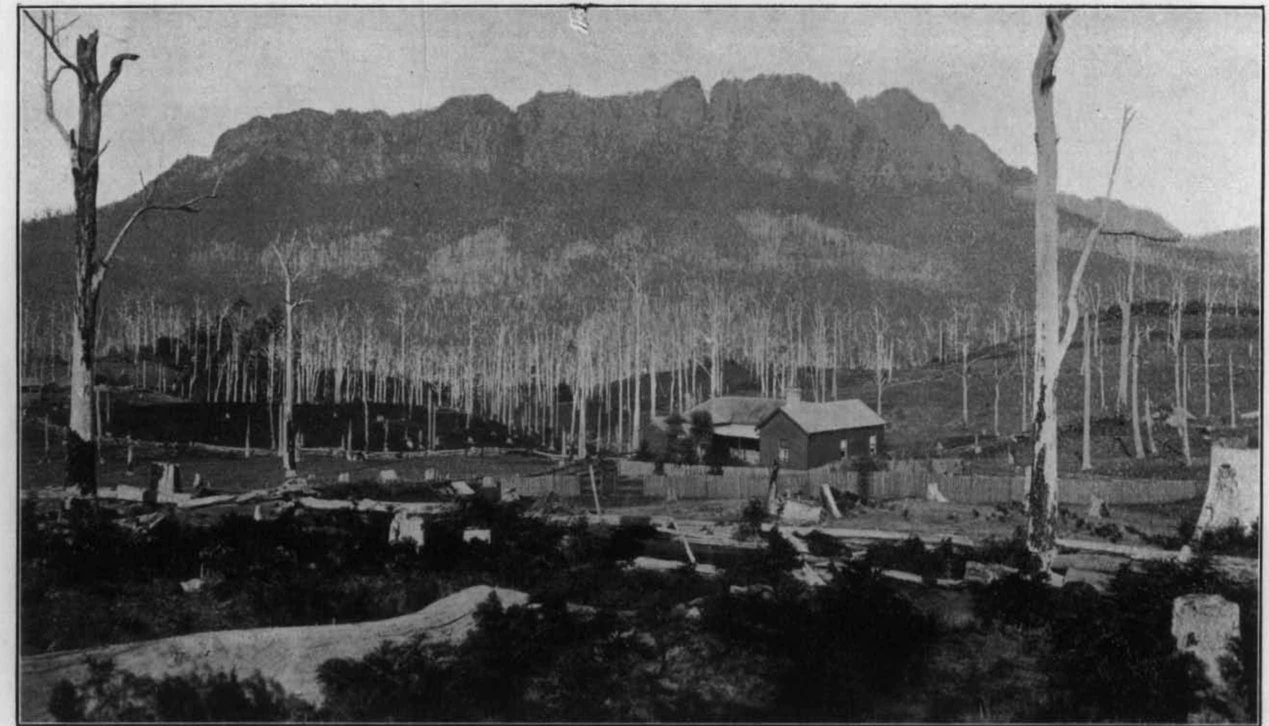

Mount Roland.

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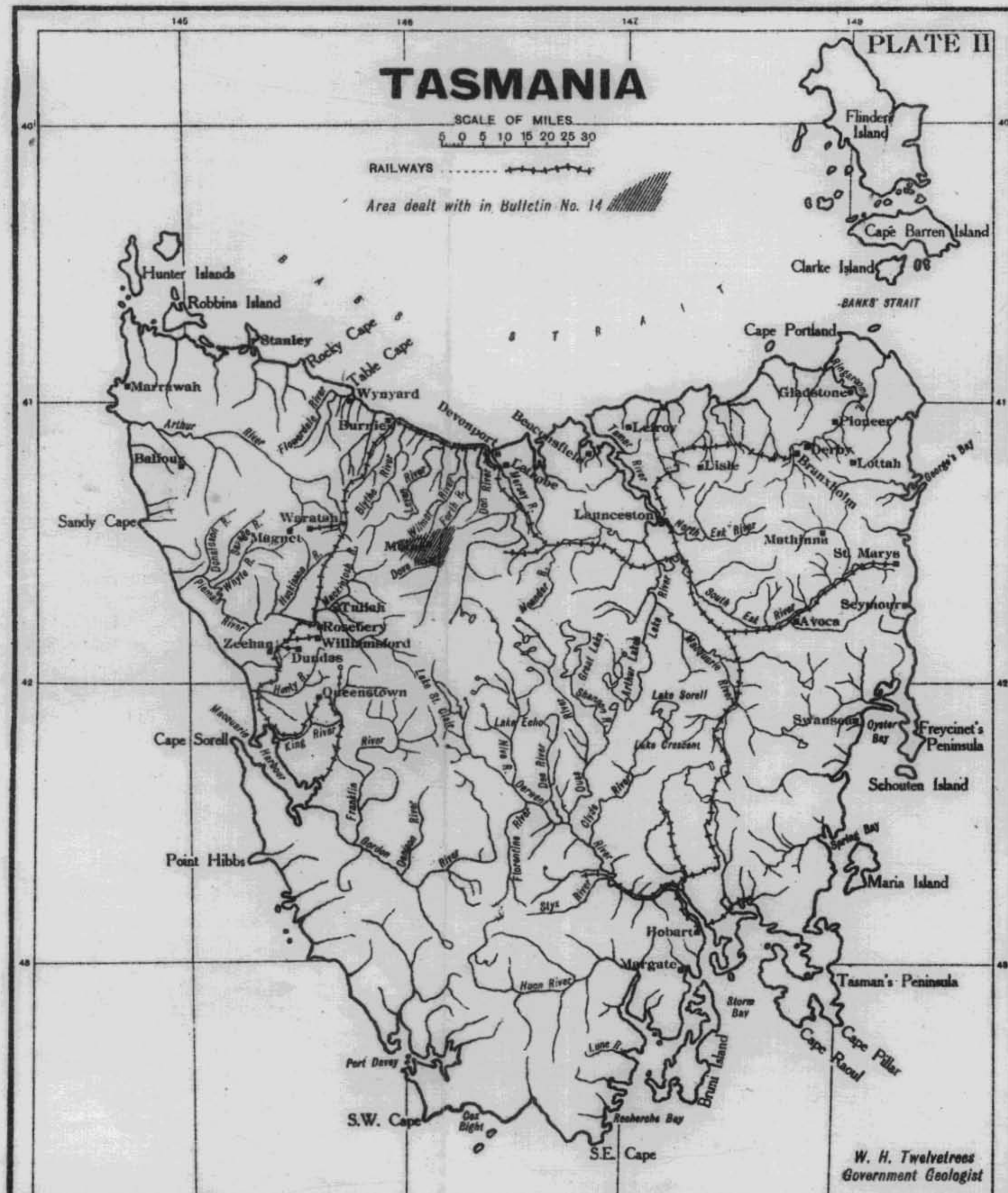

LOCALITY MAP

Photo Algraphed by John Vail Government Printer Hobart Tasmania

The Middlesex and Mt. Claude Mining Field.

I.—INTRODUCTION.

THE Middlesex, Forth, and Mt. Claude districts constitute a geological unit. They embrace strata of identical geological age, and the same great processes of ore-deposition are common to all of them.

The earliest access to the Middlesex district was given in the late twenties of last century by the Van Diemen's Land Company, which cut a track from the Western Marshes near Deloraine, *via* Mole Creek, across Middlesex, the Vale of Belvoir, and the Black Range to Surrey Hills, Hampshire, and Emu Bay. This was a pioneer track, and for many years it was the only means of transit between Deloraine and Emu Bay. It still exists, and is passable for foot or horse; but as regards the Middlesex district, many of the track difficulties are avoided by using roads which start from Railton or Leith.

The natural entrance to the country in question is from Railton. This is so not only on account of the travelling conveniences of the route, but also because at Railton one enters the mineralised conglomerate and quartzite country, which extends from there right through to Middlesex and the Black Bluff. The conglomerate and quartzite beds of the hill east of the Railton rifle-range, and those of the Badgers and of Mt. Roland, are identical with the strata on Mt. Claude, Stormont, and Black Bluff. The approach to the great mineral-bearing country of the North-Western highlands is thus from Railton.

At present the traveller leaves the railway at Railton. The coach then proceeds 8 miles south-west to the town of Sheffield, and thence 11 or 12 miles further to Wilmot. From Wilmot a road for vehicles continues to Moina, a distance of 11 or 12 miles, and thence 4 miles further south to the county boundary on the Van Diemen's Land Company's track. In this distance a gradual rise has been effected from Railton, which is 200 feet above sea-level, to the top of the Five-mile Rise, which is 2600 feet. Thence a traveller may find his way eastward down the Five-mile Rise to the Forth River, where the Mt. Claude-Barn Bluff road is tapped. Taking the road from Lorinna to Mt. Claude and Sheffield, he may return to Railton, thus completing a round journey through country of great scenic beauty, and full of interest from both a mining and agricultural point of view.

From Lorinna southwards the road to Barn Bluff keeps on the east side of the Forth River till Sloane's Bridge is reached, at about 15 miles due south of Lorinna, when the track to the Bluff sections turns to the west. A 7-mile track southward from the bridge would connect with the Pelion copper sections south of Mt. Oakleigh, and would pass through river flats with perhaps 400 or 500 acres of grazing land. At the copper leases it would join Innes' track from Liena to Barn Bluff, and would avoid the high land which that track traverses between the Forth and the Mersey. North of Pelion East Mr. Geo. Sloane has a 4000-acre grazing lease, but the present road over February Plains is a cold one for travelling stock. Seven or 8 miles south of Lorinna is Gisborne's farm, and the good road which is now being made up the Forth will be the means of giving useful access to the far southern country.

The road from Railton to Sheffield passes first over the Pleistocene gravels which mark the bed of the ancient Mersey. At between 1½ and 2 miles it begins to skirt the eastern end of the Badgers Range. The strike of the Badgers strata as observed at various points ranges between north 40 degrees and north 65 degrees west, and they have a north-easterly dip. If the interpretation of the mutual relations of the older strata as propounded by the Geological Survey proves correct, these beds of the Badgers form one leg of a great arch of conglomerate, the other leg of which constitutes the upper part of Mt. Roland.

The country between the two ranges is occupied by the Sheffield plain, averaging 900 feet above sea-level, upon which the flourishing town of Sheffield is situate in the midst of a thriving agricultural district. The surface of this plain consists of a covering of basaltic soil and lava, concealing beds of gravel, sand, and clay of Tertiary age. Below these beds, at any rate south of the town and to the west, and more particularly in the valley of the Dasher, are the crushed and schistose porphyrites which, with a north-westerly strike, form a belt of country at least 15 miles wide from the River Mersey to the Wilmot River.

These are the rocks with the gold-bearing veins which have been worked in the basin of the Minnow. They ascend the northern front of Mt. Roland to a height of 1000 feet above the Dasher River, and terminate against the fault-wall of the mountain conglomerate, which rises steeply for another 1500 feet. Access to the summit of this majestic mountain, 4047 feet above sea-level, is afforded by a steep track up a gap in its northern face. If the people of Sheffield only realised properly what an asset they possess in this noble mountain, from a visitor's point of view, they would improve this track, provide accommodation on the summit, and lay themselves out to advertise scenic attractions which cannot easily be surpassed. The top is broad, and the southern side slopes down to the Mersey near Liena.

The mountain appears to have lost its original name. Mr. Thos. Stephens, M.A., has called the writer's attention to the fact that the name originally was Rolland's Repulse, and that he once had in his possession a map of Van Diemen's Land, published in London in 1828, in which the mountain appeared under this name. In a useful little work by Mr. J. Moore-Robinson (1) Mr. R. S. Sanderson (late of the Van Diemen's Land Company) is quoted as stating that the mountain was named after Captain Rolland, who in attempting to reach the coast from Quamby was repulsed by this range, and that the name was spelled "Rolland" correctly in 1827 in old records. In the same work, also, Mr. Thos. Stephens is quoted as saying that old colonists told him that the mountain was called Rolland's Repulse, after a certain Lieutenant Rolland, who made an unsuccessful attempt to climb it; and that when he first visited the locality many years ago the local name among the early settlers was "Rollingses."

In a Survey Office report, dated 26th May, 1827, by Joseph Fossey, a surveyor in the employ of the Van Diemen's Land Company, the name is mentioned as Rolland Mountain; but the Survey Office editor in a footnote to the report, when published in 1861, adds: "properly Rowland's Repulse." (2)

On the other hand, the old maps in the Lands and Surveys Department show the name as follows:—In 1830, 1837, 1839, 1859, Roland; in 1854, Rolland.

From Sheffield a good coach-road leads across the Forth River to Wilmot, the centre of an expanding cattle and

(1) "A Record of Tasmanian Nomenclature," Hobart, 1911, p. 83.
(2) Legislative Council Paper No. 16, 1861, p. 9.

dairying industry. The road thence to Moina has in recent years been greatly improved, and is now a highly convenient thoroughfare. It climbs with an easy grade to Bell Mount, where the first panoramic view of the mining fields is presented to the traveller. At this point the road is 2200 feet above sea-level. On the one hand the profound valley of the Forth lies below one, on the other the horizon is bounded by the highlands of Stormont and Black Bluff. A descent of about 300 feet brings one to the mining settlement of Moina, which is the centre of the tin and wolfram mining of the district. The township has its store, school, post and money-order office, and telephone service. Bush fires have cleared off some of the surrounding timber, mining has continued without interruption, and the place altogether wears a more open and civilised aspect than it presented a few years ago.

In the neighbourhood are selections which have been taken up for farming and grazing. The principal mine—that worked on Bismuth Creek by the S. and M. Syndicate, is responsible for the distribution of a considerable amount of money in the district, and with the combined mining and farming industries, things generally are quietly and steadily progressing. During the past few years practically all the basalt farm land between the Iris and Forth Rivers as far south as the Five-mile Rise has been selected, and is now in the grazing stage of the industry. The improved roads and the better results from mining—the latter largely due to the introduction of a successful magnetic separation process for the treatment of the mixed ores of the field—have brought about this change in the erstwhile idle and silent wilderness.

The proposed Railton-Wilmot railway will contribute greatly to the advancement of the district. In particular, mines which at present are handicapped by heavy transport and realisation charges will be relieved. Those situate in the Dove and Forth River valleys will for the first time be brought within the sphere of practicable working conditions, and in addition prospecting within a still wider radius will receive a beneficial stimulus.

In 1899 Mr. Ross Reynolds carried out a useful exploration survey for a light railway from Sheffield through this part of the country to Rosebery. His report, with reconnaissance-map, was published as a Parliamentary paper (No. 43), and may be consulted by prospectors travelling in this part of the island. A practicable route was found with sufficiently good grades for the probable 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 Mt. 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-line of the Middlesex Plains block to the north end of Mt. Farrell is, however, only 32 miles.

The writer wishes to acknowledge the assistance and information which he received during his visit from leaseholders, mine managers, and prospectors. Among those to whom he is particularly indebted are Messrs. W. E. Hitchcock, W. M. Black, C. F. D. Adam, B. Gurr, Wm. Goldsworthy, Warwick Castles, P. Bateman, — Gabbedy, Geo. Sloane, and S. Reardon. He also desires to thank Mr. Leslie J. Smith for much information communicated by letter, and Mr. A. Bradshaw for permission to use the photograph of Mt. Roland which appears as frontispiece.

II.—PREVIOUS LITERATURE.

From time to time Departmental reports on this district have been published. These are as follows:—

(1) Report on the North-Western Mineral Deposits, by G. Thureau, 30th December, 1881.
(2) Report on the Mineral Discoveries in the Neighbourhood of Bell Mount, by A. Montgomery, M.A., 6th November, 1893.
(3) Report on the Shepherd and Murphy Tin Mine, Bell Mount, by J. Harcourt Smith, B.A., 26th July, 1897.
(4) Report on the Bell Mount and Middlesex Mineral Fields, by J. Harcourt Smith, B.A., 6th September, 1898.
(5) Report on the Mineral Districts of Bell Mount, Dove River, Five-mile Rise, &c., by G. A. Waller, 3rd April, 1901.
(6) Report on the Bell Mount and Middlesex District, by W. H. Twelvetrees, 17th June, 1907.

The district covering as it does a wide area, the inaccessibility of some of the localities, and the intermittent character of much of the mining, have led to several inspections being made by officers of the geological branch, but it is only quite recently that the means of communication have been substantially improved. The earlier examinations, it may be mentioned, were made at a time when our knowledge of the general geology of the island was more meagre than it is to-day.

Mr. Thureau in his 1881 report details the result 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 silver-lead ore-deposits which are now owned by the Round Hill Silver and Lead 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.

Mr. 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.

Mr. J. Harcourt Smith in 1897 and 1898 traversed the Mt. Claude and Middlesex district, and described the workings on the various mining leases. Incidentally it is of interest to note the then rate of transport on the field, the carriage of ordinary mining supplies from Sheffield to the Shepherd and Murphy Mine costing £7 per ton.

Mr. 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.

The report by the writer 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.

III.—PHYSIOGRAPHY.

The several rivers and streams impress upon each part of this large district distinct physiographic characteristics, but viewed as a whole, and taking into account only broad panoramic features, the entire area is an elevated plain or tableland, dissected by stupendous gorges and diversified by residual mountain ranges. Views from the road round Bell Mount, from the summit of Stormont, and from Black Bluff tend strongly to support this interpretation.

The general elevation of this tableland is between 2200 and 2600 feet above sea-level, being 2200 to 2400 feet along the road above the Shepherd and Murphy Mine and about 2600 feet from the Caledonian Mine westward through the Middlesex Plains block. The track along the Stormont Valley to Black Bluff is about 2400 feet.

The mountain summits rise to varying heights above this general level: Bell Mount to about 2600 feet above sea-level, Stormont 3400 feet, and Black Bluff 4300 feet.

Broadly speaking, the ranges of Black Bluff, Stormont, Mts. Claude, Vandyke, and Roland, form a physiographic block unit with tilted strata along east and west lines of fault. A great fault-plane exists along the northern wall of Mt. Roland, and also at the east end of Mt. Claude on the road near the turn to the Round Hill Mine. The junctions at Stormont are not visible, and this mountain requires further examination before the position of the line of faulting can be traced.

There is here a great block of country from Mt. Roland to the meridian of Mayday Mt., which embraces strata striking east and west, consequently different from the usual meridional strike of the folded rocks elsewhere in Tasmania. The pipe-stem rocks in the Wilmot River gorge north of the Bell Mount diggings strike north-west, and the slate and schistose porphyrites of Bell Mount and the Dasher Valley have the same bearing. The Pre-Cambrian mica schist south of Lorinna has also a north-westerly strike.

The east and west belt is about 7 miles across from north to south. It is within this zone, and conforming roughly with the direction of its linear extension, that the Dolcoath-Tin Spur granite is exposed. This is of significance in connection with Mr. L. K. Ward's hypothesis of an east-and-west chain of granitic magma reservoirs across the island from Heemskirk.

This tableland is dissected by two large rivers, namely, the Forth and the Wilmot with its tributaries or head streams, the Lea and Iris.

The head waters of the Forth River descend from near Mts. Pelion East and West. The stream at Sloane's bridge, 15 miles south of Lorinna, is 1200 feet above sea-level; at the Lorinna bridge, 650 feet; and at the Wilmot bridge, 400 feet. From Lorinna downwards it is evidently flowing rather flatly, with rapids at intervals. Its banks here are steep, the river 100 to 130 feet in width, and the gorge in which it flows rises on either side into hills 1600 feet and upwards above the river-bed.

At Bell Mount the confluence of the Lea and Iris Rivers forms the Wilmot; and at Alma, at about 5 miles from the sea, the Forth receives the Wilmot River. All these streams flow in deep gorges, but near the confluence at Bell Mount the valley of the Iris expands and the country is more open.

The minor features of the tableland are not structural, but are the result of erosion.

Where the present river valleys are young their channels are narrow and their sides steep. The present Forth, however, may in parts be termed a revived stream, for in sections of its course it is following the direction 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. The present river there has intrenched its bed, and is developing a freshly graded slope. That is to say, it is in an early stage of its new physiographic cycle; and by and by, in the ages to come, it will cease to cut downwards, but will continue to widen its valley all through its maturing period. Finally, in the distant future it will attain old age, and if uninterrupted by crustal movements the cycle will approach its close and usher in once more the features of the former plain.

The old Forth Valley is old enough to have preceded the outpouring of the Lorinna basalt. The lavas cover its terrace-drifts, but the younger channel appears to have been carved down through the basaltic sheets.

In some of the valleys on Black Bluff two stages in their past history may be observed: a Pleistocene or glacier stage, when the wide shallow valleys received their streams of moving ice from the higher snow field; and a recent stage, in which the broad glacial valleys have been deepened, with a consequent change of slope in their sides.

Evidence to the same effect was collected at the Wilmot bridge over the Forth River by Professor T. W. E. David, who accompanied the writer on a part of this journey. He relevelled the Forth Valley basalts near that bridge at their various horizons, and established the fact that there is at least one old Forth Valley antedating the latest of the basalts. He recognised this as being a more mature valley than the present Forth, which has been rejuvenated through comparatively recent uplift. Appended is Professor David's sketch section (Plate III.) showing the relations of the gravels and basalts at this point. The accuracy of his observations received strong confirmation when later the writer visited Lorinna and noted the elevated terrace-drifts of the ancient wide river valley there.

RAINFALL.

There is a Federal weather station at Moina, where Mr. W. E. Hitchcock, manager of the Shepherd and Murphy Mine, records temperatures, barometrical readings, and rainfall. At Lea River, Black Bluff, Mr. W. Malcolm Black records the rainfall for the Commonwealth Weather Bureau.

The tables furnished herewith comprise information received from Messrs. Black and Hitchcock and from Mr. Watt, the Divisional Officer of the Weather Bureau for Tasmania:—

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	100·00
	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	90·09
	1913	3·50	2·03	5·66	1·93	2·54	...	...	...	...	...	...	...	...
Moina	1911	?	6·28	6·97	6·07	4·19	5·13	?	2·70	4·45	?	1·96	8·78	60·47
	1912	3·12	·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	...	...	...	...	...	...	...	...

IV.—GENERAL GEOLOGY.

A.—THE SEDIMENTARY ROCKS.

The stratified rocks of the area belong to the following geological systems:—Pre-Cambrian, Pre-Silurian, Silurian, Tertiary, and Quaternary. The strata of the first three divisions have been penetrated by igneous intrusions, which were responsible for ore-occurrences. These bedded rocks will be described, beginning with the most ancient.

(1)—*Pre-Cambrian.*

Rusty micaceous schists compose the country south of the Dove River belt of granite porphyry. These strata have the north-westerly strike of the older sedimentary systems. Lithologically they appear to be quartz-biotite-muscovite schists, and belong to the Algonkian division of the Pre-Cambrian formations. Where not interrupted by intrusions of igneous rock, these beds underlie the whole of the Palæozoic strata from here to the shore-line on Bass Straits.

(2)—*Pre-Silurian.*

(*a*) *Dundas Slate Series.*—The Bell Mount and Mt. Claude slates and schistose conglomerates are crushed beds of sedimentary rock of grey to purple colours, which for the most part expose weathered surfaces in the cuttings on the road. The bedding-planes appear to be coincident with the present stratification-lines. The beds alternate rapidly from slate to conglomerate, and are interbedded with bands of the crushed porphyritic igneous rock, which in Tasmania presents many lithological varieties, all of which are for the time included under the group-name of porphyroid.

Slates and gritty quartzites, presumably of this series, are exposed in the valley of the Forth at the Wilmot bridge, where they strike north 60 degrees west, and dip south-westerly at 70 degrees. The slates on the road at Bell Mount strike from north 25 degrees to 47 degrees west, and dip north-easterly at angles of 82 to 85 degrees. On the road at the west end of Mt. Claude, where it winds round to Round Hill, the beds strike north 60 degrees west, and dip north-easterly at 60 degrees.

Microscopical examination is frequently necessary in order to determine whether some of the apparent slates are not crushed porphyroids or bedded tuffs.

The junction of these slates, both with the Mt. Claude conglomerate and with the Bell Mount or Moina pipe-stem sandstone, is unconformable and apparently faulted, but from recent observations elsewhere, mentioned below, it appears that the slates are older than the other two groups.

On the coast west of Goat Island these slates succeed the Pre-Cambrian schists; at Gunn's Plains they underlie the Silurian limestone; at Dundas and Zeehan their base is not known. The base of the slate series in the North Dundas field has also not been ascertained. The identification of graptolites in beds on the North-East Dundas tram-line by Dr. T. S. Hall points, however, to Ordovician or Cambrian age.

The Bell Mount exposures extend (interrupted by pipe-stem sandstone and granite) south-east to the Campbell's Reward sections, east of the Forth north of Lorinna, where they disappear under the basalt or terminate against pipe-stem country; and north-westerly the Gunn's Plains and Leven slates are on the same line.

These slates, together with associated igneous breccias and schistose porphyrites, belong to what is known in Tasmania as the porphyroid group. The age-relation of this group to the conglomerates of the West Coast Range has long been unsettled. Professor David diagnosed on this journey the porphyroids at Mt. Roland as the older rocks, and the accuracy of his view has since been confirmed by observations made by Mr. Loftus Hills at Mts. Jukes and Darwin. Mr. Hills has discovered waterworn pebbles of porphyroid in the basal beds of the conglomerate there.

This discovery sets at rest the doubts which have long been felt with regard to the true sequence of these strata, and seems to establish, notwithstanding many puzzling sections, the prior age of the porphyroids and their associated slates and breccias. Their lithological aspect is also in entire harmony with this age-relation, for they are often intensely schistose, and the interbedded conglomerates which occur among them are strongly metamorphosed and bear the impress of a high antiquity. A period of extreme diastrophism evidently separated the period of the porphyroids from that of the West Coast conglomerates.

The important point is that the true sequence in the geological column has been settled; correlation with world systems can follow as our knowledge grows. At present any reference of these Pre-Silurian strata to European systems can only be extremely tentative. For the present the West Coast succession appears to be as follows:—

4. Period of diastrophism accompanied by intrusions of gabbro and granite.
3. Silurian:
   Zeehan and Queen River sandstones.
   Zeehan and Gordon River limestone.
2. Pre-Silurian.
   Pipe-stem sandstone.
   West Coast conglomerate.
   (Period of diastrophism.)
   Dundas slates and porphyroids.
   (Period of diastrophism.)
1. Pre-Cambrian:
   Quartzites and schists.

(b) *West Coast Range Conglomerate.*—This forms the bulk of Mt. Roland, Mt. Vandyke, and Mt. Claude, and the central portions of Stormont and Black Bluff.

It is a quartzose rock of reddish appearance, composed of pebbles of quartz and quartzite, set in a siliceous matrix which constitutes a very small proportion of the mass. Occasional stones of quartzite schist occur in it. These stones do not belong to our schistose porphyroids, but have been derived from the Pre-Cambrian rockmasses. Colouration by iron oxide is often very pronounced, and the rock becomes at times extremely hematitic. Grits or coarse sandstones, as well as laminated argillaceous bands, alternate with the pebbly beds, but all combine to form one great series. The alternating sandstones 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 any signs of intense rock-folding, and in general have resisted deformation. They have for the most part been only gently arched, but have been much tilted by vertical movements. These movements *en bloc* have produced numerous faulted junctions with the strata of other systems, making the question of relative age a most difficult one to determine from the exposures available.

This conglomerate used to be interpreted by successive geological observers as being of Devonian age, and as resting like a more or less horizontal covering on the porphyroids and sedimentary rocks composing the lower parts of the mountains. The resistant conglomerate forming the crests of the ranges had an aspect which lent support to this view. Mr. G. A. Waller, a former Government Geologist, noticed that the conglomerate on Mt. Zeehan formed the arch of an anticline there, and descended in steeply inclined beds to the foot of the mountain, where it plunged beneath the pipe-stem strata. The work of the Geological Survey has gradually established the Pre-Devonian age of the conglomerate series in other parts of the island, though exactly how much older cannot at present be positively asserted.

It has faulted junctions with the porphyroids at Mt. Roland, Mt. Claude, Mt. Farrell, and Mt. Lyell, and is slightly unconformable with overlying pipe-stem rock at Mt. Zeehan as far as the dip is concerned. At the Gordon Bend it dips below unconformable beds of Silurian limestone; at the Denison Range it rests upon Pre-Cambrian schist. At Railton it has apparently unconformable junctions with the Cambrian Dikelocephalus beds. The age determination has always been attended by difficulty, but it is only lately that serious doubt has been cast on its supposed pre-porphyroidal age. Professor David, who accompanied the writer on a visit to Mt. Roland, was very doubtful whether this relation obtained there. The absence from the conglomerate of any porphyroid pebbles has always been regarded as a strong argument in favour of the more ancient date, but the discovery of these recently by Mr. Loftus Hills is another illustration of the unsafe character of purely negative evidence.

Professor David writes to the author on this subject as follows:—" I think certainly the pipe-stem rock succeeds the conglomerate. That may be considered a postulate. I also think that the porphyroid series at Mt. Roland must be under the conglomerate in all probability. But is it there intrusive into the conglomerate? As far as I know at present, one can only say that intrusion is not proven. If the porphyroids are largely contemporaneous tuffs, one fails again to see how they can intrude anything; and if they include an intrusively behaving member, such as granite, in their series, is not that member an intruder in the porphyroid series itself, and therefore probably later than the porphyroids in age? One might, I take it, say that the granites of the Dove River may represent an end series to the porphyroid group, and that it represents an emerged batholith which earlier in its career formed part of a reservoir from which the porphyroid tuffs were drawn, if one were disposed to argue that the whole porphyroid group with the exception of perhaps its end series (?) of granites was older than the pipe-stem strata."

On the flanks of the Badgers the strata of the conglomerate system are developed as quartzite, coarse felspathic grit, and sandstone. These are comparable in every way with the grits which are associated with the conglomerate on Tim Shea (Mt. Stephens), at the Humboldt Divide, in Southern Tasmania. Their strike is from 295 to 310 degrees, with a northerly dip. Fossils are very rare in the strata of this system. The Badgers rock has yielded an undetermined brachiopod; and in the conglomerate on Mts. Lyell and Sedgwick tubular casts have been found which are identical with the pipe-stem forms so common in the Middlesex district. A specimen collected recently by Mr. J. H. Levings on the crest of Mt. Sedgwick shows small vertical tubes projecting from the surface of the rock, and recalling the appearance of stubble in a cornfield.

The indecisive fossil evidence does not lend much help in determining the age of this series of strata. Its difficult stratigraphical relations form the principal guide in this respect. In the field the difficulty is increased by the mantle of disintegrated rock and fallen boulders which usually mask the actual junctions on the mountain-flanks.

This great conglomerate group extends from north to south in Tasmania for about two parallels of latitude, and is seen strongly developed at intervals from the west coast to as far east as the Mersey River. The nature and form of its constituent pebbles and the regularity of its linear extensions support the view that the conglomerate was the resultant of wave-erosion, and is the survival of an ancient shore-line. The true thickness of the beds, as observed on Mt. Roland, is fully 1500 feet.

(c) *Tubicolar Sandstone ("Pipe-stem Rock").*—Under this head comes a widespread series of sandstones and quartzites, generally succeeding the West Coast conglomerate. In these are interbedded bands of conglomerate and breccia, which at first sight are liable to be mistaken for the older conglomerate beds. The principal differences seem to be that the younger stone (1) is more intensely silicified than the older conglomerate; (2) has a far greater proportion of matrix; (3) often contains reddish quartzite and sandstone pebbles apparently derived from the older formation; (4) has frequent tendencies to breccia formation.

The general colouration of this younger conglomerate is pale-pink to white.

