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No. 30

# The Mount Pelion Mineral District

BY

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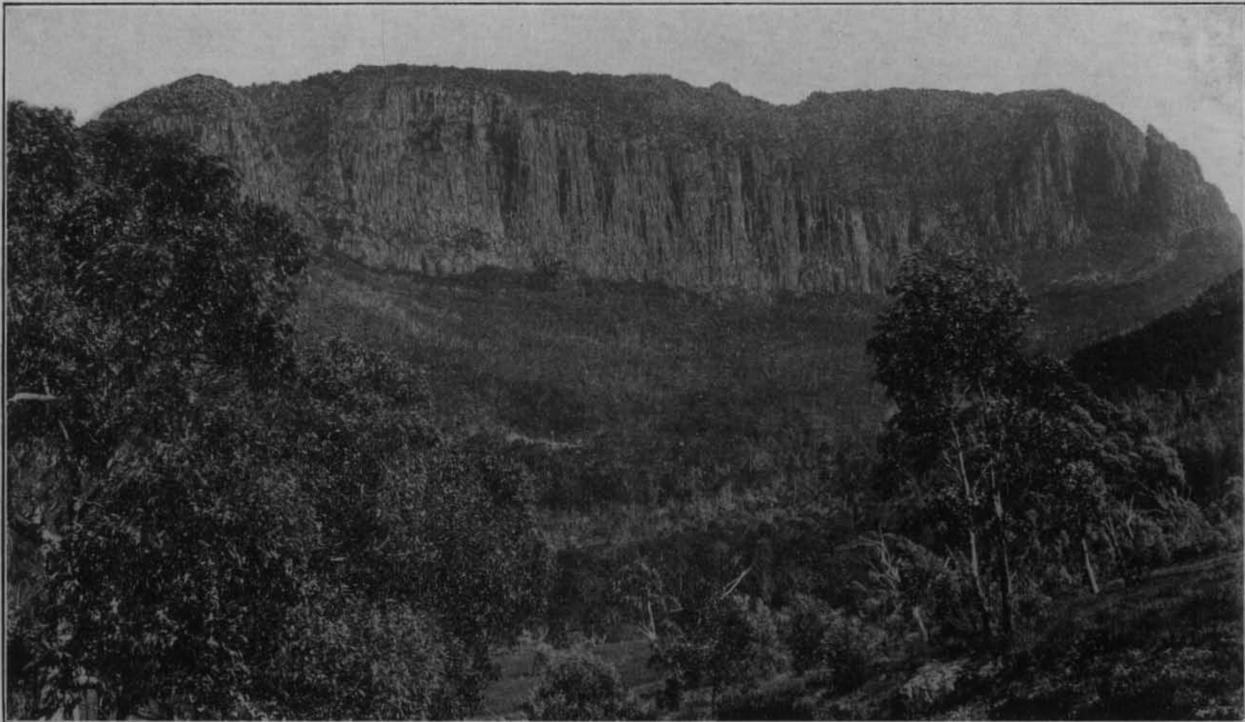

*Spurling Photo.*]

Frontispiece.

PHOTO. 1.—MT. PELION (WEST), SHOWING COLUMNAR DIABASE RESTING ON COAL MEASURES STRATA.

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### CORRIGENDA.

Page 22, line 20, for Devonian *read* Ordovician.
,, 22, ,, 22, ,, Porphyroid *read* Devonian.
,, 58, ,, 3, ,, deposed *read* deposited.
,, 66, ,, 5, ,, than *read* that.
,, 74, ,, 3, ,, 40 ft. *read* 400 ft.
,, 74, ,, 19, ,, Dover *read* Dove.

