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The Scamander Mineral
District

BY

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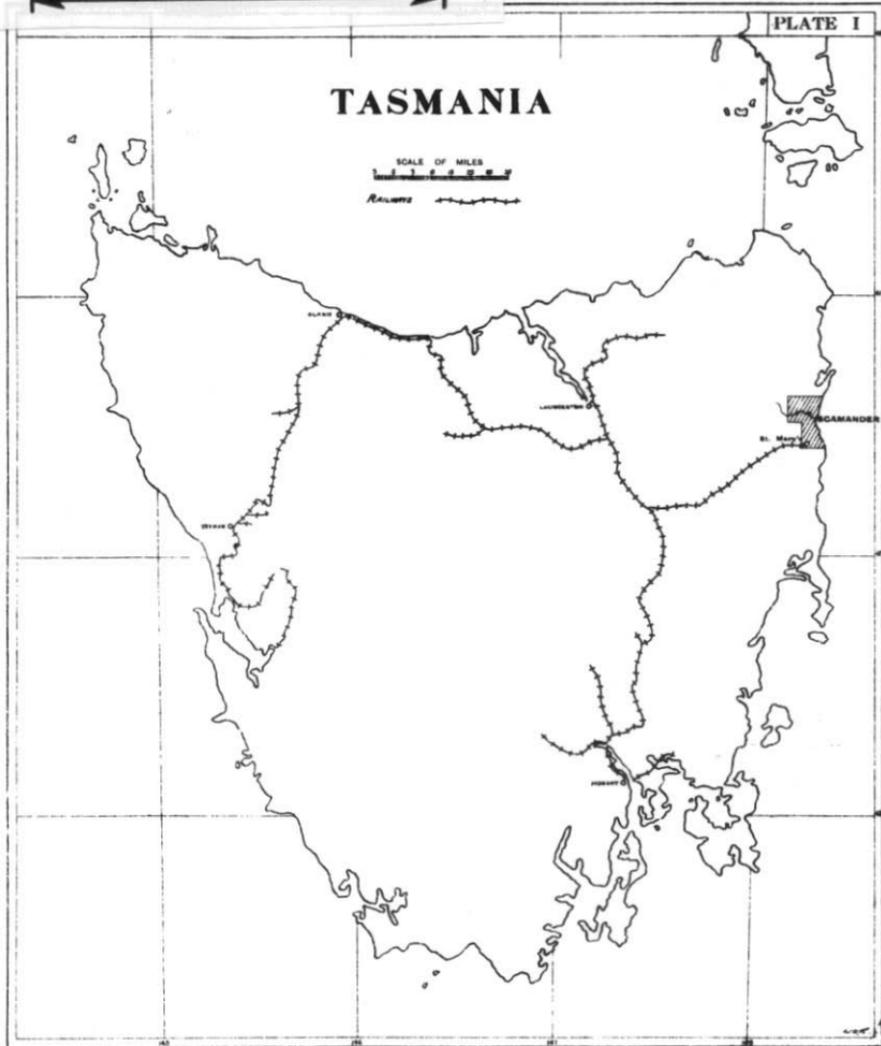
PLATE I

TASMANIA

SCALE OF MILES



Reprints



LOCALITY PLAN

W. H. Tuckwell
GOVERNMENT GEOLOGIST

Photo Allographed by John Veil Government Printer Hobart Tasmania

10 x 130

The Scamander Mineral District.

I.—INTRODUCTION.

DURING the past year some prospecting work in the watershed of the Scamander district was renewed, and an entirely new discovery of tin ore was made, which at one time promised to provide work on a large scale, and bring much capital into the district. Lately the Orieco Company acquired possession of the Great Eastern Proprietary Copper Mine, and after cleaning up the level and raising a little ore, disposed of its rights to a Balfour company, which is prepared to sink and develop the lode below the present workings. West of the field proper, desultory prospecting of wolframite veins has been carried on.

The energetic development of operations at the Great Pyramid Tin Mine drew to the field the attention of investors, impressed visitors greatly, and filled workers with the hope that a large and permanent mine would be opened up. It was recognised that the deposit was one of low-grade ore, but the general opinion seemed to be that a large tonnage would be available for treatment. The hopes of all concerned were, however, dashed to the ground by a sudden cessation of operations, after the receipt of an adverse report from the consulting engineer.

Apart from the direct loss involved in this failure to respond to the anticipations just referred to, a serious result was that prospecting on surrounding sections ceased also.

Mines have now been worked in four parallel belts of country at the Scamander, viz., in the silver-gold granite belt near the mouth of the river, in the copper belt adjoining the preceding on the west, in the cassiterite belt at the Great Pyramid, and in the wolframite belt west of the Pinnacles. It may be mentioned here that in none of these cases have the lodes been fully developed. In the copper belt some payable work was carried on for a time, but afterwards operations were suspended. The silver-gold veins are irregular, and the wolfram deposits bunched and erratic, and exploration has been intermittent. Tin-mining is of recent date, though higher up the Scamander

are some flats which nine years ago were worked for alluvial tin and gold.

The Department of Mines lately considered it desirable that the district should be examined, so as to remove misunderstandings, and to provide reliable information concerning its prospects, as they appear in the light of recent work.

II.—PREVIOUS LITERATURE.

From time to time one part or another of the field has been officially visited. The first visit was paid in 1861, by Mr. Chas. Gould, Government Geologist, who, without reporting on the district, included it in his geological map of Fingal. The last visit was by Mr. G. A. Waller, Assistant Government Geologist, in 1901.

The publications issued by the Government have been:—

1. C. Gould's Map of the Fingal Goldfield and Mt. Nicholas Coalfield, 1861.
2. G. Thureau's Report on the Scamander Silver and Gold Deposits, April, 1886. (Parl. Paper 73.)
3. A. Montgomery's Report on the Silver-bearing Lodes of the Scamander River District, June 22, 1893.
4. J. Harcourt Smith's Report on the Scamander Mining District, May 15, 1897.
5. G. A. Waller's Report on the Mining Districts of the Scamander River and St. Helens, June, 1891.

Each of these reports covers slightly different ground from that comprised in the others, but taken together they may be said to give a comprehensive idea of the old work undertaken in the district.

Mr. Thureau's brief report of 1886 deals exclusively with the Scamander Silver Mine, on the south bank of the river, and principally with the nature of the ores. He identifies these as native silver, silver chloride and bromide, associated with cerussite and free gold. He recommends treatment by calcination, crushing, grinding, and a pan process.

Mr. Montgomery's report of 1893 is principally on the silver lodes, and refers to those on both sides of the river. He is of opinion that the mine on the south side, while it cannot be recommended as a promising venture, is by no means one to be altogether condemned, and quite probably might be a successful undertaking. He considers the veins on the north side of the Scamander as too small to work on a large scale, but the rich ore met with in them makes it probable that if larger bodies occur they will be payable, and therefore they offer inducement for further prospecting.

Mr. Harcourt Smith's report of 1897 describes the work done on the silver sections, and states that the ore-bodies exposed in decayed rock in the mines on the north side of the river are small and patchy, and when the solid granite is reached the mines will not pay unless larger lodes are discovered. He also describes the workings on the Eastern Proprietary property, and concludes that the prospects disclosed are decidedly encouraging.

Mr. G. A. Waller's report of 1901 deals with the mines in the copper and wolfram belts. He refers to the enriched zone existing at the Eastern Proprietary Mine, and regards the probability of striking rich shoots of ore at a greater depth (150 feet below adit level) as very great, and the risk, from an investor's point of view, very small. He is doubtful about the wolframite veins being payable.

III.—PHYSIOGRAPHY.

At St. Marys, 1000 feet above sea-level, a gap through the coastal range, known as St. Mary's Pass, furnishes a passage for a descending road winding its way down to the sea. St. Marys itself is on the watershed, which discharges its drainage into the system of the South Esk; the divide, to the north and east of which streams flow down to Falmouth, is at the head of the pass. The pass affords a pretty drive, the admiration of tourists. To the east of it is St. Patrick's Head, a diabase-crowned peak, rising 2200 feet above the sea, and bearing witness to the extent of depression of the strand-line since the deposition of the Mesozoic sediments which fringe its flanks. The pass debouches on an alluvial plain covering granite bedrock 3 miles from the coast. Through this plain run Fern Tree Glen Creek, Devil's Creek, and Binn's Creek, emptying into the outlet of Henderson's Lagoon, near the little township of Falmouth. Binn's Creek appears to mark the boundary of the granite, which here plunges beneath the slate and sandstone strata of the Scamander field. Henderson's Lagoon (or Broad Water, as it is called locally) is a branching sheet of water 2 miles long, behind the sand dunes of the coast, receiving the drainage of the hills to the west. Into it, also, escapes a good deal of water from the Scamander River, which at one time possibly had its principal mouth at Falmouth. The sea entrance to the lagoon, like the mouth of the Scamander River and of all the creeks along this coast, is blocked by a beach or sand bar, below which the water slowly percolates into the ocean, and behind which considerable damming back of water takes place during a wet period.

An old coast-road runs along the shore-line south of Falmouth, but is available for spring-carts only as far as the Four-mile Creek. If it were opened up and made good for vehicles as far as Seymour, it would form a magnificent drive for tourists. The granite rock shelves flatly into the sea, but the outlines of the various headlands and of the coastal range are picturesque. Fine mountain views are obtainable from Falmouth. Four miles south of Falmouth are some farm buildings, but there does not seem to be much cultivation. The coast-line for the most part consists of grass and rush-covered slopes, fringing the open timber which clothes the hills. Fresh water is scarce,

and this dryness of climate, pleasant enough to visitors, prevents cultivation and retards settlement.

The rocky shoulder of St. Patrick's Head branches into two spurs, which descend to sea-level north and south of the Four-mile Creek valley. A rather curious sight along the coast is the continuous rampart of granite boulders—a veritable sea wall—built by the sea above high-water mark.

Sand dunes line the coast northwards from Falmouth to Diana's Basin, 15 to 20 feet in height. The sand of these ridges is kept in constant movement by the wind, and if the prevailing winds had been easterly instead of westerly and northerly, the dunes would have moved inland appreciably. As it is, a good deal of the surface sand west of the main-road is wind-blown.

The country at the Scamander and to the north shows a low coastal plain covered with beach sands, evidencing a slight recent uplift above sea-level. This gives place a short distance inland to a raised plain 60 to 100 feet above the sea, and preserving on its surface some remains of a Tertiary marine wash. The plain rises gradually to the west, and at from 1 to 2 miles inland meets the base of the coastal range, which has a direction of a few degrees west of north, and the peaks of which rise steeply to 600 and 800 feet above sea-level. The broad valley of the North Arm of the Scamander River bounds this range on the west. A parallel mountain chain, charted as Scamander Tier, exists a mile to the west of the coastal range. Its southern termination abuts abruptly on the Scamander River between the North Arm and Jas. Berwick's farm land. The Orieco Copper lode is in this chain. Still further west, and running in a north-westerly direction, is the irregular range with the tin ore deposits of the Great Pyramid and Pinnacles. The ravines and valleys between the hills are steep-sided, V-shaped, and for the most part dry, though accumulations of stones point to torrential falls of rain. The rain, however, must drain off these steep mountain sides very rapidly. Some of the hills rise to a height of 1000 feet and upwards. The western Pinnacle is 1200 feet above sea-level. The variations of altitude, however, are not great, the general elevation being from 600 to 900 feet, and this feature of surface configuration continues as far south as the northern slopes of the Mt. Nicholas Range. The existence of a former plain, now dissected by innumerable gullies, suggests itself to the physiographer.

The country is well timbered, and being as a rule free from undergrowth is easy to get about in. The timber comprises iron-bark, blue-gum, peppermint, bull-oak, wild cherry, &c.

On the whole, the hill ridges are higher in a westerly direction, though the difference in height between the coastal range and the western hills is slight. It is sufficient, perhaps, to indicate that the surface of erosion is a peneplain, rather than a horizontal plain. The ridges have been created by the corroding and eroding creeks, the valleys of which were formed during a period of uplift in Quaternary times, for they dissect the deposits of Tertiary wash found on the hills.

Prior to this uplift the pre-existing plain had sunk below sea-level, and received its covering of drift. Between the Scamander and Mathinna, and also at St. Marys, the 1000-foot line shows remnants of the Permo-Carboniferous sediments, and this horizon is pretty uniform over the country between Fingal, St. Marys, and Mathinna. Over this area the Permo-Carboniferous and Mesozoic strata once extended. They approach the sea now at St. Patrick's Head and Mt. Elephant to within a distance of 4 miles. They are not folded, and do not plunge at acute angles below any overlying beds. They lie in flat shelves overlooking the Scamander field. The disturbances to which they have been subjected are those of block faulting. The strata continued eastwards over where the sea now rolls, but have disappeared below its waters with the settling of the ocean bed. This fracturing took place in Post-Mesozoic times, and was, perhaps, connected with the breaking up of the supposed Pacifico-Antarctic continent. These stupendous dislocations made themselves felt all round Tasmania, and gave the island its present topography—that of a central plateau, with step fault plains outwards to the coasts.

The outlet for the drainage of a piece of country about 12 miles square is the Scamander River.* It takes its rise in the high ground some miles west of Hogan's Track, and flows south-easterly until it unites with a southern

* "Eskamander," a provincial corruption, is a common expression locally. Scamander is the ancient name of the river in the Plain of Troy which by its floods played an important part in the Trojan war.

"The sacred flood that rolls on golden sands:
Xanthus his name with those of heaven y birth,
But called Scamander by the sons of earth."

— Pope's "Iliad," Book XX.

branch called the Avenue River, about 8 miles from the sea, after which it pursues a more or less easterly meandering course, acquiring an estuarine character as it approaches the coast. In this part of its course it crosses the general trend of the strata, and is nearly at right angles to the direction of the mountain ranges. The sand bar at its mouth is open only a few times during the year, and the tide then flows for about 5 miles up the river. For some time now the closed bar has dammed back the river water, which has risen about 2 feet above the normal level, and caused some of the farm lands to be flooded in places.

The estuary of the Scamander has a fiord-like appearance. Its rocky banks plunge below the water steeply without the formation of shingle or sandy beaches at the edge of the stream. The appearance is that of a submerged valley. The depth of the river for 4 miles up is from 10 to 12 feet, in places 25 feet, and under the bridge about 15 feet, but is shallower in the lagoon behind the bar.

The river is full of fish, principally bream; but sea trout, mullet, perch, rock cod, and at times flathead, are also caught. Mr. J. G. Walker furnished me with the following figures of fish caught by himself and visitors to his hotel:—In 1897, 7409 bream and 738 mixed fish; in 1898, 7711 bream and 461 mixed fish; in 1899, 8353 bream and 36 mixed fish; in 1905-6, 5208 bream; in 1907-8, 8652 bream and 2455 mixed fish; in 1908-9, 8092 bream and 1854 mixed fish; in 1909-10, 7369 bream. If the bar remains closed too long, the water becomes fresh, and the fish lose condition.

I am indebted also to Mr. Walker, who is the meteorological observer at Scamander, for the following rainfall statistics:—

RAINFALL IN INCHES.

		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1901	Inches	2.11	0.09	1.40	2.70	0.08	1.79	0.42	2.01	2.88	2.86	1.12	0.28	17.74
	Wet Days	5	1	6	9	4	11	3	9	12	6	2	3	71
1902	Inches	7.91	1.32	0.77	1.00	0.40	2.70	1.17	2.67	7.19	0.86	0.97	7.26	34.22
	Wet Days	8	5	3	3	4	8	8	8	5	2	4	7	65
1903	Inches	1.02	0.50	3.03	2.41	3.91	4.25	4.61	1.12	2.44	2.90	2.03	1.19	29.41
	Wet Days	2	2	8	6	9	6	10	6	6	7	4	3	69
1904	Inches	5.13	6.28	2.61	1.39	0.94	1.36	0.73	0.28	0.54	0.92	1.21	...	21.39
	Wet Days	9	7	6	5	4	3	4	3	4	3	8	...	56
1905	Inches	3.80	0.39	0.27	3.14	13.09	1.66	1.81	0.44	0.42	3.74	0.15	0.49	29.40
	Wet Days	8	4	2	4	9	3	7	2	6	8	2	2	57
1906	Inches	0.25	1.38	2.37	0.61	1.63	1.12	2.75	1.15	1.20	4.01	4.03	0.79	21.29
	Wet Days	1	2	6	3	4	6	6	7	5	13	7	2	62
1907	Inches	4.03	5.21	3.46	0.38	0.95	1.64	0.91	1.23	1.18	2.27	0.66	3.20	25.12
	Wet Days	7	3	4	3	3	6	7	6	4	7	3	4	57
1908	Inches	1.94	0.38	2.44	0.46	1.70	0.66	0.87	0.66	2.22	1.46	0.58	0.21	13.58
	Wet Days	4	3	5	3	5	7	7	5	6	9	4	4	62
1909	Inches	2.42	1.07	3.07	1.37	2.48	5.37	2.09	2.78	0.77	0.37	0.36	1.12	23.27
	Wet Days	8	5	9	5	8	9	12	9	7	2	4	6	84
1910	Inches	1.90	0.41	1.06	0.80	0.95	4.94	3.88	1.66	3.77
	Wet Days	4	3	6	4	6	13	?	?	10

The humid westerly winds, which are responsible for so much of the rainfall in Tasmania, have parted with a great deal of their moisture before reaching the Scamander district.

Some attempt is being made to cultivate the sandy soil along the coast wherever a little water is available. In general, however, conditions are unfavourable, and settlers will need special inducements. Otherwise, the mild, equable climate, and the health-giving breezes from the Tasman Sea,* invest life here with many enjoyable features.

