GUNN'S PLAINS, ALMA, AND OTHER MINING FIELDS, NORTH-WEST COAST.

I.—INTRODUCTION.

ATTENTION has been lately directed to some copper ore properties situate up the Leven and Forth Rivers, and these ore deposits having some bearing on the question of railway facilities now under discussion, it was deemed advisable to make a geological examination of the localities and ascertain the prospects of any mineral output which would contribute in any way to the traffic on the proposed line to Castra.

The examination was considered also as likely to be of use in elucidating further the geology of the North-West Coast, as up to the present not much has been definitely known with respect to the sequence of the strata, more especially as regards the position of the copper-bearing beds in the geological record.

Copper and silver-lead ore veins are being frequently discovered (in many instances rediscovered would be the more appropriate term) in the older rocks which have been cut down into the creeks and rivers, but none of these occurrences have so far been shown by actual work to be of any great importance. Some of them have been worked and abandoned as soon as the ore-shoot pinched, and as a result a feeling of uncertainty has developed as to the outlook and the possibilities of these fields. Some information seems to be necessary in regard to the correlation of the ore-deposits with those in other parts of the island, and their probable permanence. The geological age of the enclosing strata is a question which of necessity has hitherto remained unsettled, and it is quite time that some attention should be paid to it. Economic geology and general geology are indissolubly connected, and if one is pursued to the total exclusion of the other, results of work cannot be illuminating and informative, while the State eventually must inevitably suffer reproach.

For the last 18 months some work has been carried on at Gunn's Plains, 12 miles from Ulverstone, by the Copper

Creek Mining Company, and as the Public Works Commissioners have strongly recommended the construction of a line of railway from Ulverstone through the Plains, under the provisions of "The Local Government (Tramways) Act, 1907," mining enterprise in the district merits consideration. Some other ore outcrops occur along the Leven River, which may in time receive attention. Some of the known copper ore occurrences on the east flank of the Dial Range may also receive a stimulus when this tramway is built. A little silver-lead prospecting at South Preston likewise indicates the existence of mineral-bearing country within range of the proposed railway.

Mineral country also exists between the Wilmot and Forth Rivers, a short distance above their confluence. West of the Forth is the old Barrington Copper Mine, on which the Alma Prospecting Syndicate has recently resumed work. Deposits of barytes occur on this property.

Westwards, between the Blythe and Emu Rivers, is a line of copper and iron ore deposits, tried for copper ore by the Burnie Copper Company and the Rutherford Company somewhat inconclusively. The former company would doubtless have proved its lode to a greater depth but for losses in other parts of Tasmania. The Rutherford lode remains to be tested. The noted iron ore lode of the Blythe is in this belt.

This coastal country, largely covered with basaltic soil and occupied by agriculturists, unquestionably possesses mineral lodes which indicate possibilities and appeal legitimately to mining enterprise. The points at which mineral appears are, however, somewhat scattered, and this renders the work of fixing the relationships of the deposits and making comparisons a little difficult, for the area under review is wide and broken.

The limestone beds on the Coast, too, are of importance. Good limestone occurs at Railton, the Don, Gunn's Plains, and the same stone is known at the Blythe River. These beds are destined to be greatly exploited as population increases, both for building and agricultural purposes.

II.—PREVIOUS LITERATURE.

Official reports on various parts of the Coast have been issued from time to time by the Government of Tasmania.

In a report by Mr. G. Thureau, Government Geologist, on the North-Western mineral deposits, dated 30th December, 1881, reference is made to quartz reefs up the Castra-road, S.S.E. from Ulverstone, and to the Barrington Copper Mine, near Alma. Mr. Thureau describes Reid's reef as cropping out at the side of a gulley emptying into the Clayton Rivulet: "This reef observes a strike of W. 3° N., and the strata in which it is embedded of N. 38° W. It is a very massive one, being over 15 feet wide at the surface, with a northern underlay of 65°. The quartz is hard, coarsely laminated, and reddish in colour near the surface; where the stone has been followed beneath the surface it assumes a bluish hue, owing to the presence of crystalline iron pyrites . . . The tunnel intersected the reef at a distance of 60 feet from its mouth, and the quartz broken down exhibits a more favourable appearance."

At this time the Barrington tunnel was "driven in a north-westerly direction to a length of 281 feet. Two crosscuts extend from this tunnel to the west for a length of 33 feet and 32 feet respectively."

Mr. A. Montgomery, Government Geologist, in his report on the Gawler River, &c., of the 29th July, 1895, described a visit to a gold-bearing reef which had been discovered about 2 miles from Ulverstone: "The lode consists of from 8 to 12 inches thickness of quartz and some 6 inches of clay, the latter being on the walls. The quartz has a vitreous appearance, and contains a good deal of iron pyrites, with a little copper pyrites and blende. Strike about W.N.W. and E.S.E., dip 67° to the northward. . . . Several prospects washed from the quartz gave very poor results, though a little gold was seen, and it would appear that the reef is auriferous, but as yet nothing like payable. It might, however, be prospected with advantage, and should be traced both east and west along its strike, and tested at intervals to find if its gold contents increase. . . . From time to time it has been reported that a little gold occurs in the Gawler Range itself. . . . . Though nothing of much consequence has yet been found, it seems probable that the locality is of a favourable nature for minerals, more especially gold, and is therefore worth some attention from prospectors."

The writer, in his report on the Dial Range, 19th December, 1903, described some of the copper ore formations on Walloa Creek, and his report on North-West Coast mineral deposits, 26th July, 1905, included an account of the Barrington Mine at Alma.

III.—PHYSIOGRAPHY.

This part of the North Coast is a raised peneplain dissected by river systems, the waters of which are discharged into Bass Straits. Two fine rivers—the Leven, at Ulverstone; and the Forth, at Leith—empty into the sea at those places, having their sources far away in the interior in the high land near Mt. Pelion, and west of the Middlesex Plains. These rivers, with their tributaries, have cut deep channels through the basaltic covering of the table-land, through the sub-basaltic gravels, and down into the underlying ancient rocks, with the result that sections of the latter are frequently well exposed in the banks of the valleys or walls of the river gorges. Each of the rivers named has an estuarine expansion at its mouth, and the adjoining flats occupying the township areas have only emerged from the sea within the Recent period. The Leven, at 10 miles south of Ulverstone, is not more than 150 feet above sea-level, while the surrounding plateau has risen to between 700 and 900 feet.

The town of Ulverstone is situated at the mouth of the River Leven, on both banks. This thriving town is in a picturesque position, commanding striking views of the Dial Range to the west, the gnomon of the dial being a prominent feature. The flat ground extends back from the sea for nearly a mile, and then the land rises to form the table-land, the soil of which nourishes the potatoes and other root crops for which this coast is famous. Various gorges and romantic river reaches occur at intervals along the course of the stream. At the south end of the reserved township of Leven the road passes alongside the river through a charming ravine for 2 miles, winding round the base of the Sugar Loaf before it emerges on Gunn's Plains—an open, hill-locked valley, 5 miles in length from north to south. The alluvial soil which forms the floor of this valley is highly suitable for agriculture, fruitgrowing, and dairying. The Public Works Commissioners, in reporting on railway facilities for the Castra District, and recommending the construction of the line through Gunn's Plains and Preston to Blackwood Park, say:—"Gunn's Plains have an area of 9040 acres, mostly rich agricultural soil, of which 697 acres have been under cultivation this year (1908); 1300 acres have been cultivated, and are now in grass; 5543 acres are in rough grass; and 1500 acres in scrub. The produce this year has totalled 2092 tons

The River Leven keeps to the west side of the Plains, having probably cut its channel from time to time further and further west. The bed-rock underlying the alluvial bottom is limestone, and the open valley which constitutes the plains probably owes its formation to this. After the river has traversed the limestone belt and enters the hard conglomerates and igneous rock area, the plain contracts to a narrow ravine, the only available outlet for the river. The massive rocks of the Dial Range system are responsible for many windings of the stream on its way to the sea.

A good carriage-road exists from Ulverstone to the Plains. After attaining an altitude of 700 feet above sea-level it descends through Leven for 500 feet in a couple of miles to the farms on the river.

IV.—GEOLOGY.

The rock-types developed on the North-West Coast are of somewhat numerous varieties. They have, so far, been imperfectly examined, and offer a fine and comparatively untouched field for geological study. Students may usefully devote time to the examination of the different rock-exposures on the sea-coast, and to following up the geology inland.

The geological sequence and the rocks observed near Ulverstone and the Forth will first be dealt with, and some outlying occurrences also referred to.

(1)—Pre-Cambrian Strata.

These are strongly developed at Ulverstone, and deserve attention, as being the floor on which the whole superstructure of our Cambrian and Post-Cambrian sediments rests. We have not yet succeeded in obtaining evidence of the existence at surface in Tasmania of rocks really belonging to the Archæan complex. The oldest rocks which have been found are those dominantly sedimentary foliated strata which belong to the Upper Pre-Cambrian. The United States Geological Survey has separated these sedimentaries from the igneous Archæan complex below, and termed them Algonkian. Chamberlin and Salisbury, the American geologists, have designated them Proterozoic, reserving the title Archæozoic for the great granitoid and schist series of the Archæan. It is these Algonkian schistose quartzites and micaceous schists which occupy so large an area in the western part of Tasmania. They constitute the

headlands which project into the sea at Cox's Bight and Port Davey, and form the mountain ranges generally in the south-west of the island. They form a large block of country west of the Denison Range and the Thumbs, and comprise a good deal of the high land at the head of the Forth. The quartzite at Rocky Cape and Sisters belongs to this division, as also the micaceous schists of the lower Forth. Further east the group is represented by the schists of the Asbestos Range.