One occurrence of it is just south-west of the Bell Hill, where it forms precipitous crags of pink quartzite with white quartz pebbles. This appears to bear away westwards to the angle formed by the confluence of the Lea and Iris Rivers. The stone is identical with conglomerate on Hitchcock's and Maddern's lots, west of the Iris, and also seen on the road near the Iris bridge on A. Hinman's 227 acres. It outcrops in various places on the latter block, as well as in the valley of the Bismuth Creek. Some scattered boulders, which seem to have broken away from these outcrops, are somewhat perplexing until the solid occurrences have been located.

Across the track near the Stormont Mine is a line of outcrop of white quartzitic conglomerate with pebbles of quartz. This is unmistakably a pebbly band in the pipe-stem series.

A belt of white quartz conglomerate occurs on the southern section of the Lady Barron Mine for 70 to 100 feet in width, and bearing from 265 to 275 degrees or approximately east and west. Its continuation is seen across the valley half a mile to the east, on the settlers' new road from the Dolcoath Hill.

What may be the eastern prolongation of the same belt is the white conglomerate cut through by the new road to Lorinna, on the east side of the Forth, between the Tin Spur Mine and the granite contact.

On the Lorinna-road, west of Round Hill, leading up to Paton's mark at the road point, boulders of hard white conglomerate and breccia occur in the soil of the bank. This conglomerate is full of waterworn stones and large angular fragments of banded pink grit and sandstone and white quartzite. The latter attain a size of 3 feet in diameter. Judging from its position this conglomerate or breccia must form a band in the pipe-stem series.

A similar breccia occurs on the track from Tiger Plain up to the Devonport sections on the Black Bluff Range. In the creek-bank are boulders of it containing large angular pieces of sandstone and some quartz in a matrix of pipe-stem rock.

It is only on the Lady Barron property that the white conglomerate is known to carry mineral. On the ridge south of the mine segregations and veins of quartz ramify through the rock and enclose large crystals of wolframite.

The tubicolar sandstone covers a wide area of country between Mt. Claude and Black Bluff. It is the country-rock of the ore-veins at the following mines:—Round Hill, Tin Spur, Devonian, Oliver's Hill, Packett's Reward, Narrawa, Lady Barron, Shepherd and Murphy, Wilmot Silver, Stormont, Golden Hill, Golden Cliff, Thistle, Union, Caledonian, &c.

It is white (occasionally yellowish), granular, friable to indurated sandstone, or sometimes even a quartzite. Its texture is sometimes uneven, owing to the presence in it of small pebbles of quartz.

So far no fossils have been recorded from it. 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. Some of the remains found at the diggings have undoubtedly come from the neighbouring Silurian limestone; and the brachiopods which have been found on the Five-mile Rise are in a buff-coloured matrix which is suggestive of Silurian sandstone.

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 3 or 4 inches up to a foot in length, giving a cross-section which is usually cylindrical but occasionally elliptical. Sometimes they are perfectly straight, but when any length is attained, they are slightly curved. For the most part they traverse the stone at a right angle to its bedding. Microscopical examination reveals no trace of organic structure, the stems being composed exclusively of grains of quartz sand.

From the resemblance to the stem of a clay pipe, these casts are locally called "pipe-stems." At one time it was imagined that they represented extinct fucoid stems, but although their real nature is not yet absolutely established, the consensus of informed opinion seems to be in favour of them being the filled burrows of some marine worm. The nearest allied form appears to be the pencil-like burrow of *Scolithus linearis* (Hall), (3) found in the Upper Cambrian of North America.

Mr. Robert Etheridge of the Australian Museum, Sydney, has examined the casts, but in view of the structure

(3) *Scolithus*, from Gr. σκώληξ, *worm*, and λίθος, *a stone*.

less character of the material is unable to express any opinion as to their origin.

Similar structures occur at the foot of Mt. Zeehan, above the Oceana flat, in sandstone pertaining to the same geological horizon. Specimens of these were submitted to Dr. F. A. Bather, of the British Museum. These specimens were better preserved than those usually found in the Middlesex district. Dr. Bather says that there is a certain similarity between them and structures occurring in the Cambrian sandstone of Sweden, to which the name *Scolithus linearis* (Hall) has been applied. The forms occur fairly low down in the Cambrian of Sweden, and Dr. Bather has collected them from loose blocks on the shores of the Baltic about the region of Oland.

Dr. Bather has furnished the writer with the following references to Swedish authors:—

Nathorst, in "Sveriges Geologi" (p. 117), says: "In certain parts of the sandstone vertical cylindrical portions are not rare, and remind one almost of closely set stubble on a field. These have usually been interpreted as the filled vertical burrows of worms. In many cases, however, it may well be questioned if the structure has not arisen in a purely mechanical way without the intervention of organisms."

N. O. Holst, in "Sveriges Geologiska Undersokning," 1893 (Ser. C), No. 130 (p. 6), says: "Sandstone with vertical tubes, often very long, but varying in thickness (the thickness of the tubes sometimes as little as 1 mm.), which have been regarded as worm tubes, *Scolithus lineaaris* (Hall). This sandstone is sometimes white, sometimes reddish. It is hard, and is that which is occasionally used for millstones."

Dr. Bather, however, is by no means certain that the Swedish specimens are the same thing as the true *Scolithus linearis* of Hall.

These forms are met with rather sparsely at the Shepherd and Murphy Mine; more plentifully on the Lady Barron property and north of it; also on Stormont, Black Bluff, and the Five-mile Rise; on Oliver's Hill and the Tin Spur; on Lemonthyme Hill, south of Gad's Hill; and at the Round Hill. At the latter place they may be seen just round the corner of the road above the Falls, showing white sectional outlines in the dark mineralised rock; they would not be noticed at the latter place unless sought for, owing to the colour of the rock, and this accounts for the geological horizon of the Round Hill strata remaining so long unrecognised. ([4])

Information is to the effect that this rock continues west as far as Mayday Mt. It exists also on the flanks of Mt. Zeehan. Mr. L. K. Ward, B.E., in 1909, discovered tubicolar sandstone with casts up to 2 feet in length in the country east of Frenchman's Cap (Loddon and South Loddon Rivers, and Calder's Pass). ([5]).

The junctions with the conglomerate indicate the greater age of the latter, and as the rock noticed by Mr. Ward in Calder's Pass overlying the pipe-stem beds contains peculiar discoidal impressions resembling forms occurring in the Cambrian sandstone at Caroline Creek, these tubicolar sandstones have been thought to be of Cambrian age. This view, too, harmonises with the comparison of the pipe-stems with similar forms occurring in the Cambrian strata of Europe and North America.

(3)—*Silurian*.

Limestone.—The survivals of this formation are found in disconnected parts of the district, viz., at Moina and westwards across the Iris bridge; at Lorinna, east of the Forth; and at Round Hill on the Claude Creek and in the Round Hill Mine.

The rock is a light to dark bluish-grey limestone, 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 which appears to be a band in the limestone, as limestone is again seen below it.

The width of the limestone area is a little over 1 mile, for it is traceable as a contact-metamorphic rock a little up the hill on the Stormont track, south-west of the bridge, and to the east as far as the Bismuth Creek in the township of Moina. This area forms a depressed basin, which is not surprising, for, as is well known, limestone is readily attacked by carbonated waters, and is perhaps the most soluble of common rocks.

([4]) For figures of *Scolithus* see "North American Index Fossils," A. W. Grabau and H. W. Shimer, New York, 1910. Vol. II., p. 246, fig. 1539; and "Quarterly Journal of the Geological Society," Vol. XLVI., 1890, pp. 603-604, figs. 7 and 8.

([5]) Western Exploration: Report of the Department of Lands and Surveys for 1908–1909, p. 33.

Between Bismuth Creek and the Iris River are numerous circular depressions in the surface-rock measuring as much as 200 and 300 feet in diameter. These are sometimes called limestone sinks, and generally indicate the falling-in of the roof of a subterranean cave.

The curious garnetiferous contact-metamorphic rock at the Shepherd and Murphy Mine and west of the Iris River is apparently a metamorphosed limestone.

In the long adit at the Round Hill Mine the ground for the last 150 feet is limestone, and the same rock is reported as being seen higher up the Claude Creek to the south-east. The hill debris above the adit prevents it from being observed at surface.

The 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 fossil evidence is not on an entirely satisfactory footing. On the present visit Professor T. W. E. David identified the hydrozoan *Stromatopora* in the limestone at the Iris bridge. Mr. R. Etheridge, of the Australian Museum, determined some Bell Mount fossils for Mr. G. A. Waller, but these appeared to have been obtained from alluvial, and their parent rock is uncertain. They were *Phacops* or *Hausmannia*, *Rhynchonella borealis*, var. *schlotheimii*, *Orthis* of the type of *Orthis calligramma* (Dalman), and a monticuliporid coral. It is probable that all these were derived from the limestone. They suggest a Silurian age.

For a long time the older limestones in Tasmania were considered as situate at the very base of the Lower Silurian, or in what would now be called Ordovician, but owing to the accumulating evidence the various limestone beds at Zeehan, Queenstown, Gunn's Plains, Bell Mount, Lorinna, Mole Creek, Winkleigh, and on the Jane, Gordon, Franklin, and Florentine Rivers, are at present regarded as belonging to one system—the Silurian proper.

The distribution of the limestone in the Middlesex and Forth district denotes plainly the relations of its horizon to that of the pipe-stem sandstone. It clearly succeeds the latter in the Shepherd and Murphy Mine, at the Round Hill, and at Lorinna. This sequence accords with that at Mt. Zeehan.

(4)—*Tertiary and Quaternary.*

The sediments of these two periods belong to the Cainozoic era, and cannot always be distinguished from one another. The drifts below the basalt fall in the Tertiary, while the later gravels, belonging to the Pleistocene (or Glacier) and Recent (or Human) epochs, are Quaternary. The divisions of this group of strata commonly met with in British text-books are not universally applicable. The epochs were local, and not general; and in using the term "Tertiary" in Tasmania a comparison with the local subdivisions in other parts of the world cannot be implied. The term should simply denote the earlier deposits of the Cainozoic which succeeded the Mesozoic, and without any implication of a threefold subdivision.

The Tertiaries in the districts at present under review appear everywhere to be associated with the basins of existing drainage systems. High-level terraces of shingle and drift extend along the road at Lorinna. A yellowish-white friable sandstone is very frequent as wash-stones, apparently the result of the breaking-up of Tertiary beds. Sediments of this age are found 300 or 400 feet above the present river, and seem to indicate a great age for the present drainage-lines. A wide valley exists at Lorinna, and this has evidently been filled at one time with river deposits which have shared the subsequent movements of the land.

On York's alluvial section, on the west side of the Forth, and below the cage, is a flat which shows a boulder-wash, probably a river-terrace of the older Forth. The present river has made a deviation, and now flows further to the east in a narrow gorge.

Professor David's observations in the river valley near the Wilmot bridge show the existence of river-drift, termed by him "plateau gravels," at a height of between 400 and 500 feet above the Forth, but still more or less associated with the drainage-line marked out by the present valley. Towards the floor of the valley Quaternary gravels appear, the oldest drifts lying at the highest levels.

Similar occurrences may be noted in the valley of the Dasher River, between the Sheffield basaltic plateau and the foot of Mt. Roland.

The writer also observed deposits of gravel and Tertiary clays north of Sheffield, fringing the basalt which covers the two lots of 320 acres, 4718 and 4008, in the name of Jas. Bennett. On Chas. Gould's old map of the Mersey field (1861) coal is marked as reported here. No Permo-

Carboniferous measures are visible, and the geology makes it rather probable that the coal belongs to the lignitic and brown coal series of Tertiary age. These Tertiary beds are on the watershed between the basins of the Dasher and Don Rivers, but their relations to the river systems have not yet been worked out.

B.—IGNEOUS ROCKS.

(1)—*Porphyroid Group.*

The most ancient rocks of an igneous nature are the porphyrites and fragmental schistose rocks of Bell Mount, Forth, Mt. Claude, Mt. Roland, &c., and the Dove River granite and granite porphyry. All these belong to the porphyroid system. The granitic rocks are possibly the end term of series. The series includes tuffs and igneous breccias.

The granite at Reardon's Mine is a granular reddish rock, consisting of pink orthoclase, quartz, and green chloritic pseudomorphs after biotite and hornblende (?) Micropegmatitic or graphic structure is present. It is not so fresh-looking as the Devonian granite, is less quartzose, and has a red and green appearance, due to the felspar and chlorite.

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's Peak is essentially similar to that of the Dove River.

Interbedded with beds of sandstone, slate, grits, and intensely altered conglomerate are schistose and shattered porphyries and porphyry tuffs. These underlie, or are in faulted juxtaposition with, conglomerate or pipe-stem at Bell Mount, Mt. Roland, Mt. Claude, Thomas' Road, and Oliver's Hill, near Lorinna. The porphyries and porphyrites are effusive acid and sub-acid eruptives, strongly deformed by diastrophic agencies.

These igneous schists represent a great suite of eruptives varied in form, and embracing an assemblage of rocks perhaps of equal valency with the calcic and alkali divisions. In Tasmania this large group comprises granite,

granite porphyry, keratophyre, quartz keratophyre, spilite, basalt, porphyroid, tuffs, and igneous breccias. The keratophyres are not normal andesites and quartz porphyries, but dynamically metamorphosed representatives of those rocks, and largely characterised by the presence of albite as a porphyritic constituent as well as a replacement mineral in the groundmass.

Professor Rosenbusch, after examining the schistose porphyroids of Mt. Read (which are identical with those of Bell Mount and Mt. Claude), informed the writer: "Undoubtedly we have here strongly dynamically altered forms of the acid eruptive rocks. The typical porphyritic structure, the nature of the phenocrysts, the still recognisable fluidal structure, the nearly entire absence of dark constituents, the occasional spherulitic forms still recognisable in their replacement products (quartz, albite)—all point with certainty to members of the quartz-porphyry family, and with great probability, not to quartz-porphyry in the narrower sense, but to quartz keratophyre and keratophyre . . . The rocks greatly resemble our German occurrences in Westphalia, the Fichtelgebirge and Thüringen, and especially the occurrences in Wales. These are the forms which in Germany were originally called porphyroids and flaserporphyries." (6)

The writer's synopsis of the microscopical characters of the Mt. Read felsites, prepared in conjunction with his collaborator, the late W. F. Petterd) (7) may be reproduced here as applicable to the porphyroids and flaserporphyries of this district:—

"As the aspect of the rocks differs in the field in different parts of the same mass, so their microscopical structure varies to an equal extent. Sometimes they are typically porphyritic, though the crystals are never very large; or the porphyritic crystals are set so closely together as to resemble somewhat a plutonic rock like granite; or they are broken and mutilated, giving a fragmentary appearance to the rock. The mineral constitution, too, varies. There is a set in which quartz phenocrysts accompany those of felspars, and another series from which they are absent. Nevertheless, despite all these variations, the observer recognises that he is looking at one group—the acid and sub-acid eruptives.

(6) "On the Felsites and Associated Rocks of Mount Read and Vicinity," by W. H. Twelvetrees and W. F. Petterd. (Proc. Roy. Soc. Tas., 1898-9, p. 43).

(7) *Ibid.*, pp. 43-44.

"The mineral constituents of one or other of the members of the group may be classed as under:—

Essential.	*Accessory.*	*Secondary.*
Orthoclase.	Magnetite	Albite
Oligoclase?		Chlorite
Albite		Epidote
Quartz		Sericite
		Calcite
		Limonite
		Sphene
		Zoisite
		Quartz

"The changes are all rung on these minerals, the secondary ones replacing or obscuring the essential constituents in varying degrees.

"In addition to orthoclase, a felspar of the albite or oligoclase-albite series appears as a porphyritic constituent, and is sometimes very abundant, becoming the prevailing felspar. This shows us that these are not the ordinary orthoclastic felsites."

Mr. G. A. Waller, in his report on the Mt. Farrell field, proposed to adopt the name "porphyroid" for this group of rocks. The Geological Survey has incorporated this name in its literature, using it to designate the entire group, though in its narrower sense it is applicable only to certain members of the group.

Some of the rocks of the group are represented in the Heathcotians of Victoria; and Dewey and Flett have recently called attention to a similar suite in Great Britain (8) (spilitic), which according to them comprises a great variety of types—picrites, diabase, minverite (9), quartz-diabase, spilite, keratophyre, quartz-keratophyre, soda-felsite, and albite granite, ranging from ultra-basic to acid in composition, and characterised essentially by an abundance of soda-felspar and the remarkable frequency with which they have been albitised.

The common purple quartz-porphyrite on the road round Bell Mount is a rock with angular and fragmentary quartz and polysynthetically twinned felspars, much albitised and dynamically flexed in a highly devitrified and albitised felspatho-quartzose groundmass. Another variety at the south end of the mount consists of a coarsely cryptocrystal-

(8) Geol. Mag., June, 1911, pp. 245-8. See also May, 1911, H. Dewey and J. S. Flett.

(9) = proterobase, with brown primary hornblende.

line groundmass, in which are set crystals of quartz (corroded), multiple-twinned felspars (oligoclase-albite ?), and chloritised crystals of mica.

A quartz-porphyry which crops out on the new road to Thomas' farm beyond Mt. Claude shows the usual corroded crystals of quartz and decomposed porphyritic crystals of felspar and a ferro-magnesian mineral in a holocrystalline quartzose groundmass.

Quartz-porphyrites are also frequent along the Lorinna-road between the Tin Spur and Campbell's Reward huts, forming varieties of a hard siliceous bluish rock used for the road-metal. One variety shows microscopically clusters of small crystals of biotite replacing decomposed phenocrysts which possess the outlines of felspar crystals.

Some of the rocks along this road are fragmental, containing felsitic or other siliceous inclusions. Such may be called clasto-porphyroids. Tufted actinolite and epidote are occasional minerals.

On Mr. G. Sloane's farm at Lorinna, overlooking the Forth, is a whitish quartz-porphyry occasionally looking like a granitoid rock. It contains crystals of fresh-looking quartz and decomposed felspars in a felsitic groundmass. The probability is that the rock belongs to this series, and not to the Devonian granite; consequently tin ore need not be expected in it.

Some porphyroid rock has been reported from the Iris River by Mr. W. E. Hitchcock, who discovered it *in situ* west of A. Russell's 100-acre block. Mr. Hitchcock states that it occurs for a considerable distance along the bed and banks of the river going south.

(2)—*Devonian Granite.*

This granite, which is the home of the tin and wolfram ores of the district, is not often to be seen in its normal and unmodified phase. The least altered variety may, however, be found along the new road between the Tin Spur and Lorinna, where the eastern prolongation of the Dolcoath stock crosses the Forth. It is here a pink granitite 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 oligoclase-andesine series. The mica is brown and dirty-green in thin section, and a little fluorite is occasionally associated with it.

The central seat of deposition of the tin and wolfram ores is in the granite on the western side of the Forth, and here it is greatly modified in consequence. Its habit is largely aplitic, with a tendency to greisenisation, and it is traversed by veins and bands of pegmatite.

The aplitic form is well shown in the rock in Sayers' No. 1 adit below the main shaft. It consists there of an even-grained mixture of quartz and felspar with a small proportion of bleached biotite. The felspars are potash felspar (orthoclase with microcline and microperthitic intergrowths) and an acid plagioclase (oligoclase), the latter in the isometric forms characteristic of aplite. The quartz is not interstitial, as in normal granite, but in grains, which frequently have outlines approaching crystal forms. Some of the larger grains give the rock a pseudo-porphyritic appearance. Fluorite is also present. The rock in Urquhart's adit is also an aplitic granite.

The greisen form of granite, in which quartz is the substitute for felspar, and a white mica (most frequently 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.

(3)—*Basalt*.

The tablelands of Moina, Wilmot, and Sheffield are covered in part by remnants of lava-sheets, accompanied by basaltic agglomerates and tuffs. The latter are frequent at Moina, the cliffs of knobby rock denoting agglomerate. These fragments of lava are sometimes mixed with shreds and patches of volcanic glass (tachylyte), the whole indicating showers of ejectamenta. The varieties of basalt lava range from pure tachylyte to normal olivine- and olivine-augite basalt. The decomposition of these lavas has produced a soil celebrated for its fertility. Their age is Tertiary.

C.—THE SEQUENCE OF GEOLOGICAL EVENTS.

The bare framework or material of the geology of the district has been described in the preceding, but to ensure an intelligent appreciation of its meaning the historical sequence must be explained. In doing this, a resort to the deductive faculty becomes necessary, for geology has to be interpreted as the geography of the past.

(1)—*The Earliest Sedimentation.*

The most ancient rocks in the entire district are the Pre-Cambrian mica schists which emerge in the valley of the Forth about a quarter of a mile south of the Dove River. These are the earliest rocks which are found anywhere in Tasmania. The floor on which they rest has nowhere been observed. The crystalline nature of some of these foliated rocks is apt to be misleading when considering their origin, for there is reason to believe that they are altered sediments. Rosenbusch in discussing several analyses of mica-schists mentions that their chemical relationships with many sandstones, clay slates, calcareous slates, and marls are unmistakable, and analogies with the chemical composition of eruptive rocks are entirely lacking. ([10])

If Mr. L. K. Ward's subdivision of the Algonkians into an upper and a lower group is to be accepted ([11])—and there are strong grounds for doing so—the upper Forth schists must be regarded as belonging to the Lower Algonkian.

These deposits were laid down, were metamorphosed, and converted into the present foliated and crystalline strata as a consequence of crustal movements; were then raised again, 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.

The earlier Pre-Cambrian (Archæan) land which contributed to the formation of these Upper Forth sediments has completely vanished. Perhaps it existed further west below the Southern Ocean. The Algonkian, in its turn, covered one-half of the present area of Tasmania from north to south, and from the western shores to as far east as the Badger Head range. In the north it is seen at Ulverstone, Hamilton-on-Forth, and near Latrobe and Kimberley. In the south it spreads all over South-Western Tasmania in a tumultuous sea of snow-white serrated mountain ranges.

([10]) Elemente der Gesteinslehre, 1910, p. 632.

([11]) Contribution to the Geology of Tasmania, by L. Keith Ward. (Proc. Roy. Soc. Tas., 1909, pp. 140-141.)

(2) *The Porphyroid Diastrophism.* [12]

The time-interval between the elevation of the Pre-Cambrian strata and the deposition of the West Coast 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 deepseated or plutonic phase in the igneous cycle is represented by the Dove River granite. The crustal movements at the close of this epoch were intense, as shown by the crushed porphyrites of the Bell Hill, Forth River, and Dasher Valley. These porphyroids or porphyrites are the dynamically altered quartz porphyries or dacites of the period.

Whether a metallogenic epoch was created in association with the consolidation of the Dove River granite porphyry is debatable, but certainly Reardon's quartz-hematite lode in the granite-porphyry south of Lorinna seems to belong to this period.

(3)—*The Post-Silurian or Devonian Diastrophism.*

On the worn edges of the porphyroid strata were deposited the heavy conglomerates of Mt. Roland, Mt. Claude, and Black Bluff, the pipe-stem sandstones, and the limestone beds. The conglomerates formed the littoral zone; they were the pebbles on the sea-shore. They extend from the western coast of the island to the meridian of the Mersey River. They must have been laid down on a slowly sinking continental shelf, and possibly fringed a north-and-south shore-line.

Succeeding the conglomerate are the strata of pipe-stem rock. The materials of this sandstone are the products of a more mature decomposition, but many of the quartz and quartzite pebbles of the older conglomerate have apparently been utilised in forming fresh conglomeratic belts of rock. The deposition of the calcareous beds followed on a subsiding ocean floor.

The Post-Silurian diastrophism comprised the earth-movements which affected the Silurian strata and was connected with the consolidation of the granite magma. The action of the rock-deforming agencies was much less intense than that of the post-porphyroid diastrophism.

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(12) Diastrophic movements embrace all movements of the crust of the earth, whether of subsidence or elevation.

The uprising of the granite magma was probably coincident with the relief of crustal stress. On its consolidation it expelled its metalliferous gas-aqueous contents into the surrounding strata, where they were deposited in appropriate channels as the ores of tin, tungsten, lead, &c.

The belt of Devonian granite including the granite porphyry at the Iris is 2½ miles from east to west and a mile from north to south; another mile and a half may be added to its length if it is assumed to underly the Moina field. It is therefore here a rockmass with linear extensions, as far as regards its upper part. The limits of its bounding surfaces downwards, however, are problematical. Any statement with regard to its essential shape as a whole must be highly hypothetical, and will depend upon what one's opinion is in respect of batholiths, laccolites, and chonolites in general. There are indications of its influence as far as 2 miles south-east of any known exposure of it in the form of tin-bearing porphyry in Machinery Creek, near the old Devonian Mine.

This exposure of granite represents a part of one of the many intrusions of acid magma which occurred in different parts of Tasmania during this period. The period of occurrence cannot be fixed more definitely than the time between the Middle or Upper Silurian and the Lower Permo-Carboniferous. The consolidation certainly took place prior to the latter, because the Permo-Carboniferous basal conglomerates contain stones and boulders of granite. Again, it took place subsequent to, or synchronously with, the folding of the Silurian strata, for this granite throughout the island is uncrushed, and bears no impress of dynamic action. The date, therefore, would correspond broadly with the Devonian period. In this respect the Tasmanian granite consolidations differ from most of those of Eastern Australia, which occurred in the Permo-Carboniferous period. The east and west warp-lines, called "Bassian lines" by Professor David, (13) are probably of Devonian age in this part of Tasmania, as indicated by the trend of the granite outcrops. (14) The forces responsible for the earlier north and south tectonic lines were, however still active on the East Coast, as shown by the marginal belt of granite from Schouten to Flinders.

(13) Presidential Address, Royal Soc. N. S. Wales, 1911, p. 30.

(14) Also pointed out by L. K. Ward. *Vide* "The Heemskirk Massif," by L. Keith Ward (Proc. Section C. Aust. Ass. A. Science, Sydney, 1911, p. 172).

Rock-folding in Tasmania ceased with the Siluro-Devonian period. Later sediments are horizontal or moderately inclined.

(4)—*The Cainozoic Oscillations and Eruptions.*

The intrusions of widespread diabase sills and laccolites at the close of the Mesozoic era must have produced some effect on the general elevation of the land, but any associated disturbances were plateau-building movements, and not orogenic. They were not related to the deposition of ore in any respect. No signs of these intrusions exist in the area now being dealt with.

The terrace or plateau gravels, some of them carrying gold and tin ore, were succeeded by eruptions of basalt lava, which choked the river-channels and buried the leads. After this the land oscillations are difficult to follow. There appears to have been an uplift of the whole of the island, with block-faulting and downthrow fractures to the coast-lines. Land connections with Australia still existed. Glaciers sculptured the valleys on Black Bluff. Subsequent events in Northern Tasmania were the immigration of the aboriginals, the subsidence which broke down the land bridge to Australia, and the slight coastal elevation forming raised beaches along the sea-shore.

V.—ECONOMIC GEOLOGY.

Economic geology is that branch of the science which has the most important bearing on the ore-deposits of the area under review. The principal object of the present investigation is to apply the principles of geology to the elucidation of the existing mineral occurrences, and to bring the resulting exposition before the notice of the public. This constitutes what F. L. Ransome has called "applied geology." ([15])

The present chapter, therefore, will include the discussion of matters relating to the minerals, ores, and metals of the district.

A.—THE MINERALOGY OF THE ORE-DEPOSITS.

As may be readily supposed, over such a wide area the metallic contents of the deposits vary and the vein-types are also variable. The deposits may be grouped as (1) tin-tungsten-bismuth deposits, (2) gold deposits, (3) silver-lead deposits. An aberrant form is furnished by hematite-pyrite lodes.

(1) *The Tin-Tungsten-Bismuth Deposits.*

These metals are usually wholly or partly companions in the same lode, as at the Shepherd and Murphy, the Lady Barron, and Sayer's mines; all three being present in the lode of the firstnamed mine, tungsten and bismuth in the Lady Barron and Gurr's, and tungsten and tin in Sayers' mine.

Ores of these metals are distributed throughout the mass of granite (with its greisen, aplitic, and pegmatitic modifications) which forms the Dolcoath Hill, and in the aureole of sedimentary strata which surrounds it.

The deposits of the Shepherd and Murphy and Lady Barron Mines are in veins which traverse the fringing sandstone strata: the Tin Spur deposits on the east side of the Forth are also in the sandstone. On the other hand, the lodes and formations on the Dolcoath, Gurr's, Sayer's, and Urquhart's occur in the granitic rock.

Cassiterite, wolframite, and bismuth ores (bismuthinite and, in a lesser degree, native bismuth and bismutite) pos-

([5]) Economic Geology, 1905, Vol. I., p. 1.

sess an economic value, and are those which are worked. Molybdenite is widely disseminated, but not in commercial quantities.

Cassiterite.—This mineral, as occurring in the Shepherd and Murphy lodes, is black and of adamantine lustre, in crystals of medium size, sometimes stout and square, sometimes with the form of sparable ("sparrow bill") tin; or in twinned and repeated twinning forms.

On the Tin Spur the ore is of extremely fine grain, and is disseminated through the sandstone, which used frequently to be referred to as "porphyry."

Singularly enough, tourmaline appears to be absent throughout the region.

The minerals associated with the cassiterite of the district are as follows:—

At Shepherd and Murphy Mine; in the lode—

Rock-forming minerals: Quartz, topaz, fluorite, monazite, mica, beryl (Secondary: Stilbite).

Metallic minerals: Wolframite, scheelite, bismuthinite, bismutite, native bismuth, pyrite, arsenopyrite, chalcopyrite, molybdenite, magnetite (?). Galena, in crystal clusters, has recently been recorded by Mr. Hitchcock from the coarse jig concentrates.

At Lady Barron Mine—

Rock-forming minerals: Quartz, topaz.

Metallic minerals: Wolframite, scheelite, bismutite, native bismuth, monazite, topaz (?), molybdenite.

At Gurr's Mine—

Rock-forming minerals: Quartz, mica, monazite, topaz, beryl.

Metallic minerals: Wolframite, bismutite, molybdenite.

At Sayer's Mine—

Rock-forming minerals: Quartz, mica, beryl, topaz, fluorite.

Metallic minerals: Wolframite, tungstite (?), manganese, iron oxide, pyrite, bismuthinite, bismutite, molybdenite, specular hematite, chalcopyrite.

At York's Mine—

Rock-forming minerals: Quartz.

Metallic minerals: Wolframite.

At Pochin's Mine—

Rock-forming minerals: Quartz.
Metallic minerals: Wolframite.

At Urquhart's Mine—

Rock-forming minerals: Quartz.
Metallic minerals: Wolframite, iron oxide.

At Dolcoath Mine—

Rock-forming minerals: Quartz, mica.
Metallic minerals: Wolframite, molybdenite, arsenopyrite.

Ores of Tungsten: Wolframite [(Fe, Mn) WO_4], tungstate of iron and manganese, occurs in the Shepherd and Murphy and Lady Barron Mines, and in the mines of the Dolcoath granite stock as a primary mineral of the veins and greisen formations. It is in the form of tabular and bladed crystals, sometimes also granular with a tendency to a massive habit. It has a perfect cleavage in one direction only, is brittle, and has an uneven fracture. Its lustre is sub-metallic and sub-resinous, colour brownish black, with streak dark-brown to nearly black.

The following complete analysis of wolframite from the Shepherd and Murphy Mine has been made by Mr. Loftus Hills, M.Sc., Assistant Government Geologist:—

	Per cent.
WO_3	75·3
Fe O	18·0
Mn O	6·0
SiO_2	0·8
H_2O...	0·2
	100·3

Ratio, Fe O: MnO = 3:1.