* The Tasman Sea is that part of the South Pacific Ocean which lies between Tasmania and New Zealand. Tasman in 1642 with his ships Heemskerck and Zeehaen sailed round the Tasmanian coast from Cape Sorell to 24 miles due east of "a high round mountain," which is considered to have been St. Patrick's Head. He then set his course east, and crossed to the West Coast of the South Island of New Zealand, south of Cook's Strait. See "Early Tasmania," by J. B. Walker, p. 207 and p. 231, Hobart, 1902.

IV.—GEOLOGY.

The geological sequence, as shown by the structure of the area under consideration, is not a complicated one, for its interpretation involves only a few systems, viz.:—

1. Ordovician.
2. Tertiary.
3. Quaternary.

Pre-Ordovician rocks have not been observed. The nearest known beds of earlier age are the Pre-Cambrian schists of the Asbestos Range, west of the Tamar. Such rocks as those no doubt furnished the material of which most of the Ordovician strata are composed.

Although the above form the three recognisable systems of sedimentary rocks, igneous intrusions and effusions occurred in the intervals. Thus, during Devonian times, granite and granite porphyry irruptions formed large masses of rock. At the close of the Mesozoic, sills of diabase were intruded in the upper coal measures sandstone at Mt. Nicholas, St. Patrick's Peak, and Mt. Elephant, near St. Marys, and these, with their associated strata, probably extended over the Scamander area, as the edges of the sills, 2000 to 2800 feet above the level of the sea, are exposed in vertical scarps, showing no sign of thinning out.

Near St. Marys, in Gardiner's Creek, is a flow of Tertiary olivine basalt, which has descended the valley from some source not yet established.

These basic igneous rocks are outside the Scamander field, and need not be referred to further.

(1) ORDOVICIAN.

The older sedimentary strata of the Scamander district consist of slate and sandstone, which are practically a part of the Mathinna series, and continue to the north-west through Mt. Victoria to Warrentinna and Gladstone. Southward they extend to the south of the Break of Day Rivulet between Mt. Nicholas and St. Mary's Pass; on this parallel they are cut off by, or sink below, the diabase of the Tiers.

No graptolites or other organic remains have been found in these beds, and the evidence in support of assigning them to the Ordovician system is not altogether conclusive, but lithologically their aspect suggests a greater age than the Silurian. No strata attributable to the Silurian have been observed in this part of the island.

The rocks range from soft drab, greenish grey, and purple and dark slates through argillaceous and indurated sandstones to white quartzite. The soft slate and sandstone rocks are generally micaceous to some extent. The purple slate recalls the variety which is common in the series of strata called Cambro-Ordovician in other parts of the island. The sandstone and quartzite are often short jointed, and the result is an accumulation on the hillsides of angular debris unpleasant to the walker, besides impeding the prospector.

The strata have been folded regionally in large anticlines and synclines, but where the arching is on a minor scale and acute, rupturing has followed. At the bridge at the mouth of the Scamander the strike is from 15° to 17° west of north, and on the east side of the granite belt south of the river N. 25° W., the dip being to the north-east. North of the river, on the back road to St. Helens, the dip continues north-easterly, but the crystalline sandstone (and quartzite) outcropping on the sea beach south of Freshwater Creek shows a south-westerly dip, and the same dip is seen on the beach opposite Paddy (Rabbit) Island, where brown quartzite and dark slate strike N. 40° to 45° W., and dip at a low angle to the south-west.

(2) TERTIARY.

The coastal plain north and south of Yarmouth is strewn with waterworn pebbles, the survivals of a sheet of marine wash. The Tertiary age of this deposit is assumed from the height to which it extends up the flanks of the coastal range, 200 feet above sea-level, and from the fact that the present-day valleys and rivers have cut through it. It was, for instance, certainly once continuous across the present Scamander estuary, and all the steep creeks and gulleys descending from the range have intersected it. It extends for 9 or 10 miles from south to north, and to within $\frac{1}{4}$ -mile of the present sea coast. Though no marine shells are found in the wash, its position points to a marine origin.

(3) QUATERNARY.

This period embraces the time from Pleistocene to Recent. The deposits of this period are the river terraces on the upper Scamander and the sands and sand-dunes of the sea coast. The lagoons and sand-bars at the mouths of the rivers were formed during this time interval. The recent sands rise to 30 or 40 feet above sea-level.

(4) IGNEOUS ROCKS.

There appears to have been no sedimentation in Tasmania during the Devonian period. Terrestrial conditions must have prevailed, leaving behind no trace of the time interval. During this period, however, crustal movements were widespread, accompanied by intrusions and consolidation of the granite-gabbro magma. The great granite masses of the east and north-east coasts were formed at this time, with their related mineral veins.

Between St. Marys and the coast the granite rock (granitite and granitite porphyry) covers an area of 6 miles square, and extends to the north as far as the parallel of Falmouth. A mile south of Yarmouth a narrow tongue of the same rock reappears, and continues northward, forming the axis of the coastal range, eventually connecting with the granite exposures of Diana's Basin and St. Helens. About 6 miles from the coast at the Scamander, on Cato's Rivulet, and further north, is a parallel exposure of granite. Paddy's Island, off the coast towards Diana's Basin, appears to consist of light-yellow muscovite granite, similar to some which outcrops on the beach outside George's Heads.

But few dykes have been observed in this area. A dyke of lamprophyric or dioritic affinities, 25 feet wide, traverses the sedimentary strata on the Great Pyramid Hill in a direction N. 70° E.; and outside George's Heads a plagioclase-augite rock (augite-diorite) intrudes in the granite on the beach.

(a) Granitite and Granitite Porphyry.

The varieties of granite occurring in the district come for the most part under this head, and they are mostly porphyritic. Granitite is distinguished from granite proper by the absence of muscovite (it is a biotite granite),

and an increase in the quantity of plagioclase felspar and ferro-magnesian minerals. The plagioclase, in fact, may increase until a dioritic or quartz-dioritic facies of granite is the result. The rock then becomes difficult to distinguish from the "granodiorite" of American authors, and in such cases its geological occurrence perhaps furnishes the most satisfactory basis for nomenclature, the term "granodiorite" being reserved for the acid modifications of diorite and gabbro, while the pronounced plagioclastic varieties met with in the St. Marys and Scamander area are regarded as basic facies of granite. Victorian geologists, however, would probably call the rock granodiorite porphyry.

The granite at the Scamander is a light-grey rock, even grained to coarsely porphyritic, with biotite and hypersthene as the ferro-magnesian constituents and porphyritic quartz and felspar as the colourless elements. At St. Mary's Pass and along the sea coast south of Fal-mouth it is finer grained, and of a dark-bluish colour, and continues the same porphyritic elements.

The Rosenbuschian definition of granite porphyry implies a rock which has the constitution of granite combined with a structure in which visibly large crystals of felspar (mostly orthoclase) and quartz, accompanied by crystals of the ferro-magnesian minerals (mica, hornblende, pyroxene) are surrounded by a groundmass consisting of quartz and felspar. The porphyritic felspars are mainly orthoclase, but with them are associated in minor proportions felspars of the lime-soda division (oligoclase, andesine, and even labradorite).

Although granite porphyry belongs to the division of dyke rocks, it does not always occur in dyke form. As a marginal modification of granite, it sometimes, as in this district, exists as the marginal part of granite masses.*

At the Scamander the narrow exposure of the granite porphyry on the south side of the river at the old Scamander Silver Mine is certainly suggestive of dyke form, and it has a linear extension, though in a wider belt, on the north side, where it practically forms the axis of the

* The same may be said of quartz porphyry. The apophyses which extend from masses of granite into the surrounding strata occasionally possess the structural characters of quartz porphyry, (Hartz, Norway, &c. See H. Rosenbusch. *Elemente der Gesteinslehre*, 1910, p. 102). The Yass porphyry in New South Wales from Mr. L. F. Harper's description seems to be of this nature. (The Geology of the Murrumbidgee District near Yass, by L. F. Harper. *Rec. Geol. Survey N.S.W.*, Vol. IX., 1909, pp. 32-33.)

Coastal Range. But at points in this area the structure of the rock passes into that of typical granite, so that it seems necessary to regard the porphyry as a facies or border zone of granite.

Petrographical Descriptions of Granitite Porphyry and Granitite.

Rock at Beulah Mine.—Macroscopically it has the appearance of a light-grey medium to fine-grained granite showing glistening crystals of feldspar and quartz, with a plentiful sprinkling of small crystals of dark mica, with some hypersthene.

Under the microscope the porphyritic structure shows itself plainly. The groundmass is a granular mixture of quartz and untwinned feldspar. A second generation of the ferro-magnesian phenocrysts is absent. The porphyritic minerals are plagioclase, quartz, hypersthene, biotite, orthoclase. A striking characteristic is the sparseness of orthoclase phenocrysts. The numerous porphyritic crystals of twinned feldspar, often beautifully zoned, appear to belong to the oligoclase-andesine series. Hypersthene in formless crystals is abundant. Biotite is a normal constituent in imperfect brown crystals subject to frequent flexures, and tending to collect round the borders of the hypersthene. Quartz is present in imperfectly idiomorphic and rounded forms, having the usual fluid cavities.

In connection with this structure the remarks of H. Rosenbusch (*Massige Gesteine*, Vol. I., 1907, p. 95) may be referred to. Speaking of variations of structure in granite, he says:—"The porphyric structure progresses as far as the development of a proper groundmass only in the peripheral parts of granite massifs and in their apophyses, especially in granites which have the form of dykes. Then structural facies of granitic rocks originate, which, according to the particular form of development of the groundmass, are called granite-porphyritic, granophyric, spherulitic facies, &c. Examples of these may be found in most occurrences of granite."

Granitite at Scamander Bell Mine.—In places the granitite porphyry of this belt loses its porphyritic structure and merges into granite. A slide prepared from a specimen taken from one of the granitic kernels at the Scamander Bell Mine shows the rock to be a hornblende-

bearing granite, the structure being hypidiomorphic granular. Orthoclase is here predominant, plagioclase felspar subordinate. Graphic intergrowths of quartz and orthoclase occur. The other essential minerals are biotite and quartz. Pale-green hornblende is an accessory, and its crystals collect readily in nests.

Other Occurrences of Granitite Porphyry.—The rock at George's Bay, St. Helens, has to the naked eye the appearance of a granite, but microscopically is porphyritic. Among the porphyritic felspars, plagioclase predominates. No hypersthene is present, but green hornblende is plentiful—as abundant as the biotite. It contains the usual corroded quartz crystals, and the groundmass is a coarse granular mixture of quartz and untwinned felspar.

Up Cato's Creek, on Ryan's clearing, the granitic rock is hornblende-bearing granitite porphyry, with but little orthoclase; and further west, between Cato's Creek and the Avenue River, is a very pronounced granitite porphyry with a fine-grained groundmass and phenocrysts of plagioclase felspar, biotite, and quartz.

Viewed exclusively from a mineralogical standpoint, these rocks might be held to suggest dioritic affinities, but it must be borne in mind that the massifs on this coast are granite, not diorite.

Granitite Porphyry of St. Mary's Pass.—This is a dark, fine-grained rock, containing sporadic crystals of hypersthene, in addition to the usual phenocrysts of felspar, quartz, and biotite. At some distance down the pass it varies into a paler and coarser variety, similar to the ordinary type met with in the Scamander district. Mr. W. N. Benson, B.Sc., of the Sydney University, has submitted the darker variety to a microscopical examination, and furnishes the following note on same:—

“*Petrographical Description of Rock at St. Mary's Pass,*
by W. N. Benson, B.Sc.

“The rock has, under the microscope, a porphyritic texture, with a fine-grained granulitic groundmass. The phenocrysts are plagioclase, orthoclase, quartz, hypersthene, and biotite. The plagioclase and quartz crystals are occasionally broken into fragments, and the mica flakes may be a little bent. The *plagioclase* is generally fairly idiomorphic, though sometimes slightly corroded.

It is twinned on the albite law always, on the pericline and carlsbad laws less frequently. In composition it approaches acid labradorite, and though frequently zoned, there is not a great difference in composition between successive zones. Such changes are oscillatory, and are not continuous from the centre to the periphery, for several layers of identical composition may be separated by others of different composition. Though generally free from inclusions and quite fresh, a few crystals occur containing (usually centrally) some sericitic mica, and others small fragments of hypersthene, now mostly chlorite, included in an almost poikilitic fashion. The average diameter of a plagioclase phenocryst is about one millimetre, though some are considerably larger. The *orthoclase* is less abundant. It occurs in clear undecomposed grains, rather rounded by corrosion. As a rule, it is free from twinning. Rarely it contains very small zonally-arranged grains of quartz or untwinned plagioclase. It is usually under a millimetre in diameter. *Quartz* occurs in clear grains with very slight optical strain. It is greatly corroded, long pits having been dissolved in them by the molten groundmass. In average size they are a little larger than the plagioclases. *Hypersthene* forms in prismatic crystals about 1.0 m.m. by 5 m.m. in size, and showing the characteristic green to pink pleochroism. Decomposition is commencing along the cleavage and transverse cracks, and along the periphery with the formation of green chlorite and a brownish fibrous amphibole. As a rule the hypersthene is quite uncorroded, but a few crystals have been rather strongly attacked, and considerable chlorite has been formed in these, probably by interaction with the felspar of the groundmass. Hypersthene was the first of the silicate phenocrysts to form. In one instance a prism of hypersthene, now almost completely chloritised, occurs in the centre of a zoned plagioclase. *Biotite* forms irregular or idiomorphic flakes or crystals, usually quite fresh. It is moulded on hypersthene or surrounds magnetite crystals. It contains a number of dark-brown inclusions, some of which prove to be the darkened zones surrounding *zircon* crystals. Zircons also occur sparingly in the groundmass and the phenocrysts. A little *apatite* is also present. The groundmass constitutes about 35 per cent. of the rock. It is composed of granules of quartz and plagioclase, the latter usually untwinned: orthoclase forms the cement holding these together, being the last constituent to crystallise."

The macroscopic appearance of the rock recalls that of some of the acid or intermediate varieties of the charnockite series in the Archæan hypersthene gneiss of India, Mr. Benson's description, however, shows that the resemblance is merely superficial. The dominant felspar in those varieties of the Indian rocks is a potash one (microcline and microperthite). The charnockites, too, are not porphyritic, but panidiomorphic (granulitic) in structure. T. H. Holland remarks* that "the persistent granulitic structure and the almost constant absence of pronounced porphyritic crystals is remarkable for such large masses of igneous rocks."

Microscopic examination shows that the only leading feature common to the Indian and Tasmanian rocks is the presence of a rhombic pyroxene in both. T. H. Holland, the author of the name charnockite, correlates the group with the orthogneisses, and adds that though mineralogically the acid and common intermediate types correspond generally with enstatite granites and pyroxene diorites, charnockite is not a name for any hypersthene granite occurring in other petrographical provinces.†

Occurrences of the charnockite series have also been observed in Scandinavia in association with anorthosites, in Saxony, and Alaska.

But the Tasmanian occurrence shows, perhaps, a closer relationship to some of the few other instances in which a rhombic pyroxene is recorded as appearing in granite. In the Julian Alps and in Sweden accessory bronzite is present in granitite. Rosenbusch sees in these occurrences a tendency to the development of a gabbro facies in the granitite.‡

Mr. L. F. Harper has recently recorded a hypersthene-bearing intrusive quartz porphyry from near Good Hope Public School, New South Wales. The rock is described as follows§:—

"Hypersthene and biotite-bearing quartz-porphyry of a prevailing grey tint. Phenocrysts very numerous, with quartz predominating, and biotite and hypersthene about equal in quantity. Groundmass cryptocrystalline."

* "The Charnockite Series." T. H. Holland, Mem. Geol. Surv. India Vol. XXVIII., p. 244.

† *Ibid.*, p. 131.

‡ "Mikr. Phys. der massigen Gesteine." H. Rosenbusch, 1907, p. 63.

§ Rec. Geol. Surv. N.S.W., Vol. IX., 1909, p. 32.

It would appear that no grounds exist for connecting the Tasmanian rock with any of the hypersthene granites associated with the anorthosites in the charnockite series. Rather may it be regarded as a border facies of the normal granite, in which the basic ferro-magnesian silicates have become concentrated in the part of the rock-mass nearest to its cooling surface. This differentiation of an eruptive magma is illustrated by E. Weinschenk*, who figures the centre of a granite stock as consisting of muscovite-biotite granite, surrounded by successive concentric zones of biotite granite, amphibole granite, diorite, and finally gabbro. Rosenbusch also, in his chapter on the development of facies in granite, refers to numerous instances, showing passages from typical granite to basic diorite and gabbro. These passage rocks comprise amphibole granite, augite-amphibole granite, quartz diorite, augite diorite, and quartziferous augite-biotite gabbro; and he adds that these phenomena are not local, but of general occurrence.

In harmony with this view the hornblende-bearing granitic rock of the Devonian period in Tasmania is usually found situated externally to the biotite granite masses, *e.g.*, at the Scamander, at Lisle, Golconda, Diddleum, Mt. Maurice, &c., in the eastern part of the island; and on the borders of the Meredith Range, in the Heazlewood district; doubtless, also, in other localities not yet examined. The gabbro amphibolite aureole round the granite mass of Heemskirk presents slightly different phenomena, as two intrusive moments are represented there, the earlier gabbroid phase and the somewhat later granitic one.†

A. Lacroix voices the views of the ultra-metamorphic school in his classic bulletin on the granite of the Pyrenees‡ when admitting a progressive basicity of the borders of

* "Grundzüge der Gesteinskunde." E. Weinschenk, 1906, p. 51.