The bearing of these strata does not diverge much from north and south, and is mostly a few degrees east of north. At Ulverstone, on the East Beach, they are exposed in long lines at low tide, running out northerly into the sea, and dipping steeply to the west. At Picnic Point. on the West Beach, they strike N. 20° E., with a north-westerly dip. Going west they crop out occasionally in the sand, but are shown strongly at Goat Island. In the bay west of this island they are covered by Tertiary basalt, and on the beach opposite Barkworth's are succeeded by drab slates. The last strike of the schistose conglomerate west of Goat Island is N. 10° W., while the slates of the succeeding systems strike N. 20° W. The junction of the Cambrian and Pre-Cambrian strata is here unfortunately concealed by the basalt lava flow.

The rocks composing this system are schistose quartzites or quartzitic schists, sericite schists, and schistose conglomerate. All these represent rocks originally sandstone and conglomerate, with, perhaps, some shale or argillaceous beds. Sometimes the metamorphic process has not been intense enough to obliterate the original granular texture; at other times the deforming forces have produced a development of the silky, filmy mica known as sericite, which coats the folia of the schist and causes the rock to become a sericitic quartzite schist or a sericitic schist. Some of the schistose conglomerates show beautiful examples of stretched quartz pebbles. Thousands of these pebbles may be seen stretched by rock movements several inches in length without breaking, and bent in conformity with the curves in the schist. When crowded together they often present the appearance of drawn-out strings of quartz, forming a purely quartz schist.

The Algonkian sediments have resulted from the mature decomposition of still more ancient rocks, either Lower Algonkians or Archæan. The earlier systems have not been yet identified in the island. As matters stand at present, these schists are the oldest which are known to

us, and spread, as they are, over so large an area of Tasmania, thicknesses are involved which denote an enormous period of time during which this sedimentation proceeded.

They are seen in a quarry three-quarters of a mile south of Ulverstone, up the North Motton-road, where the land rises to form the plateaux; but are concealed from view at Gunn's Plains, even though the height there above sea-level is inconsiderable. They are also prevalent in the Forth Valley, south of Hamilton. There was evidently a Pre-Cambrian schist-forming period in Tasmania, because the Cambrian sandstones and slates are not schistose.

The quartz, which is abundant in the schists, is not in the form of reefs, but seems to occur generally as segregation veins and irregular patches and strings, without any economic mineral. Considering, however, the proximity of the intrusive granite to the coast-line, there is no apparent reason why the schists should not prove to be the receptacles of ores, as they must have been invaded at various points by the granitic metal-bearing magmas.

(2)—Cambrian.

The only certain exposures of rocks belonging to this period in Tasmania are between Railton and Latrobe in the north, and at the Humboldt Divide and in the Florentine Valley in the south.

The Caroline Creek beds near Railton have furnished fossils which have been identified by Mr. Robt. Etheridge as representing the genera Ptychoparia, Dikelocephalus, Asaphus, and Ophileta. Mr. Etheridge states that it is more than probable that the age is "that of the Lingula flags or Menevian beds of Great Britain, and the Potsdam sandstone of North America.*.

Sandstones on the north flank of Mt. Stephens, at the head of the Florentine Valley, have yielded imprints of Dikelocephalus which Mr. Etheridge has named D. florentinensis.

By general consent the upper limit of the Dikelocephalus fauna is considered as the upper limit of the Cambrian system; and at Railton a fortunate exposure at Mr. Blenkhorn's quarry shows the Dikelocephalus sandstone passing (apparently conformably) below the Lower Silurian limestone (Gordon River series).† The upper-

* Proc. Roy. Soc. Tas., 1882, p. 158.

† On this occasion I collected from the Dikelocephalus beds at the quarry a fragment of a trilobite, recognised by Mr. Etheridge as Ptychoparia stephensi (formerly known as Conocephalites stephensi).

most Cambrian beds consist of cavernous argillaceous strata, containing indistinct fossils. These are exposed at the abovementioned quarry for a width of about 6 feet, and are underlaid by the Dikelocephalus sandstone beds, which pass downwards into chocolate-coloured clay slates and thinly-bedded sandstones and pebbly grits. The whole series continues north-west from the quarry along the Latrobe-road, crossing the railway-line at the bridge over Caroline Creek, about 4 miles from Railton. The dip is uniformly south-westerly. At the bridge the strata appear in the railway-cutting as chocolate-coloured sandstones, dipping at an angle of about 30°. On the bank here fragmentary and ill-preserved remains of trilobites may be collected after a little search. Boulders of yellow friable sandstone seem to be the home of most of the fossils.

In the Railton township yellowish slates, sandstones, and coarse grits are exposed near the Wesleyan Church, the latter carrying impressions of univalves, considered by Mr. Etheridge as belonging to the genus Raphistoma. The strata are steeply inclined, sometimes vertical, but on the whole dipping to the N.E.

The Railton exposures of Cambrian strata correspond with similar exposures on the Humboldt Divide, where the trilobite sandstone underlies the Gordon River limestone and passes down into chocolate-coloured slates near the Humboldt Mine.

At Gunn's Plains the limestone rests upon a series of cherty conglomerates, breccias, tuffs, and chocolate-coloured slates, which are probably of Cambrian age. The yellow fossiliferous sandstones of Caroline Creek, however, appear to be absent there, and until further evidence is available, it is perhaps safer to use the indefinite term Cambro-Ordovician for this breccia-slate system.

(3)—Cambro-Ordovician.

At Gunn's Plains, the northern boundary of the Gordon River limestone (Ordovician) is seen on the west side of Walloa (Copper) Creek, in the block charted in the name of C. J. Kent. Its strike is N.W.-S.E., and dip S.W. The cherty conglomerates of the Sugar Loaf Gorge and the Copper Creek country pass below the limestone at a high angle.

The accompanying map shows the remarkable development of the conglomerate series as exposed along the Leven River for a couple of miles from the Plains. The whole series has a N.W.-S.E. strike, with a south-westerly dip.

The ravine of the river intersects numerous parallel belts of conglomerate, breccia, slate, and tuff, alternating in rapid succession and interrupted at intervals by dykes or other intrusions of igneous rock.

The conglomerate is characterised by three marked features. Its texture on the whole is fine or medium-grained. The pebbles have a tendency to become angular in form, the rock assuming the nature of a breccia; and the dominant components are not quartz pebbles, but stones or fragments of chocolate-coloured or greenish cherty slate. These characters produce a lithological *tout ensemble*, which invariably makes the recognition of this series easy, in whichever part of the island it may occur. It may be remarked *en passant* that they distinguish it from the variety of the West Coast conglomerate familiar on the mountain ranges north and south of Mt. Lyell. It is identical with the fine-grained breccias which are exposed on the coast-line east of Lodder's Point and at the Neptune Mine. The breccias tend to become gossanous and pyritiferous, and either to enclose patches of igneous rock or to be subject to intrusions of same. They are themselves largely tuffaceous. This association with tuffs and intrusive rocks will be referred to subsequently in this report.

The same series of purple, green, and black slates continue west to the mining sections on Copper Creek, alternating there also with conglomerate and breccia. Opposite Mr. E. Wing's house, at the north end of the gorge, black slate crosses the bed of the Leven, and probably exists below the flat land of the valley there. Where the road turns to ascend the Leven Hill it intersects a band of conglomerate, and thereafter is in igneous rock of the porphyroid group right up to the level of the plateau.

These Cambro-Ordovician strata extend east and west below the basaltic covering of the North-West Coast, interrupted at intervals by intrusions of porphyroid, serpentine, and granite. They are exposed at Stowport, between the Emu and Blythe Rivers, and at the Blythe Iron Mines. Here, however, they strike N.E.-S.W., and dip S.E. The same geological succession appears to prevail as at Gunn's Plains. The limestone rests upon the older series on E. Addison's 31 acres, No. 9336, west of the Blythe Bridge. Although the underlying rocks are greatly concealed by the overlying basalt, enough can be seen to establish the occurrence of conglomerate between the limestone and the slate strata. The conglomerate is visible on

the main-road, east of the Blythe iron lode, on O. Allen's land, and descends south-westerly to the Blythe River, where it constitutes the hanging-wall country of the iron lode. Two miles further south it emerges on the 320 acres, (T. S. Rutherford), east of the iron lode on that property. The copper-bearing strata west of this line are those in which the Burnie and Rutherford Mines have been worked. The ascending sequence is accordingly—(1) Copper-bearing slates. (2) Conglomerate. (3) Limestone.

At Alma a succession of copper-bearing slates, conglomerates, and breccia also occurs, but no definite datum-line for deducing their geological horizon-line has been found. The limestone is absent, but schists occur on the Forth River further north, and these are assumed to be Pre-Cambrian. The Alma strata are, therefore, probably Cambrian or Cambro-Ordovician. They are associated with porphyroids, and may be taken as members of the same system as the copper-bearing series at Gunn's Plains. It must be borne in mind that the term Cambro-Ordovician is only provisional. It is extremely probable that later research will make it necessary to transfer many of these strata to the Cambrian.

Mr. L. K. Ward, after examining the slate series of the Dundas field and the brecciated conglomerates there, and comparing same with the above observations, and my specimens from the North-West Coast, correlates these strata in both districts as belonging to one system.

The task remaining for the survey is to establish the exact geological position of the breccia slate series, *i.e.*, to determine whether it is higher in the record than the Dikelocephalus sandstone or whether it occupies a lower horizon in the Cambrian. At Gunn's Plains it is immeddiately below the limestone; at Lodder's Point it succeeds the Pre-Cambrian schists.

(4)—Ordovician.

The limestone occupies the floor of the Gunn's Plains Valley from north to south, bearing in a N.W.-S.E. direction, and dipping S.W. It would thus have an observed width of about 5 miles, and its strike, if prolonged S.E., would take it into the Mole Creek district. Its first appearance on the Plains is on the west bank of Copper Creek, at Mr. Wells' farm, where it comes down from Kent's land on the hill. It occupies the slope of the hills on the west side of the Leven River, and has a similar position on the east side of the Plains. It is sparsely fossiliferous, and the fossils are generally replaced by calcite. However, a few imprints of a small Orthis are occasionally obtainable. It undeniably belongs to the Mole Creek and Gordon River series.