Its specific gravity is 7·2 to 7·5, approximately that of cassiterite, and its hardness 5· to 5·5.

It is constantly being mistaken on this field for cassiterite. It may be readily determined in camp by dissolving it in sulphuric or hydrochloric acid, and adding metallic zinc or tin. The solution assumes a blue colour, which disappears on continued dilution; or when decomposed by aqua regia, tungstic acid separates as a yellow powder.

It crystallises in the monoclinic system: well-formed crystals have been found at the Shepherd and Murphy Mine.

Scheelite ($Ca\,WO_4$), tungstate of lime, occurs in small quantities in these lodes. Colour, white to pale-yellow. Streak, white. Translucent. Specific gravity 5·9-6·1. The test for tungsten above described will distinguish it from barytes. Dana mentions the alteration of wolframite to scheelite: other writers adduce instances of the converse.

There is no evidence to prove that wolframite and scheelite are not primary minerals in these mines. The only signs of any alteration of wolframite is the presence on it of what is possibly yellow tungstic ochre.

Ores of Bismuth—Bismuthinite ($Bi_2\,S_3$) or trisulphide of bismuth; bismutite, carbonate of bismuth; native bismuth. The three varieties occur at the Shepherd and Murphy Mine; native bismuth and the carbonate at the Lady Barron; the carbonate at Gurr's; and bismuthinite at Sayer's and across the Forth.

At the Shepherd and Murphy Mine the bismuthinite occurs both in massive form and handsome specimens of acicular crystals with bright metallic lustre. At the Lady Barron Mine carbonate of bismuth was found as a thin selvage to the lode. It occurs also in numerous places all over the granite area.

Molybdenite ($Mo\,S_2$), disulphide of molybdenum. The most common form of this mineral is that of basal laminæ, soft, sectile, flexible, with metallic lustre and lead-grey colour.

Small flakes like tinfoil are found in the mines of the granite area (Gurr's, Sayer's, Dolcoath, and across the Forth), but the concentrations are nowhere sufficient to be payable. It is perhaps most abundant at the old Dolcoath Mine, where it seems to be disposed on the joint faces of the granitic rock.

Monazite.—This mineral is a phosphate of cerium, lanthanum, and didymium, with variable proportions of thorium. On the latter the value of the mineral depends. Its specific gravity is 5, thus somewhat lower than that of cassiterite. Its colour is light brownish-yellow or reddish, and it has a resinous appearance where fractured. It can be readily scratched with a knife.

In the Moina field it is apt to be confused sometimes with scheelite and garnet, and passes locally under the latter name, but its cleavages distinguish it, and its tint is deeper than that of the scheelite of the district.

Although it is easy to pick out small stones of monazite from the Lady Barron concentrates, the mineral is not present in commercially payable quantities.

The other metallic minerals in the lodes are unimportant (pyrite, arsenopyrite, chalcopyrite, galena, manganese).

Rock-forming minerals in these lodes are for the most part such as are met with in pegmatitic veins, *e.g.*, topaz, fluorite, beryl, mica, and quartz. Stilbite is present locally.

Vein Topaz occurs at the Shepherd and Murphy Mine, Lady Barron, Gurr's, and Sayer's Mines. At the Shepherd and Murphy a pale-green mineral decomposing to soft, massive, olive-green material forms a fair proportion of the vein-matrix. This was formerly thought to be a variety of spodumene, but is now recognised as topaz. What the soft green matrix is precisely has not yet been determined. Dr. C. Anderson, of the Australian Museum, has been kind enough to examine some of the topaz crystals embedded in this matrix, and reports that he was able to extract one and measure it on the goniometer, with satisfactory results. These crystals, he says, are quite brilliant and hard, and perhaps the matrix is not altered topaz, as has been supposed, for if so, he would not expect to get perfectly defined unaltered topaz enclosed. In a preliminary analysis which he made, he estimated the ignition loss provisionally as water only, but later he tested the water given off on ignition, and found it to be distinctly acid, presumably from fluorine.

He reports the results of crystallographic measument as follows:—"*b* (010), *M* (110) (*O* 560?), *m* (230), *l* (120), *g* (130), *f* (021), *y* (041), *u* (111), *O* (221) [Dana's lettering and indices]. Thus the crystal is fairly well developed. The prism faces *b*, *M*, *m*, *l*, *g*, are striated vertically, as is usual in topaz, but the measurements were quite good and convincing."

Fluorite, another characteristic pneumatolytic mineral, is an element of all these tin and tungsten ore-bodies. It is singular that while the fluorine-bearing minerals are present, tourmaline is absent.

Beryl has been found in the Shepherd and Murphy lodes, and is freely developed in the main vein on Sayer's property. Here it appears in the form of pale bluish-green prismatic crystals up to $\frac{1}{4}$-inch diameter and 3 or 4 inches long, and is associated with wolframite. Beryl is essentially a pegmatitic mineral.

Mica.—A white to light-green secondary mica, allied perhaps to gilbertite, occurs in the Shepherd and Murphy lodes; and the yellow mica of greisen is common in the ore-deposits of the Dolcoath granite.

Quartz.—This is a constituent of all the deposits. The combed crystals in the Lady Barron lode are well formed, and the lode vughs in that mine and the Shepherd and Murphy yield bunches of crystals, both smoky and transparent, of great size and beauty. Specimens occur with enclosures of the metallic vein-minerals.

Stilbite.—A reddish-zeolite mineral occurs in the Shepherd and Murphy lode in the northern part of the mine. It has a radiating habit, and ramifies through the vein-matter after the manner of an infiltrating solution. Stilbite is a zeolite which is found in basalt and other eruptive rocks, and rarely in metalliferous veins. Here it may be accounted for by assuming its derivation from overlying basalt. Mr. L. L. Waterhouse, B.E., Assistant Government Geologist, has submitted it to examination, and reports as follows:—

"Note on a Mineral occurring in the Lode Material of the Shepherd and Murphy Mine.

"The mineral occurs in masses of radiating crystals up to 3 millimetres in length, and in strings and threads throughout the lode material; also as an encrusting coating on crystals of quartz, &c.

"The colour varies somewhat, from light salmon-pink to reddish-orange. Lustre, pearly. Hardness, 3 to 3·5. Streak, white. Tenacity, brittle. Mineral apparently translucent. A pure piece of sufficient size could not be obtained for specific gravity determination.

"Flame, reddish-yellow; bright-red after moistening with hydrochloric acid.

"On heating in closed tube, much water is given off.

"Before the blowpipe it intumesces and fuses to a white enamel. After heating, moistening the white substance with cobalt nitrate, and reheating in the oxidising flame, the residue is blue.

"Borax bead, colourless; microcosmic salt bead shows an insoluble residue.

"On treating with hydrochloric acid the powder is decomposed with the separation of slimy gelatinous silica.

"The mineral is a zeolite, and answers the description of stilbite, hydrous silicate of lime and alumina. Sodium is present, probably replacing some of the calcium.

"The stilbite is associated with some calcite. The occurrence of stilbite in lode-material (here consisting of cassiterite and pyrite, with quartz, topaz, fluorite, and some muscovite) is unusual, but is probably to be explained as having been introduced, with the associated calcite, by solutions filtering into the relatively porous lode material."

(2)—*The Gold Deposits.*

Some of the iron and lead sulphides of the district are auriferous. Thus pyrite at the Shepherd and Murphy Mine has been found to be slightly gold-bearing; galena from the Round Hill Mine has yielded from traces to 13 dwt. per ton; galena from the Thistle Mine has assayed up to 19 dwt. 14 gr. per ton; concentrated pyrite from the Golden Cliff has yielded as much as 6½ oz. gold per ton. Galena from the Devon Mine has assayed upwards of 5 dwt. per ton.

We may take it that these auriferous sulphides are the vehicles of the primary gold in this region. The free gold met with at certain points in the district is for the most part in all probability derivative from the decomposition of the sulphides. Thus the moss and wire gold found at Campbell's Reward and Stormont; the gold in micaceous iron ore at the Lea River; the free gold on the Five-mile Rise; the fine gold from rusty bands in porphyroid on Oliver's Hill; and the alluvial gold at the Bell Mount diggings—are all the result of secondary depositions. Vein gold occurs in kaolin at the Devonian Mine and Campbell's Reward, in veinlets of quartz in sandstone at Packett's Reward, in the lode-formation at the Narrawa Mine, in quartz and hematite lodes at Black Bluff, in bismuth carbonate at the Lady Barron Mine, [16] in veins of cellular silica at the Great Caledonian Mine and elsewhere in the district.

The wire gold at Stormont and Campbell's Reward presents the appearance of short hairs and dendritic moss-like aggregations, showing all the signs of incipient crystallisation from an aqueous solution. At Stormont thin facings of gold occur between thin leaves of quartz. At Black Bluff gold exists both in veins of quartz and in micaceous iron ore. As regards its occurrence in the latter, it has probably been derived from auriferous pyrite. The gold is described as being light and flaky, almost like bran.

[16] Up to 11 dwt. per ton.

At the Devonport sections the gossan is auriferous, and at the Golden Cliff claim on the Black Bluff Range residual gold occurs in rusty cavities in quartz, suggestive of original pyrite.

The Petterd collection of minerals in the Tasmanian Museum, Hobart, contains the following specimens of gold from this district:—(1) Gold crystals, very rare, from Middlesex; (2) wire gold in quartz, Stormont.

The gold of the district is not as a rule associated with the cassiterite and wolframite deposits. An exception perhaps is the gold on Packett's Reward, where it has been found with tin and wolfram ore in disintegrated, friable sandstone. It is associated also with copper pyrites in the lode-formation on the Narrawa Reward sections, where samples, assayed in the Government Laboratories, have yielded as much as 4 dwt. per ton.

Hematite is in some instances the host of gold. This is particularly the case at Black Bluff, where the precious metal is not confined to vein quartz. Although at Reardon and Day's Mine at Lorinna minute proportions of gold have been detected by assay, it has not been determined whether its source was the hematite or the pyrite.

(3)—*The Silver-lead Deposits.*

Argentiferous galena occurs in veins on the Wilmot near Bell Mount, on the Lea River near Stormont, at Round Hill, Mt. Claude, at various mines on the Five-mile Rise, and at the Devon Mine on the Dove River. Some crystals of galena with octahedral habit have been found as mineralogical rarities in the Shepherd and Murphy lodes. The silver content of the lead ores in the district is variable. A range has been observed of from $\frac{1}{8}$-oz. to 3 oz. silver per unit of lead, the higher ratios being yielded by ore verging on fahl ore. Gold contents range from a trace to 5 dwt. per ton.

Zinc blende is occasionally associated with galena.

B.—THE GEOLOGY AND GENESIS OF THE ORE-DEPOSITS.

It seems reasonable, in attempting to account for the presence and distribution of ores in this district, to connect them with the Dolcoath intrusive mass of granitic rock. Ores of tin, tungsten, molybdenum, and bismuth are freely present within this mass, and exist also in veins traversing a stratified zone which surrounds it. This zone is composed of sandstone, limestone, and clasto-porphyroids, extending to beyond the Iris bridge on the west to the Tin Spur and Devonian Mine on the east. It is natural to expect the most intense contact-metamorphism adjacent to the actual border of the exposed granitic rock, but at the Shepherd and Murphy Mine the profound alteration of the limestone extends as far as 2 miles west from the nearest granitic exposure south of the Lady Barron. The inference to be drawn is that the intrusive rock exists at no great depth below Moina, and consequently that the horizontal surface distance referred to above gives an exaggerated idea of the true thickness of the metamorphic zone.

The conditions of ore-deposition are not easy to realise, and it does not seem quite possible at present to determine in what proportions aqueous solutions and gaseous emanations participated in the process, but the critical point above which water cannot exist as a liquid being 365° C., it would apparently be in the gaseous form that the aqueous constituent of the consolidating granite magma would be transported into fissures in the already cooling parts of the granite and the immediately surrounding sedimentary rocks.

It is generally held that the heated vapours emitted during the cooling and consolidation of rock-magma contained the metals of the magma as volatile compounds. These vapours, having extracted the metals, proceeded to deposit them in fissures as aforesaid. This process is known by the name "pneumatolytic." All round the periphery of granite masses, therefore, is a contact-metamorphic aureole, within which pneumatolytic conditions prevailed.

The tin, tungsten, bismuth, and molybdenum ores of this field are pneumatolytic, and are consequently confined to the granite and the granite aureole.

Pneumatolytic conditions came to an end when the rock-magma finally consolidated and the emission of vapours ceased. Magmatic waters, carrying metals in solutions, then took the place of gaseous emanations. These solutions, becoming cooler in their upward course, gradually unburdened themselves of their metallic load. Ores deposited by this process are known as hydatogenetic, and necessarily they will be found outside the pneumatolytic zone, and at some distance from their magmatic source.

The boundary-line between the two zones is probably indefinite.

The hydatogenic outer zone is marked in this field by the galena deposits on the Wilmot River near Bell Mount, on the Lea River near Stormont, at the Round Mill Mine, and possibly by the various galena and zinc blende veins on the Five-mile Rise and the Dove River. It is not absolutely clear yet whether the latter are genetically related to the Dolcoath granite or to the Dove River granite porphyry.

Both within the granite and in the surrounding aureole the bulk of the ore-deposition is related to pegmatite (aplite and greisen) and pegmatitic veins. The main lode at Sayer's with its beryl and topaz crystals, is pegmatitic; the combed quartz lode at the Lady Barron, with some monazite and topaz, is also pegmatitic; Gurr's lode, with quartz, topaz, mica, monazite, topaz, beryl, is pegmatitic; the lodes at the Shepherd and Murphy, with quartz, topaz, fluorite, mica, beryl, are undoubtedly pegmatitic veins.

The metamorphism of the sandstone immediately surrounding the Dolcoath granite stock consists, for the most part in its conversion to quartzite. There is, however, a small development of green quartz-pyroxene contact-metamorphic rock between Gurr's and Sayer's. The most important development of this class of rock, however, is at the Shepherd and Murphy, where the lodes pass from the quartzite into thickly bedded garnet-magnetite rocks, containing diffused fluorite and veins of pink unstriated felspar.

These rocks consist for the most part of magnetite, fluor and garnet, the garnet being sporadic, and consequently absent from many specimens. The garnet is yellowish-green, colourless in thin section, and does not occur in visible crystals, or at least rarely. It is massive, but under the microscope is seen to exist as formless grains. Optically it is difficult to distinguish andradite garnet from grossularite, and the isolation of the garnet mineral in this rock for quantitative analysis would also be attended by difficulties. The magnetite-bearing andradite-hedenbergite skarn rocks in the Kristiania district in Norway, which have resulted from the metasomatic conversion of limestone, are perhaps the nearest relations to the Shepherd and Murphy rock. (17) There is some pyroxene in the latter rock, but again its determination as diopside or hedenbergite is optically difficult.

(17) Consult "Die Kontaktmetamorphose im Kristianiagebiet," by V. M Goldschmidt, Kristiania, 1911, pp. 213 *et seq.*

Dr. V. M. Goldschmidt, of the University of Kristiania, who has examined this rock for the writer, says: "Rocks similar to this, consisting of fluorite and iron ores, occur also in the Kristiania region, and originate from limestone through pneumatolytic contact-metamorphism. They are genetically related to the skarn rocks."

A light-brown splintery and hornstone-like rock from the trenches east of the creek at the Shepherd and Murphy Mine consists of idocrase (vesuvianite), pyroxene, and garnet, and belongs evidently to the lime-silicate hornstones.

Professor Dr. U. Grubenmann, of the University of Zurich (the leading authority on crystalline schists), has favoured the writer with the following diagnosis of this variety:—

"The slides from the specimens of rock from the Shepherd and Murphy Mine received from you permit a diagnosis to the effect that we have to deal with a nearly isotropic mineral, which in a few places gives a faint light between crossed nicols. This weak birefringence, together with very strong refraction, indicates vesuvianite (idocrase). Whether any garnet accompanies the idocrase could not be determined from the thin section. Besides idocrase, aggregates of diopside could be identified in association with a carbonate probably of the nature of a relict, and in some places a little green epidote."

The garnetiferous magnetite-bearing, skarn-like rock is traversed in all directions by thin veins of pink potash felspar (orthoclase) which appear to be anterior to the mineral lodes, as the felspar is absent from the lode-matter. Fluor permeates the veins of felspar, and probably vitiates the analysis. The Government Analyst (Mr. W. F. Ward) has assayed the material, with the following results:—

	Per cent.
Silica	56·5
Alumina	17·4
Peroxide of iron...	4·7
Lime	5·6
Magnesia	0·7
Potash	12·0
Soda	1·1
Loss at red heat	2·0
	100·00

He reports that "the rock fuses before the blowpipe, bubbling slightly, and forming a somewhat blebby white glass. It appears to consist mainly of felspar."

The ore-veins at this mine traverse sandstone or quartzite as well as the garnetiferous rock, and the economic minerals are consequently not those of a contact-metamorphic deposit. The contact-metamorphic minerals, in their turn, are absent from the lodes. The gangue of the veins is quartz-topaz-mica, in which the ores are pegmatitically set. One is shut up, therefore, to the inference that the metamorphosis of the limestone was a stage quite distinct from that of the filling of the lode-fissures. It does not follow that these stages were separated by any considerable interval of time, but the two moments were distinct. An apparent exception is that of bismuth ore, which has been found in the No. 3 adit at 672 feet from the entrance in the form of disseminations in the hard garnetiferous rock, without any apparent connection with ore-veins. In the west drive on No. 4 lode the grey garnet rock between the ore-veins has been observed to contain minute quantities of the same mineral; but it is a little doubtful whether this is not due to impregnation from the lode-channel. In addition to this, bismuthinite in splashes has been found in the grey lime-silicate hornstone (pyroxene-garnet-idocrase rock) east of the creek, and quite unassociated with any vein or lode-channel. In this connection it is interesting to note that Beyschlag, Krusch and Vogt draw attention to the fact that bismuth figures as a constituent of contact-metamorphic ore-deposits. This question assumed a practical aspect here when it was desired to know whether the presence of the bismuthinite was indicative of the proximity of a lode.

The garnetiferous zone in the limestone strata appears to be roughly parallel with the borders of the latter. There must therefore have been some process at work which brought the margins of the limestone more particularly within the range of the granite influence. Signs of such a process are visible in the existence of the felspar veins alluded to above, though it is difficult to account for their absence from the underlying sandstone, unless they entered the limestone at some point now concealed.

C.—THE PERSISTENCY OF THE ORE-DEPOSITS.

The Tungsten-Bismuth.—Naturally the owners of these properties are anxious to know whether their ore-bodies are merely superficial phenomena or may be followed with confidence to deeper horizons. The owners of tin mines are aware of the frequent tendency of tin ores to disappear in depth: and wolfram miners know very well how capricious such ore-bodies are apt to be, often giving out abruptly and showing every appearance of being isolated occurrences, possessing no continuity on which mining work can be based.

While tin ore undoubtedly occasionally descends to great depths, it has constantly been observed, especially in association with wolfram occurrences, that deposits are frequent in the upper parts of granite masses. The Dolcoath massif has obviously not been subjected to much erosion in its highest portions, as may be seen by the thin cover of sandstone still surviving towards the summit of the hill. The mines are therefore in the ideal zone for ore-deposition. The same conclusion holds good for the mines in the metamorphic aureole (Lady Barron and Shepherd and Murphy). These mines are *a fortiori* in the upper part of the ore-column, and, geologically speaking, have reasonable prospects in depth.

The Tin Spur field is on the same metalliferous horizon, but the structural conditions are somewhat different. The ore here appears to have dispersed itself in diffused channels, so that it is not quite easy to form a conception of its behaviour in depth.

Gold.—In other parts of this bulletin the writer has laid stress on the probability that many of the rich occurrences of gold met with on the Five-mile Rise, Black Bluff, &c., are superficial, and that in every case deep mining would result in tracing the metal down to sulphide ores. Some of these sulphidic veins might prove payable if of sufficient size.

Silver-lead.—The two properties possessing signs of permanence are the Round Hill and Devon Mines. The Round Hill deposits have structurally much in common with those of the Tin Spur, but appear to be more pronounced. There is every likelihood that the present ore-bodies will continue downwards to a depth sufficient for mining under ordinary conditions. Reasons, however, have been given for believing that finally (at an uncertain depth) lead will give place to tin.

VI.—THE MINING PROPERTIES.

A.—TIN, TUNGSTEN AND BISMUTH MINES.

(1) The S. and M. Syndicate Limited: No. 3849-M, 397 acres.

(a) *Description of the Mine.*

This is the pioneer mine of the district, formerly known as the Shepherd and Murphy Mine, and long familiar to the inhabitants of this part of the country, and to prospectors generally, as the Bismuth Mine. The several sections have now been concentrated in a consolidated lease of 397 acres, No. 3849M, south of and adjoining the boundary of the new township of Moina.

The Bismuth Creek flows through the property in a north-westerly direction, and continues for another mile until it flows into the Iris River. The southern part of the lease is high ground, rising 400 to 500 feet above the township, and is largely covered with basaltic lava and tuff. The fragmental tuffs are readily recognised by the lumpy, uneven weathering of the rock. The basalt covering above the mine workings attains a thickness of about 100 feet, and a good thickness is also noticeable where the road crosses the creek on the northern boundary of the property. The centres of eruption have not yet been located. There were probably more than one of these, but the main source seems to have been to the south, and the lava-stream in flowing north apparently entangled in its flow the tuffaceous products of explosion. The basin of the three rivers (Iris, Wilmot, and Lea) into which the lavas descended must have been a valley already in late Tertiary times.

About two-thirds of the property is covered with basalt and basaltic soil. In places the latter forms only a thin layer covering the older strata, which emerge to view both eastwards and westwards.

These older strata are traversed by the metalliferous veins on which mining at Moina is carried on. The strata are: (1) Sandstone or quartzite belonging to the "pipe-stem" series; (2) lime-silicate rock (allied to or identical with the Swedish "skarn"), consisting of garnet, pyroxene, and magnetite (with fluorite, vesuvianite, and bismuthinite), evidently an alteration product resulting from the contact of granite with limestone.

At least seven mineral lodes traverse the lease for some distance roughly parallel with one another in an east-west direction. The country-rock through which they pass is in the eastern portion of the mine quartzite or sandstone, and in the western part the lime-silicate rock alluded to above. The latter is generally dark from the presence of much magnetite, and is intersected everywhere by veins of flesh-coloured felspar, which run in all directions, sometimes parallel with, sometimes transversely to, the course of the lodes.

The quartzite rock in the mine has a north-and-south strike, with a dip of about 20° to the west, and passes below the lime-silicate rock, which is so massive and blocky in habit as to make observation of its dip difficult, though appearances point to this being also westerly. This block of strata between the Bismuth Creek and the Iris River has a different strike from the country east and west of it, and is apparently a disturbed area. East of the creek the quartzite beds course within a few degrees of east and west, with a northerly dip. On the Wilmot River, west of Bell Mount, they run north-west—south-east. At the Iris bridge the limestone strikes north 55 degrees west. On the northern slopes of Stormont the strike of the quartzite is north-north-east.

The garnet-pyroxene rock, with veins of felspar, occurs again west of the Iris River, up the hill, south-west from the bridge, and between this and the mine the dominant rock is evidently limestone. Consequently we have here a basin of limestone with metamorphosed borders. The Shepherd and Murphy lodes have been worked so far in the eastern metamorphic zone of this basin, but work is steadily continuing westward, and it will be a matter of interest and importance to the syndicate to see how far the lodes in this direction continue metal-bearing.

In the mine the junction between the quartzite and the lime-silicate rock is a faulted one, the lode being heaved about 3 feet north. Near the junction the quartzite and lime-silicate rock become softer. The latter assumes a greenish tint, further off it is grey and hard, and still further it is hard, bluish-black, and highly ferriferous.

The lodes continue for great lengths (upwards of 1200 feet), preserving a pretty uniform width without bulges, generally from 15 to 18 inches wide. The maximum width attained is 2 feet. This width is either the width of a single vein or the aggregate width of several veins, for th lodes are in the habit of dividing here and there, while the total width remains the same. A pronounced drawback results when the branches separate too widely, otherwise they can be profitably worked even when not much more than an inch wide, provided they are entirely filled with ore. No shoots of ore occur; the lodes always carry ore, although its distribution is not quite uniform. The lodes have no walls, but represent the filling of simple fractures, and the adjoining rock is also sometimes metalliferous. The bismuthinite occurring in the form of scattered splashes in the lime-silicate rock, and having no visible connection with the lode-fissures, may have been deposited during the same phase of the pneumatolytic process, the vapours permeating the rock at a distance from the lode-channels.

The gangue minerals (quartz, fluorite, topaz, beryl, a greenish hydrated mica, monazite) indicate the nature of the lodes as being that of a facies of pegmatite. The vein-texture is heterogeneous and miarolitic, comparatively loosely aggregated, with frequent vughs in which there is a tendency for exceptional minerals of more or less perfect crystal forms to collect. The metallic minerals contained in the lodes form a somewhat long list (cassiterite, wolframite, bismuthinite, native bismuth, molybdenite, chalcopyrite, pyrite, arsenopyrite, galena). The lastmentioned is a mineralogical rarity, but has recently been detected in the form of clusters of crystals in the coarse jig concentrates. Besides the above, scheelite and bismutite occur, also calcite and a reddish zeolitic mineral (probably stilbite), which seems to have been introduced into the lode-channels in the skarn rock by infiltration from the basaltic covering.

The tin, wolfram, and bismuth minerals are the economic components of the lodes. These minerals exist in the mill concentrates approximately in the following proportions:—Cassiterite, 5; wolframite, 3; bismuthinite, $\frac{3}{4}$.

The mineral contents of the lodes have not varied unfavourably with increased depth, except that larger patches of bismuth ore (carbonate) were met with near the surface. Sometimes a bunch yielding a couple of tons would occur; and veins of mixed bismuthinite and bismutite existed in the higher levels. The carbonate is more rare in the lower levels, but the quantity of bismuth sulphide remains about the same. In the other minerals there appears so far to be no change as depth is gained.

No. 3 *Adit.*

The adit (No. 3) is a crosscut which has been driven south into the hill for a distance of 1200 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 and prospected in this direction. Here, however, it is split and poor. In the west drive a branch of the lode coursing north-westerly has been worked to its limits in that direction, where it is 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 of the lode carried high bismuth values, but the ores were frequently intermixed with massive pyrite to an exceptional extent.

The main drive west shows that the lode ultimately divided and the veins grew irregular. The backs at this point are so small that "dead" work has been relinquished, and further underground exploration towards the west will be carried on by pushing forward No. 4 level west.

No. 5 *Lode.*—This has been cut in the No. 3 adit, and driven on east for 12 feet and west for 66 feet. Where it was intersected in this adit 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 and basaltic debris.

No. 4 *Lode.*—This has been driven on east and west. In the east end at 352 feet from adit the face is 8 feet wide, with a 10-inch vein on the south side, a 4-inch vein on the north side, and a 3-inch vein in the centre. The drive is going below the creek drive workings, 150 feet overhead, and will, it is anticipated, open up a fine block of lode.

In the west drive the lode passed out of quartzite country into lime-silicate rock at 150 feet from the adit, 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. The lode at this point is somewhat pyritic, and is divided into several metal-bearing quartz veins, with a width of 5 feet over all. Bismuth sulphide is here found scattered through the lime-silicate rock, which in this drive is seen dipping west at an angle of 50 degrees.

No. 2 *Lode.*—This has been cut just behind the end of No. 3 adit at 1215 feet from the entrance. It has been driven on east for 25 feet, but the rock here is hard and the lode values low. The lode is represented by two veins, 2 or 3 inches and 6 inches in width respectively. It is here 237 feet below the level of the upper workings on the same lode, and 400 feet west of them, and will be worked upwards in a block 300 feet in height.

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 70 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. Some trenches have been opened in quartzite and lime-silicate rock, exposing some veins which have a general north-westerly course. The band of lime silicate rock is about 150 feet wide, and also strikes northwesterly. 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.

Concentrating Mill.—This is situate above the creek below the mine. Its arrangements were designed by Mr. W. E. Hitchcock, the general manager. The building has recently been entirely renovated, and the old timber replaced by celery-top and concrete.

The mineral is easily crushed, and being loosely compacted, the bulk of the values can be recovered without sliming. Sizing tests with the trommels show that not much over 1 per cent. of the stuff consists of smalls or slime. The crude ore received from the mine averages 2 per cent. of concentrates. The firsts contain 70 per cent. metallic minerals of value and the seconds 40 per cent. The concentrates are furnace-dried upon an iron tray, in a compact drying-room attached to the mill, with an open brick flue. The drying process saves carriage costs and improves the concentrates for the subsequent magnetic separation. The present cost of cartage to Railton station is 35s. per ton.

The water-supply for power and dressing purposes is provided by a water race, 5 miles 57½ chains, from Weaning Paddock Creek, 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 race is 18 inches deep by 18 inches wide at the bottom, and is excavated in earth and rock in mainly basaltic country. The 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 extra dry summers.

Since the start of the mill by this syndicate about 32,000 tons of crude ore have been raised and concentrated; and for this output 6200 feet of ground have been driven, risen, sunk, &c., *i.e.*, 1 foot of development work per 5¼ tons orestuff in six years.

The scale of work at the mine has been limited of late by the amount of labour available, and this has not been forthcoming in sufficient quantity to allow the full development programme to be carried out. The work planned for the present year is to continue the drives in the main adit on the No. 4 and No. 5 lodes and on No. 2 lode both east and west.

The output of crude ore has been on the increase for the last year or two, and the ore reserves are in a satisfactory condition, being well ahead of production. The writer is indebted to Mr. W. E. Hitchcock, general manager, for the following figures showing the tonnage milled, concentrates, and development footage for the last five years:—

Year.	Crude Ore.	Firsts.	Seconds.	Slimes.	Picked Bismuth Ore.	Picked Wolfram Ore.	Picked Tin Ore	Development Footage.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
1906–7...	...	...	...	...	...	...	...	801·5
1907–8...	5153·5	96·95	...	...	·85	1·45	·05	994·5
1908–9...	5614·5	78·9	...	...	4·65	·65	...	1043·5
1909–10..	6030	78·5	14·75	9·4	2·2	·55	...	1467·0
1910–11..	8436·5	81·3	35·5	8·75	5·7	·55	...	1279·5
1911–12..	7370·5	81·55	54·95	10·55	3·4	...	...	1112·5
	32,605	417·20	105·20	28·70	16·80	3·20	·05	6198·5

The following description of mining methods, mill plant, and milling process has been kindly supplied by the manager:—

(*b*)—Milling and Mining Methods at the Shepherd and Murphy Mine (by W. E. Hitchcock, General Manager).

The lode is broken down by blasting on to shovelling-boards laid on the filling; a layer of sacking is laid down under these boards in order to prevent loss of "fines."

Not having any "dig" or defined parting, the lode does not leave the walls easily, but rather has a tendency to "freeze" on. The tin values occur mainly along the walls, and it is therefore necessary to break a certain amount of the country-rock on each side of the vein or lode in order to include all the lode-matter. In big "heady" ground, such as usually obtains in the mine, the width of stope is often much wider than required for working purposes.

The waste rock is hand-picked in the stope and stowed for filling. Ground is good for standing and can usually be taken out up to 12 or 15 feet in height, with, where required, occasional stulls. Waste rock nearly suffices for filling, and where there is a shortage it is usual to put in a line of stulling and decking, on which the filling is again started, leaving an open space between this and the filling below. Filling is also obtained from "dead" ends and from surface, as is most convenient. The broken ore is trucked to the mill-bin by hand in trucks of 12 cubic feet capacity and reckoned as ½-ton. Road gauge is 18½ inches, and 10-inch steel wheels are used on trucks. Ventilation, where not available by natural currents, is provided for by means of 24-inch diameter blower driven by a small Pelton wheel. The water for this is piped down from surface, and a nozzle of ¼-inch diameter, with head of 100 feet, suffices for this work. A similar contrivance is used for the smithy fires.