† Prof. Ernst-Carroll many years ago advocated the existence of a genetic relationship between our granite and gabbro. At the time the writer could not assent to this view, but the accumulating evidence led him in his report on the Districts of Beaconsfield and Salisbury, 1903, to suggest a decreasing basicity of the magma as explaining the sequence of peridotite-granite. Mr. L. K. Ward, B.E., in his Geological Survey Bulletin on the Tin-field of North Dundas 1909, pp. 29-32, discusses the relation between the two groups (granite and gabbro), and infers a common origin through the operation of the processes of differentiation. In Bulletin No. 8 on the Zeehan Field, 1910, he lays it down as almost certain that the differentiated products have ascended separately.

‡ "Le Granite des Pyrénées et ses Phénomènes de Contact." A. Lacroix, Paris, 1898.

granite abutting on limestones, ranging from normal hornblende granite through quartz diorite, diorite, hornblende norite to peridotites, he argues that these transformations may possibly be endomorphic phenomena, and due to the assimilation by the granite of the calcareous strata which it has replaced and digested.

This explanation does not appear applicable to the Scamander granite. Various authors have elaborated the hypothesis that large plutonic intrusions have usually worked their way upwards through the superincumbent strata, detaching the rock immediately above in blocks which fall into the rising magma, and either become at once dissolved and incorporated in it, altering its constitution and producing new varieties of igneous rock, or sinking to unknown depths and being assimilated by the fundamental magma. R. A. Daly, in an illuminating paper,* asks, "What becomes of the blocks which sink in the magma? How far will they sink? What is their fate when they come to rest?" He believes that they yield to the solvent power of the magma at great depths, are assimilated, and gradually influence the composition of the magma itself, producing changes which are revealed to us by successive eruptions. He also appeals to the assumed detaching process, or "rifting," as accounting for the sharp granite contacts usually observed, and for the absence of endomorphic phenomena in the peripheral part of the granite. E. Suess, in his last volume,† enunciates definitely the doctrine that batholites are masses which continue down to the "eternal depths," and which have worked their way up to their present position by melting and absorbing the adjacent rock. Harker asks why the magma does not work its way up to the surface.‡ English authors for the most part, while admitting to a certain extent the detaching process, question assimilation unless in abyssal depths. They regard the granite bodies which lie exposed to our view surrounded by sedimentary strata as filling merely laccolitic reservoirs, extremely shallow compared with the profound magma basins with which they are connected, and which alone are looked upon as

* "The Geology of Ascutney Mountain, Vermont." R. A. Daly, United States Geol. Survey Bull. No. 209, Washington, 1903.

† "The Face of the Earth." Vol. IV., 1909, p. 551, *et seq.* E. Suess.

‡ "Natural History of Igneous Rocks." A. Harker, 1909, p. 86.

providing heat sufficient for the melting and assimilation of foundered blocks.*

In the Scamander district the coastal granite contacts with the sedimentary strata are sharply defined, and may be held to indicate intrusion, but not fusion.

It may be added that the phenomena of dykes with acid centres and basic margins which are met with in various countries show that marginal differences in composition cannot always be explained by assimilation.

(b) *Lamprophyric? Dyke Rock.*

The dyke in the No. 1 south low level on the Great Pyramid property is 25 feet wide where passed through in the adit, but has not been seen anywhere at surface. To the naked eye it is a dark-grey, slightly greenish rock, of fine even-grained texture, sprinkled with minute glistening facets of pyroxene, and generally resembling a fine-grained diabase. Little nests of pyrites are scattered through it. In the walls of the adit it shows a concentric parting into hard kernels.

Microscopical examination shows it to be a holocrystalline granular rock consisting of acid or sub-acid plagioclase (with a little orthoclase), monoclinic pyroxene (diopside), and biotite, with numerous needles of apatite (?) and much magnetite.

The twinned feldspars (albite and carlsbad laws) show stout prismatic and lath-shaped sections, with a general divergent arrangement. The twinning is obscured by decomposition, but the extinction angles are low. Augite occurs in small prisms and grains (diopside?), dirty with chlorite decomposition. Biotite is abundant in small irregular forms of pale-brown colour, masked by iron oxide. Magnetite plentiful in quadratic sections. Decomposition products: chlorite, serpentine, calcite.

* For an Australian view see a paper by E. C. Andrews, Rec. Geol. Surv., New South Wales, Vol. VIII., 1907, Part III., on the Geology of the New England Plateau.

A very definite opinion, adverse to the idea that batholiths are of laccolitic nature, is expressed by J. Barrell in his Geology of the Maryville Mining District, Montana, 1907 (United States Geological Survey, Professional Paper No. 57), p. 168. He says: "The universal absence of the exposure of bottoms to the larger batholiths may be taken as evidence that in all probability no bottoms exist in this class of invasions, but that on the contrary they extend downward into depths never reached by erosion, and possibly maintain throughout equal if not larger horizontal dimensions

If the rock is a member of the lamprophyre family it is abnormal, in that magnetite is so abundant, primary quartz present in fair quantity, and the general structure shown by the arrangement of the feldspars tending towards the diabase type. But the ferromagnesian elements show non-diabasic affinities. It seems nearer to the augite-kersantites than any other group.

(c) *Aplite.*

This is a fine-grained pink variety of granitoid rock met with between Cato's Creek and Avenue River. It is substantially a panidiomorphic granular mixture of quartz, orthoclase, and micropertthitic feldspars, with a minor quantity of plagioclase. A few aggregations of flaky biotite are present. The aplite is on the western side of the Cato's Creek hornblende granitite porphyry, but the exact relations of the exposure are not known. The general aspect of the rock on this hill is favourable for the occurrence of tin ore.

V.—ECONOMIC GEOLOGY.

METALLOGENIC EPOCHS.

In harmony with what has been noticed in other countries* observation reveals the fact that the occurrences of ore in Tasmania have been intimately associated with great periods of crustal movement and igneous activity. But at the same time ore-deposition does not seem to accompany igneous developments unless these are related to orogenic processes. The basaltic lavas and diabase intrusions of Post-Jurassic age appear to be entirely unrelated to ore-deposition.

In the tectonics of the island the following great periods of movement can be recognised:—

(1) *Pre-Cambrian*.—The intense folding of the Pre-Cambrian rocks at the close of the Algonkian.

(2) *Pre-Silurian*.—The folding and crushing of slates, breccias, porphyrites, &c., at the close of what is provisionally called the Cambro-Ordovician period.

(3) *Post-Silurian*.—The folding of the Silurian sediments and the intrusion of the gabbro-granite rocks during the Devonian period.

(4) *Post-Jurassic*.—The uplift of the Permo-Carboniferous and Mesozoic strata in connection with intrusions of diabase, followed by fracturing of the coastline as the adjacent oceans settled more deeply into their basins. Minor intrusions of alkaline rocks in the lower Permo-Carboniferous at Port Cygnet are apparently Pre-Jurassic, but this age is not yet absolutely beyond doubt.

(5) *Tertiary*.—The Tertiary oscillations accompanied by the outpouring of basaltic lavas.

Of the above, Nos. 2 and 3 may be described as metallogenic epochs. For the present, the Algonkian (Pre-Cambrian) and the Post-Devonian epochs are ruled out, with the exception of the period of the alkaline intrusions at Port Cygnet, associated with the deposition of gold and auriferous pyrite. The diabase sills and Tertiary lavas are unrelated to rock-folding processes, and their areas are devoid of related ores.

* *Vide* "The Metallogeny of the British Isles." A. M. Finlayson. *Quart. Jour. Geol. Soc.*, Vol. LXVI., 1910, p. 281.

The Pre-Cambrian areas are characterised by sparsely distributed gold, copper, and antimony ores, which at present are interpreted as being connected genetically with the Devonian granite intrusion.

The limestones which succeed the igneous breccias and porphyries do not appear to have been subjected to the action of the intense deforming agencies, which have left their impress on the latter. These igneous rocks belong to a complex of strata, the age of which has not been definitely settled yet, but which is apparently to be placed somewhere in the interval between the Cambrian and Silurian, if not at the base of the Silurian itself. Provisionally, they are referred to under the title of Cambro-Ordovician, always, however, with the reservation that their exact age is uncertain. They are developed along the West Coast Range at Darwin, Lyell, Mts. Read, Murchison, and Farrell, Dundas, Zeehan, Bischoff, Dial Range, Middlesex, &c. They were evidently affected by crustal disturbance prior to the middle Silurian.

Some of their lead, zinc, copper, and iron ores may be authigenic, while others possibly belong to the subsequent granite period.

The folding of the Silurian strata and the intrusions of granite occurred at the close of the Silurian period or during the Devonian. With the relief of crustal stress great movements of the igneous magma took place, transporting dissolved metals, tin, tungsten, copper, lead, zinc, gold, and silver, from their magmatic hearth along channels in the surrounding rocks, where under the changed conditions of temperature and pressure they were deposited in accordance with their several physical properties at increasing distances from their source. Thus the crustal or sub-crustal stresses may be said to have conditioned the intrusion of the mobile magma, and the consequent deposition of metallic ores.

The tin ores throughout Tasmania, most of the galena, copper, zinc, and iron ores belong to this period. The gold of the gold quartz veins also pertains to it.

Metalliferous veins later than this period are confined to the isolated occurrences at Port Cygnet and on the shores of D'Entrecasteaux Channel, where intrusive alkaline rocks have penetrated Permo-Carboniferous beds, impregnating them with gold at their contacts. These intrusions are probably of Pre-Tertiary age, for they seem to have been intersected by Post-Jurassic diabase. They occur in a region of block-faulting, and do not appear to be con-

nected with folding processes. No attempt has been made so far to work out a scheme of metallogenetic provinces for the whole of Tasmania. This may, however, be expected to be accomplished gradually, as the examination of the island proceeds.

The East Coast metallogenetic province is the expression of the forces comprised under period (3) in the above list. The slate sandstone sediments of the Mathinna-Scamander area were folded during this period and extensively invaded by the granite magma. The metalliferous veins throughout the area belong to the same period, and emanated from the magma of that invasion.

THE ZONAL SEQUENCE OF ORE-DEPOSITION.

The conception of a normal sequence of metals and vein types has won its way in recent years among workers in this department of science. Some of the lode types have yet to find their final position in the theoretical sequence, but certain broad fundamental postulates are agreed upon:—

(1) At the base of the column are the metallic segregations, which have separated out direct from a molten magma. Ex. iron, platinum, nickel, &c.

(2) The above are succeeded by the pneumatolytic ores, the metals of which were extracted and conveyed to their present positions by gaseous or gas-aqueous emanations. Ex. tin, tungsten, and molybdenum ores. These pass over into the next class.

(3) Beyond the region in which the influence of the preceding prevails, the after-eruptive solutions proceeding from the cooling magma migrated along lines of least resistance, either in the already consolidated igneous crust or beyond it in the outlying sedimentary strata, transporting their metallic burden and depositing it at gradually increasing distances from the magmatic source. These are the deposits known as hydatogenetic. The succession of metallic precipitation is fixed by determinant physical conditions which are becoming increasingly subjects of study.

The idea of a normal succession of precipitated minerals at varying distances from their magmatic source, according to their relative solubilities in the cooling solutions was put forward by Mr. G. A. Waller in a report on the Zee-

han Silver-lead Mining Field, published by the Mines Department in 1904.

In 1907 Mr. J. E. Spurr* published a paper on ore-deposition, in which he constructed a scheme of successive vertical zones of deposition. These were in ascending order:—

- (1) The pegmatite zone with tin, molybdenum, tungsten, &c.
- (2) The free gold-auriferous pyrite zone.
- (3) The cupriferous-pyrite zone.
- (4) The galena-blende zone.
- (5) The zone of silver, and also much gold (tellurides, tetrahedrite, stephanite, argentite, &c.).
- (6) The zone of earthy gangues, barren of valuable metals.

In the present year in a Geological Survey Bulletin on the Zeehan mineral field, Mr. L. K. Ward has outlined the vertical succession of metal deposition in the Zeehan-Comstock district, stating a sequence of cassiterite deposits in the granite zone, of iron, galena, blende, and copper in the metamorphic zone, galena and blende with pyritic gangue in the pyritic belt of the trans-metamorphic zone, and finally galena and blende with sideritic gangue and nickel-silver-cobalt in the sideritic belt of the trans-metamorphic zone.

Mr. A. M. Finlayson has recently, in a communication to the Geological Society of London,† deduced the vertical zones of ore-deposition in the British Isles as follows:—

- (1) The deep pneumatolytic zone, with tin, tungsten, &c., and some copper.
- (2) The intermediate zone, with copper, gold, and some lead and zinc.
- (3) The upper zone, containing chiefly lead and zinc.

In attempting to apply the sequence set out in Spurr's and Finlayson's schemes to the Scamander some difficulty presents itself in the interpretation of the silver zone. The ore occurrences are found in three well-marked belts, which embrace the three following divisions:—

- (1) The pneumatolytic group, containing the wolframite veins west of the Great Pyramid, and the

* "A Theory of Ore-deposition." J. E. Spurr. *Economic Geology*, Dec., 1907.

† "The Metallogeny of the British Isles." By A. M. Finlayson, *Quart. Jour. Geol. Soc.*, Vol. LXVI., May, 1910.

veins of tin ore on the Pinnacle and Pyramid Hills. The wolframite occurs both in the western granites and the surrounding sedimentaries. The cassiterite veins so far have only been found in the latter, but with additional prospecting they will be traced back to the granite.

- (2) The sulphidic copper group, comprising the copper ore lodes of the Orieco district. These arsenopyritic veins carry subordinate quantities of lead and zinc sulphides. They occur in the slate and sandstone strata of the Scamander Tier.
- (3) The silver-bearing group of arsenopyrite-quartz veins, carrying minor quantities of lead, zinc, and copper sulphides, with silver and generally traces of gold. High silver assays, due to cerargyrite (silver chloride) are obtained from the weathered parts of the lodes, which are in the granitite and granitite porphyry of the Coastal Range at the Scamander. At the Yarmouth Proprietary Mine, however, they are in the sedimentary strata.

The actual horizon of these silver ore veins in the metallogenetic column must remain doubtful until the metallogeny of the ore veins on the East Coast in general has been more closely studied, and data which are now lacking come to light. They may be more closely allied to the arsenopyritic gold quartz veins than can at present be established.

THE WOLFRAMITE AND CASSITERITE VEINS.

These have hitherto been found only on the north side of the Scamander River, but there is no reason why they should not also be met with on the south side. Between Cato's Rivulet and the Avenue River are exposures of very likely-looking granitic rock, the incipient greisenisation of which is a favourable indication. The quartz veins carrying wolframite in the northern part of this belt traverse both granite and the adjoining sandstone. They frequently contain tourmaline, and a little molybdenite. Veins of a width of a couple of feet are infrequent, and these are always poor in ore. The richest ore has hitherto been met with in the narrow veins or veinlets, but the

uniform experience of prospectors here is that the distribution of the wolframite is exceedingly irregular.

Travelling eastward, the wolfram deposits are replaced by cassiterite veins on the Pinnacle Range and at the Great Pyramid. These occur here exclusively in the slate-sandstone strata, and vary in size from half an inch down to veinlets of microscopic dimensions. They traverse the strata as parallel quartz-cassiterite veinlets, diverging frequently to follow a course parallel with the planes of bedding. At other times the crystals of tin ore have formed in open spaces between the walls of rock-joints. The country on each side of the veinlets is frequently intensely silicified, and the veins traversing it closely in every direction form structurally a typical stockwork on a minute scale. No granite or stanniferous igneous rock is visible anywhere, but its existence in depth below this area is a foregone conclusion. The channels or conduits for the tin ore are the fracture-lines followed by the numerous veinlets. Future search must be in the direction of pursuing these whithersoever they lead. It is quite possible that at a greater depth they may junction with wider joint-channels in which richer concentrations exist; or, on the other hand, floors of barren country may alternate with tin-impregnated rock.

The permanency of tin and wolfram deposits generally is a question of interest to mine-owners. Some authors have feared an impoverishment below a zone of secondary concentration; others, baffled by sudden disappearances of ore, look upon the deposits as superficial phenomena. But tin oxide and wolframite form no secondary ores of any importance. They are chiefly primary deposits, and any changes in depth must be primary. Sudden disappearances are frequently due to diversions along the lines of jointing, leading through a barren block of ground to a recurring metalliferous floor below. Where the veins occur in stratified rocks, they must be assumed to be connected with the underlying granite.

THE COPPER ORE VEINS.

These follow the trend of the sedimentary strata on the Scamander Tier range, east of the Great Pyramid Hill. Both lodes and strata have a north-westerly strike. The strata are not different in nature from those further west, and belong to the same series. But tin ore veins are no

longer met with. Instead, we have a group of parallel arsenopyritic quartz-chalcopyritic lodes occupying narrow fissures, but showing replacement zones of mineralised material on each side of the primary fissures. At the Orieco Mine the lode has been subjected to extensive leaching in its upper parts, and has been worked for secondary ores a little above and down to ground water-level. No further payable ore-shoots have been found on the northward extension of this lode, and the southern extension has not been sufficiently explored to say whether additional shoots exist in that direction, but the outcrop is strong and the outlook is hopeful. At the extreme southern end on the north arm of the Scamander River the dominant minerals in this lode are galena and zinc blende.

Parallel lodes to the east of the Orieco have similar barren outcrops, and have probably been subjected to identical leaching action. Nothing can be urged against the possibility of copper-bearing shoots being met with at water-level.

THE SILVER ORE VEINS.

These veins are in the Coastal Range east of the copper ore belt, and are almost confined to the granite and granite porphyry, which trends parallel with the coast. They appear, however, to pass into the slate and sandstone belt which fringes the granite on the east, *e.g.*, at the Yarmouth Proprietary.