A small lime-burning industry exists at the Plains, and the lime, which is of excellent quality, finds a ready sale at Ulverstone at 2s. per bushel bag. The stone is also used for metalling roads at the Plains.

Caves have been known and visited for some time at the Plains, but until recently they have not attracted attention. Those on the west side of the Leven are not of a striking character, but the cave on the Limestone Reserve on the east side of the valley, officially opened this month by the Hon. the Premier, possesses spectacular merits which make it an undoubted asset from the tourist point of view. It deserves to be opened up on a still larger scale.

(5)—Igneous Rocks.

(*a*)—*Porphyroids.*

Ancient igneous rocks are strongly developed in the Leven Basin near Gunn's Plains. Along the course of the Leven River after it issues from the Plains various members of the Porphyroid complex are exposed. This complex comprises a series of dynamically affected quartz and felspar porphyries represented elsewhere in Tasmania at Mts. Farrell, Lyell, Jukes, Darwin, and other points on the West Coast Range. They range from distinctly acid types through subacid to rather basic varieties. The latter are characterised by abundance of pyroxene and comparative poverty in quartz.

A remarkable series of bedded tuffs is seen exposed for 400 feet along the roadside south of Hampton's cottage, in the Sugar Loaf Gorge. These are evidently contemporaneous with the conglomerate and slate, and are perhaps the oldest directly igneous rocks known in Tasmania.

These are soft, short-jointed, light-grey rocks, dotted with numerous specks of kaolin, yielding forms of felspars, which are usually lost in preparing slides for microscopical examination. Under the microscope the base appears as a pellucid glass, with numerous vesicular steam cavities. In this base is a confused groundmass of particles of ash and felspar microlites, with occasional grains and nests of quartz. It is evidently an acid tuff, and its position, interbedded with the slate and conglomerate series, points

to a much higher antiquity of the porphyroid complex than has hitherto been ascribed to it.

The next members of the series to be considered are the clastoporphyroids. These are brecciated rocks, often gossanous, and enclosing irregular tuffaceous patches, with an occasional sprinkling of pyrite. They are characteristically calcareous, but have a partially vitreous and felsitic base, with much quartz, some of it secondary. In part they are probably fragmental tuffs. These rocks are strongly developed north of Brown's cottage, and again further on the road towards Wing's. The forms of calcite seen microscopically in this rock are rather suggestive of being pseudomorphous after felspar. Porphyroidal rocks which have been derived from tuffs, as well as altered porphyroid tuffs, are known under the name of clastoporphyroids, and these irregularly fragmental igneous rocks seem to belong to that type.

East of Wells' farm are some low hills, north of the road, which appear to be composed of a reddish hornblendic porphyroid, also met with on the west side of the Leven in the Sugar Loaf Gorge. The same rock occurs on the Forth River at the Waterworks building intrusive in slates, with an exposure of two or three chains in width. Numerous stones of the same rock are to be seen in the shingle on the beach at Ulverstone.

It is a granophyric quartz-felspar porphyry, with most of its porphyritic felspars triclinic, and approximates to the quartz porphyrites. Besides the phenocrysts of felspar there are others of corroded quartz, and some imperfectly preserved forms of green hornblende. The groundmass is an aggregate of quartz and felspar in granophyric intergrowth.

On the west side of the Leven, opposite Hampton's cottage, is a bluff of rock belonging to this group. The groundmass is a quartz-felspar aggregate. The phenocrysts are quartz, felspar (mostly triclinic), and a few doubtful remnants of ferro-magnesian minerals. The quartz phenocrysts have angular fragmentary outlines or are embayed.

Not far from the south end of the Sugar Loaf Gorge the road intersects a band of bluish porphyroid between slate on either side, 75 feet wide. This is a siliceous variety, quartz phenocrysts being abundant. These are either angular or with corroded boundaries. Orthoclase and plagioclase felspars are the principal remaining phenocrysts. A few remnants of a light-green hornblende can be detected.

Besides the acid and sub-acid rocks referred to, more basic varieties occur, to which it is hardly possible to give definite names until they have been more closely examined. In the meantime, they are designated pyroxenic porphyroids. They are essentially augite-plagioclase rocks with accessory hornblende, biotite, or quartz. The presence of these accessories is taken to indicate relationship with the porphyroid group rather than with our diabase and basalt, which they otherwise recall. One variety of this type is seen at the point of the road south of E. Wing's house.

It is known locally as serpentine, owing to the development of asbestos on its joint-faces. It is very much decomposed, but the exposure along the roadside can be traced for 200 feet in width. On its south wall are conglomerate and breccia. Its north wall is concealed, but is probably slate, as the latter is exposed in the river opposite Mr. Wing's house.

Under the microscope the rock appears to consist of plagioclase felspar and augite, with accessory hornblende and biotite. Where there is any interstitial material in the groundmass, it is quartzo-felspathic, though it is doubtful to what extent the quartz is original. The idiomorphism of the augite is less than that of the felspars, the prisms of the latter frequently penetrating the forms of the pyroxene. To the naked eye the rock is dark, of granular texture, with no distinctive characteristics. It here evidently forms a dyke.

The next basic variety is the rock exposed in the roadside all the way up the Leven Hill from Clark's farm, 10 miles from Ulverstone. The general appearance, weathering, and occurrence, conform with those of a basaltic rock, and it might very well be mistaken for the usual Tertiary basalt of the North-West Coast. It contains, however, visible pyrite, and microscopical examination shows that there is a considerable quantity of granular quartz in its base. It is a plagioclase-augite porphyritic rock, with the augite crystals generally collected in nests, somewhat after the fashion known to petrologists as glomero-porphyritic. Microscopically, it shows signs of crushing, and must belong to the older rocks.

Future work on these rocks will show whether all of them can be included in the group which, using the term in a liberal sense, we are designating by the name of porphyroid. In Tasmanian geology the whole group bears the name of some of its most prominent members. Thus, strictly, porphyroid is dynamically-altered quartz-porphyry.

But in our quartz-porphyry complex we have a great variety of types, *e.g.*, granite, syenite, granophyres, felsites, porphyrites, quartz-diorite porphyrites, diorite porphyrites, and apparently some imperfectly understood more basic members.

The whole group at Gunn's Plains seem to be confined to the slate and conglomerate area, *i.e.*, infra limestone. Once the limestone country is entered upon, the porphyroid exposures are absent. Whether this is merely a coincidence or not is uncertain, but it is, to say the least, suggestive of the eruptive rock being older than the Ordovician limestone. The bedded tuffs certainly are older, but the other eruptives appear to be intrusive in the slates and conglomerates, and to have been dynamically affected in their own way as much as the slates have been in theirs. In this they differ from our Devonian granite, which is always uncrushed. The porphyroid group, therefore, must be Pre-Devonian. It seems to have been contemporaneous with the Cambro-Ordovician, and perhaps in part later than the lower members of the system.

In accordance with this view, we find the granite of which the porphyroids are modifications developed elsewhere in the island under conditions which point to it pre-dating our Devonian granite. Thus, on the Murchison River, Mt. Farrell, Mr. L. K. Ward (in his report on the Mt. Farrell field, Bulletin No. 3) mentions it as a medium-grained basic granite or syenite altered by dynamical stresses and merging into green porphyritic felsites. This is the rock that used to be called in Germany syenite-granite. In the Rosenbusch classification it would be termed amphibole-granitite, *i.e.*, a biotite granite containing hornblende. The hornblende varies in amount, and to its quantity, quartz and orthoclase (according to Rosenbusch) occur in inverse ratio, plagioclase directly, and the latter becomes more basic. In this way, complete passages to plagioclastic rocks are effected, on the one hand to the dioritic and tonalitic facies of granite, and to orthoclase rocks without quartz, or poor in it, on the other (the syenitic facies of granitite). In Tasmania, syenitic or dioritic modifications are frequent in connection with our porphyroidal granite.

Whether the Devonian is the only granite to which our ores are genetically related, or whether some of them are connected with the porphyroid series, is a question which is occupying the attention of the Survey, and cannot be definitely settled until more complete data are collected.

In any case the distribution of the latter group is acquiring increased importance in the geological scheme, and may prove to govern ore-deposition more directly than has been hitherto supposed.

An outcrop of porphyroid also occurs on the Alma Mine property, at the top of the hill above the mine works, where it forms a crag of hard projecting rock of reddish-brown colour.

(*b*)—*Serpentine.*

About ¾-mile south of the township of Hamilton, serpentine is exposed along the road, apparently for about a couple of hundred feet. It must extend to the north-west, as I am informed that it also occurs on Mrs. Jas. Smith's property at Westwood. Its boundaries are not clearly visible, but it seems to be between quartzite on the east and schistose, garnetiferous zoisite-amphibolite on the west. It is a handsome stone, and if any demand existed, could doubtless be worked for ornamental purposes.

Microscopic examination of it shows that the serpentinisation has proceeded pretty far. However, crystals of rhombic pyroxene can be clearly identified, and the forms of the other crystalline component (which is thoroughly serpentinised) point to this being olivine. The rock would accordingly be the olivine-enstatite peridotite known as harzburgite.

At surface it does not show any connection with gabbroid rock, and gabbro is not known in the vicinity, but the rock is, nevertheless, a product of the gabbroid magma. Rosenbusch, in his "Massige Gesteine,"* states:—"Peridotites and pyroxene rocks have no sovereign geological independence; they partake of the character of vassals, and in classification should be attached direct to the members of the gabbro family, of which they represent the non-felspathic forms."

Although at the Forth the serpentine appears not far from amphibolitic schist, no causal relationship has been established between the two at this spot.