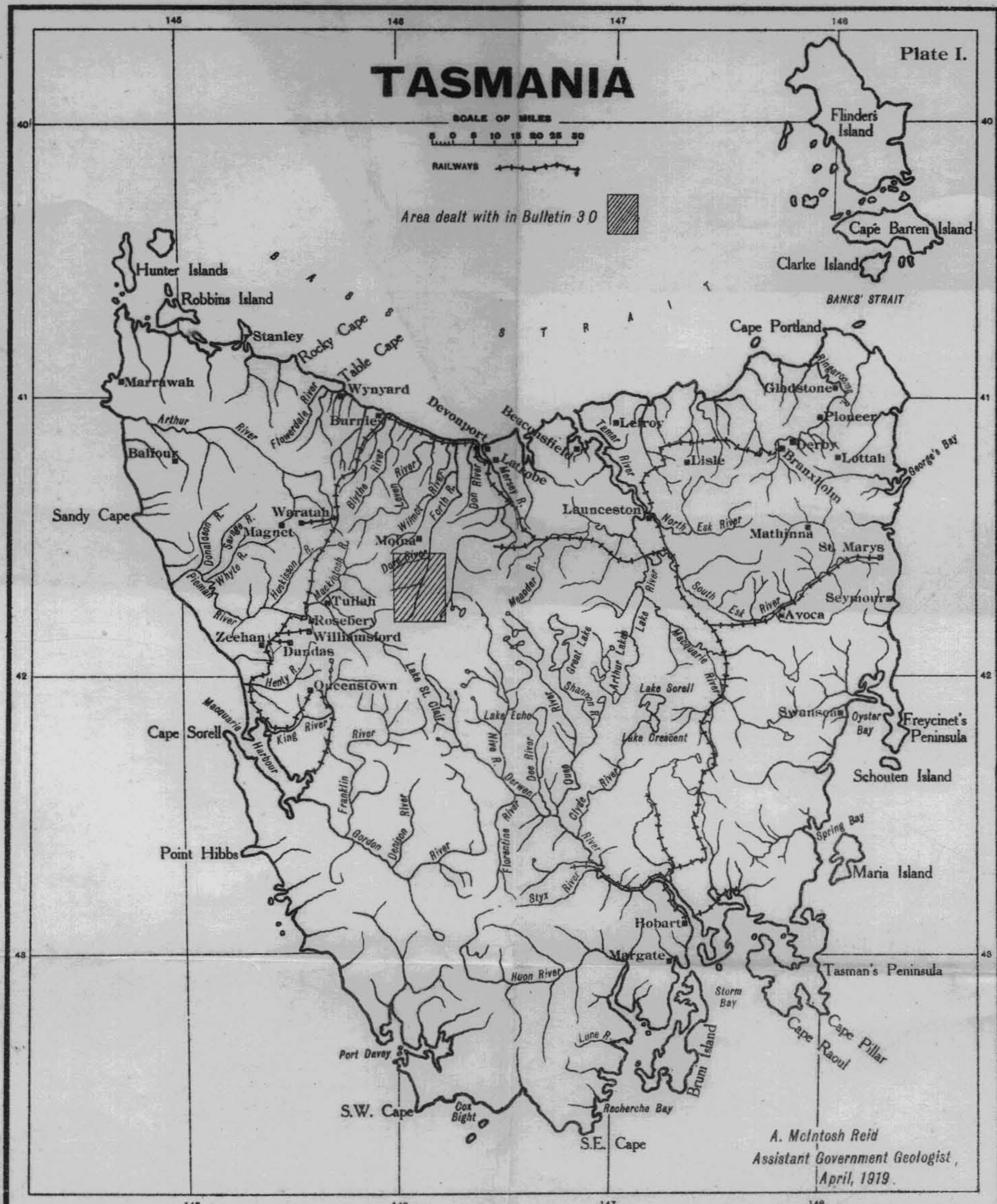


Photo Algraphed by John Vail Government Printer Hobart Tasmania.

# The Mount Pelion Mineral District.

## I.—INTRODUCTION.

### (1)—Preliminary Statement.

Since the decline of mining following the boom period of the Barn Bluff Copper group, no detailed examination has been made of this district. The earlier work was confined principally to the areas where active mining was in operation, but these constitute only a small part of the district. From time to time, during the past three years, reports have been brought in by prospectors and others concerning the discovery of rich wolfram and cassiterite deposits in the Forth Valley. These developments have been considered of sufficient importance to justify the undertaking of a detailed geological survey of the accessible parts of the region. The object of the report is to give an account of the results obtained from the performance of this work, which tend to show that this hitherto neglected field promises to become one of the important mining districts of north-central Tasmania.

### (2)—General Statement.

The present report is based on the results of investigations made during the period extending from the 25th January to the 7th March, 1919. This work may be regarded as the continuation of that completed by the writer during the winter of 1918 in the adjacent areas to the north—the Moina, Mt. Claude, and Lorinna mining fields.

The examination was carried out with the aid of the mineral chart of the district, drawn to a scale of 40 chains to 1 inch. A few isolated areas of small extent have been selected, and appear on the chart, and on these only have the topographic features been accurately noted. The locations of the more important features beyond the surveyed areas were determined by prismatic compass and chain, and they may be regarded as substantially correct. The lack of complete field maps, the rugged nature of the country, and the comparative inaccessibility, made it impracticable to carry out in detail a geological survey of the whole region in the short space of time that could be devoted to the work. It was decided, therefore, to confine the study of details chiefly to those areas where lodes are located or where mining development is being carried on.

The territory within the confines of the Mt. Pelion district includes the coalfields of the Pelion Range and those of Barn Bluff, the metalliferous mines in these localities, and the wolfram group in the Forth Valley. It includes also the widely separated Devon group, situated at the extreme northern part of the district. For the purpose of description, these fields have been broadly divided into two groups, separated by the unexplored central area lying between the Brown and Dove Rivers.

## (3)—Acknowledgments.

The writer desires to express his appreciation of the courtesy and hospitality extended to him by many residents of the district during his six weeks' visit. The asssistance rendered by Messrs. G. Sloane, S. Reardon, R. H. T. Brook, G. Gabbedy, G. Day, and J. Simpson greatly accelerated the work of the investigation.

He wishes also to gratefully acknowledge his indebtedness to Messrs. C. P. Smith, J. C. Macmichael, H. Andrews, P. Hartnett, and P. Parsons for much valuable information received.

The writer was accompanied on this expedition by Mr. Patrick Hartnett, as field assistant. It is a pleasure to place on record the splendid services rendered by him. His skill, energy, and knowledge of the district made it possible to cover this large tract of country in the short space of time that could be allotted to the work.

## (4)—Location and Area.

The district to which this report relates is in the County of Lincoln, in the north-central part of Tasmania. It is occupied on the southern and western confines by the Pelion and Barn Bluff ranges of mountains, and on the east it is bounded by the Mersey River. Middlesex and Mt. Claude districts adjoin it on the northern boundary.

The nearest settlement is Lorinna, 22½ miles north of the wolfram mines; and Sheffield, the main centre of population, is 43 miles distant.

Mt. Pelion district occupies an area of 260 square miles, but only one-third of this area was examined in detail. The southern portion has an area of 74 square miles, and the northern portion 11 square miles. The remaining central part, being so difficult of access, is not included in this discussion.