They appear to belong to the arsenopyritic silver quartz veins. When they contain gold in addition to silver, there is some difficulty in distinguishing this vein group from that of arsenopyritic gold quartz veins. More or less galena and blende, with a little chalcopyrite, are present.

In the Scamander Silver Mine two kinds of ore occur, *viz.*, clean quartz and arsenopyrite, poor in silver as a rule, but reputed to carry rich argentiferous patches, and a second variety consisting of mixed sulphides with fair silver contents. Gold has only been detected as traces.

At the Scamander Bell and Beulah Mines the lodes are quartz-arsenopyrite, with silver chloride in cavities in the quartz, and some gold is said to have been obtained by assay from the arsenopyrite (which is also argentiferous).

Further north, at the Yarmouth Proprietary, similar lodes exist in the sedimentary rocks.

It is difficult to form an opinion as to how these lodes will be found to behave in depth. The probability is that

in descending the principal valuable element will be found to be gold.

J. M. Maclaren, in his important work on gold, connects the goldfields of eastern Australia and Tasmania with granitoid rocks of the type represented by the Tasmanian granitite facies (granodiorite of Australian authors).^{*} In Eastern Tasmania the gold occurrences which are related to igneous intrusions visible at surface follow a line from Camden Plains across St. Patrick's River to Lisle and Golconda, along which at intervals are outcrops of hornblende-bearing granitite, from which tin ore is absent. The granite at the New Carthage Gold Mine, between Scamander and Mathinna, is also a non-stanniferous granitite. So far as observation has gone, the presence of hornblende in the granitoid rock may be taken as a warning that tin ore need not be looked for. The occurrence of gold and silver-bearing veins is, however, indicated.

The gold reefs of Mathinna are unaccompanied by exposures of any igneous rock. They traverse the Ordovician? sedimentaries which lie between the stanniferous granite of Ben Lomond and the auriferous granitite belt of the New Carthage and other gold mines on Hogan's track. The sulphidic gold-quartz veins which have made that field famous are probably related to the New Carthage eruptive.

The galena-blende ores of the West Coast are not represented on the East Coast. Where these minerals are present in the east part of the island, they appear to be accessory components of gold, silver, and copper ore veins, or to occur in tin ore formations (*e.g.*, Rex Hill).

* "The great chain of important goldfields developed along the Eastern Cordilleras of Australia—to use the term proposed many years ago by Murchison for this mountain range—are apparently all to be assigned to strongly developed igneous intrusions of a general granodioritic facies. . . The rocks and veins of Tasmania must be grouped with those of the mainland, since that island has only very recently been separated from Australia."—"Gold: Its Geological Occurrence and Geographical Distribution." J. M. Maclaren, 1908, p. 70.

VI.—MINING PROPERTIES.

The ore-deposits are zonally disposed, with reference to the granite range situated 7 miles from the coast. The wolframite veins are situated both in this granite and the sedimentary strata adjoining it on the east. About 2 miles east is the Great Pyramid Tin Mine, and the whole of this belt may be referred to the tin-tungsten zone. East of this is the zone of copper ore veins. This zone contains the Orieco lode and parallel veins, and comprises the range forming the Scamander Tier. The silver ore-bearing lodes are those of mines situated in the coastal zone, chiefly in granitic porphyry. The ore-deposits in these three zones preserve distinctive characters, but all no doubt owe their origin to the magma of the western granite.

(1) WOLFRAMITE DEPOSITS.

North-west of the Great Pyramid property, and north of several sections charted in the name of S. P. Crisp, lodes of quartz which carry wolframite begin to be frequent. The westerly sections of Crisp appear to be in this belt, while the easterly ones are in the Pinnacle tin belt, but no work is being done on the property, and no local information is available respecting it. Indurated sandstone and slate country striking north-west and dipping north-east continues west of the Pinnacle for about a mile or more, when normal grey granite, with occasional greisenised bands, comes in. Wolframite veins occur in both granite and the adjoining sedimentary strata.

On Section 4025-M, 40 acres, in the name of R. F. Purdue* (formerly belonging to Isaac Jacobs) are several small veins in which a little wolframite and molybdenite may be seen. A number of open-cuts have been made at several points on the northern slope of the spur which descends from the Pinnacle, and several ore-bearing veins have been exposed. The veins have a general north-easterly—south-westerly bearing, and vary in width from an inch or two up to over a foot of quartz, carrying veinlets and bands of wolfram ore. Nothing payable seems to have been discovered, and the work done so far has only served to show a very irregular distribution of ore.

* For these wolfram sections see Scamander Mineral Chart issued by the Department of Mines.

On Section 4695-m, 40 acres, situate north of the preceding, and which formerly belonged to the Carson De Beers Wolfram Company, several parallel veins have been discovered, mostly striking a few degrees north of east. Some of these attain a width of one or two feet, and a few bags of wolfram ore were formerly raised and sent away. The country here is crossed by the lodes, which are composed of quartz carrying a little tourmaline. The lodes seem strongly developed, but the ore is evidently extremely patchy. Some underground work has been carried on, but with the small and irregular bunches met with no remunerative results have been obtained. The present high market prices* led to some recent prospecting of these deposits, but it has been since abandoned. In addition to the sporadic nature of the ore-deposition the situation of the property is unfavourable for cheap transport of the ore to the shipping port (St. Helens).

Further west, in granite country, not far from the junction with the quartzite and sandstone, wolfram lodes have also been opened upon. Some of these are from a foot to 2 feet wide, but the widest veins contain the least ore. Tourmaline is a frequent associate, and the country granite is frequently greisenised and traversed by soft felspathic bands. The tourmaline is present both in the quartz veins and in the granite itself. Wolfram is sparsely distributed in the quartz lodes and veinlets in unpayable quantities.

(2) TIN ORE MINES.

Great Pyramid Tin Mines, No Liability.

Sections 4011-m, 80 acres; 4015-m, 80 acres; 4138-m, 20 acres; 4101-m; 40 acres; 4057-m, 80 acres; 4115-m, 54 acres; 4045-m, 80 acres; 4024-m, 80 acres.

The company took up these sections last year, and carried out a prospecting scheme, by means of which it was anticipated that a large tin mine would be opened up. Some of the statements circulated by visitors and others were decidedly extravagant, and rested on no proper basis. As the work of testing the property proceeded, it became apparent that the expectations of the over-sanguine promoters would not be realised, and work was finally abandoned at the end of last year.

* The present local quotation for wolfram ore, 70%_{or}, is 32s. per unit, equal to £112 per ton.

Numerous pits were sunk and adits driven. Nevertheless, the work of proving the property can hardly be said to have been carried to a final and decisive conclusion. However, the promoters learned sufficient to be convinced that the ore was not present in the enormous quantities necessary to realise their expectations; their funds also were exhausted, and work ceased quite suddenly, causing widespread disappointment. As is usual in such cases, the technical advisers and managers of the company came in for much blame at the hands of the public. With this, however, the present report has nothing to do.

The approach to the mine may be made by the cart-road from the Scamander, 6 miles up the river along the south bank as far as Jas. Berwick's farm, where travellers can cross to the north side of the stream either by the ford or a suspension bridge.

About $\frac{1}{2}$ -mile north of the ford, on W. Ligger's 100 acres (since purchased by the Pyramid Company), is the camp, where the mine offices and dwelling-houses were erected on the flat, timbered ancient river terrace ground which fringes the base of the hills. The mine works are situate on the upper part of the Pyramid Hill, $\frac{3}{4}$ -mile to the north-west. The summit of this hill is 700 feet above sea-level. The longest diameter of the apex is in a N.W.-S.E. direction, and on the level summit four pits or shafts have been sunk. One of these (No. 3) occupies a central position a little west of an excavation from which the company's samples assayed 0.14 per cent. metallic tin. This pit is down about 40 feet in quartzite, and some tin-bearing stone has been turned out from it, but the company's assays of it show a falling off in metallic value from 0.48 per cent. at surface to 0.15 per cent. at the bottom.*

No. 2 shaft, east of the above, about 30 feet deep, was sunk in stone, which also diminished in quality from 0.17 per cent. to 0.11 per cent. This shaft is about 60 feet west of a surface excavation, from which stone was obtained containing 6.37 per cent. metallic tin.

One hundred feet south-east, in the same zone of country, No. 1 shaft was sunk about 70 feet, the stone improving from 0.14 per cent. at top to 0.60 per cent. at bottom.

* I may here mention that, as can be seen by the plan annexed to this report, the company's samplings and assays have been systematic and comprehensive. The assays were made at the Mt. Bischoff Smelting Works, and the results may be accepted as trustworthy exponents of the value of the samples treated. With the method of sampling adopted, however, completely representative results would not be obtained in cases in which the veinlets have a direction parallel with that of the adits.

Below the brow of the hill along its western side, trenches have been cut, exposing tin-bearing quartzite, yielding an average assay of 1.72 per cent. Some of these excavations have returned 1 per cent., 1.31 per cent., 1.7 per cent., 4.9 per cent., 6.37 per cent.

At the northern end of the hill a trench has been cut which yielded stone averaging 0.96 per cent., and it was thought that a shaft close to this would intersect good values. No. 6 shaft was accordingly put down, but the quartzite rock returned only an assay value of 0.07 per cent.

I have not been able to procure any record of the work done at No. 4 shaft on the north-western corner of the summit. It is not far ahead of E tunnel end, which is unpayable.

No. 5 shaft, on the northern end of the summit, was sunk to 50 feet in quartzite, when a faulted slate contact was met with. No payable stone was passed through, though the ground was tin-bearing all the way down. The lowest value was 0.04 per cent., and the highest 0.20 per cent., but at the surface there are samples of fair-looking stone from this shaft.

Nature of Ore.—The tin ore of the Great Pyramid deposits is cassiterite, usually well crystallised, sometimes coarsely so, in simple crystals of square prism habit, or often in other extremely minute forms. The general colour of the mineral is brown to nearly black, but is occasionally ruby red. The large crystals common in granitic and pegmatitic lodes are absent.

When any gangue mineral is present it is quartz. Some pyrite occurs occasionally, and its decomposition has probably produced the iron oxide which stains the rock in the neighbourhood of the veins. A little chalcopyrite has been detected, and also some magnetite. No tourmaline occurs. In the wider veins there is sometimes a little crustification of the quartz, and a tendency to greisenisation is frequent. Minute veinlets of cassiterite unaccompanied by quartz are plentiful. These often are distributed irregularly through the silicified rock in a branching form presenting the appearance of a stockwork on a small scale. The rock traversed by the ore veinlets has undergone various degrees of silicification. The outlines of the quartz grains in the original sandstone can usually be seen, but are obliterated as the silicification proceeds until the rock becomes definitely a quartzite. Cubical cavities occasionally occur in the rock, undoubtedly occupied at one time

by pyrite, though this mineral is an infrequent one in the veins. Gold has been obtained by assay from some of the loose tin-bearing stone on the Pinnacle Hill, but my samples, though assaying 15.5 per cent. tin, did not yield more than a trace of the precious metal, according to Mr. W. F. Ward, Government Analyst. Stone from the Pyramid Hill assaying 14.6 per cent. tin yielded no gold.

Underground Mining Work.—In order to understand the aims of the various tunnels, a conception must be gained of how the ore-body appeared to the company's advisers.

Mr. Chas. Chesshire was the discoverer of tin here about two years ago. He first obtained tin ore from the wash in the creek at the foot of the hill, and concluded that there must be a vein formation higher up the hill. He then put in some surface trenches near the summit on the east side, and prospects from these confirmed his anticipations. The company which was subsequently formed took in hand the matter of prospecting the property.

The Pyramid Hill was found to consist of alternating bands of indurated sandstone or quartzite and slate, the direction of which is approximately N.W.-S.E. On the eastern side of the hill the dominant dip or underlay of these strata is to the north-east, and on the western side the prevailing dip is to the south-west. A natural supposition was that the beds on both sides were legs of an anticlinal arch, and that the strata on one flank were continuations of those on the other. This conclusion may or may not be correct. I think it more probable that we have here no continuous arching, but rather a rupture of folded strata, which when ruptured were disturbed and rendered discontinuous.

A series of adit levels has been driven into the hill on each side at from 90 to 130 feet below the summit, and a lower series between the 200 and 300 feet levels.

North Adit.—Dealing with the upper series first, the most important adit on the east side is the north adit, driven 300 feet in a southerly direction across the southern end of the hill at 80 feet below the summit. This adit has been designed to intersect the line trenched on the east side of the hill. It has passed through the continuations of most of the strata forming the apex of the hill, and has also passed through the anticlinal line, for the strata towards the end of the drive dip south-west, while those nearer the entrance are either vertical or dip north-east. For the first 50 feet from the mouth of adit the

sandstone and slate contain a third of 1 per cent. tin, and then a band of quartzite is passed through in the drive for 25 feet, assaying 0.80 per cent. This band has been driven through at right angles to its direction. The rock in the crosscut is rather massive, and looks kindly for ore, being micaceous near the end. The 30 feet driven average nearly 2 per cent. tin by assay, but this is made up by a 10-foot band in the centre, assaying 2.95 per cent., while the stone in the face has fallen off to about $\frac{1}{2}$ per cent. This irregularity of metallic contents is the great drawback in the Pyramid proposition. However, this locality is one of the best on the property, the 6 per cent. outcrop being only 25 feet west of the end of the crosscut.

The 1 per cent. assays of stone west of the adit past this crosscut in a southerly direction were not realised as the adit progressed, though the good stone at surface continues to the east of the adit. Underground, however, nothing like this value prevails, and the tin contents diminish gradually towards the end. For 100 feet behind the end the rock has only yielded traces of tin. The end is in grey and reddish quartzite and slate, and shows a very little tin ore.

This adit is of great informative value. It illustrates the extreme irregularity of the ore-deposition, and shows also that payable bands of stone exist. At the same time it indicates a very important fact, namely, that the trend of these bands is not identical with that of the laminations of stratification. The veinlets of tin ore in the Pyramid occurrence appear to course at a right-angle to the lines of stratification, to follow, in fact, joint-planes, rather than bedding-planes, although they do diverge along the latter also. The principal direction of the veins is therefore north-easterly. In this connection it may be noted that the general direction of most of the adits driven is north-easterly and south-westerly. This will be referred to later. The position of the adit at the east end of the hill crown is an excellent one from a prospecting point of view if it was designed to test the continuations of the strata forming the crown and northern flank of the mount. It appears to have fairly established the fact that these continuations are, with one notable exception, unremunerative.

E Adit.—At the west end of the hill, on Section 4011, and only a few feet below the level of the north adit, the E adit has been driven for 230 feet in a south-easterly direction. The major part of the drive is across the

beds which form the north-eastern leg of the anticline, but towards the end it passes through to the beds dipping south-westerly. Its direction is nearly that of the normal strike of the strata, and this, combined with the presence of flat joint-floors and somewhat massive bedding, tends to make observations of strike underground difficult, and not altogether reliable. The strata are slate and quartzite of chocolate and pink tints. Towards the end of the adit are a few seams of kaolin. The face shows flat heads and cross joints in the pinkish quartzite, and carries a little fine tin ore, but the tunnel throughout is dry and uniformly unpayable.

B Adit.—As an exploring tunnel the E adit is suitably placed for advancing into the ground round No. 4 shaft, and could be connected with B adit, a drive carried north-east for 200 feet into the hill further south, which, however, has only yielded traces of tin. The ground on the west flank of the summit has been tested very little, and the work of proving, to be complete, should embrace it. Between the end of B adit and the end of the north adit the ground is quite unknown.

The B adit first passes through massively-bedded quartzite, striking north-west and dipping south-west, which is succeeded by slate, and sandstone and slate, and in the face is pink quartzite with oxide of iron. Only traces of tin were obtained in this adit.

A Adit.—A tunnel 160 feet long, driven at the south end of the hill in a north-easterly direction across the western leg of the anticline at 130 feet below the summit. The strata passed through consist of slate with bars of quartzite. The strata become vertical towards the end of the drive, and the face is in quartzite. Only a trace of tin has been obtained. The tunnel passes through the southern continuation of the poor ground intersected by the last part of the north adit.

C Adit.—This is an important tunnel on the west side of the hill, a little lower than the north adit on the east side. It has been driven 220 feet in a north-easterly direction, consequently across the trend of the strata.

South of the approach the outcropping strata have been sampled for 100 feet in length, showing a tin content of $\frac{3}{4}$ per cent. These strata continue north-west, perhaps a little below the mouth of C tunnel.

At a little distance in, tin-bearing quartzite is passed through for 130 feet, yielding occasional assays of nearly

1 per cent., and in the last 30 feet of the band 1 per cent. After this, unpayable rock continues to the end. In this adit the direction of veins of tin along the cross-joints of the rock and parallel with the adit may be observed. It would be interesting, and probably useful, to open out from the tunnel where the 1 per cent. band occurs, and define the contour of the deposits.

This adit and the north adit and No. 2 low adit (south) are the only tunnels in which payable stone has been met with, and the idea appears to have occurred that the line of ore occurrences on the east side of the summit will be found to have a corresponding extension on the west side. It seemed, then, to follow as a consequence that ore would be met with on each side, descending with the strata forming the legs of the anticlinal fold. A set of lower adits all round the hill was designed to prove the descending strata.

The following remarks on the lower adits will show how far the work realised expectations. If the result has proved disappointing, we shall do well to withhold criticism, and to remember that it is easy to be wise after the event. The problem was admittedly a puzzling one.

No. 1 Low Adit North.—This has been driven on the north-east side of the hill, at about 200 feet below the summit, and in a south-westerly direction, for a distance of nearly 300 feet. Its object has evidently been to intersect in depth the northerly extension of the payable band in the north adit. It has been driven through unfavourable-looking slate and quartzite, with a low and quite unpayable tin content. The distance between the end of this adit and the tin-bearing stone in the north adit is not more than 150 feet, yet the strata in that part of the low adit, which might be expected to correspond with the north adit quartzite, contains only from a trace to 0.20 per cent. tin. This adit, if extended, would pass below ground in which shallow assays at surface returned as high as 4.9 per cent.