(*c*)—*Granite.*

The granite of the Hampshire Hills and Housetop area extends northwards as far as the southern portion of the Rutherford Mine property between the Emu and Blythe Rivers, and its northern edge continues south-easterly

* 1907, I., p. 452.

across the intervening country to the southern boundary of Riana township. There is some granite also east of the Dial Range at Hardstaff's Mine, and there must be some also in the hill east of Copper Creek, as I picked up a piece in the bed of a small creek which flows east into the Leven at the Gorge.

The copper-ore lode at Hardstaff's—an ore-channel from 18 inches to 21 inches wide—is in the granite on the side of a hill, which is one of the slopes at the base of Mt. Duncan, a peak of the Dial Range.

None of the intrusive rocks exposed on the sea-coast between Ulverstone and Penguin belong to this division. Where they are granitoid they are connected with the porphyroid group, and not with the Devonian granite.

(*d*)—*Basalt.*

The Tertiary olivine basalt caps nearly the entire table-land south of the sea-coast for miles inland. The ordinary type has, under the microscope, hypocrystalline and doleritic structure. Occasionally the felspathic component disappears, and the micro-structure and mineral constitution indicate a limburgitic facies. This is noticeable in the basalt in the Forth Valley.

Amphibolite.

South of Bourke's land, about a mile from Hamilton-on-Forth, on the Wilmot-road, a hill range of amphibolitic schist skirts the road. Judging from the exposure of quartzite schist in the hillside at the back of Bourke's, the amphibolite would lie between that and the serpentine. An outcrop of it also occurs in the garden in front of the cottage. Apparently it belongs to the Pre-Cambrian series.

The rock is a zoisite-bearing garnet amphibolite, and may be placed in Grubenmann's order of meso-amphibolites. The three families composing this order [garnet amphibolite, plagioclase amphibolite and zoisite—(and scapolite)—amphibolite] are often geologically associated with one another, and passage-rocks are known. In the present instance we have a variety which unites the garnet and zoisite amphibolites.

The variety probably represents the metamorphism of a basic rock, the original pyroxene having contributed to the formation of amphibole, olivine and plagioclase being represented by garnet and zoisite. Grubenmann derives the garnet amphibolites from eclogites, and points out that the garnet of many eclogites changes in the middle zone into a mixture of hornblende and felspar (or of biotite and felspar), and subsequently into zoisite and epidote.

No felspar is present in this rock. The component minerals are hornblende, garnet, and zoisite, with granular quartz. The hornblende is pale green, the zoisite colourless to grey, giving fusiform sections with prisms parallel with the hornblende crystals and with each other. The garnet is in anhedral rounded crystals, pale pink by reflected light, colourless or pink-tinged in thin section. The structure of the rock shows the schistosity of recrystallisation.

Another amphibolite, coarser and non-schistose, occurs on the crest of the hills above and west of the Alma Mine. This was possibly originally a gabbro. It consists of large plates of hornblende pale green in thin section, crystals of colourless augite and cloudy felspar, in which lamellar twinning lines are well nigh obliterated. This rock seems to fall in the family of plagioclase amphibolites. Its geological occurrence cannot be properly known until more is known of its immediate surroundings. It does not occur in the crystalline schist area, but in the slate-breccia Cambro-Ordovician zone, and in the neighbourhood of porphyroid exposures.

V.—MINING PROPERTIES.

(A)—Copper Creek Mine.

This mine is situate on the Copper Creek (or, as it is named on the charts, Walloa Creek), about 1¼ mile from its confluence with the Leven River, at Mr. Wells' farm, Gunn's Plains. The section, 40-acres, No. 252-M, is charted in the name of Mr. W. R. Applebee. Besides this, three adjoining prospecting areas, of 80 acres each, have been taken up by the mine-owners, who have now registered their syndicate as the Copper Creek Mining Company, No Liability.

In the old days outcrops of copper ore were discovered on the banks of this creek by the late Mr. James Smith, and it is believed that he worked somewhere in the vicinity of the present mine.

An outcrop in the steep creek bank was discovered about seven years ago, and Mr. W. R. Applebee took up 40 acres for mining purposes. In 1903 a departmental examination of the creek was made, and a copper ore lode-forma-

tion with a calcite gangue was inspected a little below the present mine. Samples chipped from the outcrop were assayed in the Government laboratories, and returned 4·8 per cent. copper and 2 ozs. of silver per ton. Other samples taken to Launceston by Mr. Percy Harrison were assayed at the Mt. Bischoff Smelting Works and yielded 2·3 per cent. copper and 9 ozs. 16 dwts. silver per ton. The bands of copper-bearing calcareous slate were recognised as being in a favourable position for prospecting drives, and it was considered likely that further exploration would disclose something more payable.

Another lode was found to crop out on the hillside about 250 feet above the creek, and the present company has devoted its attention to this.

The work which has been taken in hand by the company in connection with this lode comprises the following:—

(1) Trenching on the gossan outcrop near the hut 300 feet above the creek.
(2) An open-cut into the lode outcrop on the hillside.
(3) An adit driven 60 feet into the hill, intersecting the lode at 39 feet in. This is 30 feet below the open-cut.
(4) A lower adit driven at creek-level for 28 feet, intersecting the lode in 200 feet of driving.

The above will now be described *seriatim*.

(1)—*Gossan Trench.*

A small cut has been put in at 40 feet south of the hut for 12 feet in a north-westerly direction on the course of a line of gossan which looks fairly promising. About a foot of gossanous material is showing in the trench, but the full width has not been ascertained. The company sent some of it to the Government Analyst, with a result of 0·75 per cent. copper and 1 dwt. gold per ton. My samples, assayed in the Government laboratories, yielded 17 grains gold and 18 grains silver per ton.

(2)—*Open-cut.*

An open-cut has been driven into the hill for 17 feet in a south-easterly direction, exposing the lode 3½ to 4 feet in width, vertical, widening underfoot, and striking about 15° east of south. The lode gangue is slate, calcite, and quartz, and contains bunches of specular iron ore, pyrite, and a little copper sulphide. The country rock is a light-coloured slate, which becomes harder as it approaches the lode.

(3)—*Upper Adit.*

Thirty feet below the open-cut an adit has been driven for 62 feet in a direction S. 65° W., cutting the lode at 23 feet. The bearing of the lode being here S.E., the adit has intersected it obliquely, and, in consequence, the width of lode passed through in driving is greater than its actual width. The apparent width is between 6 and 7 feet, but the true width is about 5 feet. The lode-matter consists of a siliceous slate gangue of greenish hue, and distinctly brecciated, well mineralised with pyrite, chalcopyrite, covellite, and specular iron ore. It is widening also in this adit underfoot, and the stone is of better quality than in the open-cut above.

My samples from this lode returned, in the Government laboratories, 2·9 per cent. copper and 2 dwts. 8 ozs. silver per ton. I am informed that the ore broken and sent away was of higher grade, and that the owners anticipate that it will be possible by selection to produce ore of marketable quality. It has been driven upon for a few feet south. Two and a half tons of ore from this point have been forwarded to the Mt. Lyell Company's smelters at Queenstown, but the quantity was too small for treatment by itself, and the ore sent has remained unsmelted.

Both the lode and strata underlie to the N.E., but a few feet behind the end of the adit a pug seam occurs, beyond which the slate dips S.W. into the hill. The underlay of the lode will cause it to be met with in crosscuts lower down at increasingly shorter distances.

(4)—*Lower Adit.*

A bottom adit has been put in to intersect the lode at the level of the creek. No surveys have been made of the surface features, and from the precipitous nature of the ground, it is not easy at a glance to see what positions the mine openings occupy in relation to one another. The bottom level, however, appears to be 150 feet or 200 feet below the upper adit. It has first been driven from the creek in a south-easterly direction across regularly cleaved slates, which have here a strike of N. 70° E. It would appear, therefore, that the strike of the strata differs considerably from that in the upper adit, and it could not be expected to intersect it by driving across these. After

driving 90 feet into the hill, the direction of the crosscut was changed to south-westerly, and at 100 feet thereafter a lode-formation, 9 feet wide, with wet flucans on each side, and carrying about 3 feet of hard, ore-bearing stone, was crossed. It carries a sprinkling of iron and copper pyrites, and its gangue is calcite and slate, the latter inclined to be black and greasy. From its position and character it would seem to be the same lode as the one cut above, but absolute certainty on this point is not possible until a survey has been made.

The broken and steep country prevents a simultaneous view of the various outcrops and tunnel openings, and a comprehensive surface and underground survey would be extremely useful in giving data for reliable determinations of positions. The lower crosscut has been driven 80 feet beyond the intersection of the lode. At about 20 feet behind the end is a pug, slate, and quartz-formation, carrying no mineral, but yet indicative of some lode action. This might very well be tested to see whether it leads to anything. After passing through the main lode the country rock changes; it becomes harder and rougher, and a little behind the present end it merges into a breccia. The lode cut in this adit, though not so rich in copper as in the higher level, is not less strong as a formation. It has been strong enough to break through the strata in descending, notwithstanding their change of strike, and it appears to be going down unimpaired. The company states that the lode-matter yielded about 4 per cent. copper by assay. My samples returned 1·6 per cent. copper and 1 dwt. 15 grs. silver per ton.

The lode in the upper level will no doubt be tested first, and the pitch of the ore-shoot ascertained before driving aimlessly at the lower intersection. The company will probably obtain good advice as to whether it would be well to cut the lode a little lower than the present upper tunnel so as to avoid the shallow ground of the gully.

The lode has practically only been cut at the different points mentioned, but sufficient has been disclosed to justify further work, with a view of proving its value.

The section taken up by the company seems to comprise an ore-bearing channel of slate country between two belts of conglomerate or breccia. The lode in the bottom level is situated on a line where the country changes. The end of the drive is unmistakably in a bed of breccia. The face is tolerably dry, though a little water is dropping from the roof a few feet behind the end.