Air is conveyed to the workings in 6-inch galvanised pipes of 26 B.W.G., rivetted and soldered with telescope joints.

A 2-stage belt-driven air-compressor of enclosed type is being erected to provide air for machine-drills, and is located at mouth of main adit. A main 4 inches in diameter is being put in along the adit to convey air to drives.

Power for compressor is provided by a 40-inch diameter Pelton wheel, the head of water being approximately 350 feet. Auxiliary power, either suction gas or steam, will be required during summer months; estimated power water required is 112 cubic feet per minute.

Ore from mill-bin is hand-fed into 9-inch by 16-inch Blake pattern rock-breaker running 275 revolutions, and driven by 36-inch Pelton wheel with ½-inch diameter nozzle under head of 375 feet.

Nozzle is fitted with deflecting shield, which cuts off part or whole of jet, and a lever is attached to this enabling the feeder to adjust the speed to suit.

Era manganese steel liners are used, costing ·146d. per mill ton, as against ·152d. for chilled cast-iron. In addition, a saving is made in cost of changing liners. The steel liners crush about 4143 tons, against 1877 tons for cast-iron.

The desired maximum product is below $1\frac{1}{4}$-inch cube; but difficulty is experienced in getting this, especially when liners are worn, and it is proposed to put in an intermediate breaker of rotary type, by which it is expected to obtain a 1-inch maximum, which is more suitable for rolls.

The product from breaker passes through a conical trommel 5 feet long, slope 1 inch to 1 foot, and punched with $\frac{1}{2}$-inch round holes. Oversize from this trommel goes to rolls, and undersize to main set of trommels.

Rolls are 26 inches diameter by 10 inches face, and run at 35 revolutions. Shells used on rolls are of special toughened steel, and last for about 5500 mill tons, as against 4300 tons for chilled cast-iron. The former wear much better than cast-iron, and do not "pit." Wear on shells is regulated to a certain extent by distributing the feed to suit. Cost of shells is approximately 1d. per ton of ore milled.

The product from rolls is elevated by bucket-elevator, consisting of 8-inch "Ballata" belt with life of 5600 to 6000 mill tons, mounted with buckets 7 inches by 5 inches by $3\frac{3}{4}$ inches, spaced 15 inches, head and boot pulleys 24 inches diameter, and flanged both sides. Revolutions per minute, 64.

The elevator delivers to trommel with $\frac{1}{2}$-inch round-hole-punched screen; oversize is returned to rolls, and undersize passes with that from breaker trommel to main trommels.

Reduction is completed when ore passes $\frac{1}{2}$-inch round hole. Main trommels: these are arranged in 2-screen sections, the first being $\frac{1}{4}$-inch and $\frac{3}{8}$-inch round holes, and of these undersize of $\frac{1}{4}$-inch passes to next section, and under and over size of $\frac{3}{8}$-inch pass to $\frac{3}{8}$-inch and $\frac{1}{2}$-inch jigs. The jigs are of ordinary Hartz type, and each has two working compartments.

The $\frac{1}{2}$-inch jig first compartment gives firsts product on sieve, and a specimen product is taken off by gate discharge. Second compartment gives seconds product and a small amount of specimen from gate discharge.

A certain amount of sand and fine mineral is obtained from hutches under sieves, and is returned to mill.

From the ⅜-inch jig a "firsts" product is obtained from hutch in first compartment, and "seconds" from hutch in second compartment. Sieves on this jig are ⅜-inch square-hole punched. Hutch products contain a small amount of fine sand, and are hand-sieved, the oversize being fit to bag and the undersize returned to mill.

When bedding other than ore is required for coarse jigs, steel punchings are used. Undersize from ¼-inch trommel passes to double-screen trommel with ⅛-inch and 1/16-inch round holes. Undersize of 1/16-inch passes to classifiers, and the undersize and oversize of ⅛-inch pass to respective jigs.

These jigs have three working compartments, and from the first a "firsts" product is obtained, from the seconds a "seconds" product, and from the third the product is returned to the second compartment. Both firsts and seconds contain a small amount of fine sand, and it is necessary to sieve them to obtain a finished product. The aim is to obtain "firsts" containing practically no silica or pyrite. Jigs are made of 2¼-inch celery-top pine, cut by mine saw-bench. Sieves are 36 inches by 18 inches, and plungers 34 inches by 16 inches, with strokes of length and number to suit each jig. Clacks are at times used in plungers, but in this mill do not appear to be a necessity.

Undersize from 1/16-inch trommel passes to two Rittinger Spitzlutte classifiers, each of which provides a feed for Wilfley tables. From head of these tables a product of clean fine mineral is taken off by adjustable chute. This requires finishing off in buddle or tub. Second product is sent to a dressing-jig of three compartments. This jig gives excellent grades of firsts and seconds in the respective hutches.

Tails from Wilfleys go to tail-jig, from which a small amount of seconds is obtained.

Overflow from Spitzlutten goes to Spitzkasten of two compartments, the spigots of which feed two Frue vanners.

Vanner concentrates are buddled and tossed, yielding firsts and seconds. Tails from vanners go to canvas strakes.

Strakes are 24 feet long by 3 feet wide, made with hardwood framing and celery-top pine decking. Canvas costs 11d. per yard, and is laid across the flow of pulp.

Strakes do not produce much concentrate, owing mainly to the fact that they do not provide any better means of saving than the vanners whose tails they are handling. Rolls, trommels, elevator, and coarse jigs, together with second rolls, are driven by 60-inch diameter Pelton wheel with $\frac{3}{4}$-inch nozzle, under head of 390 feet and speed of 360 revolutions per minute. This wheel has deflecting shield fitted to nozzle, in order that the wheel may be slowed or stopped without closing down the stop-valve.

Fine jigs, Wilfleys, and Frues are driven by 36-inch diameter Pelton at 540 revolutions, under head of about 394 feet. Nozzle is $\frac{1}{2}$-inch diameter. A 2-inch centrifugal pump is also driven at times off this Pelton, for returning water for dressing purposes. The extra power for this necessitates a 9/16-inch nozzle being used. This is equal to about 1200 gals. per hour extra, and the water pumped amounts to 5500 gals. per hour, the height forced being 25 feet.

Provision is made for further reducing the tails of jigs by a set of 18-inch by 10-inch rolls and a set of trommels and elevator.

So far it is found that the mineral is easily freed from the gangue, and that the tailings from the coarse jigs are low in value. It is also found that the country-rock, which forms a very large proportion of these tails, is impregnated with pyrite, and the product obtained by reducing these tails is very pyritic, and, being fine, difficult to dress up to standard. The leading feature of the dressing is the production of firsts and seconds.

Firsts are practically free from silica and pyrite, and contain tin oxide, wolfram, and bismuth (usually as sulphide).

Seconds contain mainly pyrites, with up to 40 per cent. metallic values in the valuable metals, and are also practically free from silica. It is found that a better separation can be obtained, such as firsts and seconds, with a fine jig than with a table; probably in this case the variation in amount of feed and mineral contents is against the table.

Capacity of mill is from 4 to 5 tons per hour, or 200 to 220 tons per week of 48 hours when milling one shift.

The minimum water consumption for power required is 60 cubic feet per minute, and for dressing purposes, including jets for chutes, from 32 to 38 cubic feet per minute.

The minimum power required is 37 h.p. It is found that in cold weather a little more power is required to obtain desired speed for the first hour or so after starting, and on the concentrator Pelton, driving tables, vanners, and fine jigs it is usual to put a nozzle slightly larger than required under normal conditions, and with the deflecting shield to cut off part of the jet as the bearings warm up.

Concentrates after being finished off are drained and dried.

Bags holding 1 cwt. are used for bagging, and for slimes a calico bag is used inside the ordinary jute bag.

Bagged concentrates are despatched by teams to Railton, a distance of 30 miles by good metal road, and from there railed to Launceston. Water-race is $5\frac{3}{4}$ miles long, and has a fall of 16 feet per mile. This fall is found necessary owing to race traversing forest country, and consequently much debris, in the shape of leaves, barks, &c., is dropped and blown into the race. The soil (basaltic) does not cut with this fall, but rather tends to wear a rounded surface in contact with the running water.

Alluvial Workings.

Up the hill south of the mine is some alluvial drift which has been worked for tin ore. The surface drift consists of basaltic soil and rubble carrying a little stream-tin. 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 as a whole, but a layer of rubbly wash, 8 inches to a foot, immediately above the bedrock was payable. Large boulders of white, hard conglomerate carry crystals of cassiterite and topaz: the tin ore is arranged in these in lines of coarser and finer grains, evidently the result of concentration by water. The boulders apparently represent silicified and cemented drift.

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. All these are of Tertiary age (probably Pliocene). Payable portions are likely to be restricted to some buried gutter yet undiscovered. This would probably rise in a southerly and easterly direction, and fall to the west.

(*c*)—Carswell's Tribute on S. and M. Lease.

In the eastern portion of the lease, between the main road and the eastern boundary, Mr. Carswell is working on an alluvial tin-bismuth deposit.

The bottom is soft quartz porphyry carrying veins and nests of tin ore associated with a yellowish mica. On this floor rests a wash from 6 inches to a foot deep carrying coarse black crystalline cassiterite and a little bismuth and wolfram ore.

The product is consigned to Launceston.

Magnetic Treatment of Ores in Launceston.—A plant was erected at Messrs. Hinman and Wright's in Launceston in 1908 for treating the Shepherd and Murphy concentrates of tin, wolfram, and bismuth ores, and has successfully dealt with not only the ores from this mine, but also with other ores from the Moina field.

Mr. Loftus Hills, who was in charge of the works, has prepared the following paper on the electro-magnetic separation of tin, wolfram, and bismuth ores, and the application of the process in the above plant. His remarks are applicable up to the date of his communication:—

(*d*)—Electro-magnetic Separation of Tin, Wolfram and Bismuth Ores.

By Loftus Hills, M.Sc.

(*a*) *The History of the Process.*

It had been known for many hundreds of years that a certain black mineral possessed the power of attracting pieces of iron. This mineral was known for many years as lodestone, but now bears the mineralogical name of magnetite.

No serious attempt was made to study this phenomenon until Faraday by his brilliant investigations laid the foundation of our knowledge of the science of magnetism. The knowledge he gave us, together with the additions made by subsequent investigations, made it possible to evolve, from this physical property of matter, a practical metallurgical process.

It has been customary for many years to employ this property of magnetism in machines for separating adventitious particles of iron from the raw materials used in many trades, where the presence of iron would be injurious. The miller, for instance, often uses a primitive magnetic separator for holding back the nails and other ferric particles occurring in the grain as it passes into the mill; the glassmaker submits the charcoal which he employs to the same process, while the machinist uses a similar appliance for separating iron turnings from brass turnings.

All these earlier appliances were constructed of permanent steel magnets, and it was found that they were capable of separating some minerals from others, particularly the mineral magnetite from gangue material.

In 1896 John Price Wetherill, of Bethlehem, Pennsylvania (U.S.A.), demonstrated by practical trials that, on employing a field saturated with magnetic flux of a density never before applied to such purposes, it was possible to separate a great number of minerals that were formerly considered to be non-magnetic.

It is to this man Wetherill, therefore, that we owe the modern process of electro-magnetic ore-separation.

(b) *The General Principles of the Process.*

(1) *The Electro-magnetic Separators.*—All modern magnetic separators use, as their basic principle, the electro-magnet. This consists essentially of a cylindrical core of soft wrought-iron surrounded by coils of insulated copper wire, through which an electric current is passed. The iron core becomes imbued with magnetic properties having north and south polarity, and remains in this condition so long as the current flows; but immediately loses all such properties on the cessation of the current. This behaviour of soft iron is in contrast with that of steel, which when once magnetised retains its magnetic properties for considerable periods of time, and thus gives us what are called permanent magnets.

The region surrounding the electro-magnet, and through which its influence is felt, is known as the "magnetic field." This magnetic field is traversed by what are called "lines of force," which really represent the lines that would be traced out by allowing a small compass-needle to travel in the direction in which it points, when placed in successive positions in the field.

The unit of magnetic field is represented by one line of force per unit of area of the field, and its "intensity" by the number of lines of force per unit of area.

The absolute measure of magnetic attraction is given by Maxwell's law, which states that "the magnetic attraction varies as the square of the number of lines of force."

It will be seen, therefore, that the maximum efficiency from a given number of lines of force is obtained by concentrating them into the smallest possible area.

The intensity of the magnetic field, as defined above, depends on the size of the magnet, the form of it, the position of the north and south poles relative to each other, the distance between the body to be attracted and the magnet, and the number of ampere-turns in the magnet coil; that is, the number of amperes of current flowing in the coil multiplied by the number of turns round the core.

In a good magnetic separator the intensity of the field should be capable of being accurately regulated.

From what has been said previously it will be seen that this can be accomplished by the regulation of two factors, viz., (1) the distance between the magnet and the particle to be attracted, and (2) the amount of current passing through the coil.

There are several systems upon which electro-magnetic separators [18] are constructed, and these may be arranged in four classes, as follows:—

(*a*) Separation of the particles while falling in air—or deflection separators.

(*b*) Separation while travelling upon belts—or lifting separators.

(*c*) Separation by adhesion to magnets—or roller-type separators.

(*d*) Separation in the presence of water—or wet separators.

(2) *The Magnetic Properties of Minerals.*—All substances are either attracted or repelled by a magnet. The attractability of a substance is indicated by the number of lines of force which pass through it; the larger the number of lines of force, the greater the attraction. This is due to the fact that the passage of the lines of force through the substance converts it into a temporary magnet, with north and south poles. Some substances seem to attract the lines of force, and compel them to pass through their bodies in preference to the surrounding medium, whilst other substances compel the lines of force to pass round them.

Since air is the common medium of passage of lines of force, it follows that a substance which is more "permeable" to lines of force than air will be attracted towards the strongest part of the magnetic field, whilst substances

(18) For complete descriptions of modern electro-magnetic separators the reader is referred to "Electro-magnetic Ore-separation," by C. Godfrey Gunther (Hill Pub. Co.), pp. 22-78; and Richards' "Ore-dressing," Vol. II., pp. 797-813, and Vol. III., pp. 1521-1543.

which are less permeable will move in the opposite direction. The "permeability" of air is therefore taken as 1, and the permeabilities of other substances are referred to it as unity.

Substances which have permeabilities greater than 1 are called "paramagnetics," and those having permeabilities less than 1 "diamagnetics."

All minerals are either paramagnetic or diamagnetic, but the latter have permeabilities so near unity that they may to all intents and purposes be regarded as non-magnetic.

For practical purposes, therefore, all minerals may be classed under two heads, viz.:—

(*a*) Magnetic minerals.
(*b*) Non-magnetic minerals.

Many attempts have been made to determine the specific magnetic permeabilities of minerals, but with very indifferent results. The writer's experience shows that no safe or reliable forecast can be made as to the magnetic permeability of a mineral, from its chemical composition. In addition, if one mineral has its magnetic permeability ascertained, it cannot be taken for granted that the same mineral from another locality will act in exactly the same way towards a magnetic field.

Iron has a very high magnetic permeability, but it certainly does not follow that any mineral containing iron will be magnetic. An illustration of this is given by the fact that pyrite, which contains 46·6 per cent. of iron, is generally found to be non-magnetic, although the writer has had experience of fresh unaltered cubical pyrite and marcasite varying from non-magnetic to very highly magnetic. There is no apparent explanation of this anomaly. In the greater number of cases, however, the presence of iron in a mineral will give it some magnetic permeability.

Another striking instance of the variable magnetic behaviour of the same mineral is that of galena. This mineral is ordinarily non-magnetic, yet at Gem, Idaho (U.S.A.), there occurs a galena which is highly magnetic.

Still another instance is given by zinc blende, which varies from highly magnetic to absolutely non-magnetic.

The paramagnetic metals are iron, nickel, cobalt, manganese, chromium, cerium, palladium, platinum, and osmium, and, in general, any minerals containing one or more of these metals may be expected to be susceptible to treatment by magnetic separation. From what has been said previously, however, it will be seen that the only satisfactory way to determine the applicability of electro-magnetic separation to any ore is a preliminary test of a small parcel on a suitable machine by a capable operator.

Some minerals, which ordinarily have a magnetic permeability of unity or thereabouts may be rendered highly magnetic by heating or roasting. Thus pyrite may be rendered highly magnetic by a short roast; the mineral chalybite by simple heating is converted into highly magnetic oxide of iron; and some varieties of zinc blende when warm are highly magnetic, while they are almost non-magnetic when cold.

A condition essential to successful magnetic separation is, that the several minerals must exist as separate and distinct particles. To bring this state of things about it may be necessary to crush the material down to a state of comminution where each mineral is free from the other.

All material for magnetic separation should be accurately sized, as the uniformity of the size, fed to the machine at one time, and under certain conditions of adjustment, is one of the determining factors of a good separation.

The first three classes of separators mentioned above require the ore to be perfectly dry, but the fourth class of machines is used in the presence of water.

(c) *The Scope of the Process.*

The application of this process to ore-dressing falls under two heads: (*a*) Magnetic concentration, and (*b*) Magnetic separation.

(*a*) *Magnetic Concentration.*—Magnetic concentration finds its chief application in the treatment of magnetite ores, and in general may be described as an operation which serves to increase to a maximum the percentage of any valuable constituent by eliminating the valueless material.

(*b*) *Magnetic Separation.*—It is in this field that the process has its most numerous and complex applications.

The wet methods for the separation of minerals from each other become more and more difficult as their specific gravities converge, so that when the difference in density between two or more minerals is small it is practically impossible to induce any separation, even with the most improved forms of jigs, tables, or vanners.

In practice we meet with many minerals so intermixed in mass that they are industrially of little value, seeing that one or other of the constituents is often given away in order to realise the other. Not only so, but the value of the second mineral is often reduced owing to the penalties imposed for the presence of the deleterious mineral, and in some cases is reduced to nil. It will thus be seen that if these minerals can be separated from each other a great improvement in the net value of the ore will result.

Not only may a magnetic mineral be separated from one which is non-magnetic, but two or more minerals of different magnetic permeability may be separated from each other.

The object of an electro-magnetic separation of an ore may be: either to remove a mineral or minerals whose presence is not actually deleterious to the valuable mineral, but merely acts as a diluent; or *complete* separation of one or more minerals from each other, the presence of any of which with another is deleterious, and would cause penalties to be imposed.

The former operation is usually carried out by machines of relatively high capacity, capable of treating large quantities at a small cost. The latter operation is generally performed by machines designed to give high-grade extraction with a sacrifice of capacity.

(*d*) *The Application of the Process to the Treatment of Tin, Wolfram, and Bismuth Ores in Launceston.*

(*a*) The Plant.

The electro-magnetic separator plant was erected in March, 1908, for the purpose of treating the concentrates from the Shepherd and Murphy Mine, Moina, near Wilmot, Tasmania. It was arranged and erected by the writer, who has been in charge of it since that date. There have been several alterations and additions during the four and a half years during which it has been in operation, and the installation as now constituted is described below. It is the only plant of its kind at present working in Australia.

There are two electro-magnetic separators, which belong to Class (*b*) mentioned above. They were made by the Humboldt Engineering Works Company, Kalk, Germany, which has control of the original Wetherill patents for all civilised countries other than the United States. These separators belong to that type of machine referred to previously as being designed to give as nearly perfect an extraction as is possible to be obtained.

The method adopted in these machines of obtaining a concentration of the lines of force is by the juxtaposition of a V-shaped pole of north polarity and a flat pole of south polarity, or *vice versa;* the sides of the V are protected by brass, the magnetic permeability of which is less than unity, leaving only a bare strip of iron ¼-inch wide at the bottom edge of the V. The lines of force are thus concentrated along the bottom edge of this V-shaped pole, which is placed above the flat pole. There are four pairs of these poles and four coils.

The distance between the poles is adjusted by raising or lowering the coil carrying the V-shaped poles.

The ore is conveyed into the magnetic field on an indiarubber main conveying-belt, which passes between the upper and lower poles. The paramagnetic minerals travel towards the strongest part of the field, and thus actually jump towards the bottom edge of the V. They do not reach the iron edge, however, as travelling transversely to the main conveying-belt are smaller rubber bands, which just slide along the edge of the V. The paramagnetic particles, therefore, do not rise any further than the under surface of these rubber bands, and, being carried transversely out of the magnetic field, are dropped into suitably-placed hoppers. Indiarubber has a magnetic permeability of unity, so that the presence of these belts does not in any way affect the magnetic field. The non-magnetic portion, being unaffected by the magnetic fields, passes onwards, and falls into an appropriate bin.

The coils of two pairs of poles are traversed by a current varying from 2 amperes to 10 amperes, and these are called the weaker fields, whilst the coils of the other two pairs carry a current varying from 10 amperes to 16 amperes, and are called the stronger fields.

The current for the two separators is supplied by two D.C. shunt-wound generators of the totally enclosed type, having a capacity of 3·7 K.W. each—one generator for each separator.

The current from these generators passes into a switchboard consisting of three panels. One of these panels contains the controlling gear for the current from the two generators, distributing the current to either of the other two panels, each of which supplies one separator. Each of these latter panels is fitted with two regulating rheostats, one for each pair of coils, which vary the current by ½-ampere differences between the limits mentioned above. The whole switchboard was made by the Electric Light Department of the Launceston Municipal Council, and contains all the necessary gear, such as amperemeters, voltmeters, switches, cut-outs, &c., which give complete control of the whole system.

The ore is screened on a specially designed bumping screen, which gives the following sizes:—On 6 mesh; through 6 and on 10 mesh; through 10 and on 20; through 20 and on 40; and through 40. Each of the four latter sizes is fed directly to the separators, but the oversize, *i.e.*, the material remaining on 6 mesh, is fed to the rolls.

The latter are crushing rolls (supplied by the Humbolt Engineering Works Company), the special feature of which is the attachment of the driving-pulley on the shaft of the swinging roll, an arrangement which minimises the effect of shock due to the presence of hard particles of metallic iron, &c.

The power is supplied by a 14 h.p. three-phase A.C. motor, which is driven by current supplied by the Launceston Municipal Council.

The roaster department contains a muffle roaster specially designed by the writer for use in the treatment of portion of the Shepherd and Murphy ore, together with the necessary ore-bins.

There is a cooling-floor in conjunction with the roaster department, for cooling the roasted product.

In addition, there is a dressing-shed containing appliances for the elimination of light non-metallic minerals, by water concentration, from certain products from the other departments.

(*e*) *The Ores Treated and the Results Obtained.*

(1) The Shepherd and Murphy Ore.

(*a*) *The First-grade Concentrates.*—It was to convert these concentrates into saleable products that the magnetic separator plant described above was erected. They are produced in the mill at the mine, where it is found impossible to separate the different constituent minerals by ordinary water-concentration.

The minerals present are cassiterite, wolframite, bismuthinite, magnetite, iron pyrites, and a small amount of scheelite, with quartz and fluorspar as gangue material. All these minerals exist as separate and distinct particles.

An average assay would be—

	Per cent.
Tin	40
Tungstic acid...	22
Bismuth	6

corresponding to a mineralogical composition of—

	Per cent.
Cassiterite	53·3
Wolframite...	29·5
Bismuthinite	7·0
Pyrite	2·0
Magnetite	1·0
Silica and fluorspar ...	7·2

Magnetite has a high magnetic permeability, and is therefore attracted by a relatively weak field; while wolfram has a low permeability, and therefore requires a highly concentrated magnetic field in order to ensure its rise against the force of gravity. The pyrite, as mentioned above, varies in permeability from highly magnetic to non-magnetic, but the greater portion is non-magnetic. The cassiterite, bismuthinite, and scheelite, together with quartz and fluorspar, have a permeability of unity or less than unity, so that they act as non-magnetic minerals, and are unaffected by the magnetic fields.

The three valuable metals in this case are tin, tungsten, and bismuth, and the presence of any of these with another is decidedly deleterious. The object aimed at, therefore, during the whole process is to obtain the highest possible degree of separation, as this enables far better prices to be obtained for the finished products.

The product from the first magnetic field, as adjusted under our conditions, consists of magnetite and a small amount of pyrite; that from the second field consists almost wholly of pyrite. These two products are removed together, and, containing under 1 per cent. of the three valuable metals, are dumped as waste material.

The third and fourth magnetic fields are adjusted to produce clean wolfram. The finished product, however, contains some pyrite and a little cassiterite, and assays on the average—

	Per cent.
Tungstic acid	70·0
Tin	0·7

The non-magnetic product consists of the non-magnetic constituents mentioned above, and assays—

	Per cent.
Tin	56·3
Bismuth	8·0
Tungstic acid	0·7

This product is shipped to England, where the bismuth is extracted by a chemical process, and the remaining tin residues, which are sold to tin smelters, assay—

	Per cent.
Tin	69·0
Tungstic acid	0·8

(*b*) *The Second-grade Concentrates.*—This concentrate is a very complex one, and has only been produced since the mine workings have descended below the oxidised zone. The products obtained from the ordinary magnetic treatment are unsaleable, and the process used in converting them into saleable products has been worked out by the writer.

The constituent minerals are cassiterite, wolframite, bismuthinite, pyrite, chalcopyrite, arsenopyrite, magnetite, monazite, scheelite, and molybdenite, together with the gangue minerals, quartz, fluorspar, and topaz.

The valuable metals are the same as in the first-grade concentrates, namely, tin, tungsten, and bismuth.

The average assay is—

	Per cent.
Tin	20·0
Tungstic acid	10·5
Bismuth	7·5

and the mineralogical composition approximately is—

	Per cent.
Cassiterite	26·6
Wolframite	14·0
Bismuthinite	8·4
Pyrite, chalcopyrite, and arsenopyrite...	32·5
Magnetite	1·0
Monazite	2·0
Scheelite	1·2
Molybdenite	0·8
Quartz, fluorspar, &c...	12·5

The minerals exist as separate and distinct particles, with the exception of the pyrite and bismuthinite, which to some extent occur intimately associated, besides the occurrence of some of the quartz in intimate association with the cassiterite and wolframite.

The magnetic properties of those minerals, which also occur in the first-grade concentrates, are the same as already described; monazite has a permeability slightly less than wolframite, whilst the molybdenite is non-magnetic. The chalcopyrite is mostly non-magnetic, while arsenopyrite varies in permeability from that of wolframite to unity.

In view of what has been said, it would seem that, by giving this ore a magnetising roast, three products could be obtained, viz., (1) a highly magnetic product, containing all the magnetite and the pyrites which had been rendered magnetic by roasting; (2) a clean wolfram product; (3) a non-magnetic product, containing the tin, bismuth, and gangue minerals. In practice, however, this fails utterly. The roasting was carried out under varying conditions of time, temperature, &c., but in all cases it was found impossible to bring about a satisfactory separation on subsequent magnetic treatment. A typical result would be the production of three products, as follow:—

(1) Product from weaker magnetic fields assaying—

	Per cent.
Tin	3·0
Tungstic acid	7·0
Bismuth	5·0

(2) Product from stronger magnetic fields assaying—

	Per cent.
Tin	20·0
Tungstic acid	27·5
Bismuth	10·0

(3) Non-magnetic product assaying—

	Per cent.
Tin	50·0
Tungstic acid	6·0
Bismuth	5·0

It will thus be seen that this procedure brings about no improvement of the ore for selling purposes. As it is impossible to attempt any discusion of this problem in the space here available, I will now merely give a rough outline of the process which has proved successful.

The ore is passed through the magnetic separators, and, as in the treatment of the firsts, three products are obtained, that from the first two fields being similar to that obtained from the first grade concentrates. The product from the other two (stronger) fields consists of wolframite, pyrite, arsenopyrite, and monazite, together with a little quartz, and assays—

	Per cent.
Tungstic acid	42·0
Tin	1·0
Bismuth	2·0

The non-magnetic product contains cassiterite, bismuthinite, pyrite, chalcopyrite, arsenopyrite, scheelite, molybdenite, together with quartz, fluorspar, &c.

The average assay would be—

	Per cent.
Tin	23·7
Tungstic acid	1·5
Molybdic acid...	0·9
Bismuth	9·0
Copper	0·34

corresponding to a mineralogical composition of approximately—

	Per cent.
Cassiterite	31·6
Scheelite	1·9
Molybdenite	0·9
Bismuthinite	10·0
Pyrite, chalcopyrite, and arsenopyrite	36·6
Quartz, &c....	19·0

Both the wolfram product and the non-magnetic product are then roasted, with the object of converting the pyrite, chalcopyrite, and arsenopyrite into highly magnetic compounds. This operation is rendered a very delicate one owing to the presence of the bismuthinite, and is carried out with extreme care in the special furnace mentioned above.

After roasting, each of the products is cooled, screened, and given a second magnetic treatment. In the case of the wolfram product the fields are adjusted to give (1) a product containing all the pyrite, carrying all the bismuth contents, and a little wolframite, (2) a wolfram product still containing some monazite, and (3) a non-magnetic product carrying most of the quartz and practically all the tin. The final wolfram product is readily saleable, and assays—

	Per cent.
Tungstic acid	64·0
Tin	Trace.

The magnetic fields are adjusted, in the case of the roasted tin-bismuth product, to produce a magnetic portion carrying the pyrite, chalcopyrite, and arsenopyrite, and leaving the remaining minerals as a non-magnetic product, which assays—

	Per cent.
Tin	39·0
Tungstic acid	2·5
Molybdic acid...	1·5
Bismuth	11·0
Copper	Nil

corresponding to a mineralogical composition of roughly—

	Per cent.
Cassiterite	52·0
Scheelite	3·3
Molybdenite	1·5
Bismuthinite	12·2
Pyrite	2·0
Quartz, &c.	29·0

This product is then treated in the dressing-shed, with the object of eliminating the quartz, &c.

The final product assays—

	Per cent.
Tin	51·5
Tungstic acid	2·9
Molybdic acid...	0·5
Bismuth	12·5

This is sold in the same way as the corresponding product from the first-grade concentrates.

Both of the magnetic products carrying the roasted pyrite, &c., also carry appreciable bismuth values, due to the intimate association of some of the latter mineral with the former, but are saleable as bismuth ore, being very low in tin.

(2) The Concentrates from the Iris Mine.

These concentrates consist of a clean mixture of cassiterite and wolframite in separate particles, and is ideal material for magnetic separation.

The tin product assays, on the average—

	Per cent.
Tin	73·0
Tungstic acid	0·1

The wolfram product contains—

	Per cent.
Tungstic acid	73·0
Tin	Trace.

Both these products are high-grade, and are eagerly bought.

(3) Concentrates from the Lady Barron Mine.

These consist of wolframite, native bismuth, and bismuth carbonate, together with a little monazite, in separate particles. The bismuth minerals are both non-magnetic.

The average assay is—

	Per cent.
Tungstic acid	68·0
Bismuth	3·5

The wolfram product assays—

	Per cent.
Tungstic acid	74·0
Bismuth	Nil

The bismuth product assays—

	Per cent.
Bismuth...	56·0
Tungstic acid	Trace.

(4) Concentrates from Story's Creek, near Avoca.

These consist of cassiterite, wolframite, and pyrite, but are not very high-grade. A peculiar feature is that the cassiterite, which is usually a non-magnetic mineral, is partly magnetic, having about the same permeability as wolframite. The result is that the wolfram product contains tin, and assays—

	Per cent.
Tungstic acid	67·0
Tin	3·0

The tin product assays—

	Per cent.
Tin	66·0
Tungstic acid	0·3

(5) Low-grade Tin Concentrates from North-East Coast.