It is the only adit in which pyrite has been found. It occurs as a vein of crystalline pyrite associated with vein quartz.

No. 2 Low Adit North.—This is a parallel level to No. 1, and at the same level, south of the upper north adit. It has been driven 240 feet also in a south-westerly direction with a view of cutting the deep southerly extension of the stanniferous band in the latter adit. But the strata

intersected have been poor in tin. The good-quality beds in the north adit contain here only from 0.04 to 0.14 per cent. The horizontal distance between the two levels is only 120 feet. This constant failure to find stanniferous extensions along the lines of stratification tends to throw doubt on any theory which is based on ore-deposition being governed by the direction of these lines.

No. 3 Low Adit North.—This adit is at the north end of the hill, about 250 feet below the summit. It has been driven west for 100 feet, and then south for 160 feet. The first part was in slate, but towards the end it passed into quartzite. The face is in quartzite in hard flat floors. The rock is more silicified in this tunnel than in any of the others. On the stratification theory this adit should have intersected the ore of the north adit quartzite. A little coarse tin occurs at a little distance in, but the tunnel all through is in stone of low value, and quite unpayable.

No. 1 Low Adit South.—At about the same level as the preceding this adit has been driven first 200 feet in a northerly direction and then 120 feet in a north-easterly direction on the western flank of the hill. The intention apparently was to drive beneath some lines of trenches, which returned assay values of 0.27 per cent., 0.38 per cent., 0.45 per cent. The values passed through, however, were much lower. The strata intersected are, for the most part regularly bedded quartzite. Some felspathic sandstone occurs, with coarse tin facings.

The only occurrence of an igneous rock on the property is met with in this level at a chain from the entrance. A dark pyroxene felspar rock, apparently related to the lamprophyre family, in the form of a dyke, crosses the adit with a strike of N. 65° E., and dipping north-west. It is a finely crystalline, tough rock, with a little sparsely scattered pyrite, but containing no tin, and unrelated to the deposition of tin ore. Its width is 25 feet where passed through obliquely in the adit. It shows concentric structure, parting in large kernels. On the south side the adjacent strata are broken. The relations of this rock are probably with the hornblende-bearing granite of the coast rather than with the more acid granite of the tin-fields; and if so, its intrusion here may have occurred prior to the introduction of the stanniferous veins, and while disturbing the country-rock would have no effect on the distribution of the ore. As set forth earlier in this report

there is reason to believe that the coastal granite consolidated prior to the granite of the tinfields, and assuming the lamprophyre to be related to the former, it is probable that its intrusion antedated the tin granites.

The dyke has not been traced beyond its exposure in the tunnel, but from its direction it will be found to cross the southern end of the hill. The ground south of its line appears to be much less favourable for tin than north of it, but it is hardly likely that its displacing power was sufficient to exert any general effect on the strata composing the hill, and the difference in the character of the beds must be attributed to some other cause. Such narrow, well-defined dyke intrusions usually affect the intruded strata very little. A sample of the rock, assayed by the Government Analyst, yielded no trace of either gold or tin.

No. 2 Low Adit South.—This is a parallel adit to the previous one, and a little further north. It has been driven north of east for 280 feet, with the intention probably of getting below the 1 per cent. band of quartzite in the C tunnel. It will, however, require extending a considerable distance yet before reaching that point. At about 100 feet in a break occurs, crossing the drive in an easterly direction, and filled with pug, carrying quartz, and assaying for 10 feet 1·7 per cent. tin. The strata passed through are slate and quartzite, regularly bedded and containing seams of favourable-looking kaolin. The ground ahead of this tunnel is favourable. At 150 feet in the adit there is a 10-foot band of rock, assaying 0·83 per cent., and at 170 feet another band assaying 0·71 per cent.

No. 3 Low Adit South.—This is situate 5 chains east of No. 1, and has been driven 140 feet north-east, presumably to pick up the continuation of the stanniferous quartzite in Adit C. The beds in this adit have an unusual easterly strike, and dip to the south. They lie rather flat at the entrance, but a little way in are faulted against steeply inclined strata. The tin content of the stone is trifling (0·06 to 0·19 per cent.).

D Adit.—This is about 5 chains west of C, and has been driven 50 feet in a north-easterly direction across almost barren slate, underlying south-west.

Magazine Adit.—About 10 chains south-east of A adit is a short drive, which was used as a magazine for explosives. It has been driven N. 15° W. for about 170 feet in

purplish or chocolate-coloured slate, which dips towards the west. In the slate are bands of quartzite, increasing in number towards the end of the drive. The face is in dense grey or slightly pinkish barren quartzite, and behind the end is a flat seam of iron oxide. This drive bears the name of the copper tunnel, as it was started to search for that metal several years ago.

Alluvial.—The bed of the little creek at the foot of the Pyramid Hill is almost dry in the summer months, but some good tin ore can be washed from its sand. The ore has been derived from variously situated sources on the slope of the hill. The alluvial terrace on the flat has not been tested. It no doubt contains some ore, but this is probably too widely distributed for the ground to be of value.

The results of the above development work have been highly unsatisfactory. Yet, certainly in two adits, and perhaps in three, something seems to have been struck which is worth developing.

One thing has been established by the work done, and that is that ore-deposition along the strike of the strata has not been continuous. It may be that the ore-shoots which traverse the strata at right angles to the strike are short also. Whether they are so in reality or not has not been proved, except, perhaps, in the E tunnel, which is driven in the right direction for this purpose. The results here are unfavourable also, so whichever hypothesis is adopted, the outlook is not promising as regards horizontal extension of workable ground, unless the work already done happens to have missed the channels of deposition. The passage of the veinlets of quartz and ore across the bedding-planes denotes fracturing in that direction, and the fracture-planes supplied channels for the movement of ore solutions along them. These solutions evidently diverged for certain distances along the bedding-planes also, which afforded channels of somewhat greater width than those of the minute cross-fractures. Thus the deposit has a compound structure, following both fissures and laminations, the latter channels being fed from the former.

There is no granitic or quartz-porphry on the property, nor any other eruptive rock which can be connected with the origin of the ore, but the wolfram-bearing granite lies only 2 miles to the west, and it is impossible to determine at what depth granite may exist below the mine itself.

It is well known that tin-ore deposits have their home not only in the peripheral parts of granite masses, but also

in the outlying mantle of rock which surrounds these Extrusions from the granite, whether in the form of quartz or granite porphyry dykes, or quartz veins, sometimes carry tin away from the eruptive massif, even beyond the contact-metamorphic zone, miles distant from the parent mass. The Pyramid Hill, however, is situated in an area nowhere distant from granite ranges, either north, south, east, or west, and the same rock must pass at some distance below the present surface. The reason why tin is now present there is not because it was brought from outside the area along the bedding-planes of the country, but because it ascended vertically through minute fissures at certain points in the area occupied by the present hill. These points require proving in depth. The company would probably have done this but for the early exhaustion of its spending powers. A good deal of useful work can also be effected by crosscuts from the present levels. The ground south of the C adit is apparently a centre of ore-deposition, and is virgin ground; so is the ground west of the entrance of the north adit. Facilities for exploring these areas already exist. The former can be prospected by continuing No. 1 or No. 2 South low adit and the latter from a continuation of No. 1 North low adit.

It is difficult to form an opinion at the present stage of the work as to whether the north adit and C adit deposits occur in one and the same channel or not. But it is highly improbable that they ever formed a continuous layer following the roll of the strata over the crown of the hill, ascending with the sedimentary beds on one side and descending on the other. The beds were already folded prior to the introduction of the magmatic metalliferous gases. These emanations mounted in ascending fractures, but it is not easy to conceive the descent which the hypothesis alluded to postulates. The fractures are independent of the bedding laminations, and evidently follow a general east and west or north-easterly course.

Some interest has been considered as attaching to the question whether the source of the ore is to be found in the centre of the hill. There is, however, nothing visible which can be adduced in support of the idea that a pipe of ore or a concentrated stockwork situated in the centre has fed the peripheral parts. The fractured country, no doubt, persists through the hill from one side to the other. Whether the ore also persists continuously depends most likely to a great extent on the nature of the strata. The

sandstone (quartzite) beds seem to be more favourable than the slate; probably they were more porous and permeable than the clay slate, hence the difference in tin contents is very marked on passing from one to the other. The ore, in a way characteristic of deposits of pneumatolytic origin, has filled multitudinous fractures, and has been disseminated in the country-rock in the immediate vicinity of these. Consequently, its distribution is more or less regulated by the character of the fractures and by the suitability of the country-rock to the processes of impregnation. The shallow shafts which have been sunk on the summit of the hill do not give any indication of payable deposits near the surface there, and this in view of the good stone exposed in the trenches on the east side of the hill is disappointing, and must have been unexpected. But the irregular way which tin has of following joint-planes and floors may help to explain its seemingly erratic distribution here.

Pinnacle.—About $1\frac{1}{4}$ mile in a north-westerly direction is what is known as the Western Range. Two peaks or pinnacles rise from this, one at the south-east corner and the other at the north-west corner of Section 4024. These peaks attain an elevation of from 1150 to 1200 feet above sea-level. On the saddle between the two peaks two trenches have been cut at right angles to one another, exposing leaders of quartz in sandstone, oxidised and sericitised. The strike of the sandstone is N. 30° W. The veins of quartz parallel to each other intersect the country with an easterly bearing, and carry a little coarse tin. Further north-west in the centre of the section, and at 1000 feet above sea-level, an adit has been driven over 200 feet in a northerly direction, across alternating beds of slate and sandstone (quartzite). The strata bear N. 20° W., and their dip is variable. This drive was put in to test the ground to the north, where on the surface loose stones of quartzite carrying rich veins of coarse tin ore occur. Nothing payable has been found in the tunnel, but the stones of rich ore which lie on the surface of the hill have undeniably been shed from some veins existing between the adit entrance and the crest of the hill. The hill-slope is covered with loose material, which is, of course, slowly but continually working its way down hill, and the floating ore-stuff must have been derived from higher up. It should be fairly easy to prospect this side of the hill by means of trenches, and such work is well worth undertaking. It appears as if these occurrences near the sum-

mit of the hill are not isolated ones, for Mr. C. Chesshire reports having found a copper-stained tin-ore formation $\frac{1}{4}$ -mile south from here lower down the gully.

Sites on which a battery might be erected are available, but the river will not supply sufficient power for a mill as large as was contemplated. By going up the river several miles a fall of a couple of hundred feet can be obtained. The company's engineer reported a measured minimum of 10 sluiceheads, and favoured a scheme for generating electrical power with gas engines at a coal seam situate 8 miles to the south. It does not now appear likely that a large mill will be necessary, but if a battery should be shown by future prospecting work to be required, precautions against pollution of the river will be imperative. Settling-tanks and storage of tailings will be absolutely necessary, and every means must be adopted to keep the water of the river pure. There is a large area of ground which can be used for this purpose. For the present, however, it is premature to discuss the question of battery-construction. The property can only be looked at as a prospecting proposition. No definite quantities of tin ore are in sight. Veined and impregnated stone of payable value has been sampled in surface outcrops, and intersected in two levels only. It has not been developed, nor has its extension been defined either laterally or vertically. There does not appear to be any well-marked channel or formation where this ore occurs; but the processes of impregnation and veining have at certain points been somewhat concentrated. With the present amount of work done it is unsafe to predict what kind of an ore-body will be disclosed by future operations. To supplement the work already done by carrying out a well-considered scheme of underground prospecting, both horizontally and in depth, would be a legitimate undertaking.

(3) COPPER ORE MINES.

A little more than a mile to the west of the Coastal Range is a parallel mountain range charted under the name of Scamander Tier. It is a somewhat open, timbered range, about a mile in width, and rising to heights of 900 and 1000 feet. It descends somewhat abruptly to the north bank of the Scamander, west of the North Arm.

The slate and sandstone strata, of which it consists, belong to the same system as those which are exposed on

the coastline, and have the same north-westerly strike, but the general dip is opposite, viz., south-westerly.

The lodes have a general north-westerly bearing, and are essentially channels of deposition of copper ore.

The only mine which at present is in a live condition is the Orieco, which was formerly known as the Eastern Proprietary.* The remaining ones are abandoned works to the east of the Orieco, on Dunn's sections, at Paul Beahr P. A. Mine at the southern end of the Orieco lode, at the North Scamander and on the Ringarooma P. A. property, between the Orieco and the Great Pyramid.

The Orieco Copper Mines.

Sections 4376-M, 80 acres, and 4152-M, 80 acres.—This company holds two of the sections formerly held by the Eastern Proprietary Silver and Copper Mining Company, which were originally granted as reward sections for copper. The mine is situate about 2 miles north-east of the ford over the Scamander River, and is approached by a good cart road passing up the hill to the east of the Great Pyramid Mine, and descending over the saddle down to the Orieco Mine.

The property is traversed by a strong lode, which passes through the two sections, and can be identified by outcrop indications for a total distance of about 2 miles. This lode has an average strike of N. 40° W., and underlays south-west. The country-rock is indurated greenish-striped slate and sandstone, and has a similar strike and dip direction. The outcrop northwards is that of a lode forming the backbone of a high ridge, and it looks even stronger going south, though the ridge southwards from the mine does not rise so boldly. A small creek cuts through the high ground at the mine, and just above this creek a long tunnel has been driven north on the lode. This was driven by the former owners, who held the property until quite recently.

Going north at surface the lode hugs the eastern brow of the hill, and is well marked all along, except the blank interval north of the shaft. About 3 chains north of the shaft is a dense hematite outcrop, then a blank intervenes again until lode-matter appears widely spread below the eastern brow. The direction of the lode is traceable by

* Since the above was written the property has been taken over by the Mt. Balfour Copper Proprietary.

following a wide silicified slaty outcrop. A crosscourse of brecciated limonite intersects the lode in a north and south direction in J. Dunn's section (4470), and continues down the steep gully to the north. Further along another limonite course carrying pyrite crosses the lode with a strike of N. 30° E.

The outcrop, like that of many copper ore lodes, has a poor appearance. Limonite, quartz, and decayed rock constitute the gossanous capping of the lode. There is a little staining by the oxidised ores of copper here and there, but copper minerals are for the most part absent. Outcrops of decayed rock often mark the course of the lode. This valueless material represents the leached upper part of the lode. The lower part of the zone of weathering has been traversed by the tunnel, which has entered the lode at the level at which iron and copper sulphates, copper oxides, and carbonates have been formed.

The tunnel follows a dig or seam of pug or kaolin from the entrance, and the first ore makes its appearance at about 100 feet from the mouth. At 160 feet in the ore-formation was tested by a short crosscut east, and found to be 14 feet wide. This includes not only the lode-fissure proper, but also intermixed decomposed slate forming part of the shattered belt of mineralisation. A winze was sunk in the crosscut to 16 feet below the tunnel, and at this depth water was struck. The ore was followed at bottom of winze 15 feet one way and 17 feet the other, and stopped down to that depth. It consisted of copper oxides and carbonates and copper glance, with sulphate and a little chalcopyrite.

In the main level ahead of this crosscut the lode fills the drive. At 53 feet from the crosscut another cuddy east has been driven across a slaty lode-formation, 23 feet wide, stained green, with copper sulphate. Fifty feet further on a short crosscut east has been driven across the lode-channel for 17 feet, and the eastern wall followed north for 16 feet, carrying hard black copper ore pitching underfoot in the end. Arsenopyrite is associated with the ore.

The main level continues north for 140 feet in slaty lode-matter with sulphate stains until it reaches the long crosscut west, where there is a bulge of good ore (copper glance and oxide) in a lode exposed for a width of 12 feet. An exploratory crosscut has been driven from this point S. 40° W. for 200 feet across blocky sandstone and slate strata, striking N. 30° W., and dipping south-west. At 170 feet in a winze has been sunk to 16 feet on a puggy formation, and

some black copper ore is said to have been struck at water-level. The end of the crosscut is in striped slate, showing a synclinal fold. For half a chain north of the entrance of this crosscut the lode-channel continues to have a width of 12 to 14 feet, with a lens of good ore 2 or 3 feet wide.

The shoot here has been stoped overhead for 22 feet, and underfoot to a depth of 12 feet, and a winze sunk on it to a depth of 85 feet. The ore-formation increased in length to 70 feet at 12 feet below the level, which is water-level. These stopes yielded 296 tons of ore, ranging from 17 per cent. to 28 per cent. copper and 13 to 17 oz. silver per ton. The level here is about 200 feet below surface, and at the northern end of the shoot is a rise communicating with the surface. It ascends for the most part in a channel from which the metallic contents have been removed by leaching.

The nature of the lode in the A winze has rather an important bearing on future prospects. At present from the records the indications are that the lode-channel in the bottom is wide and strong, that a little copper glance was showing when work ceased on account of the water, but that the average copper and silver contents were low. In descending on the lode some chalcopryite and zinc-blende were met with. The evidence available points to the inference that the zone of secondary sulphides lying below the oxidised zone has been entered in the deeper part of this winze, and it is open to argument whether the sinking has been carried deep enough to reach the part of the zone, which, in accordance with the general rule, should show sulphide enrichment. The descending waters from the impoverished oxidised zone must deposit their metallic contents at a depth which is largely governed by the ease with which they descend, and by continued sinking a horizon must be reached at which the reactions take place which result in the formation of rich sulphides.