The breccia beds are, perhaps, not quite so favourable for defined ore-channels as the firmer slate country, but there is no reason for characterising them as barren. Some of these breccias are undoubtedly igneous in origin, and carry disseminations of mineral. Ore-bearing breccias are rather common along the flanks of the Dial Range, and are really an encouraging feature of the whole district. No valid objection can be urged against continuing this level into the breccia country.

Other lodes exist on the property, and although their exposures cannot be termed remunerative, taken together they establish the existence of a cuprifrous zone, in which exploration is highly desirable.

McDonald's adit, about 50 feet above the creek, has been driven for 30 feet into the hill across slate strata, striking N. 75° E. At the entrance a small puggy seam of copper ore was met with, and there is said to be another vein in the end, but standing water in the level prevented examination. The company states that some 11 per cent. copper pyrites was obtained here.

Below this adit, on the south side of the creek, is a vein with some copper pyrites and native copper; and still lower down the creek is a further cupriferous channel, from which the company quotes an assay as—copper, 3·6 per cent.; gold, 1 dwt. per ton; silver, 3 oz. 12 dwts. per ton.

Sufficient water-power exists in the creek for all purposes, and the creek route will, in the event of operations proving successful, no doubt be made the outlet to the property. At present a horse and bullock track winds its way up from the plain to the crest of the hill overlooking the mine, at a height of about 600 feet. Before considering the erection of plant, thorough prospecting and underground development must be carried out.

The belt of strata in which the Copper Creek lodes are situate evidently comprises the beds immediately below the Ordovician limestone, which creeps up the hill to within about 15 chains of the north boundary of Kent's block. These beds are consequently Cambro-Ordovician, or, if we regard the limestone as the base of the Ordovician, probably Middle Cambrian. They belong to the same series as the strata cut through by the River Leven in the Sugar-loaf Gorge. The conglomerate which plunges below the limestone on the west side of the creek can be traced right across to the Leven, but the slate belt has evidently been disturbed, most probably by the igneous

intrusions of the porphyroid group, which occupy a considerable portion of the hill range between Copper Creek and the Leven.

Wherever in this district we meet with rocks of the group just mentioned, pyrite and a little disseminated chalcopyrite occur, under conditions which indicate the possibility of some ore-deposits being genetically related to this series of eruptives; but further study of occurrences is necessary before any definite conclusion can be arrived at.

About 3 miles north copper-ore lodes exist in the Devonian granite , and the usual reference of minerals in lodes in our stratified rocks exclusively to the granite batholith of that age rests on too broad and firm a basis to be easily shaken. Nevertheless, the constant association of copper ore with occurrences of the porphyroids claims careful consideration.

(B)—Radford's Reef.

On the west side of the Leven Gorge, opposite A. S. Brown's 30 acres, some mining ground has been taken up by Mr. H. J. Colbourn. About 25 feet above the river an open-face has been cut in the hillside, showing slate or shale, passing down into clay strata containing a good deal of manganese oxide at top, and sandstone at bottom, with an intermediate band, about 4 feet thick, of light-grey argillaceous sandstone carrying disseminated iron pyrites and little nests of specular iron ore and copper pyrites, the latter, especially on the faces of small cavities, lined with quartz in crystals. On the north side of the open-cut is a junction of the sedimentary rock with intrusive porphyroid, and this junction can be followed east to the river, where it can be well seen at the point, at which the slate is silicified and brecciated.

The same grey siliceous pyritiferous rock is seen round the point on the river, and a few yards north of it a trench has been cut 10 feet above the water and into the hill in a westerly direction. As far as can be seen the trench is in overburden, which is very deep here, and has fallen in, preventing examination.

The impregnation of the sedimentary strata with a little copper ore near their contact with the plutonic rock is not sufficient to justify further expenditure at this point. South-west of the open-cut the porphyroid reappears on the hillside at no great distance, so that the area of stratified rocks must be extremely limited just here. The whole

hill is intersected by numerous intrusions of the igneous rock, and while ore deposits may possibly occur here and there, extreme variability within short distances is likely to be a feature of them.

(C)—Brown's Blow.

This is on the east bank of the Leven opposite Radford's Reef open-cut, and is a wide exposure of flinty slate, carrying a considerable development of quartz. A little specular iron is visible. There is no reef here, but apparently silicification of the slate has taken place near a contact with eruptive rock.

(D)—Colbourn's Show, on Road.

Beyond the point on the road north of Brennan's an excavation has been made in the solid edge of a large landslip, which has brought down a huge mass of rock bodily. The latter has parted from the standing cliff-face just east of the mine cutting.

The country is a gossanous breccia of the kind described in this report as clasto-porphyroid. The tuffaceous and igneous material contains disseminated pyrite, but the indications do not encourage much expenditure here. Mineral may be scattered through the rock-belt, but there are no signs of lodes or any definite channels in which ore-concentrations occur.

(E)—Heazlewood's Silver Mine.

This comprises some sinking and tunnelling done at an outcrop on the Leven River south of Griffin's 30 acres, 7 miles south-west of Ulvertsone. The discovery was made in 1891 by Messrs. Lines and Elliott. Mr. Lines informs me that some of the galena from it was sent to the Launceston Exhibition in that year, and that the assay went from 15 to 20 per cent. lead and 36 ozs. silver per ton. Definite information, however, is not available now. The show was idle for some time, and then between £300 and £400 were spent upon it; but I understand the country was loose, and there was a difficulty in getting into solid ground. Nothing can be seen now unless some preparatory work is done. A mile above this, I understand, a large gossan formation was found.

(F)—Preston Silver Mine.

Section 249, 80 *acres.*—This is situate in the Castra Parish, 4 miles south-east of Gunn's Plains, and is reached by the road running through from the coast to South Preston and Nietta. The road is metalled nearly to the turn-off to the mine. The tableland over which the main-road passes is capped with basalt and basaltic soil, but leaving the road, on the mine track to the south-east, the older rocks are soon met with. At a height of 1500 to 1700 feet above the sea is a felspathic (arkose) grit and conglomerate, which is probably of Permo-Carboniferous age. Descending from this to the creek where the mine is situated (one of the branches of the Gawler) the more ancient Cambro-Ordovician conglomerate crosses the creek in a direction east of south, where it adjoins metamorphic slate country on the west, dipping to the south-west at a very steep angle. A little gully on the south side of the creek appears to form the line of junction. In the slate on the west side of the contact are some parallel lode-lines, along which a little galena and zinc blende, with pyrite, have been deposited in the cleavage-planes and joints of the country. Some of the slate has been silicified by the lode-solutions, and is porous and mineralised. Veins of calcite are associated with the metalliferous bands. There is nothing very definite at surface from which conclusions may be derived. A small shaft has been sunk to 15 feet on the south side of the creek, and little pockets of pug were found, carrying galena in slugs. Mr. R. Lee first worked here three years ago, and afterwards Anderson and party. An assay is stated to have yielded 16 or 18 per cent. lead and 36 ozs. silver.

Locally some doubt exists as to the direction of the ore-channel, but a trench between the shaft and the creek should clear this. Indications point to the mineral zones running across the stream, parallel with the bearing of the slate. Other lodes are said to cross the creek higher up. A drive into the hill on the course of the main lode would develop the latter, and give facilities for crosscutting west for parallel lodes.

(G)—Rutherford Copper Mine.

The Stowport district was visited on the present occasion in order to co-ordinate the geological sequence there with that at Gunn's Plains. Enough was seen to correlate the strata and establish their *infra* Ordovician-limestone horizon.

The Rutherford Mine, on the 320 acres purchased block, has now been idle for some time. The financing arrangements appear to have been inadequate, and funds were exhausted before the prospecting work was properly completed. Ore was discovered in 1899 by the Messrs. Rutherford, who prospected the property in various directions. A tunnel was started, and a small gossanous lode cut just inside the entrance. This lode, yielding some fair quality copper ore, was followed down by sinking, and stoped at 16 feet and 32 feet. The total quantity of ore raised has been 100 tons, returning 10 per cent. copper, with negligible gold and silver contents. The bearing of the lode in slate country is north-east, and its dip north-west. Its width varies from 1 foot to 3 feet, but averages from a foot to a foot and a half. A main shaft was sunk 100 feet to enable the lode to be cut in depth. A crosscut east was opened out from the bottom for a length of 75 feet, and one west for 50 feet. At a distance of 30 feet in the east crosscut, a vein was intersected carrying 8 inches of ore, underlying towards the shaft. This was met with in a much shorter distance than was expected, and gave rise to doubts as to whether the lode had really been cut. The continuation of this crosscut, however, and also a crosscut west, showed nothing further, and the probability is that the lode has actually been intersected at a weak point. There is an obvious necessity here for the proprietors to continue the work of exploration to its legitimate finish by driving on the lode where it was cut in the bottom east crosscut. The west crosscut should also be continued to a formation which lies some distance ahead of the end.

The remarkable development of hematite on this property east of the lode, and running parallel with it, and on the direct strike of the large outcrop on the Blythe River, is an indication strongly suggestive of the deposition of copper and iron ores having taken place on parallel lines. Evidently the copper and the iron lodes in this field are closely related to one another. The copper mines which have been opened in this belt of country further north are on the lodes which are parallel with and near the strong iron lode of the Blythe. Coming south these lodes can be traced to the neighbourhood of the boundary of the granite. Both the copper lodes and the iron lodes are probably genetically related to the granitic invasion.

Local opinion is as strong as ever that these massive hematite outcrops cover lodes of pyritic copper ore. No sulphidic mineral, however, has yet been found, either

in the hematite or directly below its outcrop. The most that has been observed is the presence of a few specks of chalcopyrite in the altered quartzitic rock, which is the wall-rock of the iron ore outcrop on Clark's land, north of the Blythe. This supports the view that the iron and copper lodes have mutual relations, but is also consonant with the supposition that they are structurally distinct.