These concentrates contain cassiterite, ilmenite, pleonaste, zircon, monazite, with quartz, &c. They are generally below the tinsmelter's minimum of 30 per cent. tin when they come to us, owing to the impossibility of eliminating ilmenite and pleonaste by ordinary methods of streaming.

The zircons are non-magnetic, but ilmenite and pleonaste, which together are called by the tinminer "Black Jack," vary in permeability from highly magnetic to very feebly magnetic. These two minerals, therefore, can be eliminated together with the monazite, by a suitable adjustment of the magnetic fields. The tin contents of the resulting concentrate depend on the relative amount of the non-magnetic material; if the amount of quartz and zircons is small, the tin assay will be high, and *vice versa.* In one case the ore before treatment contained 10 per cent. tin, and the resulting concentrate assayed 65 per cent. In another case the original assayed 20 per cent. and the concentrate contained 67 per cent. metallic tin.

The treatment of these ores may be regarded rather as an example of magnetic concentration than as one of magnetic separation, and the resulting tin concentrate may be subsequently dressed by water-concentration if it contains an excess of quartz and other gangue minerals.

(6) Concentrates from the X River Alluvial.

These contain cassiterite and chromite, the latter mineral having magnetic properties similar to ilmenite.

The original ore assayed in one case 8 per cent., and the resulting concentrate 70 per cent. metallic tin.

(7) Bismuth—Wolfram Concentrates from New South Wales and Queensland.

These concentrates vary widely in character and composition, but generally may be said to contain wolframite and bismuth carbonate and oxide. In the greater number of cases the wolfram is coated more or less by the bismuth minerals, and thus a near approach to perfect separation is impossible. However, as the result of very careful work, an average extraction of over 90 per cent. of both metals has been maintained.

(f) Conclusion.

It will thus be seen that an economical process has been evolved, from an application of the principles of the science of magnetism, making it possible to work deposits which were previously unpayable owing to the impossibility of obtaining satisfactory markets for the complex ores raised.

As in most modern inventions, so in this case also, the actual inventor was preceded by a pure scientist, who put into the hands of the former all the material necessary for the carrying out of an operation which the exigencies of practical experience had shown him to be vital to a certain industry; the inventor adapting, in a unique manner and with a definite end in view, the principles evolved by a worker in pure science.

The number of ores to which the process is applicable is seen, from what has been said in the preceding pages, to be large, but there are possibilities, at present untouched, which promise a bright future for this method of treating mixtures of minerals. It is impossible, with the present limited space, to attempt any discussion of these future possibilities.

It will also be seen that there are certain matters contained in the previous pages which require some explanation. These are: the behaviour of the Shepherd and Murphy second-grade concentrates under heat, giving the anomalous results mentioned; the exact behaviour of pyrite when heated with or without access of air; the cause of the conversion of cassiterite into a more or less magnetic mineral by heat. The writer has investigated these matters, but must defer their discussion to a subsequent paper because of lack of space here available to adequately discuss them.

LOFTUS HILLS, M.Sc.

Launceston, 16th July, 1912.

(2)—LADY BARRON PROSPECTING SYNDICATE, NO LIABILITY.

Consolidated Lease—5986-M, 235 *acres*.

This mine was formerly worked under the name of the All Nations Wolfram Mine. The lease is bounded on the west by the Shepherd and Murphy property, and on the south by the Iris claim. The main-road from Wilmot to Middlesex passes through the north-western part of the property at about 2200 feet above sea-level. Aneroid readings show the mine as about 500 feet above Moina township.

The former lessees opened upon the lode on the eastern or Narrawa fall by a deep open drive along its course (E. 10° S.) for 12 chains. A few shafts were put down along the line to depths varying from 20 to 60 feet. The owners sluiced off the loose upper part of the lode, and left the harder quartz (which they had stripped) for subsequent treatment. The present proprietors have extended the drive underground at about 50 feet from the surface, and have treated several hundred tons of stone left at grass by the former lessees.

The lode varies in width from 10 to 20 inches, and consists of combed quartz crystals, some of which are 3 or 4 inches in diameter. The quartz is either absolutely clear and colourless, or again of the smoky variety. Vughs are apt to occur in the lode, and some have been met with several feet in length, generally filled with water, and sometimes with wolfram ore.

The economic mineral is wolframite principally. Some auriferous carbonate of bismuth and native bismuth are present. A few flakes of molybdenite occur in the lode occasionally, and small pieces of reddish monazite (locally called garnet) can be picked out of the concentrates.

The country-rock is sandstone, belonging to the pipestem series, and has a northerly dip, while the lode underlies steeply to the south.

The drive has been extended to a distance of 329 feet in an easterly direction. At the entrance to the drive the lode has been stoped out to surface. At a hundred feet in, a winze has been sunk 15 to 18 feet on ore 18 inches wide, but terminating at a slide. At 200 feet a slide crosses the drive, and displaces the lode 8 feet. For 130 feet beyond this the drive is in slide country, and is poor for mineral, though at surface there was fair ore. The end of the drive shows rather hungry-looking quartz.

At surface the open-trench drive has been carried about 3 chains further than the present end, and shows a strong quartz lode fully 20 inches wide, carrying wolframite in encouraging quantities. The end will have to be driven to come under this. In all, the ground stoped is about 100 feet in length, and at most perhaps 30 feet in height.

Trenches have been cut ahead of the open drive up to the eastern boundary exposing vein quartz, and the lode seems to pass into the adjoining 20-acre section in that direction.

The ore is being concentrated by means of a small steam-driven plant, consisting of crusher, three two-compartment jigs, and two trommels, with a portable engine. The concentrates are carted to Devonport, and conveyed thence by steamer to Launceston, where the wolfram is magnetically separated from the bismuth ore at the treatment works of Messrs. Hinman and Wright.

According to assays by Mr. Loftus Hills, M.Sc., the concentrates average 68 per cent. tungstic acid, and the tungstic acid content of the wolfram product obtained goes as high as 74 per cent. This is a very high-grade product.

A few hundred tons of the dumped material raised by the old proprietors have been treated at the mine with the orestuff broken subsequently. Being already mined, it paid to put it through with the current output. During the last three years about 14 tons of concentrates have been sent away from the mine. These concentrates contain between 3 and 4 per cent. of bismuth, and occasionally a little more, which would probably fully pay the separation charges.

The insufficiency of backs on this fall is a great disadvantage. Forty or 50 feet additional depth can be readily obtained by driving from the creek below the lode, and for further depth sinking must be resorted to.

The mine cannot acquire any permanency of character without being opened up. As usual in wolfram deposits, the ore is bunchy, but there has been a sufficient quantity of it obtained to justify deeper work.

Some attempt has been made to trace the lode westwards in the part of the property situate east of the Wilmot-road, and a few trenches seem to indicate the trend of the lode-line in that direction. It must be borne in mind, however, that the lode has a tendency to split into branches, and systematic trenching is necessary if reliable results are aimed at. There is a great field here for such prospecting work, as the ground is virgin between the

Lady Barron Mine and the Shepherd and Murphy workings. The line of the Lady Barron lode, if constant, and allowing 130 feet horizontal deflection due to its southerly underlay in a vertical of 500 feet, would coincide in position with the No. 6 lode on the Shepherd and Murphy property.

But the distance between the two workings is about three-quarters of a mile, and a good deal may happen to a lode in that distance. Some careful prospecting is requisite to establish the identity of the lode systems of these two mines, and the western fall of the Lady Barron ground below the Wilmot-road affords appropriate sites for such work. The full development of the property, in fact, may be said to depend upon how the lode behaves on this side of the hill. If it is followed into the hill, the ore can be raised with comparative ease, and either works placed lower down the Bismuth Creek or milling arrangements made with the neighbouring mine. At the same time work could be continued cautiously on the eastern fall. On that side any deeper adit-driving could only be tentative and temporary. Serious development of the lode in its most promising section would have to be by shaft-sinking.

Although the bearing of the Lady Barron is identical with that of the Shepherd and Murphy No. 6 lode, the dip is not the same, as the No. 6 is vertical, or if any underlay exists it is slightly to the north. The tin ore, too, which is characteristic of the latter lode, is absent from the former.

The previous owners of the Lady Barron property searched up the hill south of their workings for the continuation of the No. 4 Shepherd and Murphy lode, which normally might be expected to cross the lease 600 feet south of their lode. Small veins of quartz carrying a little wolframite and bismuth carbonate exist, but there is no indication of the No. 4 lode. In connection with this it must be borne in mind that the No. 4 lode-line on the Shepherd and Murphy property has been interrupted by faulted country on the east bank of the creek opposite the entrance of No. 4 drive, and to pick up its continuation on the Lady Barron property may prove troublesome.

On the crest of the hill, towards the south part of the Lady Barron lease, is a bed of white quartz conglomerate, which strikes east and west, and outcrops over a width of about 100 feet. It is traversed by irregular veins of quartz carrying a little wolframite. This ridge descends on its southern slope to the south boundary of the property, and the ground between the crest and the boundary-line consists of quartz porphyry, in which small disseminations of tin and wolfram ores are visible. These can be detected both in veins and on the joint-faces of the rock. The porphyry appears to be the fine-grained peripheral portion of the Dolcoath granite mass, and this part of the section merits close prospecting. Some of the alluvial ore which is being worked on the Iris claim to the south has doubtless been derived from this rock.

The Narrawa Creek in the north-eastern part of the lease has yielded a little alluvial tin ore at times, which is singular, considering the absence of that metal from the lode now being worked. Tin is known, however, to occur in wash west of the creek, and it is possible that some tin-bearing veins in that direction still await discovery. The alluvial is not of any other value than as an indication, and can only be worked in winter, or when there is sufficient water.

This enterprise possesses the disadvantages always characterising wolfram-mining in connection with the capriciousness of tungsten ore deposits; that is to say, the shoots of ore may be expected to occur at intervals, with intervening unprofitable blanks. But the existence of one good shoot, which has yielded a fair quantity of high-grade ore, and which apparently, though disturbed and somewhat irregular, is still unexhausted, should stimulate the owners to further development and exploration of their lease. A considerable amount of scattered prospecting work has been done on the property, but, evidently from lack of funds, it has been of a superficial nature and unsystematic; and the mining work, for the same reason, has been of a hand-to-mouth character.

Geological conditions are favourable to the occurrence of other shoots of ore, as the property contains the junction of the igneous acid porphyry with the sandstone strata. It is in the neighbourhood of such junctions, either in the granitoid rock itself or in the adjacent bedded sedimentaries at no great distance from the contacts, that deposits of tin or wolfram ores characteristically occur.

(3)—Section 1037-m, 20 acres (Pochin's Mine).

This is situate east of and adjoining the Lady Barron lease, and was formerly in the name of E. W. Clarke afterwards W. L. Pochin, but is now vacant.

The Lady Barron lode enters it at its western boundary, and has been exposed by various trenches and open drives. In one of the latter a quartz vein 6 inches wide carries a little wolframite along the wall of the drive. The sandstone enclosing the lode is white and gritty. The country here falls away towards the Forth. No deposit of value has been discovered, but the section merits prospecting, though it does not offer any great scope for operations.

(4)—Iris Mine: Section 950-m, 78 acres.

This section was formerly leased by H. Conder, and previously was one of the sections worked by the Iris Tin-mining Company.

It is now being worked as an alluvial tin and wolfram sluicing claim by Messrs. Adam and Davis. It is situate on the high plateau south of the Lady Barron Mine, between the Iris and Forth Rivers.

The workings are in the northern part of the section, and approach the northern boundary to within 5 chains. Tin and wolfram bearing veins in quartz porphyry have probably supplied most of the mineral which is being won. In the wash are stones of white quartz porphyry containing combed vein quartz with wolframite. Much of the quartz met with in the gravel has evidently been derived from barren veins in the porphyry.

The trend of the lead is north-westerly. About 5 feet of stripping has to be taken off in the northern workings, and from 1 to 3 feet of wash are worked, worth from 2 to 3 oz. ore per dish on the main lead. The upper and bottom layers of drift are the best for metal, and the stripping itself carries a few colours.

The proportion of wolframite in the ore bagged varies from one-fifth of the total to half wolfram and half stream-tin. Operations in summer are usually confined to stacking dirt.

The ore produced is sent to Messrs. Hinman and Wright's magnetic plant in Launceston for separation of the wolfram from the tin ore, and high-grade tin and wolfram products are obtained, assaying for tin 73 to 74 per cent., and tungstic acid also from 73 to 74 per cent.

The enterprise at the Iris is a small but payable one, and is eminently suitable for work as at present by a co-operative party.

(5)—Section 5221-m, 50 acres (B. J. Gurr).

This is an elbow-shaped section on the Narrawa Creek fall, traversed by the track leading from the Wilmot-road to the cage at the Forth. The track passes through the property at an elevation above the Forth varying from 1400 feet at the mine to 1700 feet at the junction with the road to the selections.

The section generally is in the white sandstone of the pipe-stem series, but this on its eastern boundary is intruded by the stock of granite which extends eastwards, over Sayer's and Urquhart's sections, and crosses the Forth to the Lorinna-road. At the junctions of the igneous and sedimentary systems stones of a greenish contact-metamorphic rock are plentiful. This rock is composed of quartz and pyroxene, and is traversed by narrow veinlets carrying wolframite. The eastern side-line of the property crosses a trench which has been cut just below the track, exposing a floor of greisen rock traversed by narrow veins of wolframite-bearing quartz. The tungsten mineral is also in the greisen itself, scattered among the crystals of mica. This formation courses north 30 degrees west, and south 30 degrees east.

About 4 chains west of this boundary B. J. Gurr and party have driven a short crosscut tunnel for 30 or 35 feet into the hill across an oxidised greisen formation, which seems to be from 15 to 20 feet wide. On entering the formation short drives east and west were put in on a lode which crossed the tunnel, and which is the main leader or vein in the formation. It was about a foot wide, but divided into two 5 or 6 inch veins, with mineralised greisen between them. The formation, with its leaders, continues throughout the tunnel. The quartz lode contains some large patches of wolframite, and the small leaders are also wolframite-bearing. The formation material enclosing these leaders is being taken out for treatment, and the main lodestuff appears to be payable with the present hand-jigging appliances. In the end of the tunnel another vein of wolframite is appearing in the face. This would seem to be beyond the formation, for the hanging-wall of the latter is seen just behind the end dipping southerly at an angle of 40 degrees. The material of which the formation is composed is considered as worth 1 oz. wolfram to the dish, and produces concentrates said to contain 68 per cent. tungstic acid and 3 to 4 per cent. bismuth. A little monazite is present, but the only economic ore besides the wolframite is bismuth carbonate. The wolfram ore is exported to Sydney.

The formation at present is perhaps soft enough to be sluiced out hydraulically, and it is intended to bring in water from the upper part of the Narrawa Creek by means of a race under a mile in length. It is probable, however, that as work proceeds the lode-matter will be found to contract in width or to become harder. For the present the owners seem to be doing fairly well.

The foot-track which leads past the mine ought to be improved, so as to allow material to be readily horse-packed to and from the Wilmot-Moina road.

Sparks' Drive.—West of Gurr's workings is Sparks' drive, which has been driven for about 150 feet into the Dolcoath Hill in a south-westerly direction (220 degrees), in what appears to be a soft and decayed granular fine-grained granite. Veins of quartz intersect this rock, and these show coarse wolframite. A little molybdenite and carbonate of bismuth also occur. The tunnel is now used for a dam, and cannot be inspected. It is situate at the junction of the granite with the pipe-stem sandstone.

(6)—Packett's Workings.

About 15 years ago this ground, which is now in the south-western part of Gurr's section, was worked for gold, which was obtained by "dollying" the disintegrated and cemented sandstone. The workings are at the head of a small gully descending to the Narrawa Creek.

A deep open drive has been put through friable, ferruginous yellow sandstone. Veinlets of quartz traverse the sandstone, carrying small quantities of wolfram and tin. The drive shows a quartz-wolframite vein a few inches wide on the footwall of a 4 to 5 feet formation which carries a little tin all through and an odd colour of gold. This is just below the old hut, and where the workers last stopped working for gold. An old shaft was sunk about 25 feet in sandstone carrying some gold and tin ore. The sandstone about here is traversed in places by a network of veinlets of wolframite; and there are some veinlets, also, of grey tin ore. A sample of material taken by the late Mr. J. Harcourt Smith from the bottom of the drive or trench across a width of 6 feet yielded 6 dwt. 12 gr. gold per ton; but a favourable estimate as regards quantity cannot be formed. About halfway down the shaft pyrite appeared, and was pretty prevalent at the bottom. This auriferous pyrite was probably the source of much of the gold won in "dollying." The pyrite itself, according to Mr. Smith, assayed only 1 dwt. 15 gr. per ton. The fall to the Narrawa Creek is steep, and adit-working would be easy; but the country is wet. In depth the free gold will without question be replaced by the auriferous sulphide, and the principal possibility of any improvement in values would be that the wolframite vein-lets might coalesce and offer something remunerative.

Gurr's section mounts to the top of the Dolcoath Hill on the south, which in that direction overlooks the valley in which the Dolcoath Mine lies in the depths below the precipitous crags of the hill. Wolframite-veined sand-stone crowns the summit. On the crest some trenching was done at one time with a view of cutting Packett's lode. The sandstone here strikes 260 degrees, and dips at 40 degrees to the north. An extensive view is obtained from the top of this hill, embracing the gorge of the Forth and the country as far as the Cradle Mountain.

(7)—Narrawa Reward: Section 35-93G, 20 acres.

This has been idle for a long time; the tunnel is full of slurry, and was not visited on this occasion. On the writer's previous visit he found that on the north side of the Narrawa Creek, and 30 feet above the stream, a tun-nel had been driven north 25 degrees west for about 150 feet on a siliceous formation, which consists of a dark-grey quartzite permeated with vein silica, and carrying dissem-inated pyrite and arsenopyrite with a little copper pyrites. Some of the sulphidic ore is auriferous and argentiferous, selected pieces assaying up to 4 dwt. gold and 3 oz. silver per ton. The impregnated quartzite shows no defined boundaries, but it is probably connected with some vein-channel which has supplied the mineral. Near the entrance is some topaz rock, and on the tip some vein quartz has been found carrying a little wolframite; and this seems to indicate that the whole occurrence is related to the wolfram ore-veins so common in the district.

A discovery of the schistose porphyroids of the Bell Hill was recorded by Mr. Waller on the Narrawa property, and this would point to the existence of some junction of the pipe-stem sandstone with the porphyroids. The thick scrub, however, has prevented this from being found.

Future work here would be entirely exploratory, and would consist in driving the tunnel further with frequent crosscuts west.

(8)—Dolcoath Section: 5430-m, 79 acres.

This was last held by Messrs. Smith and Thomas, and in the old days was Section 1333 of the Dolcoath Company. It is on the southern slope of the Dolcoath Hill, which falls into a profound valley The rough nature of the ground and the growth of timber make it difficult to travel through the property, and there is not much to see in the little mining work that has been done. The summit of the hill is composed of quartzite and sandstone belonging to the pipe-stem series, containing numerous little veins of quartz in which a little wolframite 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 apparently westwards as far as the Iris and Shepherd and Murphy leases. This Dolcoath granite is genetically related to all the tin and wolfram deposits previously described in this report. Towards the margin it shades off into a fine-grained quartz rock, with or without felspathic matter. A good deal of topaz is present in parts of it. The rock is very variable, but on the whole it characteristically resembles the siliceous modification of granite which is frequently met with in association with tin and wolfram deposits. The work which was done on the property 19 years ago showed that tin could be traced at surface in this granitoid rock for about 100 feet in width, and bunches of that mineral were found in the trenches and tunnel now and then, though on the whole the stuff was poor. These excavations cannot now be properly examined without being prepared and cleaned out. and little or no tin can be seen at present. 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 some specks and needles of wolframite. Some tin is said to have shown here. The tunnel has an approach of 20 feet, and has been driven 25 to 30 feet in a direction north 15 degrees east in a fine-grained quartz-mica rock (greisen) containing a good deal of topaz. Arsenopyrite is disseminated through the rock, and the joints are occasionally faced with molybdenite.

East of the tunnel are some alluvial workings on soft yellow granite, and some nice stream-tin is reported to have been obtained. The creek heads from the north-west.

The state of things in the tunnel is not very encouraging, and further underground work in this unprofitable stone is simply blind prospecting. The best plan would be to clear and strip the hillside with a view of locating the deposits. The geological conditions are favourable for tin or wolfram. If a run of ore were discovered, the adjoining rock, unprofitable by itself, would be probably so impregnated that it could be worked with the richer stone, and the whole form a payable proposition. A machinery site would have to be chosen on the Forth River.

The prospecting work on the property has not been at all adequate. The section is covered with fallen logs and fern, and requires burning off and cleaning before anything can be done properly in the way of search.

(9)—Section 5499-m, 80 acres (W. H. Sayer and others).

This is situate to the north-east of the Dolcoath Hill, with its eastern boundary a mile and a quarter west of the River Forth. At its western boundary it is 1400 feet above the river, down to which the granite surface plunges in a succession of steep slopes. A track passes through the property from the Wilmot-road 1½ mile to the west, and crosses the river at the cage, giving access to the new road from Mt. Claude to Lorinna. From the mine westwards the track can be used by horses, though it needs some attention to make it quite safe for packing; down to the cage and up to the Lorinna-road on the opposite side it is only fit for tolerably expert climbers. The crossing conditions are none too good, as the cage works stiffly. Its use is rather avoided on that account.

Several lodes exist on the lease. The principal one is represented by a long lode-line coursing for 2000 feet in an east-and-west direction. This has been cut across at surface by about 15 trenches at irregular intervals, exposing in nearly all of them signs of lode-action, though not always evidences of ore.

At about 400 feet north-east of the camp an underlay shaft has been sunk to a depth of 36 feet on a greisenised or pegmatitic blow of quartz-topaz lodestuff. When the writer was there the water-level in the shaft was 20 feet below the surface. At the surface the formation is 3 feet wide, at water-level the width has increased to 4 feet, and at the bottom (now concealed by water) it is said to be 5 feet or over. The composition of the lode-filling at the bottom of the shaft is stated to be soft ferruginous quartz-mica material for over 3 feet in width, and mineralised granitic matter for 2 feet on the hanging-wall. The dip of the lode at the shaft is rather flat, in a direction of south 10 degrees west.

The writer was informed that the outcrop of the lode where sunk upon was formed by a nice-looking mass of boulders of gossan carrying rich tin and wolfram ore. There is no reason to doubt that there was a very promising outcrop: some of this material is still visible near the mouth of the shaft. The rich ore continued down for several feet; then the values fell off, but it is reported that in the last 7 or 8 feet mineral began to make again.

Thirty feet below the shaft an adit has been driven for a distance (including the approach) of 50 feet, but not far enough to intersect the lode. It would do this in another 50 or 60 feet. At the entrance a small quartz vein 2 to 3 inches wide was cut carrying mica and coarse wolframite, and dipping steeply into the hill to the south. Wolframite-bearing stones of quartz from this vein are seen at the entrance to the adit. The occurrence is as under:—

Quartz-felspar country rock.	Soft brown micaceous formation, 1 foot wide.	Hard granular siliceous rock, 6 inches wide.	Quartz vein with wolframite.

The country-rock is pale in colour, even-grained, and predominatingly siliceous. Its components are felspar, quartz, and a little mica, and it may be regarded as an aplitic modification of granite.

At a few feet in a 2-feet quartz formation has been passed through, but where cut is apparently barren. It dips 15 degrees to the south. The approach to this adit is a chain south of the northern boundary.

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 nests and veins of quartz as well as scattered through the altered granitic rock. This trench was rather better than the shaft for tin ore.

The trenching in this direction has been carried to within about 4 chains from the eastern boundary, exposing the lode for a distance of 700 feet east of shaft.

The No. 2 trench on this line (500 feet east of the shaft) shows a formation 3 feet wide, 1 foot of which carries some wolframite associated with coarse crystals of quartz. No tin ore visible. The lodestuff is siliceous and of a reddish-purple colour.

Trench No. 1 is the most easterly one, 200 feet east of the preceding, and shows the same hard siliceous formation—here a little over 2 feet wide—with wolframite scattered through it. No tin ore visible. There are, in addition, three veins in the trench, on the north side, also containing wolframite, which are spread over a width of 6 or 7 feet.

West of the shaft four trenches have been cut in a distance of 100 feet (Nos. 5, 6, 7, and 8).

No. 5 trench was driven 100 feet without disclosing any parallel formations of importance, though one or two indications were met with.

Nos. 6, 7, and 8 trenches are across the line of lode. They expose soft micaceous granitic rock. Hexagonal flakes of dark-green mica occur. Veins and nests of quartz are present, enclosing wolframite. The formation is 3 feet wide, and radiating blades of wolframite are scattered through it. A vein of beryl in crystals 3 or 4 inches in length exists in the No. 8 trench, and the same mineral apparently persists throughout the distance from 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 of a very pale bluish-green tint. The prisms are striated vertically, and are from a sixth to a quarter of an inch in diameter. In colour and translucency they are inferior to aquamarine, the pale-green variety of beryl. Entangled in this coarse aggregate of crystals is coarse wolframite.

The lode is evidently a pegmatitic one, traversing rocks which represent the aplitic and greisen modifications of granite. The section of the lode from No. 4 trench westwards through the shaft to No. 9 is the best that is disclosed on this line. This part represents a length of about 200 feet. The trenches further west have not disclosed anything payable, and judging from appearances the oreshoot has pitched into the hill in that direction, and will only be recovered by underground mining. This is a point which might be considered in future work.

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 wolframite. The formation is split into bands of 2 feet and a foot and a half, with 4 feet of granite between.

No. 10 trench has cut the lode-capping 40 feet further west. The formation here consists of greenish-yellow quartz-mica rock traversed by bands of harder ferruginous and siliceous stone without any visible wolframite, though this mineral is said to have been obtained while prospecting. About 2 feet of formation are exposed, and from its position it would correspond with the lode at the shaft.

No. 11 trench is in soft, light-coloured, greisenised rock, but does not show any lode. It has perhaps been cut a little too far to the north. This is 350 feet west of the preceding trench.

Eighty feet further west is No. 12, a large excavation 25 feet by 8 feet and 10 feet deep. It shows a 6-inch vein and a 2½-inch one, with 4 inches of soft greisen between, and the whole dipping south at 55 or 60 degrees and enclosed between two heads of granitic rock. The lodestuff contains a little wolframite.

No. 13 is a deep trench 100 feet west of the preceding, cut into soft ground about 15 feet deep, and showing the veins which were cut through in No. 12. Here one is ascending the hill to the west, and there is an overburden of softened rock for about 5 feet before the solid bedrock is reached.

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

No. 15 trench is 100 feet further 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 downwards. The granite country has been left, and the manganese formation is conformably overlaid by sandstone, the whole dipping north. Crossing the manganese is a quartz vein 5 or 6 inches wide, which underlies southerly. It carries a little wolframite.

One hundred and fifty feet further west a small trench (No. 16) has cut a 6-inch vein of clean quartz containing a little coarse wolframite.

Forty or 50 feet below this trench a crosscut adit (No. 2) has been driven for about a chain in a southerly direction. It passes first through quartzite, then through a ferro-manganese formation for 40 feet, which dips to the north at a low angle, and finally into bedded and blocky dark quartzite or hornstone. In the end of the tunnel is a small vein of quartz containing fluor, mica, and specular iron ore. A trench has been cut just below the tip. Wolframite is said to have been obtained from it, but the earth has fallen in, and the vein is not visible.

It is not absolutely 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. There are so many joints and veins which intersect the mountain that it is difficult to be sure of their continuity when the trenches exposing them are any distance apart. West of No. 9 some doubt is apt to arise when on the ground whether the same vein has always been followed in the trenches, as it is very easy to get astray when attempting to pick up lengthy continuations of lodes which are not expected to pursue a mathematically straight line. From the survey made by the writer, however, it is probable that the trenches are on one and the same line of lode, even if the veins are not continuous for the entire distance. Observation of the wolframite-bearing quartz veins in the surrounding country leads to the conclusion that the larger ones are marked physical features persistent for great distances, though their values are irregular. There is nothing unusual in this uneven distribution of ore, as wolframite is notoriously irregular in occurrence, making in bunches from time to time and then disappearing quite suddenly. Ceaseless prospecting is consequently requisite in wolfram-mining, both vertically and horizontally. Westwards from the shaft the indications are in favour of carrying prospecting to some depth, with a view of following any pitch of the ore-shoot in that direction.

At the shaft when work was started the stone was actually payable, and the prospect for a short time was very promising.

Between the shaft and the northern side-line of the property is a parallel lode, across which trench No. 3 has been cut, showing a quartz lode in altered granite country, with green and purplish fluorspar, pyrite, and a little wolframite in the outcrop. The quantity of pyrite increases in descending. The occurrence is that of a 2-inch vein of quartz, carrying wolframite, which runs parallel with and about 3 feet away from a formation 3 feet wide. Specks of molybdenite are scattered freely through the formation. Without prospecting no opinion can be formed of its value. As the country-rock is hard, the work of prospecting will be attended by some difficulty.

Southern Wolfram Lode.—South-west from the main shaft, and up the hill on the south side of the alluvial creek, is a wolframite lode which has been trenched on its course for a considerable distance on the steep hillside. Its bearing is north 55 degrees west, and its underlay is in a south-westerly direction.

The lowest opening on it is at about 100 feet above the creek, and consists of a drive on its course for half a chain. 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 wolframite as the dominant mineral in large blades, molybdenite, and pyrite, the latter being common. Less frequent is acicular bismuthinite in small groups. Purple fluorite is present, and also a little chalcopyrite. The greisenisation effects are shown by the presence of a good proportion of soft yellowish mica.

A promising quantity of wolfram ore has been met with in this drive, and rich bunches will very probably be cut if the work is continued.

No. 1 trench is over the roof of this drive, and shows some stone with large pieces of wolframite. This is over where the best ore was found in the drive, about halfway in.

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, which has been cut into a little, disclosing the same greisen vein-matter with wolframite, but poorer.

No. 3 trench, a chain and a half further up the hill, shows a little coarse wolframite in hard vein quartz and quartz rock. Fluor and mica are associated with it. The quartz is much stained with iron oxide.

No. 4 trench is half a chain further west, and about a couple of hundred feet above the creek. The overburden has been stripped and stones on the surface of the lode exposed, consisting of vein quartz and pink quartz greisen, and containing some coarse wolframite and a little bismuth carbonate.

This lode apparently continues down to the creek, and is said to have been traced across it to the east. A steep fall exists, and good backs are available. The tunnel is the best place that is known on this line, and should be pushed ahead to search for rich points. The patchiness of wolfram occurrences makes it impossible to indulge in predictions, but the possibilities in the direction of meeting with bunches of ore are pronounced. The present patch half-way in the tunnel is perhaps about payable, but there is no extent of it at tunnel-level.

For water the Narrawa Creek would have to be depended upon, and it would have to be conserved.

Black's Upper Shaft.—This is an underlay shaft at the end of the preceding line of trenches, situated on the track about 1300 feet above the River Forth. It was sunk several years ago to a depth of 30 or 35 feet by Mr. W. Malcolm Black in granite country, on a greisenised formation bearing north-west—south-east, with a southerly underlay. A quartz vein from 6 inches to a foot wide has been followed down, carrying some clean wolframite in the combs of the quartz. The quartz is clean, vitreous, and brittle. Water is at present in the bottom of the shaft, but Mr. P. Bateman, the manager, informed the writer that he drove little prospecting cuddies both ways, and found good-looking veinstuff with 7 or 8 inches of quartz full of pyrite. The pieces lying about at surface derived from the bottom of the shaft show dense pyrite associated with vughy quartz, which bears out Mr. Bateman's statement. The best wolfram contents were near the surface, where the lode may, in parts, have been payable. A little copper pyrite is present.