## II.—LITERATURE.

The only descriptions of Mt. Pelion district that have been published refer chiefly to the extreme northern and southern parts. The intervening country, up to quite recent time, had not been carefully prospected, and no discoveries of note had been reported prior to the location of the wolfram deposits in Forth Valley, near Mt. Oakleigh. The first official record of mineral discoveries of economic importance in this district is contained in a report written in 1893 by A. Montgomery to the Secretary for Mines.(1) This report briefly describes the country traversed by the surveyed line of the proposed Mole Creek to Zeehan railway, and, in more detail, the coalfields of the Mt. Pelion and Barn Bluff areas. Mr. Montgomery refers also to the discovery of chalcopyrite and galena ores on the plateau near the head of Forth River.

In 1898 attention was again drawn to the district by the discovery of large copper-bearing deposits near Lakes McRae and Windermere. G. A. Waller (2) was detailed to examine these areas, and wrote an account of his visit of inspection in April, 1901. In his report he refers also to the Mt. Pelion copper and lead mines, and to the mines of the Devon area, in the northern part of the district.

In 1907 W. H. Twelvetrees (3) paid a visit to the Devon area on his return from an examination of the gold mines of the district. A detailed description of the Devon Mine and the geological features which he observed is contained in a publication of that year.

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(1) *Vide* A. Montgomery, M.A.: "Report on the Country between Mole Creek and the Mt. Dundas Silver Field, and on the Discovery of Coal at Barn Bluff." 1893.

(2) *Vide* G. A. Waller: "Report on the Mineral Districts of Bell Mount, Dove River, Five-mile Rise, Mt. Pelion, and Barn Bluff." 1901.

(3) *Vide* W. H. Twelvetrees: Report on the Bell Mount and Middlesex District," 1907.

## III.—HISTORY.

The history of mining development in this region commenced in January of the year 1892, when Henry Andrews, a well-known hunter and prospector, discovered a copper-bearing lode on the plains between Mts. Pelion and Oakleigh. Accompanied by Philip Parsons and Richard How, he extended the scope of the prospecting operations, which resulted in the discovery of galena and chalcopyrite ores at other localities in the neighbourhood. Although these discoveries proved to be of no immediate economic importance, they created considerable interest, and were directly responsible for the later expeditions to the district. In 1893, Joseph Will was engaged prospecting the coal seams at Mt. Pelion and Barn Bluff, and while operating in the latter locality, uncovered the copper-bearing lodes on the western bank of Lake Windermere. These prospectors spent the summer of 1893 in the district, and located a number of lodes in neighbouring areas. They did considerable work on some of the lodes, particularly on those between Mts. Pelion and Oakleigh. It is reported that the main lode of the Barn Bluff copper group, east of Lake McRae, was originally found by H. Andrews and J. Swallow; it was, however, rediscovered by C. P. Smith and Thos. Cook, who conducted an expedition to the district from Tullah in 1898. The preliminary operations of these prospectors disclosed an enormous copper-bearing ore-body, which appeared to be one of much promise. Subsequently, extensive works were undertaken here with the object of thoroughly exploring the ore-bodies. The results of these operations were disappointing, in that the copper content was found to be very low, and the mine was abandoned. For many years the district was deserted save by hunters, shepherds, and stock-owners, the latter of whom brought cattle, sheep, and horses to the fine grass lands of the plateau country, where the summer feed is extraordinarily abundant. In April, 1916, Patrick Hartnett, while engaged on the construction of the track between Lorinna and the Mt. Pelion copper and lead mines (which were then in operation), discovered several wolfram-bearing veins in the Forth Valley, on the property since acquired by the Mt. Pelion Company. Shortly after the commencement of operations one of the employees of the Company (Frederick Duncan) located the main lode from which the large boulders of wolfram-bearing quartz found strewn over the surface were derived. The several other discoveries of wolfram and cassiterite veins in the locality were made by Patrick Hartnett during the period extending from April, 1916, to the present day.

## IV.—TRANSPORT AND COMMUNICATION.

At the time of the earliest discovery of minerals in this district there were no public roads, and to the outlying parts there were no tracks. The early exploratory work was attended with the greatest difficulty. Some idea of the obstacles confronting those setting out on prospecting expeditions to these inhospitable parts may be gained by the knowledge that provisions and equipment had to be carried from Chudleigh, a distance of 58 miles, over heavily wooded mountainous country. In later years the construction of tracks and bridges brought the district into easier communication with the main centres of population, and thereby greatly facilitated the operations of prospectors. The first track leading through the Mt. Pelion country was marked out by Surveyor Innes about 20 years ago. The money for this work was subscribed by Launceston citizens, whose object it was to find a practicable route from Liena, *via* Mt. Pelion and Granite Tor to Mt. Lyell. Liena is connected with Mole Creek, the terminus of the Chudleigh branch line of the Western Railway, by means of a good road practicable for vehicles of all kinds. From Liena bridge the track ascends the eastern slope of the divide between the Mersey and Forth Rivers, for 2½ miles to Gad's Hill (2361 feet), whence it follows the ridge for 20 miles in a southerly direction, thence south-westerly, passing on the south side of Lake Ayr, descends into the valley of the Forth near Mt. Pelion (West), ascends the plateau, and takes a north-westerly course past Barn Bluff. This route presents two great disadvantages, viz.:—

(1) The greater part is within the snow-line; and
(2) It is unnecessarily long.

The latter disadvantage is offset somewhat by the easy gradients. From Innes' survey, Ewart's track leads off before it touches Mt. Pelion (West); it passes over the saddle between Mts. Achilles and Thetis, and thence courses south-westward to Mt. Lyell.