Lode on Road at Turn-off to Dicker's.

On the Rutherford property, at the turn-off down to the Blythe Bridge, a strong gossan formation has been ploughed through in forming the road. This has been intersected obliquely for 6 or 7 feet, and appears to be running south-west, as is the case with the other lodes in the district, and to dip south-east. At one point in the road some hard quartzose veinstone was met with in this formation, consisting of quartz and solid arsenical iron pyrites. Only a few pieces of this solid stone have been turned up with the pick, but there is evidently a metalliferous lode here, upon which it might be worth while spending a little money to open it out and see what it contains. The absence of copper stains or secondary copper ores in the outcrop is an unfavourable indication. The samples which I took yielded 4 dwts. 21 grs. silver per ton, and a trace of gold.

The Blythe iron lode is supposed to pass here, and some loose blocks of porous limonite and hematite are seen on the hill south of the road. I am inclined to think, however, that the true course of that lode is further west, between here and the Rutherford Mine.

The lode on the road is in quartzite country, east of which lies conglomerate and slate, succeeded further east by the limestone on Addison's land. The changes in the strata are visible, but the actual contacts are not seen. This conglomerate, as already mentioned, continues north to the east of the Blythe River iron ore outcrop and to O. Allen's 100 acres; and still further north, behind Mr. Edwards' farm, it is likely that the siliceous conglomerate with white quartz pebbles and jasperoid stones exposed there in the bank descending to a creek is the northern continuation of the same belt. At the latter place it is plentifully sprinkled with pyrite, and copper pyrites is alleged to have been found in it.

From the observations made on this journey the fact emerges, established for the first time, that this set of slate, quartzite, and conglomerate strata, comprising the

country between the Blythe and Forth Rivers, forms an infra-limestone geological group characteristically harbouring the copper ores of the coastal districts.

(H)—L. J. Clark's Lode.

Across the creek, below Mr. Clarke's house, at Stowport, a short and narrow adit has been driven west into the hill by Mr. Clark in a wide lode-formation, about 10 or 12 feet wide of lode-material, as far as can be seen. A little difficulty has been experienced in finding the directions taken by the lode, but eventually it was ascertained to be southerly. The formation is soft and oxidised, indicative of sulphides below. Black graphitic slate forms the footwall on the west. A little copper pyrites is visible in the stone, which, moreover, is coloured with copper carbonate and sulphate. A vein of hard pyrite was cut inside.

Owing to the configuration of the hill, there is hardly any use in continuing the adit, as no backs are obtainable, and no solid country would be met with. If any work is to be done here it must be by sinking. Probably some water will be encountered from the little creek close to the mine.

The position of the lode appears to be to the west of the western formation on the Rutherford property. The proximity of the granite is no doubt responsible for the series of lodes in this neighbourhood, and a little prospecting work on most of them is quite legitimate.

The present lode, from its width at surface, and its indications of copper ore, warrants some trial work being done on it, and a shaft should be put down to prove the sulphide, which, there is reason to believe, must exist in depth.

(I)—Alma Mine.

The Alma Prospecting Syndicate has been carrying on mining operations at the Alma, or old Barrington, Copper Mine, as it used to be called. This is situated about a couple of miles above the bridge over the Wilmot, and lies west of the Forth River, above its confluence with the Wilmot River, 10 miles from the sea-coast.

The approach to the mine is by means of the high road from Hamilton-on-Forth as far as the bridge, and then a turn-off through the forest. This road ascends the valley of the Forth River, which has carved its channel down through the basaltic sheet of the tableland into the ancient rocks below. Immediately south and west of the

bridge at Hamilton-on-Forth a white saccharoidal Pre-Cambrian quartzite is exposed in craggy cliffs. At about ¾-mile from the township this emerges on the road against a cliff of basalt, on the west of which is a low boss of serpentine, not more than a chain wide. The bank at the back of Bourke's (formerly Field's cottage) shows an exposure of sericitic quartzite schist, striking 340° and dipping S.W. This belongs to the Pre-Cambrian schist series, members of which crop out on the sea-beach east and west of Ulverstone. Further south, along the road, this schist is succeeded to the west by schistose garnetiferous amphibolite. On Baulch's land the amphibolitic belt is succeeded to the west by mica schist, striking 335°, and still dipping N.W.; and further south, on Mr. Wood's farm, the strata are still micaceous and quartzitic schists, with the same trend. Graphitic and quartzitic schists continue until penetrated at Paloona by an intrusion of reddish brown hornblendic porphyry, belonging to the porphyroid group, and identical with the outcrop near Wells' farm, Gunn's Plains.

South of the waterworks building, just over the Wilmot Bridge, at the junction of the two rivers, a dark granular massive rock occurs, somewhat resembling an ancient metamorphic grit; but microscopic examination shows it to be a clastoporphyroid, a tuff of the Cambro-Ordovician series. Angular fragments of quartz and triclinic felspar, with chloritic residues of ferro-magnesian minerals, and with very little base, make up the rock. It is similar to some clastoporphyroids in the Leven Gorge and the North Dundas district.

The mine was originally registered February 15, 1881, and had about £1000 or £1200 expended upon it in those days. The output appears to have been very little, but a parcel of copper pyrites was sent away at one time, the results of which are not known to me.

Literature of the Mine.

The mine was reported upon by Mr. G. Thureau, Government Geologist, in December, 1881 (Report on the North-Western Mineral Deposits, House of Assembly Paper No. 43, 1882). This report stated:—

"Certain portions of the schists in the tunnel exhibit occasionally native copper in the joints. Heavy spar (barite) occurs in conjunction with copper pyrites (chalcopyrite) in small veins enclosed also by these schists, and

some of the beds of rocks are slightly stained by green carbonate of copper.

"The workings made by the prospecting proprietary include the usual descriptions of cuttings from the surface on the course of the deposits, and a main tunnel driven in a north-westerly direction to a length of 281 feet. Two crosscuts extend from this tunnel to the west for a length of 33 feet and 32 feet respectively. . . . Throughout the whole length of this tunnel, and of the greater portion of the two crosscuts, black, hard, short-jointed schists prevail, in which the veins of barite occur, which carry a small percentage of copper pyrites. Similar veins are likewise found in similar rock about 6 chains above the mouth of the tunnel. At both ends of the crosscuts a new formation has been discovered—grey, hard, metamorphic sandstones, in which small rounded pebbles may yet be distinguished with some difficulty. . . . . Taking into consideration all the facts and features connected with the cupriferous deposits so distinctly indicated at the surface and underground, and comparing same with mines producing ores in quantity, attention should be drawn to the fact that regular walls are here altogether absent, and that the only reassuring feature on the ground consists in the recurrence of outcrops of gossan in quartzose veins, also containing barite (heavy spar) and carbonate of iron (siderite). These minerals are frequently found in connection with metalliferous deposits, and therefore I would suggest that the tunnel be extended a further distance of 200 feet, more or less, in the direction of and under the largest surface outcrop of ochreous gossan. It would be also judicious to crosscut further west from the tunnel in order to test the contact of the porphyries there with those of the metamorphic schists."

In July, 1905, the present writer reported on a visit to the mine (Report on North-West Coast Mineral Deposits, 26th July, 1905), from which the following is extracted:—

"Three crosscuts have been driven from the tunnel in a south-westerly direction. These crosscuts have touched a parallel belt of hard pebbly sandstone or breccia, which is also seen outside the tunnel entrance to the west. The first one intersected a flat vein 1 foot to 1½ foot wide, carrying a little copper pyrites associated with barytes and siderite, as well as vughy quartz. This was followed for some distance by a drive parallel with the tunnel. A crosscut 50 feet ahead of the end of this drive failed to pick up anything; and a crosscut was driven from the

tunnel north-easterly to see whether the mineral continued in that direction. Nothing, however, was met with beyond a little barytes and specks of pyrite. I am told that 9 cwt. of copper pyritic ore were obtained. . . . The occurrence of mineral here cannot be well understood without a knowledge of the geology of the country west of the breccia formation, as the latter may possibly be a shattered contact zone bordering an intrusion of some eruptive rock. . . . . Some sort of lode action has evidently taken place at this mine and produced the lode minerals, barytes, siderite, and copper pyrites. The latter may be seen scattered in the breccia, but so far all the prospecting has not revealed anything in the shape of a solid lode. The prevalence of pyrite in the country rock may account to some extent for the abundant gossan. . . . As said above, there is an unknown factor which may yet lead to some discovery in the breccia belt."

Description of the Mine.

About 400 feet west of a small creek running north on the property, and at about 150 feet up the hillside, a small shaft has been sunk to a depth of 35 feet in a strong body of gossan. This gossan line continues at surface from the shaft down the hill to the creek in a S.E. course, and is parallel with the general strike of the strata. The shaft was first started 16 or 17 years ago, when the gossan appears to have been lost; but it has been since recovered, and a drive extended for 22 feet from the bottom of the shaft in a direction S. 26° W., cut across the gossan for 18 feet, and passed into light-coloured pyritiferous wall-rock. The gossan underlies S.W., at between 60° and 70°.

The old main adit was driven into the hill from the creek at a point about 400 feet east of the shaft in a direction a little south of west, and three crosscuts were driven out south, passing through slate and entering pebbly sandstone or breccia. My report of 1905 shows that only a flat vein was followed in a drive from the first of these crosscuts. This vein was from 1 foot to 1½ foot wide, and cut across the slates, carrying a little chalcopyrite in a gangue consisting of loosely combed quartz with barytes and siderite. Lately the adit has been extended further west with the view of reaching the lode supposed to be represented by the gossan in the shaft. At the 327-feet point in the adit its direction was deflected towards south-west, so as to intersect the gossan line below the shaft on its underlay at that depth in the shortest possible distance. According to the plan there is still a distance of 20 feet to drive to reach the lode. At 13 feet behind the present end a lode of barytes 10½ feet wide has been passed through, carrying a little iron and copper pyrites. The adit intersects it obliquely, so that its true width would be about 8 feet. Beyond it the country rock changes from slate to hard conglomerate or breccia, which continues to the end, the lode occurring at the contact. There appear to be several bands of conglomerate and breccia in this hill, and the band which is now in the end of the tunnel must be crossed before the downward continuation of the line of gossan is reached. If, therefore, the idea is to prove the gossan lode in depth, driving must be continued, and when it is reached it should be driven on. A little driving should be also done on the barytes lode when funds are available, with a view of seeing whether its copper contents hold out any prospect of improving.