The lode has been trenched upon in a north-westerly direction by four cuts, in all of which the vein is seen to contain a little wolframite; but the shaft appears to have been sunk at the best point for ore. In the first trench, about half a chain from the shaft, the vein consists of comby wolframite-bearing quartz a foot in width, an associated formation 2 feet wide; the vein being in the middle. Forty feet further is another cut, which shows the formation a foot and a half in width, with wolframite still in the vein, but in less quantity. Half a chain still further north-west is the third cut, with a 2-foot formation, carrying a vein 4 to 6 inches wide. The lode contains a little wolframite, but looks unpromising at this point. The granite country here is soft and felspathic. A fourth cut, 80 or 90 feet further west, shows 2 feet of greisen formation, with 4 inches of veinstone charged with a little wolfram and pyrite. Nothing payable has been disclosed by these cuts. If payable ore can be picked up anywhere on this line, a crosscut drive would be warranted, for which there are great facilities.

About a chain west from the shaft the granite contact-line is met with, the granite rock becoming fine in grain and somewhat laminated, giving place towards the western boundary of the section to a dense, tough contact-metamorphic rock, of a somewhat greenish hue and consisting of pyroxene and quartz. This merges into a variety composed of pyroxene and actinolite. The normal rocks which bound this contact zone are granite and sandstone.

Black's Lower Shafts.—These are situate on each side of the track, about 150 feet below the upper shaft, and separate about 40 feet from each other.

The underlay shaft on the east side of the track has been sunk 35 feet, and has a chamber in it at 20 feet. The formation on which it has been sunk is a dark-green micaceous greisen, with micaceous iron ore. It evidently contains some wolframite, as quartz veinstuff with that mineral can be picked up on the tip. The lode bears north-westerly. The vertical shaft on the other side of the track has been sunk 40 feet, and a drive south is reported to have been started to cut the lode which was sunk on in the first shaft. The country-rock is greisenised granite at surface, but the shaft or the drive has apparently struck the granite-sandstone contact, for pieces of both sandstone and greenish pyroxene contact rock are to be found on the tip. A little molybdenite is present in quartz veins in the granite rock.

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

These shafts do not appear to contain anything of immediate value, and prospecting in connection with the formation must be directed to the discovery of some point in it where the ore is sufficiently payable to be worked.

Bateman's Lode.—About 3 or 3½ chains north of Black's line of lode is a lode discovered by Mr. P. Bateman. It is parallel with Black's lodes, and strikes north 30 degrees west up into a steep knob of greisenised granite, dipping south-westerly. The lode consists of a greisen formation 22 inches wide, with a vein of quartz on each side 3 inches and 4 to 5 inches wide respectively. The outcrop carries large bunches of bladed wolframite, both in the greisen and the quartz veins. The greisen between the veins is a hard, siliceous rock, which in its rusty, softened parts carries a little wolframite.

Sixty feet lower down another cut has been put into the hill, but the lode has not been reached. Six chains below this a further cut shows the two veins of quartz and the same features as the outcrop. About half a chain further north the metal-bearing capping is seen under some large greisen boulders belonging to the rocky knob above it. This lode is rather too hard for the ordinary wolfram-miner to tackle. This type of miner requires soft ground from which he can get quick returns and move away to other spots immediately the lode in one place becomes poor. The whole spur here is traversed by wolframite veins, most of which have the same general direction. The veins are short distances apart, but are too small to work.

Alluvial Workings.—A little winter work has been done in the creek on a soft granite bottom, with wash averaging 3 feet; lower down the creek the wash runs to 6 or even 10 feet. Here at the head the gutter is shallow and narrow, but below this it deepens considerably. The creek is south of the camp, and runs at first a little east of south, but eventually bends east, and flows into the Forth. Some fine wolfram ore was obtained from the wash, accompanied by a little bismuth ore.

General.—The work which has been done on this property shows wolfram ore to be present in numerous places, but at only two points has it been found sufficiently concentrated to be approximately payable (in the tunnel on the southern or western lode and at the main shaft on the northern lode). There must no doubt be other points where it exists in sufficient abundance to be workable, but they have not been discovered. Some good coarse tin ore was also found associated with the wolfram at and near the shaft, and a similar association may be discovered also in other parts of the property, but at present wolframite must be looked upon as the economic mineral. There is, however, the possibility of a development of tin ore taking place in the course of working. Bismuth, too, is quite subordinate; and molybdenite is disseminated too sparsely to be of value.

The capricious character of wolfram occurrences has frequently led to disappointment in the history of mining for that mineral. Ore-bodies which look promising enough at surface have a habit of deteriorating when followed down. This has sometimes induced the belief that wolfram ore is, like some other ores, amenable to the agency of secondary enrichment, and consequently that deep-mining will generally disclose only the primary lean orestuff. As regards the present property, it happens that beyond an occasional incrustation of tungstite the mineral at surface shows absolutely no signs of alteration, and there is really no ground whatever for believing that the outcrops contain other than the primary mineral, unconcentrated either chemically or mechanically. This being the case, ore-shoots of equal value to any appearing at or near the surface may be expected to exist in depth. The occurrence of ore at horizons separated from one another by vertical distances of several hundred feet disposes of the idea that any temporary disappearance of the mineral is a function of depth. The phenomenon is rather one of original irregularity in deposition, conditioned by certain readily conceivable but unproved factors, and lends no support to the fear that the ore may be found to be superficial. Wolfram veins in the granite on this hill occur 500 feet above Sayer's camp, and down to Urquhart's adit 500 feet below it, and this represents the minimum range of the ore downward from the upper surface of the granite.

A moderate outlay might be undertaken for the purpose of testing the shoot at the main shaft at a somewhat deeper level, and also proving the southern (western) wolfram lode below the ore in the tunnel. These seem to be the principal points worth attacking until general prospecting has uncovered some fresh ore-body.

A water scheme will require careful study, for there is none too much water available, and if the Narrawa Creek proves insufficient, it will be necessary to go further afield.

(10)—Section 5320-m, 62 acres (D. C. Urquhart).

This section occupies the steep country between W. H. Sayer's lease and the Forth River. The ground descends to the river gorge in a series of rocky slopes at angular inclinations varying from 30° to 40°, and is lightly covered with stringy-bark timber and bracken fern. The south-eastern corner of the property is on a cliff at the cage, at about a chain south of which York's Creek flows down a rocky cleft into the Forth. The river here flows in a precipitous gorge, 900 or 950 feet below Sayer's camp and 1800 or 1850 feet below the summit of the Dolcoath Hill. The river channel is in a fine-grained biotite granite; the stream is clear, and at the cage about 100 feet in width. Large rocks occur in the river bed with adjacent water-holes 8 or 10 feet deep.

The lease is in granite country, excepting along the northern boundary and in the north-west angle, where sandstone appears.

A wolframite lode discovered by Mr. Warwick Castles traverses the northern part of the section in a direction north 30 degrees west, and has been trenched upon by Messrs. J. Kenny and T. Murphy on behalf of Messrs. Urquhart and O'Dea.

In descending the hill, at about 5 or 6 chains from Sayer's north-east corner, a dark vitreous quartz lode 3 feet wide has been cut in trench No. 1, and in granite country. Its strike here is south 20 degrees east, and northwards the line passes out of the section 4 chains east of the north-west corner peg. The underlay of the lode is south-westerly.

Trench No. 2 has been cut across the lode 70 feet further down the hill. The lode formation is 10 inches wide, and consists of an ill-defined quartzo-felspathic rock (greisen or aplite) with bands of vughy and glassy looking quartz, containing, however, very little wolfram. There is much oxide of iron, and the aspect of the outcrop denotes strong lode-action.

Trench No. 3 is 30 feet lower down the hill in a south-easterly direction. It is shallow, and has merely exposed the lode-capping.

Trench No. 4, half a chain further down in the same direction, has cut through the lode, showing wolframite scattered through the capping. The formation is about 20 feet wide. A good deal of oxidation has taken place in it, and the quartz veins, which run through it and contain bladed groups of wolframite, are inclined to be combed and vughy. This is a promising formation.

Trench No. 5 is half a chain lower, and in surface-soil down to soft felspathic quartz rock. Some stones lying here with blades of coarse wolframite showing are apparently surface shoad-stones, as the lode has not been cut into.

Trench No. 6, 40 feet further down, is a deep hole cut into the lode showing some wolframite and carbonate of bismuth. The formation has been exposed for about 10 feet.

Trench No. 7 is half a chain lower, and over a short drive. The lode-track is exposed in yellow soil, but nothing very solid is visible.

A short drive or tunnel has been driven below the preceding trench in a direction north 5 degrees west, and in fine-grained quartzose granite. A 5-inch vein showing a little wolframite in oxidised quartz has been left on the west side of the drive.

The trenches extend over a length of 6 chains, and have shown the lode existing at a vertical height of about 100 feet above adit-level; and the adit, if continued, would come below the large body of lode-matter exposed here and there in the trenches. Nothing payable has been disclosed so far, but proofs of the existence of a strong metalliferous formation have been obtained by the excavations at surface, and facilities for adit-driving are excellent.

(11)—York's Alluvial Section: 1521-m, 80 acres.

This is a vacant section south of Urquhart's. It was previously 5470-m, in the name of D. Davies. It is separated from the Forth River by a narrow strip of unsurveyed land.

The shingle workings near the old camp contain stones of granite with little or no quartz. There is here some indeterminate occurrence of bluish rock, too soft and decomposed for identification, and there is some olivine basalt, besides quartz porphyry, in the banks of the race. A boulder-wash 6 feet thick lies below 5 feet of overburden. The present bottom is clay, which probably rests on granite bed-rock. There is very little fall, and the whole flat appears to be a terrace of the ancient Forth River. The large boulders cannot have belonged to the present creek. If this ground is the old Forth channel, much tin or wolfram need not be expected, as the river above this section flows through rocks of the porphyroid suite.

Further west are creek workings on a granite bottom rising into the hill. The stone here consists mostly of rubble from the hillside. A little wolfram ore is said to have been obtained from these workings; but the wash is not promising, though it may carry small quantities of wolfram and tin ore.

(12)—The Tin Spur Properties and B. L. Thomas' Mine.

The Tin Spur properties comprise a group of nearly a dozen sections east of the Forth on the southern side of Tin Spur Creek, which flows north-west for a couple of miles and joins the Forth River a third of a mile below the cage.

The country-rock is the pipe-stem sandstone, sometimes indurated, at other times quite friable. In its white, granular condition it has been mistaken for an igneous rock, and has received the local name of porphyry.

At intervals from top to bottom of the spur (a vertical distance of 1800 feet), tin ore has been found and prospected at different times. The highest point at which it has been discovered is Machinery Creek, which flows through the easternmost section of the old Devonian Mine, where both tin ore and monazite occur. A small tributary of this creek near S. Reardon's hut carries both gold and tin ore. The creek bottom is of a soft clayey nature, with veinlets of quartz, and appears to consist of granite porphyry rock. At the hut itself sandstone with the familiar pipe-stems is seen. South and east of this is the basalt of Oliver's Country, beneath which the tin-bearing rock must pass.

A little north of this is a wide outcrop marked by loose boulders of ironstone, with which manganese is associated. About 10 chains further north a little work was done on its continuation, where it is said to have yielded traces of gold and some silver. It seems worthy of a trial in depth, though sinking will be necessary, as the country is too flat for tunnelling. The probabilities are that the formation will descend into tin-bearing pyritic lodestuff.

A mile north-west of this, and on the same line of country, are two 80-acre sections, formerly belonging to W. T. York (2209-M) and P. Ashworth. York's section has been surveyed for Mr. B. L. Thomas, 5429-M.

On these a considerable amount of prospecting work has been done. On Thomas' section two long tin-bearing lodes, the main and western lodes, have been trenched upon in some eight or nine excavations on each lode. The two lodes are roughly parallel, though somewhat divergent, the distance between them increasing to 4 chains. Their direction is approximately north-west—south-east. The western lode has been opened upon in eight places, and has been bored into to depths of 20 and 25 feet. The formation comprises a belt of soft yellowish sandstone for a width of 20 feet, containing bands carrying finely-divided tin ore. These excavations are on a line of 10 chains falling towards the Forth River. The prospects are fair, and the best have been obtained from the three lowest openings.

The main or western lode has been shown in nine cuts, revealing a micaceous iron formation 4 or 5 feet wide, carrying a little tin ore and, it is stated, some gold.

These lodes can be tested by adits lower down the hill. The section is called the "Coronation" by Mr. Thomas. Formerly it used to bear the name of the Old Stag.

North of the above is a long narrow spur, called the Razorback, which passes north-west into Ashworth's old section. This ridge is the Tin Spur. Large blocks of pipe-stem sandstone are scattered profusely on its crest.

A deep cut on the north side marks the place where tin ore was first struck on the spur. The cut has been driven south-westerly across the beds of white sandstone, in which are seams and veinlets of finely-divided tin ore. Other excavations have also shown good tin.

There hardly seems to be any other way of working this ground than by open-cut, but whether it is payable or not will depend upon the quantity of dead or poor rock existing between the ore-bands.

The Tin Spur mine workings proper are passed through by the Lorinna-road on the south side of Tin Spur Creek. Just above the road, near the head of the old aerial tramway, is an open-cut in sandstone striking north 60 degrees west, and dipping south-westerly. The occurrence seems to be one of dissemination in the rock, for indications exist of finely-divided scattered tin ore. There are also veinlets of ore-bearing quartz which traverse the rock. Some tin ore is certainly present, but judging from what is visible at present, some fresh discovery would have to be made to convert the mine into a payable proposition. The concentrating facilities are none too good, as the orestuff had to be sent down to the 5-acre section below the road, and the concentrates would have to be packed up again. The power-water was obtained from a little fall in the Tin Spur Creek a few hundred feet above the river.

(13)—The Lewis Syndicate's Mine.

The ground applied for by this Devonport syndicate is traversed by the new road to Lorinna, on the east side of the Forth south of the cage.

The rock is granite, being the eastern extension of the Dolcoath granite stock, which has been cut through by the Forth River. Wolframite and bismuthinite veins traverse the rock, and are attended by greisen modifications of the original granite. The granite extends up the hill to the east, where it finally abuts against the undenuded cover of pipe-stem sandstone. One or two excavations have been made below the road, where a felspathic-quartz granite is traversed by veins of quartz up to 4 or 5 inches wide, carrying odd bunches of sulphide of bismuth. The same mineral is also disseminated through patches of the greisenised rock. A little fluorite is showing. The mineral is clean, but not plentiful. A little of it has been sent away to market.

A little further along the road to the south a fine-grained granite shows scales of molybdenite on joint faces of the rock. Further still, outside the boundary of the granite, a lode formation about 6 feet wide shows some scattered molybdenite. This is in a blue quartz-porphyroid, which, adjoining the intrusive granite, has been penetrated by veins proceeding from the granite magma. It is such phenomena as this that illustrate the difficulty which sometimes arises in determining decisively the derivation of ores met with in the porphyroid series. Here, of course, there can be no doubt of their granitic origin, but in a few instances they appear to be authigenic.

B.—GOLD MINES.

(1)—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.

The Forth River at the bridge is about a couple of chains wide, and in dry weather 3 feet deep. A few chains above the bridge the bedrock of the stream is hard sandstone, but 6 or 7 chains below it and east of the bank cliffs of bluish-grey limestone are exposed, dipping at a low angle to the north-east. The escarpment rises here to 40 or 50 feet above the river-bank. This limestone apparently underlies the Lorinna township to the east. Where concealed by grass and superficial gravel, its existence beneath the surface of the farm lands is still shown by sundry circular depressions in the soil. Some of these are seen in front of Mr. Geo. Sloane's house and on the road.

The Five-mile Rise consists of beds of pipe-stem sandstone, with alternating beds 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 (the Dove River belt) half to three-quarters of a mile wide from north to south, which occupies the country between the pipe-stem strata and the Pre-Cambrian mica schists further south. The pipe-stem forms are plentiful in places on the Rise.

None of the gold claims on the Rise were at work at the time of the writer's visit, and it was consequently not easy to see exactly what had been met with in the workings, many of which also were inaccessible. However, much information was given by Messrs. J. Crossley, S. Reardon, and Geo. Sloane.

The creeks flowing through this country into the Forth yielded a fair amount of alluvial gold in past days, and numerous auriferous veins have been worked at times, though not for long at a time, notwithstanding the occurrence of some rich shoots. The richest underground occurrences have been, not in quartz, but in a sandy pug.

In the writer's opinion most of the gold in the superficial occurrences of this field has been derived from the decomposition of auriferous silver-lead and zinc sulphides. If the present veins are followed down they will, on this hypothesis, be found to be not free-milling gold quartz lodes, but galena and zinc-blende lodes. The gold may be expected to be more abundant in the upper parts of the veins, but will diminish with increasing depth, and cease to be free when depth is attained, and the horizon of the primary minerals is reached. It may be confidently anticipated that the primary ore will prove to be an auriferous sulphide.

(2)—The Golden Hill Mine.

This old property comprised four 10-acre sections, 1475 to 1478-G, now vacant, and situate half a mile south-west from the Lorinna bridge over the Forth.

The mine raised great hopes in the old days, and some still have faith in it, and consider its prospects equal to those of any other mine on the Rise, if work is started on a proper basis.

The writer was informed that £2000 had been spent on the property altogether; but no great depth has been attained. An adit has been driven as a crosscut for nearly 300 feet, but it is full of water, and its end could not be reached on this visit. Three or four veins have been intersected in the course of this adit, which has been driven south 32 degrees west into the hill, across flat-lying beds of sandstone and shale belonging to the pipe-stem series. The first vein met with has been risen on to the surface. The second was met with about 20 feet further in, and has been stoped out for 7 dwt. gold per ton, according to Mr. L. J. Bryant's information supplied to Mr. G. A. Waller in 1901. Mr. Waller sampled some gossan from the end of the underhand stopes which (from a 6-inch vein) yielded, on assay in the Government Laboratories, 18 dwt. 19 gr. of gold and 1 oz. 19 dwt. 5 gr. silver per ton. The third vein has been driven on both ways from the adit. The south-easterly drive is a double one, following a bed of sandy shale, which was auriferous, and has been worked for a width of 10 feet. The ore taken out from this seam of shale was sulphidic, consisting principally of pyrite and zinc blende. The beds of sandstone and shale are virtually horizontal, but have been intersected vertically by a narrow vein of quartz filling a joint-fissure, which has possibly supplied the mineral which has impregnated the adjacent country-rock.

On Mr. L. J. Bryant's authority the statement is made that two crushings yielded 12 dwt. and 7 dwt. respectively. Mr. Waller's bulk sampling of quartz and pug from No. 3 vein returned 15 dwt. 12 gr. gold and 5 oz. 19 dwt. 5 gr. silver per ton, while his bulk sample of sulphide ore yielded 4 dwt. 2 gr. gold and 1 oz. 4 dwt. 2 gr. silver per ton.

Mr. Cundy, of Queenstown, informed the writer from his experience 16 years ago that the surface stopes 72 feet above the level were in a formation 16 feet wide, narrowing as it went down; and that 150 tons were crushed and 50 tons partially concentrated, averaging 1 oz. 8 dwt. gold and 6 oz. silver per ton of concentrates.

Mr. J. Crossley showed the writer a recent assay note from Footscray giving 6½ oz. gold per ton from concentrated pyrite from 1 ton of stuff lately broken out from shaft (containing 1 dwt. 6 gr. free gold). Some high assay figures are also stated to have been obtained from the pug.

The first discovery is said to have uncovered a lode which at surface was from 8 to 18 inches wide (quartz, pug, and gossan). An underlay shaft was sunk 50 feet on this. From appearances, this is a parallel lode with the one in the adit, and will be intersected when the adit is continued. South of the shaft a stope has been gouged out from the surface, and the stone with free milling ore sent to the battery.

The adit has been driven too high up to have sufficient backs. It could have commanded more ground if it had been started from tramway level.

From the small size of the quartz veins, the indications are that though rich concentrations of metal may exist for some depth still, they are likely to be of limited extent and disproportionate to the expense of working them. It may be accepted as almost certain that, in going deeper, the veins will gradually become preponderatingly sulphidic and poorer.

(3)—The Golden Cliff Mine.

This mine is on a section half a mile south of the Golden Hill. The junction of the sandstone strata with the Dove River granite occurs at the mine, which is situate under the brow of the hill which overlooks the gorge of the Forth.

The discovery was made by Mr. J. Thomas upwards of 20 years ago, who gouged out a narrow oxidised vein of quartz in the perpendicular cliff-face of pipe-stem sandstone. The rock at that particular spot shows a natural cleft, and along the course of this the narrow comby vein runs in a north-north-west direction, with a steep dip to the south-west.

About 40 feet lower down a tunnel has been driven on the course of the vein for about 60 feet. A shaft has been sunk from the outcrop, and the tunnel is in about 30 feet beyond this. The vein in the end does not exceed an inch in width, and the country-rock at this point is a soft brown clay slate. 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. The Government Analyst's assay of a sample at that time returned 1 oz. 7 dwt. 11 gr. per ton.

An earlier tunnel was driven about 100 feet lower down the hill, but with the underlay of 40 degrees which is seen in the vein higher up, this tunnel would appear to be east of the lode. It was probably aligned with the outcrop, where the lode underlies at a high angle. The tunnel has been driven about 120 feet, and a crosscut put out west for 40 feet. From a short drive off this crosscut a rise has been put up, apparently in search of the lode. The latter has not been seen in the adit at all, which is throughout in a granular dark mica granite. The junction of the granite with the sedimentary strata has not been reached, but evidently must occur between the upper and lower drives. Although the vein appears to have been of good quality, it is very narrow, and of course unpayable. Unfortunately there are no signs of any tendency to increase in size.

(4)—The Thistle Mine: Section 2444-m, 40 Acres (J. Crossley and G. M. Day).

This old mine is situate on the northern fall of the Five-mile Rise, three-quarters of a mile south-west from the Lorinna bridge. The country-rock is the usual pipe-stem sandstone or quartzite, with occasional layers of shale.

The section was pegged for gold for 20 years. The lode was discovered by the Campbell Brothers. In the workings as at present exposed a vein of galena about 3 inches wide traverses sandstone country in a direction north 10 degrees west. It consists of clean cubical ore, which has been assayed for 75 per cent. lead and 20 oz. silver per ton. A picked sample taken by the writer was assayed by Mr. W. F. Ward, Government Analyst, and returned 70 per cent. lead, 26 oz. 16 dwt. silver, and 19 dwt. 14 gr. gold per ton.

No galena appears ever to have been taken away from the mine. The gold which led to the doing of the work here was found at surface and within a few feet of the surface, facing the stone, which is often coated with recrystallised silica. The gold, it is said, could be washed off the joint-faces.

About 40 feet east from this vein is a veinlet, 1 inch wide, consisting of cubical galena and a little dark zinc blende, exposed in a deep cut. Another small vein exists still further east, composed chiefly of zinc blende in vughy quartz with cubical white pyrite. Stone from the tip, on being panned off, showed a tail of fine gold.

A crosscut adit has been driven south-south-west to intersect the lode, and the latter was then followed for about 100 feet north-west. No vein is showing in the end of this.

The country is flat on the spur, and it is very difficult to get backs. The mine is a galena proposition, but unfortunately the veins are small. We have here an illustration of the connection which obviously exists between the occurrence of gold on the Rise and veins of sulphide ore.

(5)—The Union Mine.

This old claim was not visited. It is higher up the Rise, a little over half a mile west from the Thistle. It possesses the same essential features as the other mines of the district. Over 20 years ago good prospects of gold were obtained at the surface, and a shaft was sunk to 100 feet. A short drive from the bottom of the shaft in a quartz and sandstone formation showed some galena and zinc blende. An adit was started, but though it cut other veins, it was not driven far enough to reach the lode-formation.

A few chains north from the Union shaft is MacLean's shaft, sunk on the underlay to 30 feet. Fair returns were obtained at surface from auriferous quartz gossan, but the prospects became poorer in going down.

Some of the Lorinna residents fancy this claim as much as any on the field.

(6)—O'Rourke's Hydraulic.

This mine is situate higher up the Rise, on the north side of the track. It has already been reported on by Mr. Waller. The owner was away on the present visit and the section was not inspected. It is apparently worked intermittently. Sluicing operations have been carried on in angular wash, but a payable reef has not been found.

(7)—The Glynn Mine.

This is another of the deserted mines on the rise, and was not visited. It is situated high up on the Five-mile Rise, at about 2000 feet above sea-level. Mr. Harcourt Smith described the reef as a mullocky one, consisting of crushed country-rock with rubbly ironstained quartz, from 3 feet in width downwards. Several small crushings taken from open-cut and shallow workings yielded about half an ounce of gold per ton, but Mr. Smith considered it probable that below the water-level the lode will contain a considerable percentage of pyrites. The gold is highly argentiferous, and worth only about £2 10s. per ounce.

(8)—Great Caledonian Mine.

This abandoned mine is at the summit of the Five-mile Rise. A crushing or two is said to have returned 12 dwt. gold per ton, but after a little work mining operations ceased. The battery was eventually removed, and a later fire wrecked the remaining surface installations. The shaft and levels are in sandstone which is sparsely veined with cellular silica, but in the present inaccessible state of the workings it is quite impossible to judge what prospect the mine holds out. Nothing can be seen at surface, and one can only rely for information on previous reports, which state that work was started on a rich vein of auriferous pug, which passed down into a small reef of quartz, too narrow to be payable.

(9)—Gold in the Forth River.

Colours of gold have been obtained near the mouth of the river at the coast, and at more than one place in the lower reaches. Some of this gold has probably been derived from auriferous veins on the banks of the river in the vicinity, and some, of course, may have found its way down from the tributary streams near Bell Mount and Moina. Auriferous veins, however, exist above the river between Mt. Claude and Lorinna and on the Five-mile Rise, and it is natural to suppose that a good deal of the precious metal shed from the hills in that neighbourhood would find its way into the river, and be concentrated locally in patches rich enough to pay for working. The late Mr. James Smith discovered gold in the river near Lorinna 50 years ago, and located auriferous gravel at Golden Point, near the Campbell's Reward Mine. He washed from this deposit fair prospects of flaky gold. It is still thought by some that good gold exists in the river gravels between Lorinna and Mt. Claude.

On Mr. Forward's farm at Lorinna, 800 feet above the river, some boulders of loosely aggregated pebbly sandstone lie on the basalt floor, and grains of quartz accompany the stones of basalt in the creek. From this creek the ducks collect small pellets of gold at their feeding-places. The metal probably had its proximate source in alluvial drifts belonging to the basin of the ancient Forth. The drift would seem to be inter-basaltic, above one flow of basalt and below another one. Some attempts have been made to work ground in a lower drift not far above the main road.

The beaches in the present river-banks are of comparatively recent date, and hence the likelihood that they contain payable deposits is not great. The concentrations of the older river phase have doubtless long ago been swept away. The narrow channel of the existing river, and its precipitous banks indicate its youthful age, and consequently a short term for the accumulation of deposits. A little gold would find its way into the stream from the Five-mile Rise, from the Dove River, from the porphyroid schists above Campbell's Reward, from the granite on Urquhart's, Sayer's, and the Narrawa Creek, not to mention Bull Creek. But all this would not amount to much in the aggregate.

(10)—Campbell's Reward Gold Mine.

The new road to Lorinna on the east side of the Forth passes through these abandoned sections. The workings are not in a condition for inspection. The mine is in rock belonging to the porphyroid division. Mr. A. Campbell informed the writer that it was originally prospected for a couple of years, and was then floated into a company. The gold was free, and in barbed and wire form, and occurred in a narrow vein of kaolin, which widened out and carried a foot to 15 inches of barren quartz. The gold was accompanied by a good deal of silver, and was worth less than £3 per ounce.

(11)—Evenden and Reardon's Mine.

This is on the western brow of Oliver's Hill, 1600 or 1700 feet above the Forth River. There is a junction here of igneous porphyroid with the pipe-stem rock. The line of junction trends south-easterly up and down the hill, and the pipe-stem beds dip away southerly. A formation of quartz is developed between the two rocks, and when the shaft was sunk on it four years ago by Messrs. S. Reardon and H. Evenden tests yielded returns of 10 to 15 dwt. The shaft was sunk 30 feet, and the value fell off to 4 dwt. Below this, on the slope of the hill, are four trenches or excavations, crossing the formation, and showing its auriferous character to continue. The gold which was panned off from the sandstone and ferruginous bands in the porphyry is extremely fine. About 6 chains further south a bold outcrop occurs showing the junction between the two sets of rock. The junction evidently marks a line of deposition of gold, but the values of the stone along the lines are apparently erratic. The pipe-stem beds here strike west-north-west, with a dip to the north-east. They continue to the top of Oliver's Hill, about 2100 feet above the Forth.

(12)—Devonian Mine.

The sections which belonged to this abandoned mine are vacant. They are situate on the tableland behind Oliver's Hill, at an elevation of about 1800 feet above the level of the Forth River, about a mile east from the river in a direct line and 3 miles north-north-east from Lorinna.

The country in which the lodes occur is a laminated felspathic sandstone belonging to the pipe-stem series: this passes below the plateau basalt about half a mile east of the mine. The lode bears west 20 degrees north. The shaft is on Section 416-93G, 10 acres. The lode has been stoped out east and west from the shaft. The surface excavation west of the shaft shows a main vein 4 inches wide and one on each side of the trench, with other veinlets between them. When sinking was first begun it is said that a pennyweight of gold per dish could be washed. Some stuff panned off on the present visit showed rough gold in the dish.

Further north a parallel lode was sunk on prior to the Devonian shaft at the head of some alluvial ground which was worked up to that point. The ferruginous quartz in the outcrop looks favourable, but yields no colours.

(13)—Bell Mount Goldfield.

This old field is situate between Bell Mount and the river, on Bell Creek and its tributaries, a creek system draining into the Wilmot River, and comprising Bell Creek, Mosquito Creek, Poverty Creek, Basalt Creek, &c.

Ridges of wash exist between the various creeks; and the present separate ridges, some of which are 50 or 60 feet high, must have been continuous over the whole area—and the body of drift was then a wide body of material extending across the positions of the existing creeks. The latter at a later period excavated their channels in it, and collected part of its gold contents.

It is now 20 years since work was at its height on the field. At one time as many as 200 men were at work, but this feverish activity spent itself in about 18 months, as the yield gradually fell off, and it is now a deserted place, though naturally there still remains work for prospectors in the way of exploring the margins of the field and seeking indications which may shed further light on the source of the gold of this deposit.

Within a couple of years about 4000 oz. of gold were won, *i.e.*, as estimated by those who are locally most competent to calculate it, though the writer is told that the purchases by the banks account for only a thousand ounces.

The gold was coarse as a general rule, and quite a number of nuggets were found. The heaviest one weighed 22 oz. Several weighed 16 oz. each, and there were a good many between 8 and 12 oz. Mr. C. F. D. Adam informs the writer that a 10-oz. piece was obtained from the grass roots. The gold from Poverty and Mosquito Creeks was generally fine. Bell Creek is the largest stream, and collected in its basin the coarsest gold.

Mr. A. Montgomery inspected the diggings in 1903, when 80 men were at work, and he described the drift as consisting of pretty well waterworn gravel, averaging from 3 to 8 feet in depth in the lower parts of the leads, but getting deeper towards the north. The only part of it found to be worth saving was about 6 inches on a false bottom, representing an old-surface soil, such as would have formed in a swamp. He says that a hole sunk in the eastern branch of the lead struck the bedrock of blue limestone dipping westward.