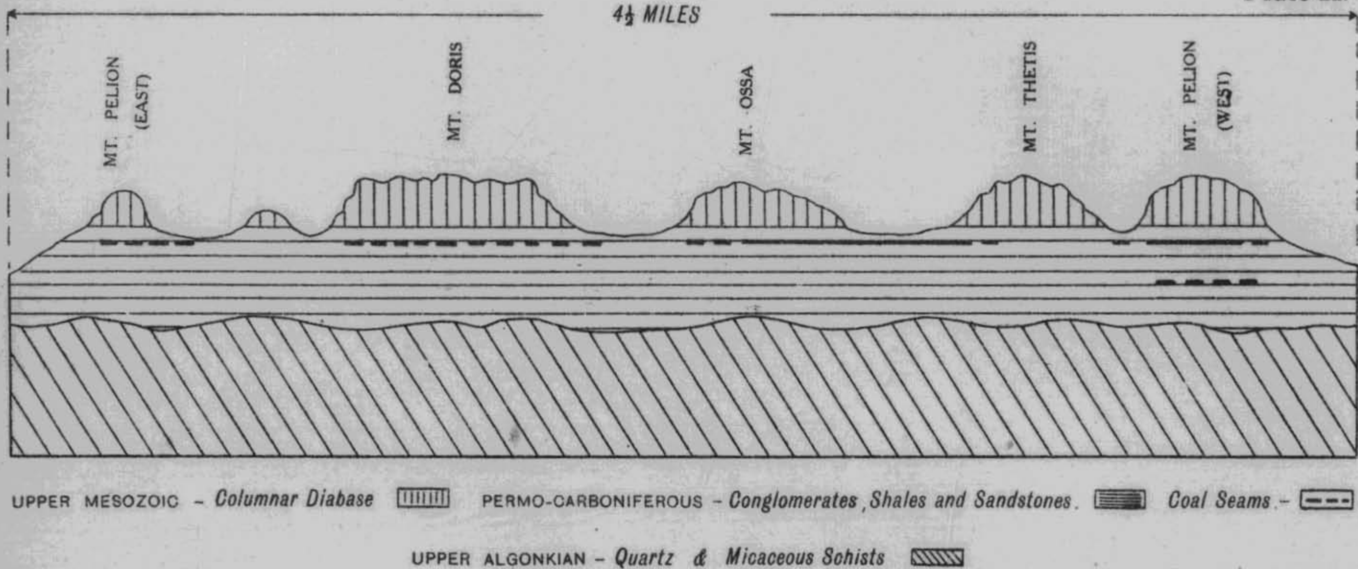
The Company operating the Barn Bluff copper mines found that a more practicable route lay along the Forth Valley, and at their solicitation the Government decided to construct the track from Lorinna, which is utilised at the present time. This route follows the east bank of the Forth River to Sloane's Bridge, 18 miles south of Lorinna, thence, after crossing to the west side, instead of rising gradually along the easy sidelong country, it continues across the flood-plain to the foot of Razorback Hill, up which it zig-zags on grades of 1 in 5 to 1 in 3 to the Barn Bluff Mine, 1750 feet higher. From Sloane's Bridge the main track continues on the east bank of the river with easy grades past the Pelion Wolfram Mines to the foot of Mt. Oakleigh, whence it zig-zags up the steep incline to the plateau. It is along this route that the main-road from Lorinna is being constructed to the mining fields. This road will be employed, not only for the haulage of freight to and from the mines and as a travelling way for stock to the grass-lands of the central plateau, but it will be the means of bringing one of the most magnificent tourist resorts in the State into easy communication with the centres of population. The ultimate value of the road as a main thoroughfare cannot be over-estimated. It is, therefore, inexplicable that the work has not been marked out by a competent engineer. The conditions for road-building are almost ideal; steep gradients can be entirely avoided, and no engineering difficulties are encountered. Up to Lemonthyme Creek, the road has been carefully graded; from this point onward it has been laid down without regard to the topography. There is no reason why a much better route could not be established by way of the eastern divide from Lemonthyme Creek to Gisborne's, whence no difficulties are encountered at all. Portions of the newly-constructed road must be entirely abandoned, as this will never be an economical route for bringing in supplies and taking out the produce of the mines.

In nearly all cases the main tracks in this district were constructed in defiance of the topography, consequently they became simply mountain paths of little or no ultimate value; whereas, if the gradients had been reduced sufficiently, they could have been widened and formed into roads.

Staverton, the terminus of the branch railway from Railton Junction, lies 34 miles northward of the wolfram mines. Rail communication to the chief ports can be had from this township.

Post-office facilities are provided at Lorinna, from which a bi-weekly mail service is run to Sheffield. Telegraph and telephone communication are available at Cethana.

Plate II.




**Ideal Section through Pelion Range**

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

## V.—PHYSIOGRAPHY.

### (1)—Topography.

#### (a) *General Description.*

The area under review embraces one of the most rugged portions of Tasmania. It consists of a series of high mountains rising abruptly from an elevated plateau, the northern continuity of which is broken by deep ravines and gorges. The most prominent topographic features are due to the occurrence of erosion-resisting igneous rocks (diabase and basalt) capping all the mountain peaks and some of the less-elevated ranges; and to the bold configuration resulting from the corroding effect of the Forth, Mersey, and Bluff Rivers. In Pleistocene time glaciers invaded the district, accentuating the topographic relief by the dissection of the upland surface and by the widening and deepening of existing valleys.