At 60 feet beyond the winze is another short crosscut east driven across the lode-channel for 17 feet, and a winze has been sunk in this for 20 feet down to water-level. From the bottom narrow drives have been put in north for 5 feet and south for 60 feet into old ground cut from the A winze. Ore 2 feet wide is being met with in the drive south, comprising copper sulphate (chalcantite) and earthy copper glance (chalcocite).

No work is at present being done north of this winze. The lode along the main level north is represented by a channel of blank rock, with occasional signs of leaching,

3 feet in width, and the face in the end shows soft slate charged with pyrites. This is 940 feet from the mouth of level.

It would seem as if the ore-shoot passed through in the tunnel is either vertical or pitches south, and any further extension of the tunnel must have in view the possible discovery of a parallel shoot.

The profuse distribution of gossan on the surface of the hill to the south of the mine indicates an uninterrupted extension of the lode southwards, and a short adit has been driven at the bottom of a deep gully on the southern section, but without any results beyond establishing the continuance of the lode.

The present company has worked in the main tunnel since the beginning of April, confining its operations at present to ground above the water-level, but intending to bale out the deeper winze and explore the deeper zone.

Several hundred bags of oxidised and secondary sulphide ores have been got ready for sending away. These have been sampled from time to time. The records in the company's office show the following assay results:—

Mt. Lyell M. & R. Company's assays of—

1. Sample supposed to be representative of 500 bags—
Copper, 8·4 per cent.; silver, 7·93 oz. per ton.

2. Sample supposed to be representative of 400 bags—
Copper, 17·8 per cent.; silver, 11·5 oz. per ton.

Assays by Mr. Loftus Hills—

	Per Cent.	
1. Copper	7·1	
2. "	5·25	
3. "	6·29	
4. "	7·92	
5. "	2·34	Silver, trace
6. "	3·7	" "
7. "	11·8	
8. "	14·7	
9. "	15·6	
10. "	4·5	
11. "	11·7	
12. Gold, 1 dwt. 1 gr. per ton. Copper ...	7·0	Silver, 7 oz. 18 dwt. 2·7 gr. per ton
13. Copper	17·92	
14. "	3·2	
15. "	13·44	
16. "	23·4	
17. Gold, trace. Copper.....	12·1	Silver, 13 oz. 18 dwt. 8 gr. per ton

When the sample was assayed for silver and gold the results are indicated as above.

The work hitherto done in this mine has revealed ore at intervals in the lode for a length of nearly 400 feet. At some of the points (where winzes have been sunk) the ore-concentration is heavier than elsewhere, and there are stretches in the lode where it has not been proved in any other way than driving the tunnel, so that a little uncertainty exists as to whether separate shoots of ore have been passed through or all the ore belongs to one shoot. The latter is the more probable view. This, conjoined with the extensive leaching which has gone on above the water-level, points to the existence of a lower zone of enrichment extending downwards. The usual vertical extension of the rich chalcocite zone in copper mines is not great, but the high backs above the adit in this mine support a belief that the secondary deposition products below water-level will prove well worth working.

W. H. Weed, in his well known work on the copper mines of the world* draws attention to the fact that many copper lodes show a vertical distribution of ore in zones which may be classed as follows:—

ZONE OF WEATHERING	Limonite Gossan Ferrous and Cupric Sulphates Oxides and Carbonates of Copper, etc.
ZONE OF SULPHIDE ENRICHMENT	Copper Glance, Bornite, Covellite, etc.
PYRITIC ZONE OF LEAN PRIMARY ORE	Chalcopyrite with Pyrite, etc.

The features of the work which has been done at the Orieco Mine indicate that the deposition of ore will be found to have run a normal course, viz., through a surface zone of sulphates and oxidised ores into the copper glance zone below these, and finally entering the zone of primary chalcopyrite.

The type of lode is that of the group of copper veins with quartz pyrite gangue. Arsenopyrite and zinc-blende

* "The Copper Mines of the World." W. H. Weed. London, 1908, p. 44.

are occasional minerals. A zone of altered country-rock accompanies the veins proper, and the whole constitutes the lode-formation. The primary minerals are chalcopryrite, pyrite, pyrrhotite, sphalerite, arsenopyrite. Secondary ores are azurite, chalcocite, chalcantite, cuprite, malachite, tenorite. Much of the black, dirty ore of loose texture, locally called black oxide, is the earthy variety of chalcocite.

Paul Beahr P.A.

This association is now defunct, but its mine works are situate on the west side of the north arm of the Scamander River, where the south-eastern continuation of the Orieco lode may be traced. On Section 3976-93M a tunnel has been driven south-westerly into the hill from river level. The lode was cut and driven upon for some distance. A stream of water and yellow mud is issuing from the adit, which requires cleaning before it can be properly inspected.

There seems no reason to doubt that this is the same lode as that worked in the Orieco ground, but its mineral constitution has changed. It carries very little copper ore, but lead and zinc ores predominate. The lode-matter is quartzose with decomposed pyrite, accompanied by a little galena and blende. Oxidised copper and zinc ores and copper pyrites in splashes are present. The lode-stuff which has been broken and brought out from the level shows that nothing payable has been cut. The outcrop is visible on the hill-side, which rises steeply above the adit, and the lode is strong enough to warrant continued exploration, but it is not probable that further driving in the oxidised zone will result in discoveries of value. The lode should be proved below water-level by sinking, but lead and zinc may be expected to furnish the economic ores until copper reappears.

North Scamander Mine.

Sections 3941-95M, 80 acres.—This is situate about a mile south-west of the Paul Beahr P.A. It is best approached by ascending the hill in the eastern part of W. Pitt's 98 acres purchased land to the saddle, and then descending into the valley on the eastern slope. A large mineral formation is seen exposed in the creek bed, apparently following a course a little north of west. The lode type

differs from that of other lodes in the neighbourhood in that its mineral association suggests contact-metamorphism. Such types occur only in the metamorphic aureole surrounding intrusive masses of igneous rock, and result from heated magmatic solutions expelled during the final consolidation of the rock. The vein minerals are pyrite, zinc-blende, a little galena, and chalcopryrite, magnetite, pyrrhotite, and pyrite, with quartz and kaolin. Samples taken by Mr. Harcourt Smith assayed 6 per cent. copper, 1 dwt. 15 gr. gold, and 5 oz. 15 dwt. 12 gr. silver per ton. The formation appears to strike a little north of west, and to be largely a replacement of sandstone. Irregular veins of galena, chalcopryrite, and sphalerite intersect the formation. The magnetite is massive, and the wall-rock is charged with pyrite. The type is that of replacement deposits. Although contact metamorphic rock-forming minerals are absent, the association of vein minerals is characteristic of contact-metamorphic zones. On this hypothesis it is necessary to assume the proximity of an igneous intrusion. The absence of the rock-forming minerals of the contact zone, however, makes it likely that the ore has been deposited in the outer part of the aureole.

Two short drives have been put across the impregnated formation from the creek north-east and south-west. Some trenches have also been cut, and about a couple of chains east of the drives a small shaft has been sunk. The tip at this shaft shows the lode-stuff broken.

Deposits of this type are apt to be patchy and not always easy to follow economically. They should not be affected adversely by depth, but no general rules governing their continuity can be laid down. In this lode no leaching to any extent has taken place, and underground prospecting below the creek level would be justifiable, for there is a possibility of finding payable bunches of galena-blende ore. The ore is more likely to make in bunches or irregular bodies than in continuous shoots.

West Scamander Outcrop.

West of the North Scamander Section 3940-93M is a vacant section east of the road to the Orieco, on which at the foot of the hill a couple of small cuts have been put in, and some solid-looking lode-stuff turned out, but not enough work has been done to show the lode or country-

rock *in situ*. Stones several inches through show that the vein must be of some width. The lode material seems to be quartz-chlorite, the quartz being in the form of bands with cross veinlets. The minerals are pyrite, arsenopyrite, blende, and galena, and are finely and sparsely disseminated in the quartz, in quantities not greater than to serve as indications.

There is nothing here which can guide in forming an opinion as to the value of the lode, for the latter has not been even exposed to view, but there is no great surface oxidation, and any ideas of its behaviour in depth must be purely speculative.

Ringarooma Bay P.A.

This association holds two sections, 4126-m, 40 acres, and 4125-m, 80 acres, north-east of and adjoining the Great Pyramid Tin Mines.

A considerable amount of trenching has been done on Section 4125 on the northern slope falling to the Oriecoroad. The country is light-coloured slate, striking north-west and dipping north-east, and lumps of limonite gossan and gossanous slate are scattered over the hill surface in parallel lines, some of which have been intersected by the trenches. A long, low trench has failed to expose solid lode-stuff. Some of these excavations appear to have been governed by the position of surface boulders. Near the crown of the hill, 700 feet above sea-level, is a persistent line of large boulders of gossan passing over the hill and down on its southern side. A trench cut on the brow across this line shows only unaltered slate country, and the trench cut at 100 feet below shows no lode-formation. The strike of this gossan is N. 50° W., and its underlay north-east.

No ore can be seen here, but there is certainly a strong line of oxidised boulders. Ground water-level will be at a considerable depth, and the vertical zone of leaching must extend downwards for some distance, but there is nothing to forbid the occurrence of copper ore at water-level. The lode has possibilities equal to any of the other lodes in the district.

J. Dunn's Sections.

Sections 4468, 80 acres; 4469, 80 acres; 4470, 40 acres.—The first two are mineral sections situate to the

north and east of the Orieco property, and were formerly held by A. Pfaff.

On Section 4468 a powerful north-west lode parallel to the Orieco lode passes right through the section and out of it, both north and south. A gossanous rock outcrop with hardly any signs of copper marks the course of the lode, which has probably been subjected to the usual leaching action above water-level. The outcrop has a general resemblance to that of the Orieco lode. From an east and west creek valley in the south-eastern part of the section an adit has been driven nearly 90 feet in a direction N. 37° W. on the course of the lode, which consists of quartz with arsenopyrite embedded in gossanous and decayed lode-material. A little chalcopyrite is said to have been met with. A winze about 13 feet deep has been sunk at the entrance to the adit.

Nothing useful can be accomplished by continuing work at this level. Shaft-sinking must be resorted to in order to explore the lode below the zone of weathering. Further north a cross lode bearing W. 20° S. intersects this lode-line, and an attempt should be made to get to the point of intersection by driving from a shaft.

On the southern section about 9 chains east of the road a shaft has been sunk on the slope of the hill. Nothing is visible on the tip except a little pyrite, but indications of copper are said to have been found. The shaft is not deep enough to be of use.

Parallel formations occur to the east. The surface work on this property could not be expected to disclose anything worth working. The topography of the country is such as favours the removal of metals from lodes exposed in the hills and their transference to horizons situate below the level of the valleys. Hence, any scheme for working must provide for shaft-sinking.

Section 4470 is traversed from south-east to north-west by the northerly extension of the Orieco lode, which is traceable at surface, and is crossed by a north and south formation of limonite gossan on the crest of the high ridge which runs through the property. It is improbable that the lode beneath the gossan could be reached by adit levels. Shaft-sinking is the only feasible method of prospecting the lode, and the ground in the neighbourhood of the intersection of the lodes would offer the best chances of success.

Country North of Dunn's Sections.

The strata of the country north of Dunn's sections consist of the usual slate and sandstone, striking N. 20° W., and dipping south-west, sometimes at a very low angle. Stones of granite appear in the bed of the creek east of the mineral sections, and a low saddle south of the main creek appears to discharge stones of granite southwards. The granite country running east and west seems to come in north of the sections taken up for mining, but the boundaries of the igneous rock in this part of the field have not been examined. The parallel lode in Dunn's section, 30 chains east of the Orieco lode, continues into the adjoining section to the north, where it has been opened upon, exposing gossanous rock. All lode outcrops, as usual, are leached or barren, but good results from the Orieco property will stimulate prospecting on most of the outside sections.

(4) SILVER ORE MINES.

The Scamander River Silver Mine.

The old workings are situate on the south bank of the river about $\frac{1}{2}$ -mile above the bridge, and are on freehold property, charted in the name of A. F. Kemp. The mine was started about 24 years ago, and again in 1893 some experiments were carried on in the way of extracting silver from the ores. It is now quite abandoned, and only the adit is open.

The ore occurrences are in an intrusive tongue of granite porphyry, which is about 3 chains wide on this side of the river, and can be followed S. 25° E. for about a mile, disappearing under marine sands at about 8 chains from the main-road. The intrusive rock is bounded at the river's edge on each side by the slate strata, which are silicified and much veined with quartz. The width of the granite porphyry and granite intrusion on the north bank of the river is $\frac{1}{4}$ -mile, and together with the narrow tongue on the south side may be regarded as an apophysis rather than a dyke. All through this belt of granitoid rock passages are frequent from the structure of granite porphyry to that of normal granite. Similar granite porphyry country comes in 3 miles to the south, extending for a width of 3 miles from east to west.

The ore is a refractory mixture of arsenopyrite, pyrite, sphalerite (zinc-blende), galena, and chalcopyrite. The

arsenical sulphide is the dominant mineral; very little of the galena and copper pyrites can be detected on the dump. Probably all the minerals are silver-bearing.

Several assays have been recorded. Spots of silver chloride and native silver have enriched the results of some of these far above the average which must be expected in working the veins.

Mr. Thureau reported assays made from time to time at the Mt. Bischoff smelting works as ranging from 20 oz. silver and 8 dwt. 9 gr. of gold to 198 oz. silver and 9 dwt. of gold per ton of raw ore.

Martin Sholl publishes assay results as from 89 oz. to 281 oz. of silver per ton.

Mr. A. Montgomery quotes Mr. Robt. French, who was experimenting with the ore in 1893, as having obtained assays from 35 oz. to 122 oz. silver per ton.

Mr. Montgomery's grab samples from the heap were assayed by Mr. F. W. Ward, the Government Analyst, with the following results:—

Quartz Ore.	Gold.....	minute trace
	Silver	3 oz. 18 dwt. 10 gr. per ton
Sulphide Ore	Gold.....	distinct traces
	Silver	41 oz. 13 dwt. 18 gr. per ton
	Lead	6%

My samples of arsenopyritic quartz, assayed by the Government Analyst, returned 1 oz. 12 dwt. 16 gr. silver per ton, and a trace of gold.

The non-metallic gangue of the ore is quartz, sometimes massive, sometimes combed. For the most part the ore is a solid crystalline arsenopyrite, with but a slight admixture of quartz. There is, however, a variety in which the quartz predominates, and the sulphides are less plentiful. The silver contents are then less.

An underlay shaft has been sunk in a small gully not far from the river. It is reported to be down to 120 feet, and a main shaft higher up the hill has been sunk to an alleged depth of 130 feet. The bottoms of these shafts are below river-level, and the underlay shaft is filled with water up to 30 feet of the collar.

A little above the river-level an adit has been driven N. 70° W. for about 120 feet intersecting several veins of quartz in decomposed granite, continuing several feet. Some slate occurs on the hanging-wall of this formation, and granite comes in again and continues to the main contact with the sedimentary strata 20 feet behind the end.

Below the adit is some communication with the workings from the underlay shaft. How the somewhat broken lode-formation behaves in depth cannot well be ascertained at present, but in view of the fact that the ore is argentiferous to a fair extent further work on the deposit is desirable. Some of the smaller veins are reported to have high values, but these probably are irregular and uncertain. A good deal has yet to be ascertained with respect to the size, bearing, and general behaviour of the lode. Large pieces of quartz are lying on the tip and indicate that the lode had bulges of stone in it at least a foot wide. It is not likely that the lode is confined to the granite porphyry dyke, and perhaps remunerative shoots may be found in its extension in the adjoining slate country. Backs of from 100 to 160 feet can be obtained above water-level by adit levels, and a considerable amount of prospecting could be done by this means with very little expenditure. Naturally, at deeper levels the higher values could not be expected to persist.

Scamander Bell Mine.

On the north side of the river a belt of granite porphyry and granite extends for a width of $\frac{1}{4}$ to $\frac{1}{2}$ mile wide between slate-sandstone strata on either side. The Scamander Bell was one of the old silver mines opened in this belt on two 40-acre sections (933-M and 934-M). On the latter section a main shaft appears to have been sunk, said to be 60 feet deep, but no lode cut. Boulders of fresh granite porphyry, which have resisted decomposition, have been thrown out of the shaft. Some 7 or 8 chains west of this shaft are two pits, 50 feet apart and 30 or 40 feet deep, in sinking which hard granitic kernels were also met with. North of these the lode has been exposed in trenches bearing N. 20° E. A small paddock of ore has been formed at the foot of a tree, in which stones of quartz from the vein have been left. These are vughy and oxidised, and some of the pieces attain a width of 6 inches. Mr. Harcourt Smith reported having broken specimens from this small vein showing chloride of silver. A parallel lode further west has been cut into, exposing similar cellular ferruginous quartz. Work has been abandoned for a long time, and nothing can now be seen which would enable an opinion to be formed as to the value of these lodes. There is nothing in the surface outcrop to

indicate the existence of any payable occurrence. The veins are reported to have been small and patchy, and those who have inspected them have agreed that the future of the mine is dependent upon the discovery of larger lodes. Parallel lodes might very well be sought by sinking the present shafts a little deeper and crosscutting from them. Hard granite is not likely to be entered within at least 100 feet from the surface, and at that depth the river-level will be reached.

Beulah Silver Mine.

This old mine is situate on the present Section 371-93M, 80 acres. The section boundaries are difficult to find, but the shafts are about 12 chains north-west of the Scamander Bell shafts. The country-rock is decomposed granite porphyry, which furnishes the usual kernel boulders. These are embedded in soft decayed granitic clay. There are two quartz lodes about 200 feet apart, and striking N. 15° E. The eastern one seems to have been the most important, and has been opened upon in a series of trenches and pits, from which, however, in their present state nothing concerning the nature of the lode can be gleaned, beyond what can be seen in the form of loose stones of quartz, which have been broken out and thrown up. One has to depend for information on old plans and reports.