The writer is informed that the diggers never troubled to sluice more than from 3 to 6 inches of the wash immediately above the pug bottom.

A little waterworn gold was obtained from pot-holes, and the wash from some of these was considered as of an older aspect than the ordinary drift, and as likely to be the residuum of the ancient drift in which the gold existed.

On the west spur Mr. C. F. D. Adam, who worked a good deal on these diggings, says they stripped the top drift off, and he obtained about 30 oz. in about six weeks. The gold, he thinks, had a narrow, sinuous track, and the claims on the track were good. The gold disappeared going up the creeks.

The bedrock varies in character in different parts of the field. In one place, as mentioned above, it is limestone; in Bell Creek it is blue slate; and at the head of the old amalgamated claim it is sandstone.

Prospectors have invariably been baffled in their search for the source of the gold. Numerous possible sources have been suggested from time to time, but it cannot be said that the arguments in favour of any of them are convincing.

Mr. Montgomery was of opinion that the gold seemed to come from the slopes of Bell Mount, but that it might possibly be derived from the rewashing of older gravels belonging to the river system obliterated by the basaltic flows. He considered that the source was as yet quite a mystery.

Mr. Geo. A. Waller contended that the wash came from the north and probably followed the general course of the Bell Creek. The most probable source of the gold was to be sought on the southern and south-western slopes of Bell Mount, more probably in the sandstone than in the schists.

The present writer, in his report of June 17, 1907, was inclined to refer the gold to veins in the sandstones and conglomerates of the country. It was thought possible that there was here a large swamp or lake which was fed by streams coming from various directions. The country to the north and west, especially west, would be the source of the metal. That to the direct south and south-east would be excluded, as it is tin-bearing country, and would have shed tin and wolfram ore into the basin.

On one of the sections there is a ferruginous gossan outcrop, with a north-westerly strike, and as it traverses the country at the head of the leads it has been named as a possible source. The angular forms of the gold and the splintery specimens of auriferous quartz make this derivation unlikely.

Mr. Leslie J. Smith says that his father, Mr. James Smith, thought there was a vein or lode east of Poverty Creek, and not more distant than a third of a mile. The former, with Mr. Packett, sank several shafts east of Poverty Creek, and bottomed on a dark slaty or chert-like rock, which was veined and carried carbonate of iron and arsenical pyrites.

The writer thinks that, as far as the quartz specimens are concerned, they must have come from veins close at hand. The schistose porphyroids of Bell Mount apparently do not contain auriferous quartz veins: the fragments of these rocks occurring in the drift are not very abundant. If the gold originated in the Moina tin and wolfram area to the south, it is surprising that those ores are not more abundant in the gravel. Very little tin ore has ever been found in it (one piece certainly is said to have weighed a pound), and wolfram ore is absent. If the drift had been derived from the Moina sub-basaltic gravels, these ores would undoubtedly have been plentiful. On the whole, the specimens have most probably come from veins quite near—in sandstone and conglomerate. The indications are that they have been derived from the conglomerate belt which extends across the field from the crags near the road at Bell Mount to the other side of the Iris River

As regards the numerous nuggets found in the wash, it is difficult to explain their presence as being due to mechanical transport, either from the more or less distant auriferous veins up the Lea Valley and on Black Bluff or the nearer rocks in the neighbourhood of the diggings. No nuggets have been recorded from any of those sources. It appears almost necessary to appeal to chemical solution and deposition. Chemical action obtaining between auriferous solutions in the alluvial, and one of two or three possible solvents could be postulated as a reasonable hypothesis for the deposition of the gold.

Attempts to locate the sources of nuggets, or the veins from which alluvial gold in diggings has been derived, have so often proved unavailing that some unrealised reason for so general a failure must surely exist. Over and over again alluvial goldfields appear to show no proper proportion between the amount of gold won and the gold contents of the veins in the surrounding rocks, even with the elements of denudation and time thrown in. Opinions of miners in such cases do not favour the idea that the rich contents and large nuggets of the alluvial could have come from the small veins known to them, and urged by a firm belief in the existence of undiscovered rich reefs, prospectors have time and again with extraordinary enthusiasm and tenacity persevered in the search.

It may be, however, that we have yet much to learn about the migration of gold salts, and about what would happen in a sand or wash permeated with water in which solutions of gold and natural reducing agents co-exist. The nuggets found under such conditions may conceivably be altogether independent of the forms in which free gold is met with in the veins of the surrounding country.

(14)—Stormont Gold Mine: Sections 535, 585, 536, 545-93g, 10 acres each.

This mine is situate at the foot of the north-western slope of Stormont, at the head waters of creeks flowing north-east into the Iris River and north-west into the Lea River, and at an elevation of about 400 feet above Moina township.

It is approached by a bridle-track from the Iris bridge, passing through the myrtle forest, and emerging into the more open country at the mine, where the basal slopes of the mount bear a scanty growth of gum and peppermint on the button-grass land. The mine is reached in an hour's walk from the bridge over the Iris. Across the track north of the mine is an outcrop of quartzite conglomerate with white quartz pebbles. This apparently is a band belonging to the pipe-stem series.

From here the view north-west embraces the workings on the Devonport sections, high up on the Bluff slopes. All round are desolate uplands, green in the middle of summer, white with a mantle of snow in winter.

In spite of the certainty that Pleistocene glaciers descended from Black Bluff and Stormont, no pronounced indications of glaciation exist. The valley between these two ranges must have been intrenched, destroying glaciation effects.

Stormont (19) is an east-and-west ridge rising to about 1500 feet above Moina (= 3500 feet above sea-level). Its crest consists of conglomerate and quartzite belonging to the conglomerate series, dipping to the north. A fine panoramic view is obtained from its summit, including the lofty eminences of Cradle Mountain and Barn Bluff. The ease with which the top of this mountain may be reached from Sheffield, and the wide panorama of the north-western highlands which opens itself to view, ought to make it a favourite item for visitors to the town mentioned. For those who are fond of climbing and exploration, the trip may be extended with advantage to Black Bluff (4381 feet).

The Stormont lode was discovered by C. F. D. Adam. Information concerning the work done was furnished to the writer by Mr. Adam and Mr. A. Campbell. The mine was floated by the late R. Mitchell, with a moderate amount of capital. The original shaft was sunk 35 feet, and a short drive put in; a little underhand stoping was done north and south from the shaft.

Recently A. Campbell and S. York sank small shafts to 14 feet, 22 feet, and 50 feet, and drove about 30 feet at the 50-feet level.

The work done showed some free gold, sometimes in wire and crystallised forms, occurring between thin leaves of quartz in pink pug. Several narrow veins were met with at times—a vein now on the footwall, now on the hangingwall. Pyrite also appeared, and this will probably be the characteristic mineral in depth. The lode strikes north, and the shoots pitch also in the same direction.

(19) Stormont, originally Storm Mount, from its wind-swept surface. The highest point of the mount was stated by R. C. Gunn in 1860 as 4000 feet above sea-level.

Work proved unremunerative, and was suspended at the end of 1911. An attempt was then made to raise capital for it under the name of the Golden Acres Mine, but was unsuccessful.

(15)—Lea River Mine (Black Bluff): Section 532-g, 10 acres.

10 acres (W. M. Black).

This is one of a group of gold leases situate on the north side of the Lea River, about 6 miles west-south-west of Moina, or 7 or 8 miles by track. They are at the foot of the Black Bluff Range. A poorly-graded pack-track leads to the sections from the Stormont Mine along the lower slopes of Stormont. These slopes are in pipe-stem sandstone, but occasionally the conglomerate of the summit descends as low as the track. Within a couple of miles of the leases Stormont Lake is passed—a shallow sheet of water, about 400 yards long, with boggy margins. The surrounding rock is basalt. The surplus water of the lake is said to drain underground into the Lea River to the north. Its height is about 650 feet above Moina.

Mr. Black's hut is situate on the north side of the Lea River, on pipe-stem sandstone, striking north 20 degrees west, and dipping south-west—about 2500 feet above sea-level. West of the hut these beds strike north 15 degrees west, and dip east 15 degrees north flatly towards the camp. The Commonwealth rain-gauge is placed at this camp, and the observations taken by Mr. Black are of value, as it is the only weather station on the north-western highlands west of Moina.

On the leases the pipe-stem beds junction with the conglomerate, and near the junction there is a development of auriferous hematite and quartz.

The original workings at this mine were carried out by the well-known prospector, B. L. F. J. Thomas, 17 or 18 years ago. An underlay shaft was sunk in pipe-stem rock to about 25 feet. The occurrence was that of a seam of gossan passing down into pyrite, but specimen gold is said to have been found on the rock-walls.

Six or 7 chains south of the above is Todd's shaft, sunk vertically 60 feet in red quartzite of the conglomerate series. A crosscut from it was driven west-south-west for 50 feet, but no lode or mineral was met with. Mr. Black unwatered it, but was unable to do anything owing to the presence of foul air.

Twenty feet west of this is another shaft, which connects with a costean running north-west and then turning south-west. These workings expose an irregular formation of quartz in veined and silicified pink quartzite. With this are associated pyrite and slickensided specular iron ore. On the hanging-wall of this formation is a main underlay shaft, in which solid veins of specular iron ore were followed. Twenty feet south of this is the most westerly shaft, sunk 55 feet on the formation, with a crosscut driven 26 feet north-north-west.

The limits of the ore-formation are not well defined. At surface the silicified portion of the outcrop seems to be about 7 feet, but mineralisation extends to a greater width. The ore-bearing portion will probably be found to be irregular in size.

The assay records vary a good deal, as might be expected in a formation in which free gold is liberated by the decomposition of specularite and pyrite. Mr. Black informed me that the samples from the dumps at the shafts assayed 14 dwt. 13 gr. gold per ton. Other samples assayed at the Mt. Bischoff works yielded 5 dwt., 7 dwt., and 8 dwt.

Mr. Hartwell Conder, M.A., who examined the mine in 1903, reported the following assay returns from his samples:—

From 120 tons round shallow shaft, 3 dwt. gold per ton.

From 100 tons round deeper shaft, 6 dwt. gold per ton.

From drive: across face, trace only.

From drive: along north side, 12 feet to the shaft, 6 dwt. 10 gr. per ton.

From drive: south-east end, practically in shaft, 3 dwt. 2 gr. per ton.

From specimen of iron oxide, trace only.

A hundred feet lower down is a tunnel which was driven by Osborn and Hancock for 55 feet across the conglomerate, but without reaching the lode. One hundred and forty feet lower than this, and 60 feet above the river, Mr. Black has driven a tunnel 160 feet into the face of the cliff overlooking the Lea. The rock passed through is pink quartzite of the conglomerate series, and the direction of the adit is north 55 degrees east. A flat seam of pug accompanies the drive, and the country intersected carries veins of pyrites. The face of the adit is somewhere about where the lode-formation ought to be met with. The drive should be continued, as being about 240 feet below the outcrop, the behaviour and character of the lode would be fully tested. The result would also throw some light on the nature of other vein outcrops on the Black Bluff Range.

There is a small space of level ground below the low tunnel, which would be available for a battery, and easy communication could be maintained by means of a self-acting wire rope. The Lea River, which brings water from the lake of that name, provides ample facilities for power water.

The gold in this mine exists visibly both in the quartz and specular iron: it also, no doubt, occurs in the pyrite. Mr. C. F. D. Adam informs me that at first the conglomerate at surface was stripped, and after heavy rains one could see the gold *in situ* in the quartz. Within the zone of weathering the assay yields are variable, and probably higher than they will be when the primary pyritic zone is reached.

(16).—Devonport Prospecting Association's Mine.

This is situate on Black Bluff Range, about 4 miles west from Moina as the crow flies—at about 3000 feet above sea-level. It may be approached from Ulverstone over the coastal tableland, with a steep ascent up the northern front of the Bluff; or it may be reached from Moina *via* the Lea River track to Black's hut, and thence up the mountain to the north. The ascent from Black's is over pipe-stem country, with bands of breccia. At one spot a small plug or neck of vesicular basalt occurs. Higher up, 600 feet above the huts, the 910 section of the old Bluff King Consolidated Prospecting Association is passed over. Here conglomerate country is entered, and on rounding the shoulder of the mountain the Devonport Mine workings are seen on its eastern slope, with the mine hut below, on the creek which heads from here down to the Lea River.

The country-rock consists of quartzite and felspathic grit belonging to the conglomerate series, but across the valley to the east indications of pipe-stem quartzite are visible, so that here, as so often elsewhere, it seems as if the ore-formations are in the neighbourhood of the junctions between the two series.

The formation-line appears to extend in a general sense north and south through several leases, *i.e.*, it cannot be affirmed to be absolutely continuous. The deposits are rather *en echelon* than in an uninterrupted line. Ferruginous outcrops are seen, with which some irregularly distributed quartz is associated, and bands of stone are sometimes highly gossanous.

Trenches have been cut into the formation-channel, and where the gossan was pronounced some good assay returns in gold have been obtained; some of these, the writer is informed, were in the neighbourhood of an ounce to the ton. Some of the rusty cavities in the quartz may also have been responsible for a certain proportion of the gold contents. But neither the gossan nor the quartz has any regularity of occurrence. They seem to be distributed in disconnected short lines in a band of country 30 or 40 feet in width. It is not probable that any quantity of the formation stuff followed down below the gossan zone would contain more than negligible quantities of gold, for the ore in depth will certainly change to iron sulphide, carrying, perhaps, a little gold.

A low-level adit has been started to intersect the lode-formation, but when it reaches this it will have no great amount of backs, and at that horizon will not have much value for exploratory purposes.

Certainly gold has been found here, and it gave some promise of value; but the writer is afraid that the encouraging assays represent concentrations of metal liberated by the decomposition of pyrites, and deeper work cannot be expected to yield as good results. If it is desired to prove the ground to a moderate depth, the formation may be sunk upon, but the country is very hard, and this and the position of the mine would make the work somewhat expensive.

(17)—Golden Cliff Mine, Black Bluff.

This is an old mine situated south-west from the Devonport sections. Not much information about it is available now, but the writer was informed by Mr. C. F. D. Adam that he discovered the veins about 20 years ago, and that gold occurred at the junction of two veins. A tunnel approach was started, and about half a ton of lodestuff was sent to Footscray, and yielded about 10 dwt. This lode is in the conglomerate country. Some of the gold was visible in small ironstained cavities in the quartz which had probably been left from the weathering-out of iron pyrites.

(18)—Bond's Peak Goldfield.

Bond's Peak is a mountain ridge south of the Lea River, opposite Black's sections. The summit is composed of the pipe-stem sandstone, but below this is granite porphyry of the Dove River system (porphyroid division). The presence of this igneous rock may be responsible for the sporadic occurrences of gold which have attracted attention from time to time. Small veins appear to exist in the porphyry, and these are occasionally auriferous; in one instance a gossanous vein is reported to have proved to be rather rich in gold (Davey's vein), but to have passed down in a few feet into pyrite and pyromorphite. The probability is that the Bond Peak veins will in depth prove to be auriferous galena veins, like the occurrence at the Devon Mine on the Dove River.

Tin has been reported in the alluvial form at the Peak, but this needs confirmation. Mr. Leslie J. Smith informs me that the late Mr. W. R. Bell discovered a small tin-bearing vein near the north-west angle of the Van Diemen's Land Company's Middlesex Block, and that a little stream-tin has been found at the Peak. These occurrences are wrapped in some degree of mystery, and require investigation before they can be understood. The late Mr. Jas. Smith picked up a piece of cassiterite on a cattle-track on the Middlesex Block 50 years ago. This was about the size of a walnut. It was before the discovery of Mt. Bischoff, and its presence here has not been explained.

At all events, the writer does not believe that the district will ever be productive in tin, nor in much gold, but auriferous galena veins may possibly be discovered; and some of the alluvial gold derived from these veins, and concentrated in the creeks, may be worth the attention of prospectors.

C.—SILVER-LEAD MINES.

(1)—Round Hill Silver and Lead Mining Company Limited.

The property owned by this company is situate at the south-east end of Mt. Claude and about a mile east of the Forth River. It is approachable by two good roads from Sheffield, from which town it is distant about 15 miles. The more level road—and a very picturesque one—is that which runs up the valley of the Dasher River, skirting the base of Mts. Roland, Vandyke, and Claude, and rounding the western end of the latter in the great gorge of the Forth, where it is joined by the valley of the Claude Creek. The road at this point is too narrow to admit of vehicles passing one another, and is unprotected by side-rails. As motor-cars use the road frequently, and sharp curves exist, driving is none too safe until the road is widened and provided with guards. As the traveller approaches the mine a picturesque view of Round Hill, or Round Mountain as it is named on the chart, presents itself at the head of the valley. This mountain dominates the wild and rugged scene. Beyond Claude Creek at the mine the road ascends to its highest point (1400 feet above sea-level), and then, descending to Tin Spur Creek, winds its sinuous way to Lorinna. Along this road continually new vistas of the great wooded ravine of the Forth are opened up.

The other road from Sheffield is through the high farm lands *via* Staverton, joining the Dasher-road shortly before emerging into the valley of the Forth.

Geology of the Mine.—Mts. Vandyke and Claude form geologically a part of the Mt. Roland and Mt. Gog ranges. The whole chain in its central and southern parts consists of beds of heavy conglomerate, identical lithologically with those which are met with on most of the mountains of the West Coast. From the west end of Mt. Roland one can descend and pass on to Mt. Vandyke, and from the latter to Mt. Claude; all of these compose a geological unit. On Mt. Roland the conglomerate beds dip to the south, showing their edges on the steep northern face of the mountain, but at Mt. Claude they form a "pudding-stone" without exhibiting any determinate bedding-lines, so that it is impossible to ascertain their underlay. They form the upper part of Round Mountain, and overlook Claude Creek on its northern side. These conglomerates, with their east-west strike, appear to be part of the conglomerate system developed further west in the Black Bluff country.

They are flanked on the north by the various igneous and fragmental rocks of the porphyroid series. The valley of the Dasher is carved in these latter beds, which rise on one side towards the Sheffield and Staverton farms, and on the other side to varying heights up the mountain-sides. Their decomposition yields a snuffy, red soil, poorer than the chocolate ground resulting from the disintegration of basalt. Some of these rocks are hornblendic porphyries and tuffs; others, purple gritty flags, blue and green slates, crushed schistose conglomerates, and green, spotted, greasy schists. The series has a north-westerly—south-easterly strike and a north-easterly dip.

This strike persists over a wide area. For instance, it prevails at the west end of Mt. Claude, north of Lorinna, at Bell Mount, at Gunn's Plains, and on the North-West Coast. This constancy of strike and the unconformability between the porphyroid beds and the conglomerate indicates a strong break between the two series.

The extraordinary east-and-west bearing of the conglomerate and pipe-stem strata in this part of the island, so different from the normal northerly trend lines, points to faulting on a large scale; and the junctions between porphyroids and conglomerates in the neighbourhood of Round Hill are confirmatory of this indication.

A junction may be seen on the sideling road to the mine overlooking Claude Creek, where the bank shows coloured slate and schist abutting steeply against conglomerate. It is plainly a faulted junction.

A fault-line exists also on the southern flank of Mt. Claude, separating the pipe-stem beds at the Round Hill Mine from the conglomerate of the mountains. The former have a northerly dip, which would take them below the conglomerate, whereas their normal position is above it.

These faults obscure the natural stratigraphical sequence of the strata, and hence the junctions in this locality throw no clear light on the debated question of the relative ages of the porphyroids and conglomerates.

The ore-deposits of the Round Hill Mine do not occur, or at least have not been followed into conglomerate country. They are in a belt of hard indurated sandstone or quartzite, the beds of which over a width at the mine of 800 feet have been folded into several anticlines and synclines.

The writer found remains of pipe-stems on the south bank of Claude Creek, below the hut, and also observed transverse sections of the same in the dark-greenish mineralised quartzite round the bend of the road above the Falls. There can therefore be no doubt that the Round Hill Mine strata belong to the tubicolar sandstone division, which is developed at the Tin Spur, Five-mile Rise, Moina, Stormont, &c. As said above, these beds normally succeed the conglomerate. They also include as members certain hard conglomerates and breccias. Across the upper bridge over the Claude Creek, and on the south side of the road, a large boulder of such breccia may be seen in the bank, consisting of angular fragments up to 3 feet in length of banded pink grit and sandstone and white quartzite. Some waterworn stones are also associated with it.

The deep adit at the mine for the last 150 feet of its course has passed out of the pipe-stem quartzite into Silurian limestone. This is not seen at surface, being concealed by soil and overburden. Similar limestone is reported as outcropping in the bed of the creek a mile or so to the south-east. The rock is probably a residuary patch of limestone formation, surviving in a trough or synclinal fold of the quartzite.

A mile south-west of the Round Hill Mine is the boundary of the Dolcoath tin and wolfram bearing granite *massif*, which emerges from beneath an area of pipe-stem strata, and is the igneous source of the minerals in the country round its borders, wolfram, tin, and bismuth ores in the immediately adjacent rocks, and argentiferous galena at a greater distance (Round Hill).

The occurrence of silver-lead ore at Mt. Claude has been known for close on 40 years. The first official report on mining at the Round Hill was written by Mr. G. Thureau, a former Tasmanian Government Geologist, in 1881. At that time he says that the Mt. Claude Silver-lead Company was working on the deposits where they were first discovered by the original prospectors. The low-level exploratory adit had not then been started. In 1885 he wrote a further report on the mine, in which he referred to the company's workings on the east side of Mt. Claude Creek, at the base of the Round Mountain, and others west of the "Jug" and upper waterfall. The main adit appears to have been driven by this time to a distance of 593 feet. He favoured the adoption of open-cut mining at the eastern workings. The company ceased driving the adit in 1884. In 1891 the Southern Cross Proprietary Silver Mining Company, No Liability, continued the long adit for another chain to the boundary of the quartzite at 650 feet, where a strong stream of water marks the junction of quartzite and limestone.

When Mr. Montgomery visited the mine in 1893 the Kentish Proprietary Silver Company, No Liability, was carrying on mining operations, and had driven the adit in limestone to its present face, 802 feet. 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 has carried out a good deal of work during the last six years in the way of prospecting and opening up the property, providing concentrating appliances, &c., with the result that the company now possesses a mining proposition with considerable facilities for economic work. At present the mine is being worked on the tribute system.

The general features of the proposition may be described in a few words. Various mine openings (cuts and short tunnels) have been made at intervals along the valley of the Claude Creek, establishing the existence of several lines of mineralisation parallel to one another in a belt of folded sandstone and quartzite beds 800 feet wide. The folding of the strata by compression of the earth's crust has thrown them into a series of pronounced arches: it is in the axial directions of the folds, below the apices of the anticlines and in the troughs of the synclines, that mining has been chiefly carried on. The structural characteristics of an ordinary simple lode are absent, and the irregular distribution of the ore in the country-rock is puzzling until the fact is realised that we are dealing with a compound lode system. A series of parallel small vertical fissures intersects the beds, especially at the anticlines, perpendicular to the folding, supplying mineral which has also extended laterally, and has accumulated between the bedding-planes of the strata. Experience here has tended to show that the principal mineralisation has taken place at the summits of the anticlines, while the inverted saddles or synclinal troughs, though seats of ore-deposition, do not carry ore-bodies of equal importance. Fractures in the rock connected with the process of folding are more likely to occur at the apices of anticlinal arches, and hence these summits, with their innumerable cracks, provided channels through which circulating ore-solutions could pass.

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

The eastern workings comprise the Bridge tunnels, Nos. 2, 5, and 7, where the 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. The No. 2 tunnel was commenced in the old days at what was termed the "Jug," and is now a broad drive in a south-easterly direction along the northern leg and crown of the most northerly anticline. About 28 or 30 feet width of ground has been taken out from tunnel-level and sent to the mill.

The level becomes narrower as it goes into the Round Mountain in an easterly direction until it possesses the width of an ordinary drive. At the time of this visit the end was 190 feet in. Behind the end a small drive has been put in 12 feet south to test the lode, and shows some milling ore.

The end of the leading stope 25 or 30 feet above the level was in 7 feet of fair milling ore, and a greater width had still to be taken out. In all, the length of ground stoped to this height above the level is upwards of 150 feet, with an average width of 12 feet. It is understood that more than half the stoping has been done by tributors. The innumerable veinlets of ore intersect the beds in all directions, forming a veritable stockwork.

An adit (No. 5) has been driven from the road for about 75 feet in a south-easterly direction (123°), 70 or 80 feet above the No. 2 tunnel, and a communication made with the latter by means of a winze. This drive is also on the arch of the anticline, and veins of galena follow the beds on each side of the fold. A few tons of first-class ore have been taken out of this drive. The end is in fairly good milling ore. The concentration is said to run 5 to 1. At the surface overhead some loose blocks carrying clean galena, were broken up with up to a foot of clean ore.

The continuation of the anticline followed in the above workings has been worked on the opposite or west bank of the creek in the No. 7 bridge 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 was 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. In the face the mineralised band shows hardly any sign of continuing.

Nearly 200 feet south of No. 5 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 or 30 feet wide, slightly mineralised with pyrite and galena. It forms an anticline, and its continuation probably passes through Sale's quarry on the western side of the creek. A little galena is seen in the creek-bank on this line.

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 feet 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 from 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 great importance. It has been proposed to work at this point by open-cut benching, but enough ore for this does not appear to have been disclosed so far. This line of ore-deposition probably coincides with a lode cut at 190 feet (on plan 170 feet) in the deep adit.

On the Lorinna-road, 400 feet south of No. 5 tunnel, is a small drive 25 feet south-easterly (123°) 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 the above drive and about a chain below the Falls, the Falls tunnel has been driven north of west for 30 feet under the third anticlinal arch, but no metal is visible. To pick up the veins seen in the tunnel opposite, the drive should have been put in a few feet further north, so as to be in the synclinal fold.

Lower down the creek, between Sale's lode-line and the No. 2 tunnel waterfall, a small drive has been put in on 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. This formation if prolonged westwards would connect with one below the manager's house.

The preceding may be grouped together as the eastern workings. At present, interest centres principally in this part of the property, for active mining is being confined to the bridge tunnel workings at the eastern end of the lode system. They are heading into the Round Mountain, and in the course of time—a long time yet—will presumably abut against the conglomerate wall of that eminence. Structural deformation is a very pronounced characteristic of this part of the mineral belt. The anticlines are most strongly developed here, providing favourable conditions for ore-deposition. It was at the bridge tunnel point (called the "Jug") that work was carried on in the old days, and it is significant that after so many years this spot should be selected again, and still worked with satisfactory results.

The central workings of the mine are along the line of the No. 3 or deep adit tunnel. This adit has been driven at creek-level for 800 feet in a southerly direction, across all the trend-lines of the mineral belt. These trend-lines bear north 20 to 25 degrees west, so that the adit must intersect them. So far, however, as can be judged from the small amount of work which has been done in the tunnel, the intersections must have happened at weak spots in the lode-formations.

The No. 2 Bridge tunnel line would appear to trend so as to bring its continuation just inside the entrance of the adit, and in fact the adit is said to have intersected a lode inside the third set of timbers. This line continues west across the Claude Creek somewhere near the mill. The arch of the anticline seems there to be almost coincident with the valley, and possibly a good deal of ore-bearing ground has been removed by the stream. The northern leg of the arch may be seen in the cliff-face on the north side of the creek.

At 90 feet from the mouth of the adit a little gouging has been done on some mineral in a formation 8 to 10 inches wide. This is probably the continuation of the outcrop just below the manager's house, and of the veins driven on in the creek between the No. 2 tunnel waterfall and Sale's lode-line.

At 170 feet in, Sale's line has been intersected and driven on west for 20 feet. The formation is 2 or 3 feet wide, with a little clean ore showing, but it pinches out in the end. A little rich ore is said to have been got from here. The drive is on the regularly bedded south leg of an anticline. Although there is not much to be seen in the adit at this point, the formation seems to be on the line extending from Sale's quarry on the east to the open-cuts at the far western end of the property, for a distance of about 1500 feet. At about 400 feet in, the adit is below some shallow works at surface (No. 1 tunnel workings), which are in a gossanous formation connected with a water-channel, but nothing has been worked in the adit below, though ore was obtained above. 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 which admits of anything being seen. 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. From this point to the end the adit is in limestone. Calcareous rock is said to have been met with after 500 feet, but the writer was unable to detect any. The limestone is a dark, bluish-grey, tough rock, and at the end of the adit it appears to have a general tilt southerly. Water is freely flowing from the end. No fossil evidence is available to establish the age of the limestone, but it may be assumed to be Silurian. It has been reported from higher up the Claude Creek. It is not visible at surface above the end of the adit, but must be concealed beneath overburden.

The adit if continued will eventually pass through the limestone into the pipe-stem sandstone, in an undulation of which the former rock has possibly been formed. Veins of lead ore in limestone frequently yield very clean mineral, but are apt to be irregular, and the lead poor in silver.

As will be seen from the preceding remarks, very little driving has been done on the veins cut through by the adit; yet such driving is necessary to get away from weak patches in the lode-formations, and open up stronger shoots. The present value of the adit appears to be not so much in respect of the actual deposits intersected by it, as of the facilities which it provides for exploring these.

The western workings are 1000 feet west of the central adit, and appear to be on the Sale's quarry line of ore-deposition, though it is impossible to be quite sure of this without work at intermediate points. Most of the stone broken in these workings appears to have been sent to the mill, but the present standing faces are poor, and from appearances would not pay to quarry.

An open-cut 58 feet wide (the lower one) shows a lode footwall, with some galena and zinc blende. No. 6 tunnel has been started from this cut, and the writer was informed that some first-class ore had been won from the approach, and good ore also came from a small pit sunk in the sole of the drive. The adit has been driven for 90 feet on an anticline, and the small mineral veins traverse the rock in every direction, after the fashion of a stockwork.

An upper, smaller, open-cut in the same lode system, 25 feet above the lower one, shows a quarried face 30 or 40 feet wide; most of the stone worked was treated in the mill. At a still higher cut, a small pile of clean ore is stacked, but the face shows only pyritic stone. This is over 200 feet above the creek. From the bottom quarry an aerial tram-line connects with the mill. One hundred and fifty feet east from these workings is No. 4 tunnel, which has been driven south to intersect the lode system, and should have cut something in the 45 feet driven. It ought, however, to be continued 25 or 30 feet further.

The ore in the above workings is more highly argentiferous than that of the eastern stopes, and this should encourage further exploration. The good ore obtained from this part of the property cannot be regarded as a merely isolated occurrence, but is unquestionably related to the general phenomena of ore-deposition at the Round Hill, and must be connected with other shoots in its immediate neighbourhood.

As might be expected in a lode system extending over such a great distance, and possessing differing physical characteristics at different points, the silver content of the Round Hill ore is variable. In practice, the average does not exceed ½-oz. silver per unit of lead, though Mr. W. B. Cocker, the company's legal manager at Devonport, informs the writer that the assay returns for the last couple of samplings of ore mined from the stopes immediately below No. 5 level, entering the hill from the road (eastern workings), show an improvement in the silver contents, the slimes and jigs reaching 69 and 70 oz. respectively, with lead at 49 and 55 per cent. respectively. A sample taken on the present visit from some ore on the floor of the open-cut (western workings) has been assayed by the Government Analyst, and yielded 66·6 per cent. lead, 128 oz. 14 dwt. 3 gr. silver, and 13 dwt. gold per ton. Mr. Jno. Ellis also obtained some high silver results from ore from the Lorinna-road. His figures are:—

From vein between anticlines on Lorinna-road (containing fahl ore): Lead, 74·2 per cent.; silver, 228·8 oz. per ton; gold, 3 dwt. per ton.