The greater portion of the area is occupied by Algonkian quartz and mica schists, which, in the unglaciated parts, present a rugged uneven outline. On the upturned edges of these schists—formerly the surface of an extensive tableland—Permo-Carboniferous sediments, over 1200 feet thick, were laid down. Subsequently orogenic movement was responsible for the uplift of the area. In Upper Mesozoic time great masses of diabase igneous material were outpoured on the surface of the Permo-Carboniferous rocks, completely covering the whole region. During the Tertiary and Quaternary periods erosion of the high lands continued with little interruption, resulting in the partial removal of the diabase and the underlying Permo-Carboniferous formations, bringing to view the Algonkian schists at their base. The great mountain peaks and ranges are erosion residuals of the later formations, resting on pedestals composed of quartzites and schists. The numerous lakes and ponds of various shapes and sizes occurring here and there on the plateau owe their origin to glacial action, and this agent is largely responsible also for the general configuration of the country as it appears to-day. The topographic features are, to an extent, governed by the geological conditions. Thus, the higher mountains are built of soft sediments, having a highly protective covering of hard diabase hundreds of feet thick. Again, the main drainage channel

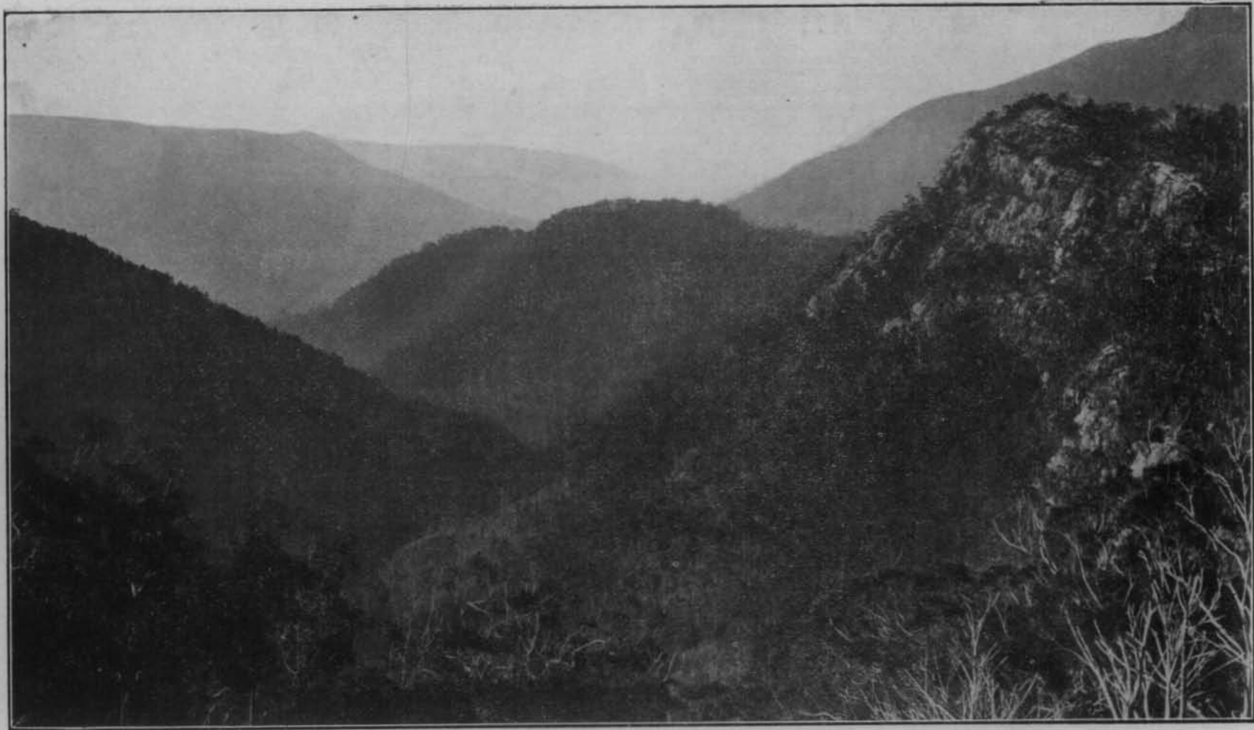
(Forth River) is cut along a great fault-line extending in a meridional course through Mt. Pelion district towards the sea. Fault-scarps on the sides of the larger valleys are not uncommon features, but they do not appear to persist for great distances.

### (*b*) *The Plateau.*

The plateau is in the northern portion of the great central tableland, and occupied by highly inclined quartz and mica schists. It represents a region that during a long period of stability has been reduced to the base level of erosion. The material derived from the disintegration of these rocks formed the deep beds of conglomerate and sandstone capping the mountains and hills in the adjacent areas to the north. The summits of the interstream areas and the undissected southern portion mark a gently rolling plain sloping towards the north. On those parts long protected from erosion by the covering of later sediments, the drainage courses have made little impression, but in the northern areas they have carved steep-walled valleys from 1700 to 2000 feet deep. The uplift of the region rejuvenated the streams, which commenced to cut channels in the elevated country, and soon they became deeply entrenched below the plateau level. In Pleistocene time the coming of the glaciers completed the dissection of the surface by increasing the size and depth of the channels and removing large quantities of the later sedimentary material. Where the latter has been completely removed the glaciers left behind them large accumulations of morainal material, now covered with grasses and reeds.

### (*c*) *The Mountains.*

In this district are situated some of the highest mountains in Tasmania. Cradle Mountain (5069 feet) and Barn Bluff on the west, the Pelion Range (including Mts. Pelion (West), Achilles, Thetis, Ossa, Doris, and Pelion (East) on the south, and the isolated peaks, Oakleigh and Pillinger, towards the east, are the most prominent. They stand out from the elevated plateau as great abutments forming the confines of an immense amphitheatre, of which the grassy plain at their base is the arena. The higher mountain peaks exceed 4700 feet above sea-level, and two of them measure over 5000 feet. Those displaying the most rugged crests are crowned with great columnar masses of diabase, from which taluses with steep slopes descend, gradually merging



*Spurling Photo.*] PHOTO. 2.—FORTH GORGE FROM CENTRAL PLATEAU. To face page 11.

into the more gentle slopes of the piedmont. The diabase capping and the deep taluses of the same material covering the slopes effectually protect the underlying Permo-Carboniferous strata, which compose the bulk of the mountains. These isolated mountains, the crests of which are remarkably even, represent the remnants of a former plateau. On the northern fall, the sandstones, shales, and conglomerates underlying the diabase present a bold precipitous wall of rock, hundreds of feet high, extending from Mt. Achilles to Mt. Doris.