Barite is a common gangue mineral in spathic copper veins, and being almost insoluble it is not likely that the gossan outcrops seen at surface will pass down into barytic lodes. Gossanous outcrops of such lodes occur only when these are heavily charged with pyrite, and even then indications of the barium mineral are visible at surface. It is probable in the present instance that if some trenching were done on the hillside below the shaft the outcrop of this barytic lode would be found, and would make it absolutely certain that the gossan lode is still ahead of the main end, though if the survey is correct there can be very little doubt of it.

The Devonport tunnel is a short adit about 4 chains south of the main adit driven into the hill from the creek for about 50 or 60 feet in a north-westerly direction. It has been driven across black slate towards the contact of the latter with breccia. The lode-matter, consisting of black slate with barite and disseminated iron and copper pyrites in a puggy channel, has been left on the north side of the entrance.

A good deal of barite exists on the property. About a hundred yards higher up the creek from the Devonport tunnel a broad belt of slate is exposed in the bed of the stream, carrying bunches and veins of barite for an aggregate width of over half a chain. Much of this appears to

be crystalline and pure. In other parts it is stained superficially by iron-bearing solutions percolating from the creek banks. A hundred feet up the hill to the east a cut for about 10 feet has been put across a rather solid outcrop of barytes, a little discoloured by iron oxides, but not sufficient to spoil it for exploitation. A sample assayed in the Government laboratories showed the iron contents to be only 0·9 per cent.

Barite is a mineral, the consumption of which has increased greatly in recent years, owing to the expanding requirements of the paint and rubber trades. The best of the crude ore is worth from 16s. to 20s. a ton in America. The ore raised in England has a value of 20s. a ton also, and the selling price of the manufactured article is about £3 10s. per ton in London, ranging from £2 5s. to £5 per ton, according to quantity, quality, and package. As there is a duty of £2 per ton on imports of the latter into the Commonwealth, the trade value in Australia would be about £6 per ton, *i.e.*, for ordinary lots of average commercial quality. Precipitated barium sulphate is chemically pure, and commands much higher prices, being quoted in London at £6 to £7 10s. per ton. No statistics are yet available as to the quantity of barytes consumed in the Commonwealth, but the tonnage cannot be very great. The world's production is not easily obtainable, as the article is frequently included in the statistics under other heads. The production of crude ore in the United Kingdom in 1907 was .42,646 tons, and in the United States 65,579 short tons. Germany exported 111,209 tons of barytes in the same year.

The principal impurities in crude barite are iron oxide and calcite. Where calcite is the main accessory, it can be removed by jigging, but iron oxide is not so amenable to wet treatment. The ore after crushing has to be bleached with sulphuric acid, with more or less success. This process removes all traces of iron. The product is then washed with water, levigated, or "floated"; the floats or lightest particles being the best. The bleached material has then to be dried and mill-crushed to a fine powder.

The porphyroid and breccia on the property show that the rocks are members of the Dial Range metalliferous group. As regards copper ore possibilities, the ore already won demonstrates that some deposition has taken place, and the persistent gossan line, which has been traced for a long distance at surface suggests the desirability of continuing the prospecting work which has been begun.

(J)—Lucas and Perry,s Lodes.

About a couple of miles south-west of the Alma Mine are some outcrops of gossan which have lately attracted attention. Two of these have been opened upon by Messrs. Lucas and Perry on Crown land south of W. H. Lucas' 100 acres, 1½ mile west of the Forth River. Its bearing is N.W.-S.E., and the country rock is slate, apparently belonging to the Cambro-Ordovician system. A shaft has been sunk 38 feet, and is still in gossan. A good deal of manganese oxide enters into the composition of the gossan. I am informed that an assay of the lode-stuff made at the Mt. Bischoff smelting works returned 6 dwts. silver per ton.

Two chains to the west is another line of gossan 20 feet wide, and a shaft has been sunk on this also to a depth of 40 feet. The two lodes are identical in character. Samples which I took from the latter one were assayed in the Government laboratories, and contained 2 dwts. silver per ton.

It is difficult to predict what these gossan lodes will eventuate in in depth, as no minerals which can be used as criteria are present in the outcrop. It is desirable to prove them below the unoxidised zone, which, however, will probably extend to a considerable depth.

(K)—Crawford's Lodes.

On Mr. A. M. Crawford's farm, at Alma, about 14 chains west of the road, is a 20-feet seam of mixed gossan and slate, with a small band of pug a few feet wide in the middle. The formation strikes N.W.-S.E., and dips to the S.W. Twenty feet lower down the creek to the west is a formation consisting of country rock veined with calcite and charged with disseminated pyrite.

Opposite Mr. Crawford's gate, on the road, is a long lode-line of limonite gossan, which has been opened upon for 4 or 5 chains at intervals. It has a kindly appearance, but the samples which I took, and which have been assayed in the Government laboratories, yielded only traces of gold. The remarks made above with reference to proving these gossan outcrops apply here too.

VI.—RAILTON.

This district is in the Mersey basin, 7 miles south of Latrobe. To the north of it is the Dulverton coalfield; to the south of it is the Dasher River district, which has yielded gold indications; to the west of it is the high ground of the Badgers, also mineral country; and at Railton itself, east of the railway-line, some land has been taken up for Tasmanite shale.

The country forms roughly the eastern boundary of the Alma and Leven mineral belt, and its potentialities, owing to the general absence of mining works, cannot yet be strictly defined. An examination of its geological features, however, shows that it is part of a zone within which it is perfectly legitimate to seek signs of ore-deposition.

The Ordovician and Cambrian strata are developed here in an instructive manner.

The limestone at Railton yields generally the remains of the genus of extinct cephalopods Actinoceras, as determined by Mr. R. Etheridge, Jun., of the Australian Museum. It corresponds in geological position with the limestone of the Gordon River, which is also rich in Orthoceratidæ, accompanied by Raphistoma, Orthis, Rhynchonella, Euomphalus, according to Mr. C. Gould (in 1862). The Gordon River limestone has always been considered as equivalent to the Lower Silurian (Ordovician) of Europe. Mr. Gould referred it to the very base of the Lower Silurian of Europe, though he placed the base of the system in Tasmania still lower, so as to include underlying grits and conglomerates, which, according to what can be seen at Railton, appear to be of Cambrian age.

This rock is in the shaft and bore which were put down some years ago, about 100 feet west of the railway-line, near the station at Railton, in a futile attempt to discover coal measures below the Ordovician. The width of the belt is about a mile, for the limestone appears again at the quarry worked by Mr. J. Blenkhorn east of the railway.

Mr. Thomas Stephens, M.A., in 1874, recorded the discovery of beds at Caroline Creek containing casts of trilobites, and in 1882 some of these were determined by Mr. R. Etheridge as Dikelocephalus Tasmanicus (sp. nov.) and Conocephalites? (now Ptychoparia) Stephensi (sp. nov.). With the tribolite remains were those of small discoidal or planorbicular univalves, which, according to Mr. Etheridge, presented all the appearance of the genus Ophileta. On

the strength of the Dikelocephalus, Mr. Etheridge was of opinion that it appears more than probable that the age of the beds is that of the Lingula flags or Menevian beds of Great Britain and the Potsdam sandstone of North America. To show the significance of this reference, the following correlation of the Cambrian groups in Great Britain and North America is inserted here:—

	Great Britain.	North America.	Tasmania.
Ordovician, Lower	Arenig group of Wales	Calciferous group of New York	Limestone at Gordon River, Denison River, Florentine Valley, Junee, New River, Blythe, Gunn's Plains, Beaconsfield, Mole Creek, Chudleigh, Don, Railton
Upper Cambrian (Olenus and Dikelocephalus fauna)	Lingula flags of Wales	Potsdam sandstone	Caroline Creek Beds, Railton; Florentine Valley and Humboldt Divide with Dikelocephalus
Middle Cambrian (Paradoxides fauna)	Menevian group of Wales	Acadian	? Cherty breccia and conglomerate with slate at Gunn's Plains, Dial Range, North Dundas
Lower Cambrian (Olenellus fauna)	Harlech and Llanberis group of Wales	Georgian	White pebbly sandstone and conglomerate at Railton and Denison Range

In 1902, Mr. Stephens discovered stone at the head of the Florentine Valley containing another form of Dikelocephalus, which Mr. Etheridge named *D. florentinensis*.

The occurrence of the Ordovician limestone at Mr. Blenkhorn's quarry at Railton shows that this rock rests upon the Dikelocephalus sandstone. The exposure of the latter on the track from the quarry is not sufficient to enable it to be seen whether the Ordovician and Cambrian are conformable. Both have a steep dip to the S.W., and strike N.W. A thin band of laminated cellular clay stone intervenes between the limestone and sandstone. The sandstone further east passes into yellow and purplish clay slates, alternating with purple or chocolate-coloured sandstones.