The main shaft is said to have been sunk 110 feet, and a crosscut driven west at 100 feet to meet the lode, which was supposed to dip east at about 45°, but this drive was fruitless. It encountered some hard granitic kernels, but failed to cut the lode. Subsequently tributors worked out the shallow stone to a depth of 40 feet from surface, and for a couple of chains in length. This proved a vein between 2 and 6 inches wide, with an occasional bulge up to nearly a foot. The stone at surface consists of a brittle, glassy-looking quartz, iron stained, and containing some crystalline arsenopyrite. Mr. Harcourt Smith quotes a year's output in 1896-7 as 51 tons of ore, averaging 92½ oz. silver per ton; one parcel of 6 cwt. going as high as 241 oz. These high silver contents are due to the presence of silver chloride in small cavities in the quartz. Mr. Montgomery reports assays as high as 900 oz. silver per ton.

The western parallel lode is also in granite country, very close to its junction with slate. Ferruginous quartz has

been thrown out from the excavations. The vein is said to be only a few inches wide, and like the eastern lode has occasionally shown a little silver chloride in the quartz. This no doubt is responsible for the quotation of a high silver value (136 oz. per ton).

If larger veins could be discovered in this vein of weathering a payable mine would be opened up, as the silver values would be remunerative, but the occurrences which have been tested are too bunched and small to work profitably. The shaft has been sunk to water-level, which is the level of the river, and deeper work would be in the solid granite, in which probably the lodes would be more pyritic. Some shafts have been sunk on the adjoining section to the south, but without results.

The crystalline sandstone with which the granite porphyry junctions on the west is much veined with quartz. The conditions appear to have been favourable for the deposition of ores belonging to the middle or upper horizon in the theoretical ore column. The genetic history of the silver chloride in the veinstone cannot be positively established. Some of the Scamander silver lodes have been opened upon virtually at sea-level. The Beulah ground was covered by the adjacent sea in the Tertiary epoch. F. A. Moesta, quoted by Beck, maintained that the richer silver chloride deposits in some parts of Chili resulted from the submergence of the outcrops in sea water.* Beck himself† is inclined to imagine that the amount of cerargyrite in outcrops may be dependent on the aridity of the climate, allowing the haloid compounds formed in minute quantities by the weathering of rocks to be concentrated in the superficial strata. Saline dust in arid regions raised and deposited by the wind is appealed to by more than one author as an efficient cause.‡ European occurrences are referred by German writers to small quantities of sodium chloride contained in ordinary vadose waters. In connection with this subject it may be borne in mind that chlorine is not absent from eruptive magmas. Krusch§ draws attention to the circumstance that rapid precipitation of minerals not easily soluble often takes place in vadose springs on admixture of two separate solu-

* "The Nature of Ore Deposits." R. Beck, 1905, p. 374.

† *Ibid.*, p. 375.

‡ See "Cerargyritic Ores: Their Genesis and Geology." By C. R. Keyes. *Economic Geology*, Dec., 1907, pp. 774-780.

§ "Die Lagerstätten der nutzbaren Mineralien." Von F. Beyschlag, P. Krusch, and J. H. L. Vogt, Stuttgart, 1909. Vol. I., p. 126.

tions containing their elements, and attributes to this process the formation of silver chloride in some gossans. This leaves the question of origin untouched. The genesis of diverse occurrences may possibly be accounted for by various explanations. The problem is obscure, and a comprehensive solution does not appear to have been reached yet.

These high values at the Scamander occur in the zone of weathering. The dry climate which has doubtless prevailed on this coast for ages has conducted to a very slow downward extension of the processes of superficial decomposition. The rich concentrations of secondary ore may be expected to recur in places down to the river level, where probably some enrichment exists. At some distance below this, the primary ore, some of which exists also at surface, will continue its descent unattended by its richer companion.

The valuable metals of these lodes are silver, and in a lesser degree, gold. On the south side of the river, a little galena and zinc-blende are present. The metallic gangue mineral is arsenopyrite. It is interesting to speculate on the changes which the ore will undergo in depth.

There is a group of pyritic gold-quartz veins in which arsenopyrite is an auriferous constituent, and the presence of gold in the veins at the Scamander seems to indicate some relationship to that group, especially as lead and zinc sulphides are common to both. The decided preponderance of silver, however, seems to favour the inclusion of the present veins in the silver quartz class.

The Freiberg district in Germany is famous for its numerous lodes belonging to this type. The gangue is quartz and the filling arsenopyrite, pyrargyrite, silver glance, argentiferous pyrite, &c., accompanied by a slight proportion of gold, as well as some galena and zinc-blende.

In the Mexican lodes, below silver sulphide and chloride and native silver, primary silver ores, galena and chalcoppyrite are encountered below ground water-level. At a greater depth zinc-blende and pyrite accompany the galena, and the lodes then suffer impoverishment. There are some exceptions to this general rule, in which at a depth of over 1000 feet richer ores have reappeared, associated with native copper.

As far as an opinion may be hazarded, the normal succession of minerals in the Scamander silver lodes in descending order is probably:—

- (1) Silver-bearing pyrite and arsenopyrite.
- (2) Galena and zinc blende, or chalcopyrite, or in the absence of these—
- (3) Gold.

But it is impossible to say how far these will be represented at any horizon. In the Scamander Silver Mine already at water-level some zinc-blende and galena have made their appearance, but it is hardly possible to state yet whether these are indicators of horizon or are merely accessory minerals.

Yarmouth Proprietary Mine.

Two and a half miles north of the Scamander bridge the main-road crosses the Yarmouth Creek, which at $\frac{1}{4}$ -mile west of the road flows through the Yarmouth Proprietary ground, now charted as Sections 4247-93M and 4248-93M, 40 acres each. A track through ironbark timber north of the creek leads to the old mine workings. The country-rock below the superficial remnant of Tertiary wash is slate, sandstone, and quartzite, striking N. 30° W., and dipping to the north-east. Three lodes have been cut in the bed of the creek. A shaft has been sunk on the main lode on the north bank about 12 feet above the creek. It is now filled with water to within 10 feet of the surface, but is said to be 37 feet deep, with a short drive at the bottom on the lode in a north-easterly direction. Water difficulties are said to have been met with. The gossanous outcrop has been cut into on the hill slope 20 feet above the shaft, showing nice-looking gossan. The dump at the shaft shows that the lode is quartz associated with brecciated quartzite, and contains massive patches of crystalline arsenopyrite. Splashes of galena and chalcopyrite have also been detected in it. Mr. Harcourt Smith reports picked specimens as assaying up to 14 dwt. gold and 40 oz. silver per ton. My sample of the arsenopyritic quartz yielded a trace of gold and no silver. A sample which he took from one of the other lodes on this property assayed 1 dwt. 15 gr. gold, 2 oz. 15 dwt. 12 gr. silver per ton, and 3.5 per cent. copper. One of these lodes contains a little pyrite and zinc-blende.

This type of vein has some similarity to the arsenopyritic gold-quartz vein type, but not enough is known of the lodes to justify positive statements.

The nearest igneous rock is the granite porphyry core of the coastal range, about 2 miles back from the coast. This rock crops out at intervals along the crest of the range.

VII.—CONCLUSION.

The mining field of the Scamander, as will be gathered from the foregoing, is one of considerable variety, gold, silver, copper, tin, and wolfram being represented in deposits of more or less economic value. The most important of these at present are those of copper and tin. It is satisfactory to know that the copper mine formerly known as the Eastern Proprietary, subsequently as the Orieco, and now as the Balfour Proprietary, is to have a fair trial after many years of intermittent work. The results will influence the future of copper-mining in the district, for other lodes exist in the neighbourhood possessing outcrops identical in character with that of the Eastern. A severe set-back was caused by the stoppage of work on the Great Pyramid sections, and undoubtedly the results of operations were far from corresponding with the hopes that were entertained. But the fact remains that good tin stone has been disclosed at several points on surface, and payable stone intersected in two levels underground. The work done does not admit of any statement being made beyond this, and the property must be looked upon simply as one suitable for prospecting and proving. The discoveries of wolfram ore are too patchy to be of value, even at the present prices of wolfram, but there is a possibility of better deposits coming to light. The future of the silver mines is more dubious. The lodes must improve a good deal below water-level if payable results are to be realised.

If the copper and tin mining proves successful, prospecting in the district generally will receive a fillip, and some of the possibilities which unquestionably exist may materialise. Hitherto the tourist traffic along this balmy coast has been the chief industry. Hundreds of visitors resort to the Scamander for rest or recreation. If, in addition, mining activity attracts an influx of permanent inhabitants, a prosperous future is ahead. Much of this, however, will depend upon the judicious direction of operations. Continuance of work steadily and on a moderate scale should be the thing aimed at, for there is nothing in the district to indicate that any phenomenal ore-deposits exist.

Some of the deposits fully warrant further work in proving them, and signs of ore-deposition at different points indicate the possibility of further discoveries of value. Capital is needed, however, to prosecute this work, for merely surface operations in this district are almost useless.

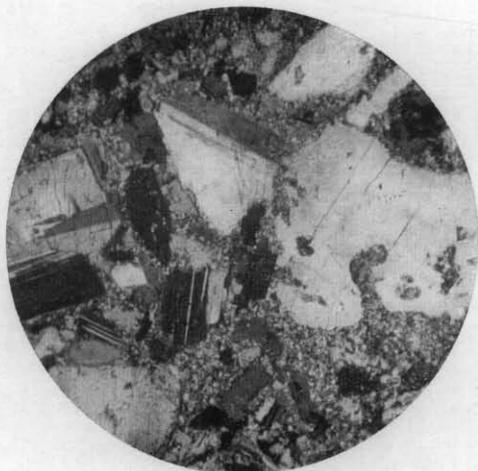
W. H. TWELVETREES, Government Geologist.

Launceston, 18th October, 1910

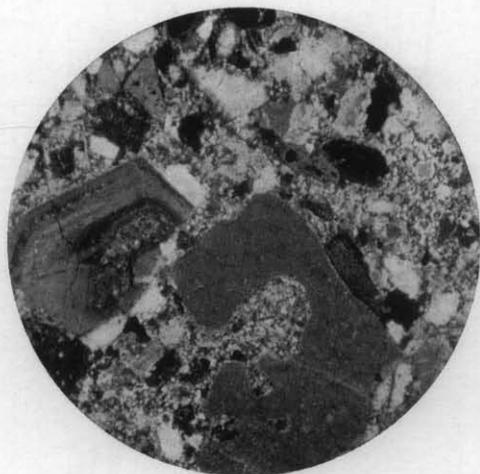
EXPLANATION OF PHOTOMICROGRAPHS OF ROCK SECTIONS.

- FIG. 1.—Hypersthene-bearing granite porphyry ("granodiorite"), Beulah Mine. The section shows twinned plagioclase feldspar, biotite, hypersthene, and corroded quartz in a granular groundmass of untwinned feldspar and quartz. + nicols $\times 17$.
- FIG. 2.—Hypersthene-bearing granite porphyry ("granodiorite"), St. Mary's Pass. The section shows zonal andesine and acid labradorite, corroded quartz, biotite, and hypersthene in a granular groundmass of untwinned feldspar and quartz. + nicols $\times 17$.
- FIG. 3.—Aplite, near Cato's Creek. The section exhibits the characteristic panidiomorphic granular structure of aplitic granite, and shows a mixture of quartz, orthoclase, and microperthitic feldspar. + nicols $\times 17$.
- FIG. 4.—Lamprophyric rock from dyke at Great Pyramid Mine. The light-coloured ground in the section consists of twinned feldspars; the ragged black spots represent biotite and pyroxene masked by oxide of iron. Ord. light $\times 17$.
- FIG. 5.—Sandstone, Great Pyramid Hill. Locally called quartzite. The section has been prepared from the indurated sandstone at the summit of the hill, and shows its sedimentary nature. The rock consists of granular quartz, with interstitial argillaceous matter. + nicols $\times 17$.
- FIG. 6.—Sandstone, Avenue River, from the cliffs of stratified rock on the east bank of the stream. The section may be compared with that of the Pyramid sandstone, which it closely resembles. + nicols $\times 17$.

IGNEOUS ROCKS.



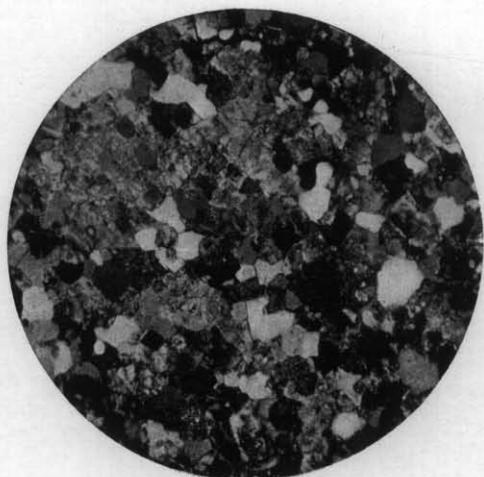
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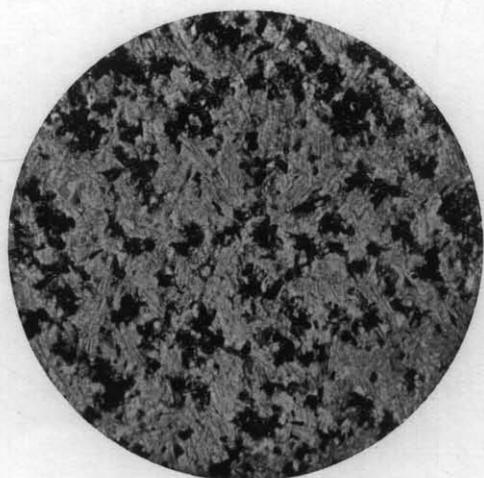
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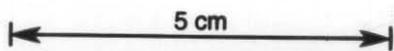
IGNEOUS ROCKS.



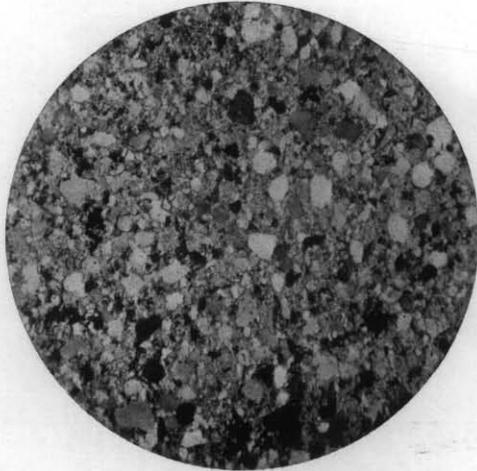
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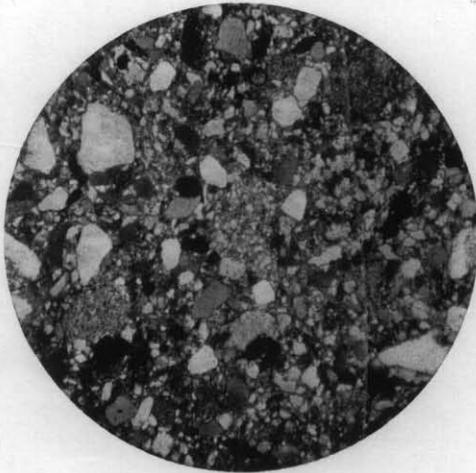
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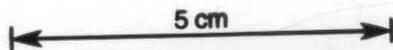
SEDIMENTARY ROCKS.