Mountain building in this region is due mainly to orogenic movement, but the topographic features have been intensified by the effects of long-continued denudation, both glacial and fluviatile, resulting in the formation of conical-shaped peaks and steep-walled ranges.

### (*d*) *Drainage.*

The drainage of the northern slopes of the Mt. Pelion Range falls into the Forth River, which receives also the waters flowing eastward from the Barn Bluff-Cradle Mountain country; that from the east of the Pelion Range and the northern slopes of the Rugged Mountains falls into the Mersey; while the drainage of the southern and western slopes flows into the Canning and Bluff Rivers respectively. These mountains are more or less covered with snow during the greater part of the year, and receive a copious rainfall even during the summer months. They are the gathering ground of many streams, and form the dividing ranges separating those flowing northward to Bass Strait and those flowing westward to the Pacific Ocean.

Forth River, which occupies the major drainage channel of the whole area, has its sources in the highlands, and flows on a meridional course through the centre of the district to Bass Strait. The source of one branch is at a glacial cirque between Mts. Pelion (West) and Achilles; another is at Lake Ayr, and this is joined by a stream from Mt. Pelion (East). The main watershed of this river is on the west side, and all the large affluents come from that direction. Cited in their order of succession from south to north these are:—Swallow Creek, flowing south-eastward from the direction of Barn Bluff through Lake Ellen, joins the main channel 1 mile north-west of Mt. Oakleigh; Commonwealth Creek, flowing almost due east from Lake McRae; Brown River, a parallel stream whose source is at

Barn Bluff, enters the main stream 1 mile north of the Lone Pine section; Campbell River, coursing north-eastward, unites ½-mile north of Gisborne's blocks; and Dove River, rising in a small lake at the north end of Mt. Cradle, joins Forth River 2 miles south of Lorinna. The River flows on a gentle gradient to the edge of the plateau west of Mt. Oakleigh, thence it plunges in a series of falls and cataracts over 1800 feet in a horizontal distance of half a mile to the level of the broad flood-plain below. From this point the rate of flow is only 30 feet per mile, gradually decreasing toward the north. Some of the tributary streams have not made deep impressions on the plateau surface; while others, such as Brown, Campbell, and Dove Rivers, have carved deep steep-walled gorges down to the level of the parent stream. All of these valleys have been modified greatly by the action of glaciers, the intensity of the erosion depending largely upon the condition of the surface in pre-glacial time. The Forth River is remarkable for its great antiquity and for the immensity of its valley. In Tertiary time even it was one of considerable magnitude, and had several subsidiary feeders, the courses of which are easily traced to-day.

Mersey River drains the extreme eastern and south-eastern portions of this district, and Bluff River the extreme south-western portion.

### (2)—The Relation of Topography to Mining.

#### (a) *Prospecting and Exploitation.*

The economically important mines of the district are situate in Forth Valley over 1500 feet below the summits of the interstream areas. These are wolfram deposits in the form of quartz veins, which course obliquely across the valley. All of the veins have been exposed from the bottom of the valley up the sides of the hills, and, consequently, the mines can be developed by tunnels. Prospecting is hampered considerably by the deep talus of quartzite and quartz schist lying on the valley slopes, and by the cover of diabase rock and soil on the ridges. The Forth River has cut a deep trench across the strata exposing magnificent sections of the quartz and mica schists for examination.

Many of the copper and lead mines on the elevated plateau can be worked only by means of shafts. All the coal seams will be operated from tunnels sent in horizontally.

The topographic relief is generally of decided advantage to mining, for not only are the facilities excellent for the economic development of the ore-bodies, but they admit of the utilisation of water-power for mining and treatment purposes.

### (*b*) *Water-supply and Power.*

The southern watershed of Forth River consists of fairly flat country occupied by boulder clay deposits with a peaty top-soil covered with native grasses and reeds. These plains always keep in a moist condition. Moreover, the many tributaries of the river have their sources in or pass through lakes or natural reservoirs, from which supplies are drawn during periods of comparative drought. Therefore, there is always an abundant supply even in the driest season. On the east side of the river the watershed is limited to a narrow ridge, separating the Forth and Mersey Rivers, consequenty the supplies from this quarter are too small to be of use for power purposes. There is, however, sufficient in the several small streams to provide wash-water for milling.

Rarely are the facilities for water conservation and utilisation for power purposes so advantageously situated as they are in the Forth Valley area. On the west side, several large streams, about 1 mile apart, flow roughly parallel to one another on easy gradients across the plateau to the edge of the main valley, thence they plunge in falls and cataracts from 1700 to 1800 feet to the bed of the river. Any one of these streams can be impounded and utilised for the generation of power. The lakes from which the streams draw their supplies have narrow outlets; and they can be dammed from 10 to 20 feet at a comparatively small cost. Large quantities of boulder clay, eminently suitable for embankments, are available at every point.

Lake McRae, the source of Commonwealth Creek, has an area of 200 acres. The construction of an embankment sufficiently high to raise the surface of the water 10 feet would increase the volume of this lake by 90,000,000 cubic feet. The top of such embankment would not exceed 100 feet in length. From the lake to any point down the side of Forth Valley the creek forms a natural conduit, supplying a large volume of water at any desired head to the centre of the wolfram area. The volume of water available at Lake McRae is sufficient to provide power for all the mines in the district for many years to come.