An exposure of these occurs on the railway-line near the bridge over the Caroline Creek, about 4 miles nearer Latrobe. Near here the sandstones are also trilobite-bearing. We have consequently a development of the Cambrian for at least 4 miles in a north-westerly direction roughly parallel with the railway-line. About three-quarters of a mile west of the line at Railton near the Methodist church yellowish sandstones and grits are exposed, from which Mr. Blenkhorn obtained a cast of what Mr. Etheridge considered to be raphistoma, a univalve with a geological range from Cambrian to Silurian. These beds, sometimes vertical, appear to have a general steep dip to the N.E. About half a mile S.E. of the quarry hard pinkish, white, pebbly quartzites, weathering into a fine-grained conglomerate, compose a hill near the rifle-range. The rock resembles similar strata, which form Mt. Wright and the east front of the Denison Range, in the Valley of Rasselas, and occupy a similar position with regard to the limestone there. These quartzites would appear to be geologically lower in the Cambrian than the Dikelocephalus sandstones.

(A)—Tune's Reef.

About a mile south of the railway-station, at the summit of a hill, some mining work has been carried on at intervals during the last 18 or 20 years in the way of prospecting quartz veins alleged to be gold-bearing. Trenches and shafts occur at several spots, one of the latter 70 or 80 feet deep; but beyond colours, nothing seems to have been obtained. The country is a coarse yellow and white friable sandstone, belonging, apparently, to the Cambrian system, and is intersected by frequent veins of white

quartz. There is no geological reason why some of these veins should not be gold-bearing. A shaft has been sunk at the summit of the hill to a depth of 25 feet, and at the bottom a drive has been put in 20 feet to a lode, and 10 feet further, to the end, in a direction N. 20° E. The bearing of the lode is north of east and south of west, and its dip towards the north. The lode or lode-channel consists of sandstone veined with bands or lumps of white unmineralised quartz of a vitreous appearance. Sometimes the stone is dense and compact, and again loose and vughy. The stone continues in veins and patches from where it was first struck, right through to the end. I have not been able to detect any gold in it.

Railton Resources.

In some of these veins at Railton I believe gold will eventually be found. There has been very little prospecting, and no reliable information can be said to exist as to the reef occurences which are met with at various points. The possibilities of copper ore-deposits in the neighbourhood should not be overlooked. At present the principal mineral product is lime. Mr. Blenkhorn is manufacturing this, and crushing it fine, so as to encourage agriculturists to use it with their seed. Bricks, too, are being made at his kilns.

VII.—CONCLUSION.

The present investigation has resulted in an important advance being made in our knowledge of Tasmanian geology. It has laid the foundation for a more correct appreciation of the geological age of the ore-bearing strata on the North-West Coast. It has tended to disclose the very important part which the igneous porphyroids play in connection with the distribution of several hitherto ill-understood ore-occurrences on the Coast. Incidentally, it has thrown some light on the age of the North Dundas slate series by enabling a correlation to be made. Further information has been gained in respect of the stratigraphical relations of the Early Palæozoic systems with the Pre-Cambrian platform, as well as collateral confirmation of observations made last year in the Gordon and Florentine valleys.

The study of the mineral indications presented in these pages will, it is hoped, be of service to those interested in mining. It will be seen that the deposition of copper

ore has been very general all along the Coast, but in no instance has work on the lodes been pushed to a conclusion. Either work has been suspended before cutting the lode, or the lode, when cut, has not been driven upon, or when the ore-shoot which was first cut has been worked out operations have been suspended. The value of the Coast as a mining field has consequently not yet been proved. It is difficult, however, to believe that with so many ore-occurrences there are not some which, when proved, will be worth exploitation. There is still a great field open here for prospecting work. Owing to the trivial nature of many of the indications progress will probably be slow, but there is some justification for anticipating eventual discoveries of value.

W. H. TWELVETREES, Government Geologist.

Launceston, 26th January, 1909.

PLATE I

GEOLOGICAL TRAVERSE

OF THE

LEVEN GORGE, GUNN'S PLAINS

SCALE 400 300 200 100 0 400 800 1200 FEET

LEGEND

ORDOVICIAN	LIMESTONE
CAMBRO - ORDOVICIAN	SLATE, CONGLOMERATE AND TUFFS

W. H. Twelvetrees,
Government Geologist.

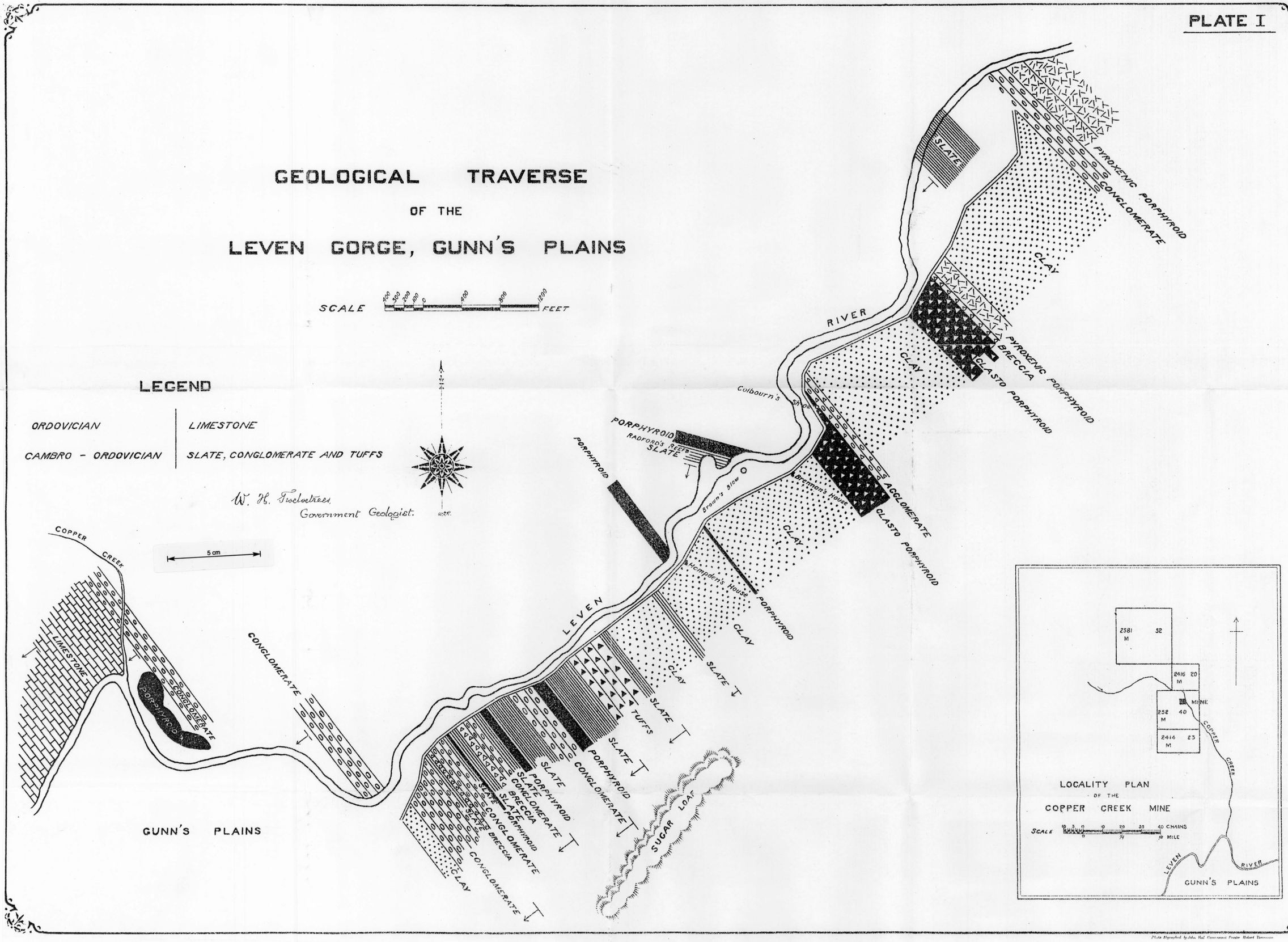


Photo Lithographed by John Vail Government Printer Hobart Tasmania

PLATE II

GEOLOGICAL SECTION OF COUNTRY AT RAILTON

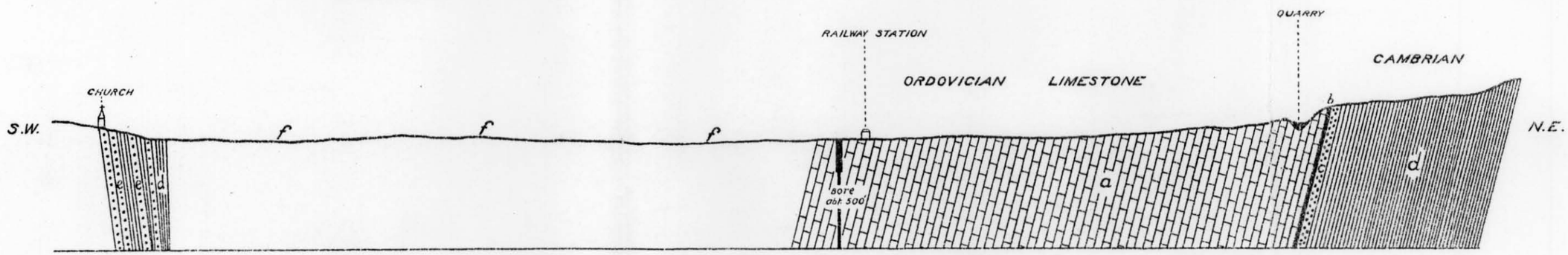
— SCALES —

Horizontal 300 150 0 300 600 900 FEET

Vertical 250 125 0 250 500 750 FEET

W. H. Twelvetrees.
Government Geologist.

5 cm



LEGEND

a ACTINOCERAS LIMESTONE

b CELLULAR CLAYSTONE

c SANDSTONE WITH DIKELOCEPHALUS, PTYCHOPARIA AND RAPHISTOMA

d YELLOW AND PURPLE SLATE

e PEBBLY GRIT WITH RAPHISTOMA

f ALLUVIAL AND DETRITAL COVERING

Photo Lithographed by John Vail Government Printer Hobart Tasmania.