From Bully's lode, between second and third anticlines on Lorinna-road: Lead, 58·7 per cent.; silver, 127·8 oz. per ton; gold, nil.

A report in 1909 quotes a rich assay from the vein of galena in the adit at the western workings at 80 feet from the entrance, as follows:—Lead, 84 per cent.; silver, 243 oz.; gold, 6 dwt. per ton. The average hand-picked firsts from this portion of the mine, however, gave an assay value of—lead, 48 per cent.; silver, 29 oz.; gold, 2 dwt. per ton.

The rather peculiar type of lode-formation makes the laying out of work for the exploration and development of the property somewhat difficult, and has led to a variety of recommendations. Working the property by open-cut benches appears to have been the favourite advice, and where the lateral development of the ore-formation is extensive enough, this system is obviously indicated. But this lateral spreading of the ore down the legs of the anticlines is unfortunately irregular and bunchy; and where it is confined to a narrow channel, ordinary underground methods have to be adopted. Sometimes one method is preferable, sometimes the other, and this difficulty of choice has to be met. In the end it may resolve itself into a choice between larger returns of low-grade ore and smaller returns of higher grade. As regards the existing openings, open-cut work must naturally depend upon whether the ore-bodies are sufficient to warrant milling the stone as it is broken down.

There must be much ore to be taken out yet at present levels. The position of the eastern workings at the foot of the Round Mountain is a favourable one, and adit work can proceed there almost indefinitely. Above creek-level it is not likely that any great change in the character of the deposits will occur. They will probably still be found somewhat discontinuous in occurrence, with concentrations of ore at intervals. Where these concentrations form bodies of promising size, it will be necessary to sink on them, for there is no reason to believe that the ore is confined to one horizon, and the vertical components of the lode system may be expected to descend in the manner of ordinary veins. Thus a general rule for progressive work may be formulated: drive on the anticlinal axes and sink in centre country.

The irregular distribution of the ore in this mine will always make heavy demands on the judgment and technical skill of the management. The property, however, has potentialities which cannot be fully realised until the owners provide the necessary funds for exploration and development and take the work into their own hands.

The ore at the Round Hill is galena, with some copper indications in the neighbourhood, but the occurrence bears an interesting resemblance in habit and structural features to those characterising the deposits of tin ore on the neighbouring Tin Spur. This is in harmony with modern views on the zonal arrangement of vein-types round a granite magma basin. The Dolcoath granite mass, with its pneumatolytic ores, is the expression of the originating magma in this instance, and the Round Hill area represents the outward galena zone. There are only sparse indications of the copper and gold zone, immediately outside the limits of the deep pneumatolytic zone in the normal sequence. Tin ore has been found on the spur very near to the Round Hill workings, thus extending the range of the pneumatolytic minerals almost to the borders of the area in which the hydatogenic galena veins of the Round Hill Mine have formed. The doctrine of the zonal sequence of ores implies correspondence of both horizontal and vertical sequences, and thus if sinking at Round Hill were carried deep enough, lead would probably be found to be replaced by tin.

(2)—The Devon Mine.

This mine has already been officially reported on twice, and is at present closed down. Its drawback is the small size of its lode, combined with an extremely inconvenient position at the bottom of the Dove River gorge, making transport cost excessive.

It is situated on the south or west bank of the Dove, 2 miles south of the V.D.L. track on the Five-mile Rise. The workings are in the granite porphyry of this belt. The lode-channel at surface varies from a few inches in width to 3 feet, containing country-rock, quartz, siderite, and pyrite. The ore-shoot is a few inches wide up to 10 inches or a foot. The economic ore is galena, accompanied by a little chalcopyrite, zinc blende, pyromorphite, and in the upper part of the lode cerussite. The ore won is clean, the last shipment returning 69·9 per cent. lead, 87·2 oz. silver, and 3·8 dwt. gold. The high gold content is a striking feature of the ore, nearly one-half of the entire output containing approximately 5 dwt. gold per ton and the remainder nearly 3 dwt.

The mine has produced 400 tons of silver-lead ore.

(3)—The Wilmot Silver Mine.

Two vacant sections—No. 4092-93M, 48 acres, and No. 4093-93M, 50 acres—are situate on the east bank of the gorge through which the Wilmot River flows, about a mile and a half west of Bell Mount. These sections were formerly charted as No. 1960-91M and 1961-M respectively, in the name of W. T. York.

An upper tunnel has been driven in a south-easterly direction for 30 feet, with a small cuddy at its end. The country-rock is hard quartzite belonging to the pipe-stem series, and is traversed by irregular veinlets of galena.

A second short tunnel has been put into the hill-face a hundred feet lower down. This shows some clean silver-lead ore in irregular vein quartz.

The veins disclosed by the mining work are not large enough nor sufficiently defined to warrant further expense in following them up, but surface prospecting might very well be carried on with a view of seeing whether better lodes exist on these sections.

D.—MISCELLANEOUS.

(1)—REARDON AND DAY'S MINE.

This is situate on an extended prospecting area east of the Forth River, about a couple of miles south of Lorinna. The new road to Mt. Pelion is followed south from the township.

On leaving the basalt on J. W. Bullock's 32 acres, granite and granite porphyry country is entered. This is not the Dolcoath tin-bearing granite, but belongs to the more ancient Dove River belt, and is a plutonic member of the porphyroid suite. Tin ore has not been found in Tasmania in this series, but copper and silver-lead ores and gold are frequent.

The lode of this mine is in the granite porphyry opposite the mouth of the Dove River, which flows here into the Forth about a quarter of a mile further south than is indicated on the charts. It is a quartz-hematite-pyrite lode, containing small quantities of gold and silver.

Mr. Reardon informed the writer that a sample of the ore sent to the Government Analyst returned 1 dwt. gold and 1 dwt. silver per ton. The writer took samples which, on being assayed by the Government Analyst, yielded: silver, 4 dwt. per ton; gold, none; copper, none. A bulk sample has also been asayed by the Mt. Lyell Mining and Railway Company, and it is understood that the results were: Silver, 5 dwt.; gold, a trace; copper, none; lead, none. Some idea existed locally that copper might be present in this lode; up to the present, however, it has not been detected.

The full width of the lode has not yet been quite determined, for some of the cuts have been driven into it for 20 and 25 feet without completely crossing the whole formation. There are indications that the lode system, divided by horses of granite, extends for a width of 40 or 50 feet.

The strike is north-west—south-east, with an underlay to the south-west at an angle of 30 degrees. The direction of the underlay consequently corresponds with that of the slope of the hill down to the road.

Four principal cuts have been put into the lode at intervals along its course, about 120 feet above the road.

Cut No. 1 has been put into it for 11 feet, where it is surmounted by a massive outcrop 15 feet high on the surface of the hillside. The footwall has not been reached in the drive. Quartz veinstuff is distributed in seams irregularly through the lode, and occurs also in brecciated patches of micaceous iron ore. Pyrite is also showing in patches.

Cut No. 2 has been driven across the lode for 18 feet. The lode is flat here, perhaps disturbed. The veinstuff is similar to that in Cut No. 1, but more massive; the quartz is white and glassy-looking; some of the pyrite is enclosed in the hematite. Green stains of iron sulphate are present; these may have suggested the idea of copper.

Cut No. 3 is 20 feet south from the preceding, and has been driven north 60 degrees east across the lode for 25 feet in strong lodestuff.

Cut No. 4 is a small tunnel, a chain south from No. 3, and has been driven north 10 degrees east to the footwall, which here shows a face of greasy granite porphyry dipping in a westerly direction at an angle of 30 degrees. The lodestuff in this drive contains more hematite and less pyrite. A boss of granite porphyry occurs between Nos. 3 and 4, and this perhaps has divided the lode, a portion of the latter passing behind the boss higher up the hill, for on going back north, further up the slope boulders of quartz-hematite are seen.

The lode appears to underlie with the hillslope, and consequently no great depth can be attained by adit-driving. Taking the inclination of the hill as 35 degrees and that of the lode as 30 degrees, the latter would run out to surface before reaching the road, and in that case an adit from the road would pass below the outcrop. On the other hand, the underlay in this rock is apt to be irregular, and it may have assumed a steeper inclination, in which case the adit will intersect it.

The quartz is sometimes brecciated, sometimes banded, and has every appearance of being definite vein quartz. The lode-structure may be said to be typically brecciated, showing fragments of white vitreous-looking quartz surrounded by micaceous iron ore and crystalline pyrite. The quartz is sometimes cavernous, and the pyrite is then lodged between the crystals. On the whole pyrite is more abundant when quartz is plentiful. The lodestuff is largely reddish in colour in consequence of oxidation. The lode is a strong one, and its features suggest that it should be tested to a moderate depth.

The question of immediate interest to the owners is what the prospects of deeper work hold out. The gold and silver contents, though quite trivial, might appear at first glance to indicate the possible existence of some economic ore as an accompaniment or as host, such as lead, zinc, or copper.

The country-rock traversed by the lode is a reddish granular granite porphyry, composed of pink felspar, quartz, and green chloritic pseudomorphs after biotite or some other ferro-magnesian mineral. It differs from the usual Devonian granite in being less siliceous and in the presence of chlorite, thus giving to the rock as a whole a red and green appearance. It is apparent that at this horizon the country-rock has not influenced the composition of the lode; the same gangue minerals are the same throughout its course.

The writer's opinion is that the minerals represent a low horizon in the vertical column of ore-deposition, viz., the auriferous pyrite zone below the copper and galena blende zones, the latter having been obliterated by denudation. Future work will probably have to be limited to searching for more highly auriferous parts of the pyritic constituent of the lode.([20])

Half a mile south from this mine the granite junctions with Pre-Cambrian mica schist. The schists strike north-west and dip to the north-east. They form the river-bed, and ascend to the summits of the hills on either side; and continue southwards for about 3 miles. Gold has been found in the river-sand, but no tin. In the schist belt galena is said to have been found, as well as a little copper in quartz.

([20]) Since writing the above an adit has been driven from the road, cutting the lode, which is reported as being a strong one, and containing more pyrite than at surface.

(2)—D. Davies' Show.

On Mr. D. Davies' land, south of and adjoining G. Day's purchased 173 acres, a little work has been done on a lode of micaceous iron ore, shown in a gossanous outcrop which traverses the farm in a west-north-westerly direction. The approach is up the hill south-easterly from Lorinna over Pleistocene or Tertiary wash, and then through basaltic land till schist country is reached on Mr. Davies' run.

A little pit has been sunk to a depth of 10 feet, where an oxidised iron outcrop occurs, north of the road; and further east a small cut has exposed a vein of micaceous iron ore 6 inches wide. Samples taken from this and assayed by Mr. W. F. Ward, Government Analyst, returned neither gold nor silver.

VII.—CONCLUSION.

From the foregoing description of the geology and mining of this large district, it is clear that mineral-deposition has been extensive. This visit has established the high probability of the view that the various occurrences of ore throughout the area (with the possible exception of Bond's Peak and the Devon Mine) stand in genetic relation to the underlying granite magma which is visibly expressed by the exposed stock at Dolcoath. The deposits of tin, wolfram, and bismuth ores are in the pneumatolytic zone within the granite itself and the surrounding mantle of sediments; while auriferous silver-lead and zinc blende, with free gold released from them, are found in the outside zone at a greater distance from the magmatic reservoir.

None of the mines in the district are very large, but on the scale upon which they are being worked they are producing ore profitably. Their aggregate output during last year totalled a value of £15,000. The market prices of the metals involved have been favourable. The prices at 30th June are:—

- Tin, £194 per ton.
- Wolfram (70 per cent.), at 34s. 6d. per unit, £120 15s. per ton.
- Molybdenite, at 2s. per lb., £224 per ton.
- Bismuth ore, at 7s. 6d. per lb., £500 per ton.
- Lead, £20 per ton.
- Silver, 2s. 2 13/16d. per oz.

Molybdenite has not been found sufficiently concentrated to form workable deposits here, though it is a very constant accessory to the tin, wolfram, and bismuth ores. There are indications at one or two points of it being more plentiful than usual, and perhaps some discovery may be made in the future which will lead to the ore being made marketable.

Up to recently molybdenum had only chemical applications in the industrial field, but for some years now it has been used in lieu of tungsten in the manufacture of hard steel in the electric furnace. Its competition with tungsten for this purpose is not excluded by its high price, for it is used in half the proportion, but the limited and irregular output is unfavourable to its extensive employment. The world's output of molybdenite is about 300 tons per annum, the bulk of which comes from Queensland and New South Wales, small quantities being produced in the United States, Canada, and Norway.

The improvements which have been, and are still being, made in magnetic separation methods have had beneficial effects on tin-tungsten-bismuth mining in the Moina field. Mining is proceeding quietly and profitably. The Shepherd and Murphy Mine continues to be the pioneer mine of the district. Its ore reserves are satisfactory, and with increased development work there is reason to believe that it has a long career before it. Endeavours are being made to put the Lady Barron Mine on a proper footing. Gurr's Mine is being worked profitably by its owners; and the lessees of the Iris tin claim have been doing well. If satisfactory developments can be secured on Sayer's fall, that part of the field would receive a great stimulus; and the Tin Spur is not without possibilities.

As regards silver-lead, the Round Hill Mine is now the only producer, and the tributors have every reason to be satisfied with their work; but the property cannot undergo full development until adequate capital is provided. The Devon Mine has struggled for many years against adverse transport conditions, and with the drawback of a small lode; but transport in the future will be favourably effected by railway extensions.

In past times the district produced a considerable quantity of gold, but this industry died a natural death, as the stores at surface became depleted. Mr. W. M. Black is about to continue his underground driving at the Lea River, with a view of tapping the formation in the conglomerate, which at the surface and in shallow works was gold-bearing. This will really be the first piece of deep work in the Black Bluff country, and will throw some light on the probable behaviour of gold-bearing veins in these mountains.

Interspersed with barren mineral areas are stretches of fertile soil, admirably adapted for grazing and dairying purposes. These have been selected by farmers, notwithstanding the elevation of this plateau, and there is thus a combination of agricultural and mining interests, which augurs well for the prosperity of the district.

W. H. TWELVETREES, Government Geologist.

Launceston, 9th July, 1913.

GEOLOGICAL SKETCH MAP
OF
THE MIDDLESEX AND MT. CLAUDE DISTRICTS

LEGEND

SEDIMENTARY

TERTIARY AND QUATERNARY	*Alluvial*	(yellow)
SILURIAN	*Limestone*	(purple)
PRE-SILURIAN	*Slates, Conglomerates and Grits and Porphyroids, &c.*	(grey)
	Conglomerate and Tubicolar Sandstone	T
	West Coast Conglomerate	C

CRYSTALLINE SCHISTS

PRE-CAMBRIAN	*Micaceous Schists*	(orange)

IGNEOUS

BASALT	*Lava and Tuffs of Tertiary Age*	(pink)
GRANITE	*(1) Tin and Tungsten bearing Granite, Granite Porphyry and Greisen of Devonian Age*	D
	(2) Pre-Silurian Granite & Granite Porphyry	P

Lodes

Strike and Dip of Strata

Geological Boundaries

KEY TO NUMBER OF MINERAL SECTIONS			KEY TO NUMBER OF MINERAL SECTIONS		
Number of Section.	Acres.	Lessee.	Number of Section.	Acres.	Lessee.
3849-M	397	S. & M. Syndicate, Ltd.	6131-M	80	E. A. Solomon
5986-M	235	Lady Barron Prospecting Syndicate	6081-M	10	B. J. Gurr
5499-M	80	W. H. Sayer & Others	5221-M	50	B. J. Gurr
5945-M	61	E. F. Goninon	36-93G	20	Narrawa Pros. Association, N.L.
5531-M	79	G. M. Day	35-93G	20	Narrawa Pros. Association, N.L.
5814-M	40	National Bank of Tasmania, Ltd.	950-M	78	C. F. D. Adam & Others
5250-M	80	National Bank of Tasmania, Ltd.	1059 G	10	W. Redman
5813-M	40	National Bank of Tasmania, Ltd.	1097 G	10	W. Redman
5952-M	40	E. A. Solomon	1096-G	10	W. Redman
5901-M	30	Solomon & Reardon	6075-M	7	B. J. Gurr

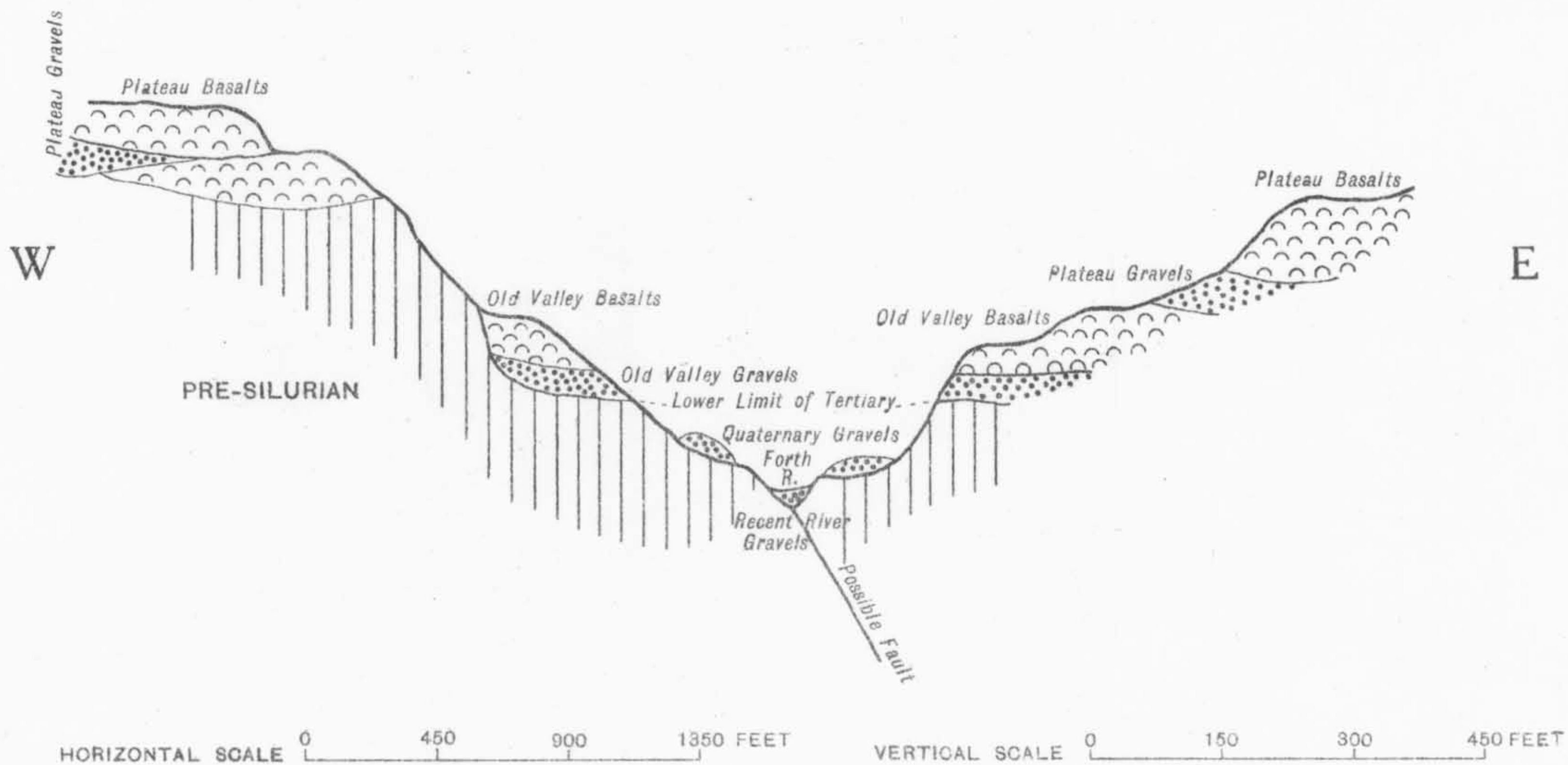
W. H. Twelvetrees
Government Geologist
August 1913

Photo Algraphed by John Vail Government Printer Hobart Tasmania.

PLATE IV

SKETCH SECTION ACROSS THE FORTH RIVER VALLEY NEAR THE WILMOT BRIDGE

By Professor T. W. Edgeworth David, F.R.S.



5 cm

W. H. Twelvetrees
Government Geologist
August 1913

W.T.R.

Photo Algraphed by John Vail, Government Printer, Hobart, Tasmania.

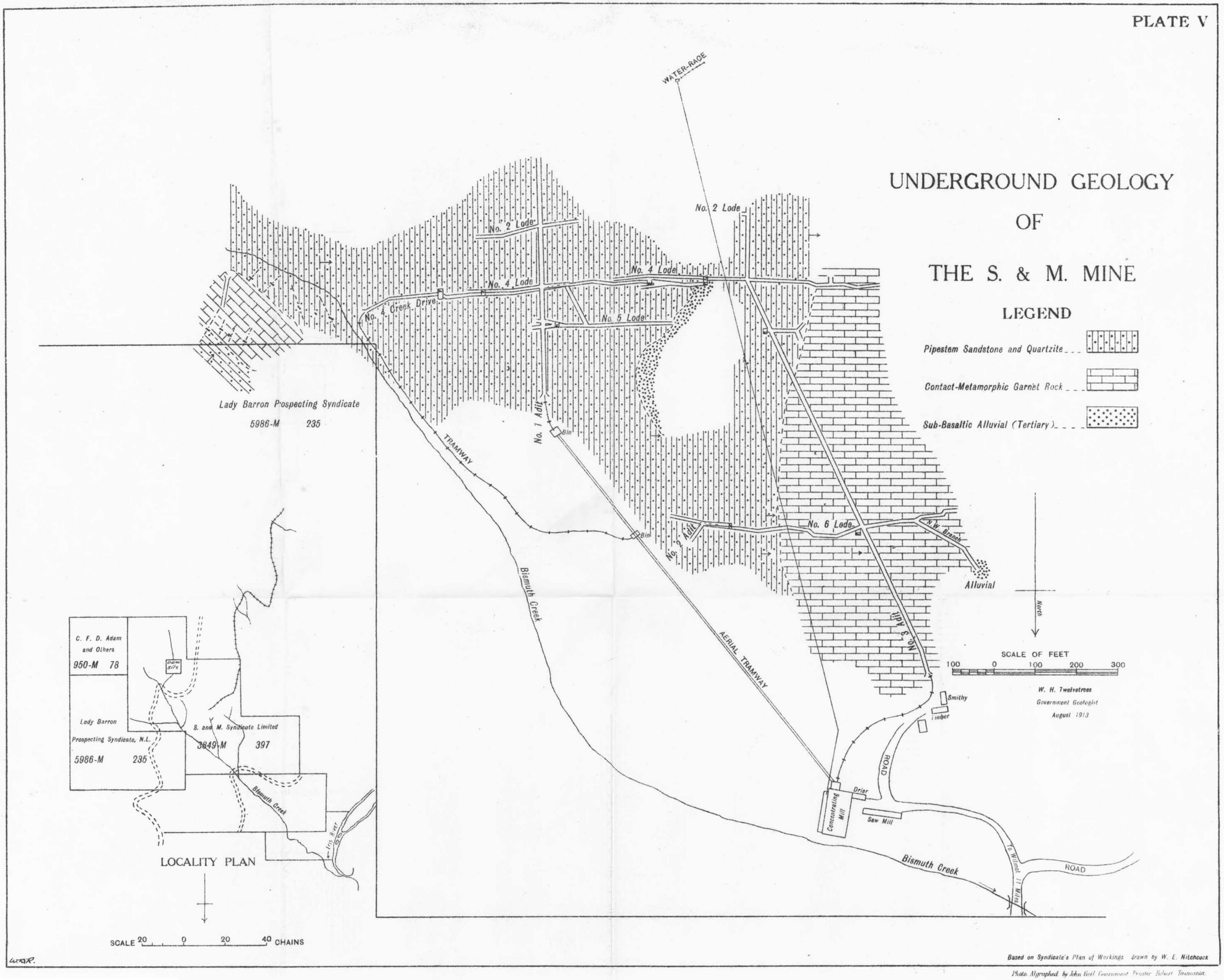


PLATE V
UNDERGROUND GEOLOGY
OF
THE S. & M. MINE
LEGEND
Pipestem Sandstone and Quartzite
Contact-Metamorphic Garnet Rock
Sub-Basaltic Alluvial (Tertiary)
WATER-RACE
No. 2 Lode
No. 4 Lode
No. 5 Lode
No. 4 Creek Drive
No. 6 Lode
N.W. Branch
Alluvial
No. 1 Adit
No. 2 Adit
No. 3 Adit
Bin
TRAMWAY
AERIAL TRAMWAY
Bismuth Creek
Lady Barron Prospecting Syndicate
5986-M 235
North
SCALE OF FEET
100 0 100 200 300
W. H. Twelvetrees
Government Geologist
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Smithy
Timber
ROAD
Drier
Concentrating Mill
Saw Mill
To Wilmot 17 Miles
C. F. D. Adam and Others
950-M 78
Lady Barron Prospecting Syndicate, N.L.
5986-M 235
S. and M. Syndicate Limited
3849-M 397
Iris River
LOCALITY PLAN
SCALE 20 0 20 40 CHAINS
Based on Syndicate's Plan of Workings drawn by W. E. Hitchcock
Photo. Algraphed by John Vail, Government Printer, Hobart, Tasmania.

PLATE VI

SKETCH OF GEOLOGY OF THE ROUND HILL MINE

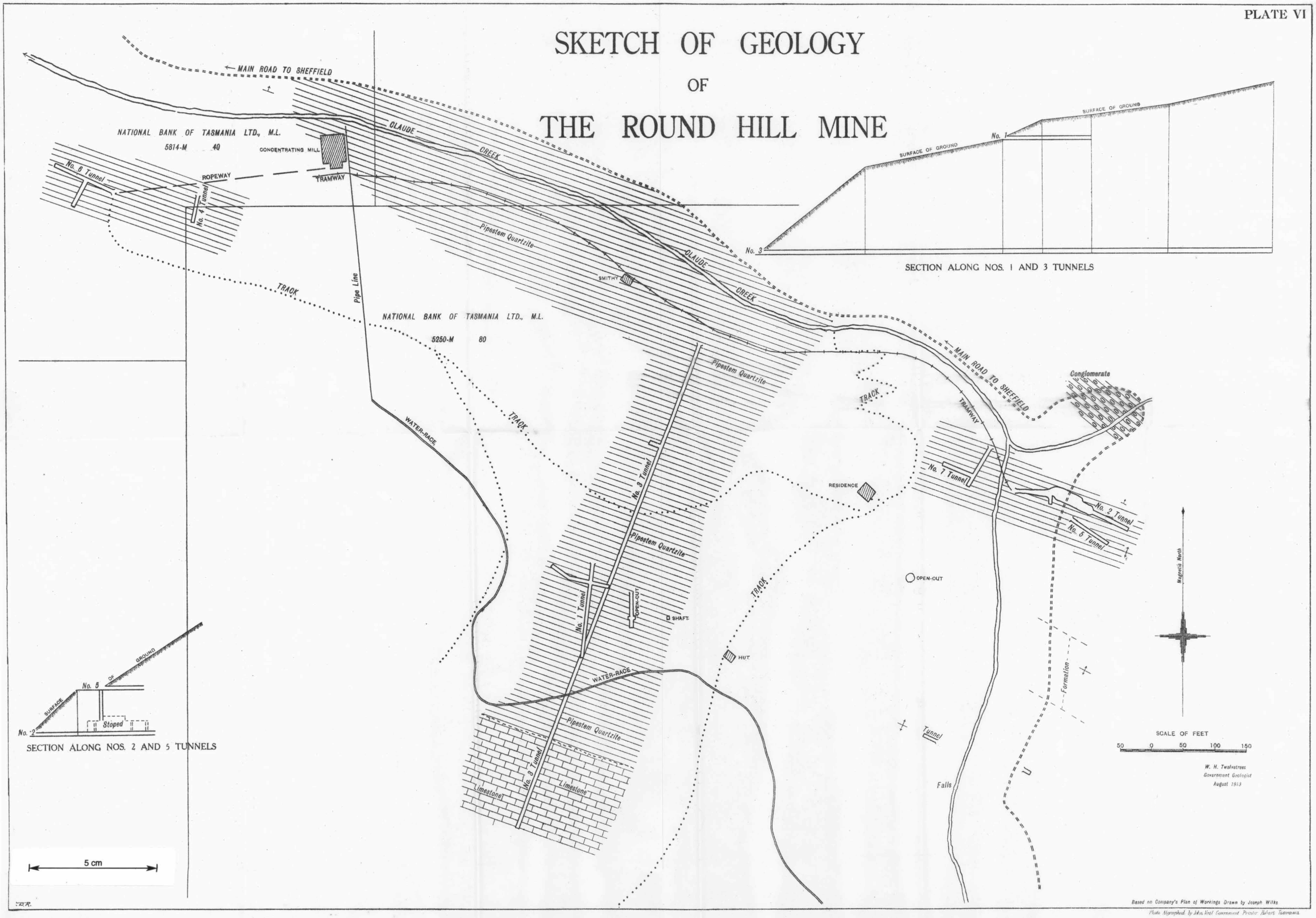

PLATE VII
MINERAL CHART
OF
THE MIDDLESEX AND MT. CLAUDE DISTRICTS
CHAINS
MILE
5 cm
BELL MOUNT
MOUNT CLAUDE
WILMOT RIVER
LEA RIVER
IRIS RIVER
RIVER FORTH
BULL CREEK
TIN SPUR CK
CLAUDE CK
BASHER RIVER
FALLS CREEK
MOINA
LORINNA
STORMONT
BOND PEAK
CONSOLIDATED LEASE
Nº 3849 397 AC.
S.A.M. SYNDICATE. LIM.
CONSOLIDATED LEASE
Nº 5886 235 AC.
LADY BARRON PROS. ASS. NO LIA.
M.L.
10,000 AC.
V. D. L. Co's
MIDDLESEX PLAINS BLOCK
V. D. L. Co's ROAD (County Boundary)
MAIN ROAD FROM MIDDLESEX TO WILMOT
C.P. Taylor
W.E. Hitchcock
J.W.J. Geale
E. Stewart
J. Russell
J. Lehman
E.S. Quaile
R. Quaile
R.J. Quaile
H.P. Collins
J.A. Cox
J.F. Cox
A. Husband
D. Wyllie
D. Duff
M. Sloane
G. Sloane
E.L. Sloane
D. Sloane
J.D. Sloane
S.B. Charleston
W.T. Connell
M.R. Connell
L.D. Connell
T. Woolton
L.G. Stubbs
E. Russell
A. Russell
E.W. Russell
F. Geale
M.E. Geale
A. Hinman
M. Best
M. Clerke
W.E. Robertson
A.R. Robertson
J.H. Carter
G.F. Hitchcock
W.D. Weston
C.F.D. Adam
J. Smith
J.G. Jackson
G.M. Day
W.Y. Smith
J. Jones
E.N. Clarke
J.T. King
M.L. King
H.J. Day
L. Day
M.A. Day
E.L. Hall
T.W. Field
E.L. Field
F. Richards
H. Day
D. Young
E.H. Duff
G.A. Morse
C. Morse
R. Braid
B.L. Thomas
B. Thomas
A.D. Austin
H.B. Austin
M.A. Pinner
S. Pointon
R. Manning
E.A. Solomon
W. Innes
Lot 8578
Lot 7391
NATIONAL BANK OF TASMANIA LIM.
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