### (3)—Glaciation.

During the Pleistocene epoch large accumulations of glacial ice were formed in the central highlands of Tasmania. These accumulations were brought about by the growth of small mountain glaciers, which existed on the protected slopes of the highest peaks, until the whole area represented by the great central plateau was covered by a continuous ice-sheet. From the plateau numerous valley glaciers, whose direction of flow was regulated by pre-existing valleys, extended in all directions. Such glacial valleys are those now occupied by the Forth and Mersey Rivers, flowing northward, and the Bluff and Canning Rivers, flowing south-westward. There are, in addition, others which are now unconnected with the main drainage system. The erosion accomplished by these mountain glaciers in the plateau country was enormous. Over the greater part of the area under review, the Permo-Carboniferous strata (1200 feet thick) and the diabase sheets covering them have been completely removed, exposing to view the tilted Algonkian schists upon which the later sediments were laid down. There is, however, undoubted evidence of the existence of pre-glacial waterways and the removal of the later formations may be attributed in part to the effects of erosion in late Mesozoic and Tertiary times. Only remnants exist now of the Permo-Carboniferous and Upper Mesozoic formations which at one time extended unbroken over the whole area. The erosive effects produced by the ice-sheets are shown by the development of *roches moutonnées* on the rocky surfaces of the plateau by the rounded profile of the hills and the polished rock protruding here and there above the morainal material, by the development of numbers of lakes, and by the accumulation of enormous masses of glacial debris. The irregularities of the valley confines were removed, and the channels occupied by the glaciers were widened and deepened, forming the great U-shaped troughs so characteristic of glacier valleys. In the mountain areas steep-walled cirques were developed at the sources of the glaciers, but the lakes at the foot of them are now filled up with debris of rock fragments broken from the flanks of the mountains Cirques that originally existed at the heads of the larger tributaries of Forth River have been plucked forward to meet others advancing in the opposite direction, thus forming passes between the mountain peaks. Hanging valleys, due to glaciation, have been formed near the points of confluence of the tributary streams with the main drainage channel. The small streams that traverse the high country flow with gentle gradients to the edge of the plateau, then they plunge in a succession of falls and cataracts to the major stream over 1800 feet below. These hanging valleys have been developed by the greater eroding power of the main glacier over the lesser ones occupying the smaller depressions. The formation of the immense hanging valley near the foot of Mt. Oakleigh is explained by the fact that at this point the Forth glacier deployed from the main ice-sheet. Most of the lesser glaciers flowing toward the main drainage channel came from the direction of the Barn Bluff-Mt. Cradle Range. One of these advanced along the valley of Swallow Creek, another through Lake McRae down Commonwealth Creek Valley, and others down Brown and Campbell Valleys. Deep ground morainal deposits occupy a considerable portion of the plateau area. The surface of these moraines is gently undulatory, but long stretches of level country are not uncommon. The more gentle topography is often the site of marshes and ponds. Terminal morainal topography is remarkable for the mass of detail it presents. This is especially noticeable south of Barn Bluff, where the surface is characterised by hillocks and hollows and by interrupted ridges and troughs which follow one another in rapid succession and seemingly without order in their arrangement. These hollows and troughs are often without outlets, and are frequently marked by marshes, ponds, and lakes. The general appearance is that of a tumultuous assemblage of rounded hills, hillocks, and serpentine ridges, with depressions of various shapes and sizes between them. These knobs vary in size from low mounds a few feet across to hills of considerable extent. The larger lakes are frequently found in rough alignment with their longer axes in the direction of the ice-flows. They were formed during the final retreat of the ice by the deposition of glacial till across the valleys. In some instances lakes are dotted with numerous islets of morainal material, thus adding greatly to the irregularity of the contour. These depressions were partly caused by the uneven scouring action of the glaciers.

A rather remarkable feature of the morainal deposits is their present condition of preservation, subaerial erosion having had little effect in the alteration of the original contour since the time of their formation. This is due largely to the gentle slopes, and to the protection afforded by the peaty covering and the matted growth of grasses and reeds.

### (a) *Erratics.*

Glacial erratics—almost invariably diabase boulders—are found strewn over the greater part of the district. On the elevated plateau especially they are particularly abundant. The diabase erratics are derived from the great igneous masses capping all the higher mountain peaks and ranges. They are found in large numbers scattered in the utmost confusion over the quartzite ridges and the hollows between them. These boulders vary greatly in size; some are small, others exceed 10 feet in diameter. Completely rounded boulders are rarely seen; commonly they are irregularly-shaped, imperfectly worn rocks, rarely showing striæ on the worn surfaces.

South of Lake Will on the west bank of Bluff River large granite erratics containing cassiterite have been found resting on the quartz-schist bed-rock. These boulders have been transported from Mt. Inglis, which is wholly composed of similar rock, showing that the direction of ice-flow in this locality was eastward.

### (b) *Roches Moutonnées.*

*Roches moutonnées* are common features of the elevated plateau. Typical examples are found on a long quartzite ridge lying between Mts. Pelion (east) and Oakleigh on the west side of Lake Ayr. The long, rounded slopes towards the south, and the short, steep ones toward the north show that the glacier moved northward down Forth Valley. Where the quartzite is very dense and hard, the rounded surface appears smooth and highly polished. Striæ on these polished surfaces are not common, and they are indistinct. On the more composite rocks the features of *roches moutonnées* are not well developed.

### (c) *Boulder Clay and Till.*

Good sections of boulder clay are exposed in a number of trenches on the ridge west of Lake Windermere. They consist of rounded boulders of all sizes ranging from a few inches up to three feet in diameter, set in a stiff, clayey matrix. The various components are jumbled together in a most irregular manner. The included boulders consist principally of diabase, which caps all the mountain peaks in the neighbourhood, and the yellowish-brown matrix is largely made up of comminuted rock of the same kind. In this particular section the boulder clay is from 10 to 20 feet thick.