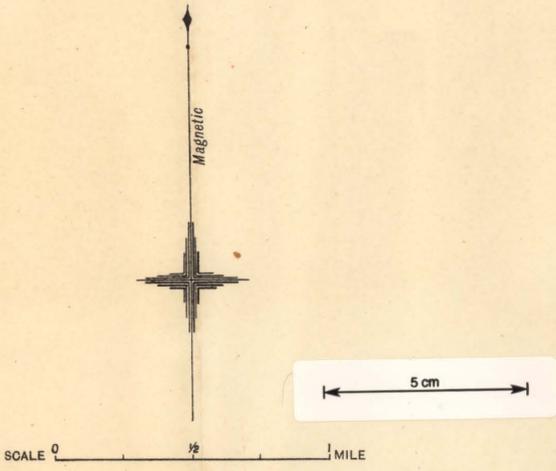
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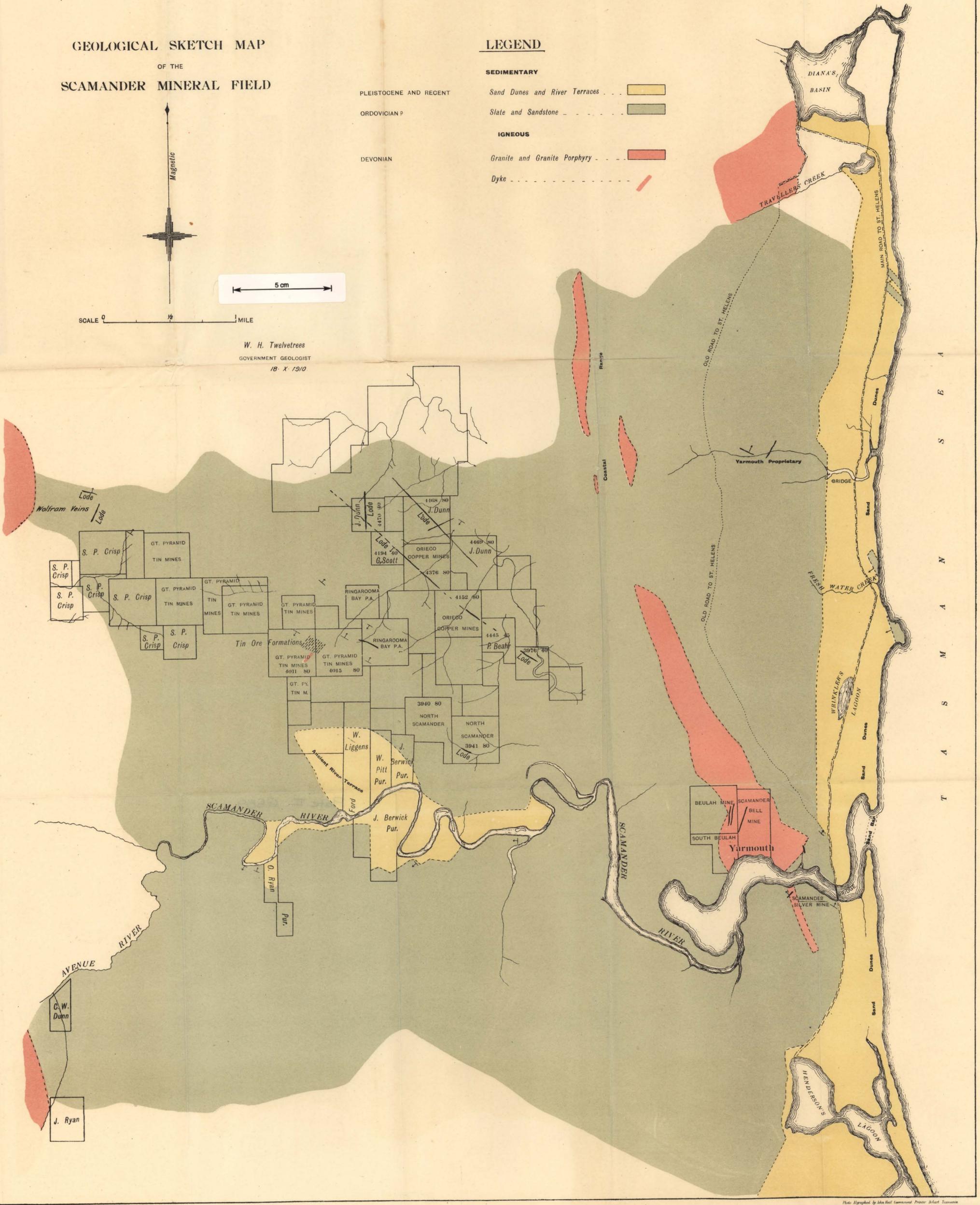
GEOLOGICAL SKETCH MAP OF THE SCAMANDER MINERAL FIELD



W. H. Twelvetrees
GOVERNMENT GEOLOGIST
18. X. 1910

LEGEND

- SEDIMENTARY**
- PLEISTOCENE AND RECENT: Sand Dunes and River Terraces (yellow box)
 - ORDOVICIAN P: Slate and Sandstone (green box)
- IGNEOUS**
- DEVONIAN: Granite and Granite Porphyry (red box)
 - Dyke (red dashed line)



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Photo Engraved by John Hill Commercial Printer, Albert, Tasmania

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GEOLOGICAL SKETCH MAP

OF THE

COUNTRY SOUTH OF THE SCAMANDER



SCALE 0 1/4 1/2 1 MILE

W. H. Twelvetrees
GOVERNMENT GEOLOGIST
18. X. 1910.

LEGEND

SEDIMENTARY

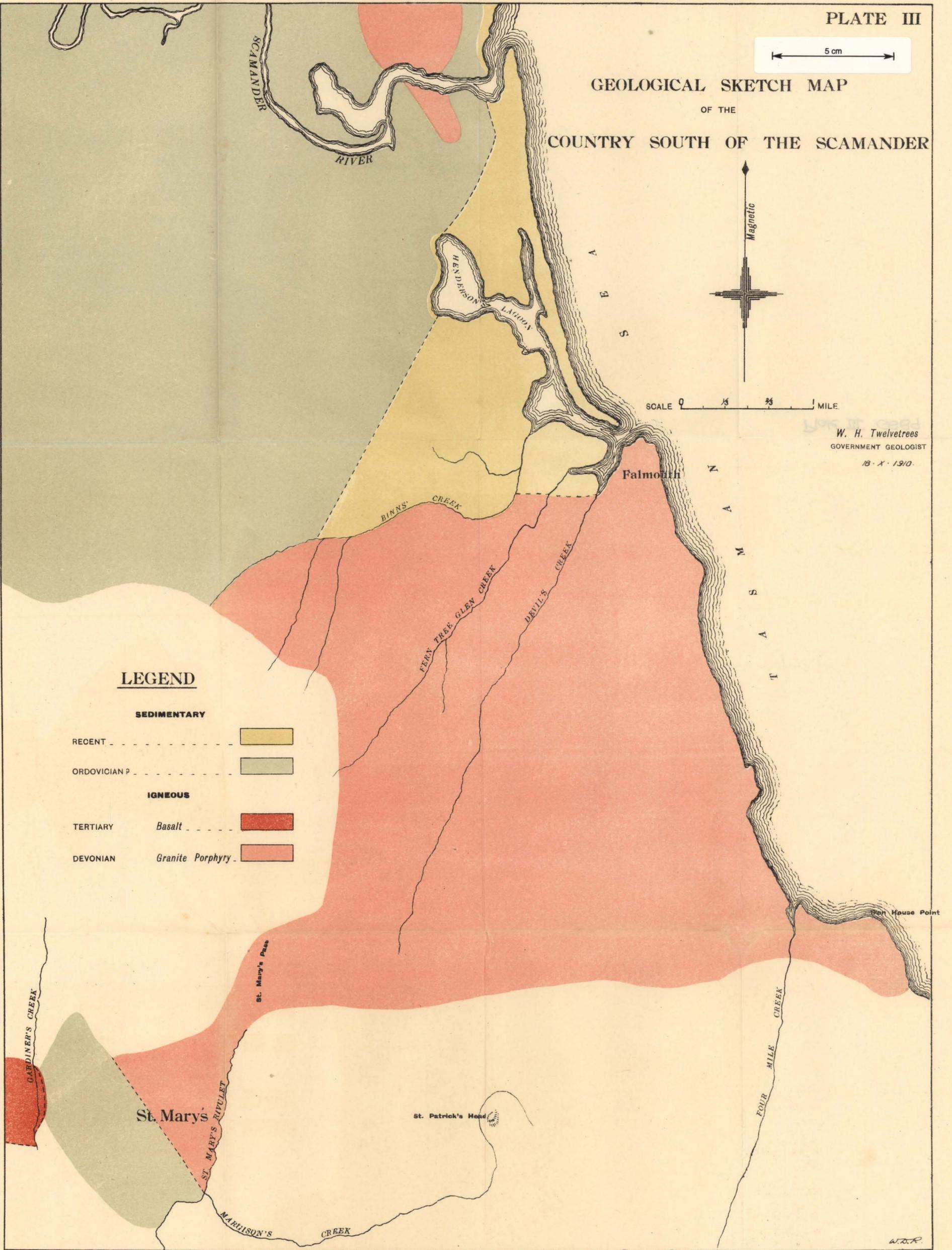
RECENT - - - - - [Yellow box]

ORDOVICIAN P. - - - - - [Green box]

IGNEOUS

TERTIARY Basalt - - - - - [Red box]

DEVONIAN Granite Porphyry - - - - - [Orange box]

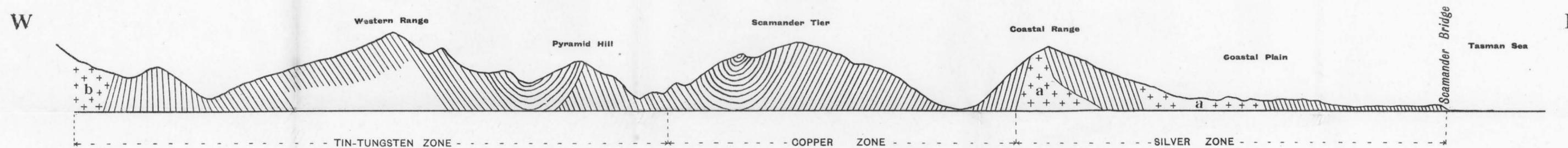


W.D.R.

Plate sketched by John Hill, Government Printer Robert Macdonald

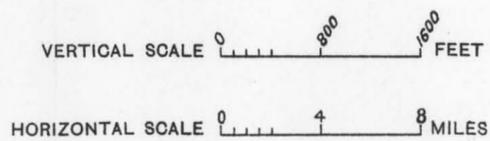
GENERALISED SECTION OF THE SCAMANDER DISTRICT

Showing Metallogenetic Zones



LEGEND

- GRANITE {
 - a Hornblende Bearing Granite Porphyry
 - b Biotite Granite
- SLATE AND SANDSTONE



W. H. Twelvetrees
GOVERNMENT GEOLOGIST
18-X-1910

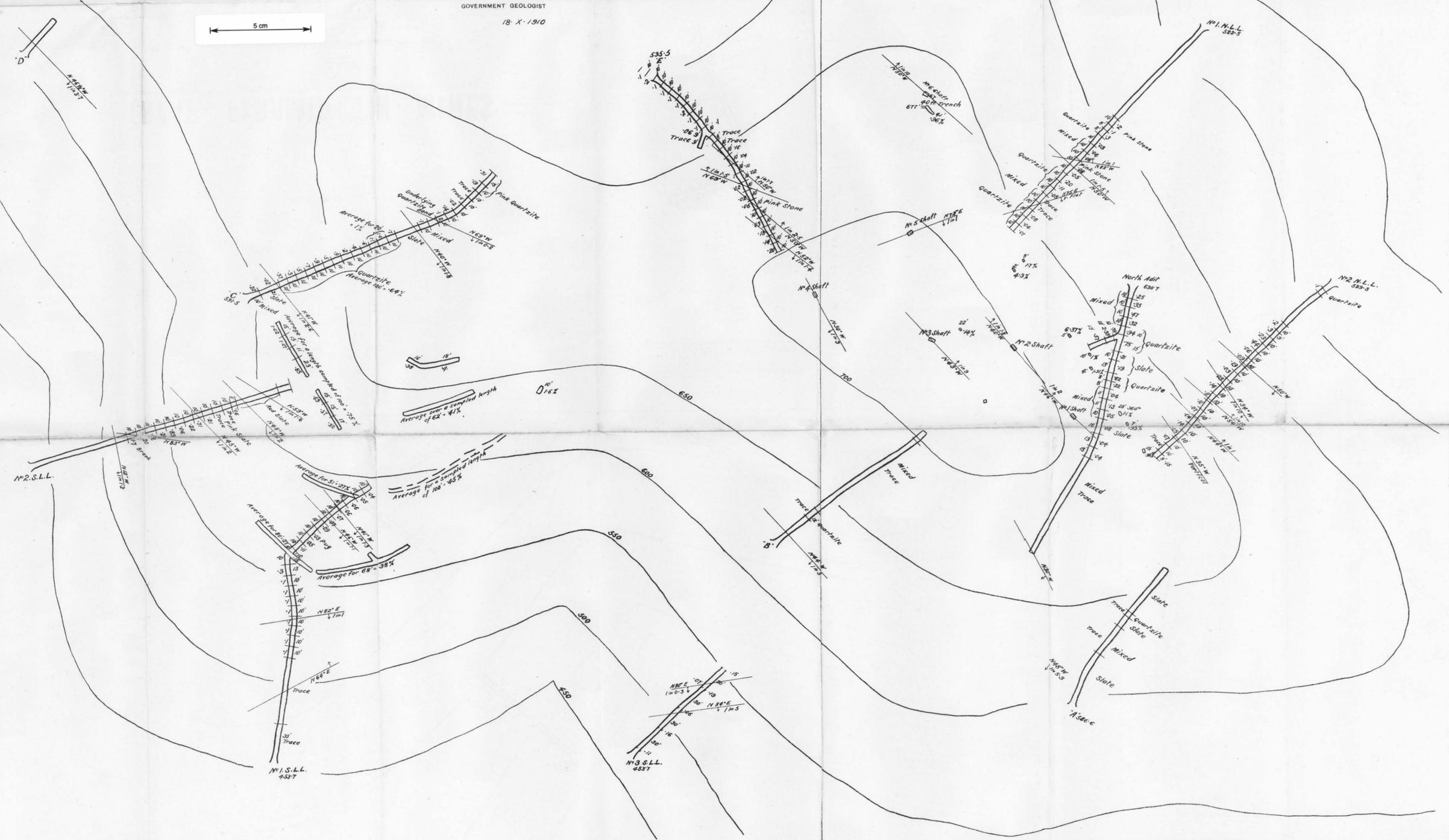
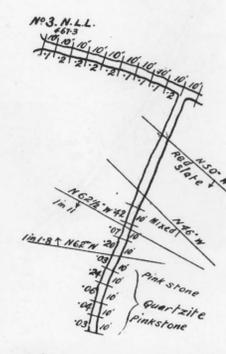
W.H.R.

GREAT PYRAMID TIN MINES

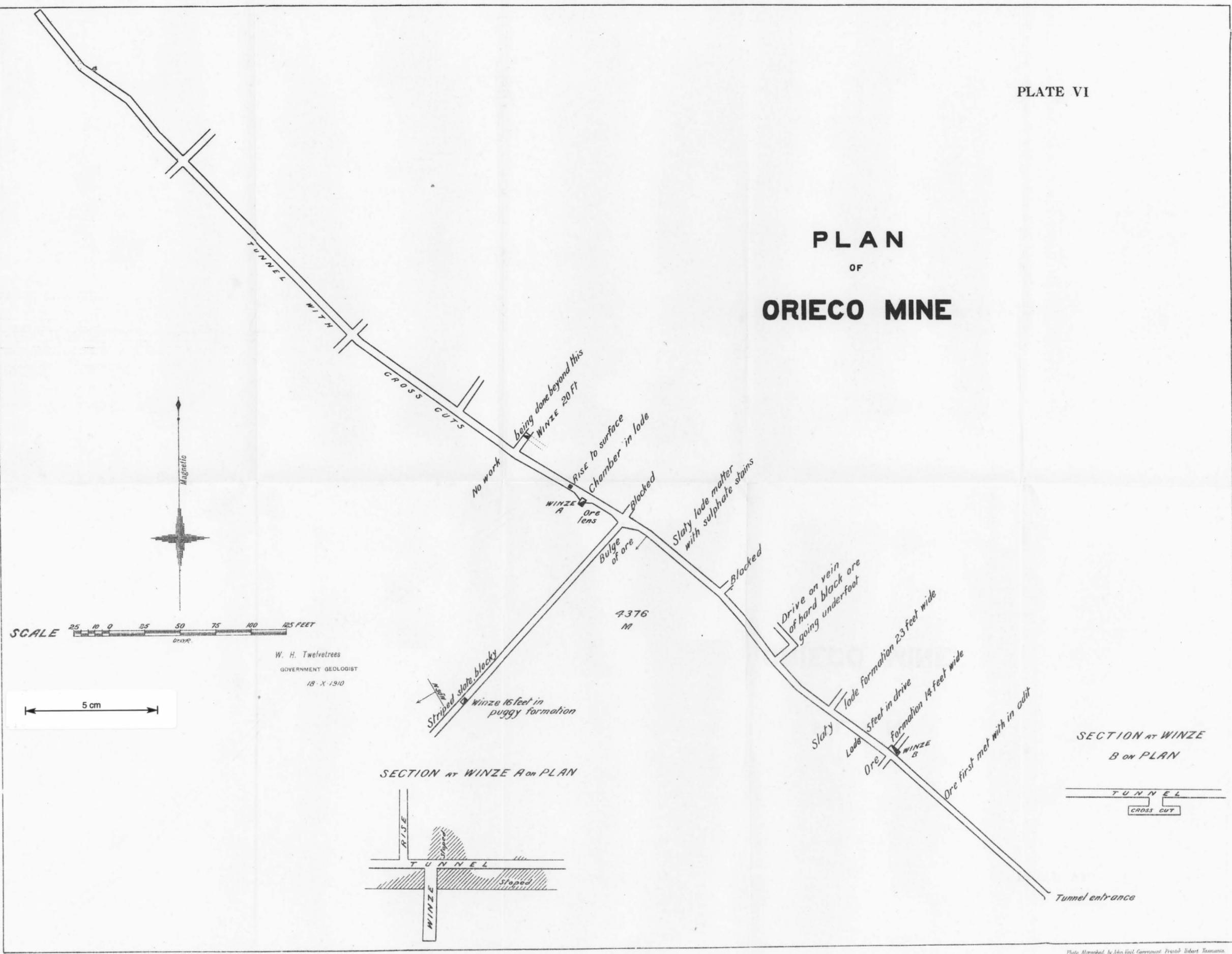
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From Company's Plan W.H.R.

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W. H. Twelvetrees
GOVERNMENT GEOLOGIST
18 X 1910



PLAN OF ORIECO MINE



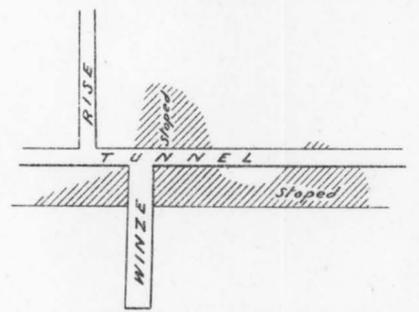
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W. H. Twelvetrees
GOVERNMENT GEOLOGIST
18-X-1910

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SECTION AT WINZE A ON PLAN



SECTION AT WINZE B ON PLAN

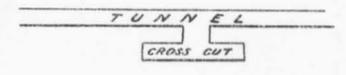


Photo Algraphed by John East, Government Printer, Sydney, Tasmania.