On the slopes of Barn Bluff there are several lines of morainal ridges separating flat valleys, which have been the beds of adjacent glaciers. The discovery of loose blocks of cannel coal on the south-east spur led to prospecting operations being undertaken in this locality. This work consisted of a number of pits from 20 to 40 feet deep at various points along the ridge. The shafts passed through morainal material composed of angular fragments of rocks from the adjacest formations and blocks of coal and shale of all shapes and sizes. ([4]) In one shaft a long sheet of cannel coal, 16 feet square was passed through; and below this again loose pieces of coal and boulders of many kinds of material were found jumbled together in the wildest confusion.

## (4)—Meteorology.

The climate of the Mt. Pelion district varies greatly according to the altitude and to the protection from the prevailing winds afforded by the mountain ranges and hills. Thus the climate of Forth Valley is mild and delightful, while that of the elevated plateau in winter is cold and bleak, and subject to heavy snow-falls. No meteorological records relating to the district are available. However, some idea of the climatic conditions may be gained by an examination of the records of adjacent areas possessing similar physical features. The average annual precipitation at Lorinna, a small settlement lying just beyond the northern boundary, is 76 inches. There the rainfall is fairly evenly distributed throughout the year, although it is heavier during the months of July, August, and September than in any other period. This may be taken as a measure of the precipitation in the southern areas of the Forth Valley.

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([4]) *Vide* A. Montgomery, M.A.: "Glacial Action in Tasmania," Royal Society Paper, 1893, p. 163.

At an elevation of 2400 feet on the eastern flank of Black Bluff, near the north-western corner of this district, the average annual precipitation exceeds 85 inches. In many respects the conditions there are similar to those on the southern plateau, but in the latter locality the precipitation is heavier, and the climate, generally, is more severe. The summers are cool in the plateau country; more rain falls there than in the valleys, and light snows covering the mountain peaks and even extending to the plateau may be expected at any time during summer. On the 25th January, this year, the mountains were entirely covered with snow, but such occurrences during the summer season are uncommon. From the beginning of June to the end of August snow covers the whole area from 1 to 4 feet deep, and during this period, ice, 12 to 20 inches thick, forms on the lakes.

Cattle are run on the grass lands of the plateau country from September to June; horses and sheep are seldom sent to the highlands before October, and they are taken away in April or May, before the severe weather sets in. Some bullocks have been running there continuously for several years, and appear to winter fairly well on tree leaves as fodder.

## (5)—Flora and Fauna.

### (a) *Timber.*

A considerable portion of the district is clothed with dense forests and thick luxuriant undergrowth; the remaining areas, especially in the plateau country, are covered with a matted growth of native grasses, reeds and shrubs. Vegetation is favoured by a plentiful rainfall evenly distributed throughout the year, and by the protection from south-westerly winds afforded by the Pelion and Barn Bluff ranges of mountains. In this district are represented many kinds of plants, the distribution of which is governed by (1) the climate; (2) the altitude, and (3) the nature of the soil. The forests consist chiefly of thirteen kinds, namely:—White gum (*eucalyptus viminalis*); Stringy-bark gum (*eucalyptus obliqua*); Peppermint-topped stringy-bark (*eucalyptus regnans*); Myrtle (*fagus cunninghami*); Celery-top pine (*phyllociadus rhomboidalis*); King William pine (*arthrotaxis cupressoides*); Cypress pine (*arthrotaxis selaginoides*); Leatherwood (*eucryphia billardieri*); Sassafras (*artherosperina moschatum*); Horizontal (*anodopetalum biglandulosum*); Musk (*olearia argophylla*); and Dogwood or Peartree (*pomaderris apetala*).

At only a few places were trees seen above an elevation of 4000 feet, and large areas in the less protected parts below that elevation are untimbered. In the southern portion of the district, at altitudes not less than 3000 feet, fagus, the only deciduous tree known in Tasmania, is commonly found. On the northern slopes of the Pelion range it grows in dense impenetrable thickets, and on the west bank of Lake Ellen it is particularly abundant. Lining the creek flowing from Lake Ellen, the upper reaches of Forth River, and its various tributary streams, are found Cypress and King William pines. They are found also near the upper edges of Forth Valley, at the southern extremity of February Plains, on the slopes of Mts. Oakleigh and Barn Bluff, and also in the northern portion of the region in the valley of the Dove River. Seldom are these trees found below an altitude of 3000 feet. They vary in size from 1 to 4 feet in diameter, and are usually solid and free from flaws. These trees are highly prized for their many peculiar qualities, but, unfortunately they are difficult of access and the cost of transport is very high.

The sandy and gravelly flood-plain of the Forth River is occupied by a dense growth of myrtle, sassafras, leatherwood, and celery-top pine trees. Looking down the Forth Valley from the edge of the plateau as a vantage point, the borders of the flood-plain are sharply marked by the change in the vegetation from myrtle to eucalyptus. Of the trees comprising the mixed forest, celery-top pine is the most valuable. Some of these trees are 3 feet in diameter near the butt, and the barrels are clear of limbs for 100 feet.

The most common and the most important trees in the district are the several varieties of eucalyptus, some of which attain enormous size. They occur on the fertile basaltic and diabasic areas in company with pear-tree and musk. In some portions of the valley isolated trees are found 200 feet tall, and others 150 feet are not uncommon.

Horizontal and bauera undergrowth are found on the rocky hillsides, and giant tree ferns (*dicksonia antarctica*), 30 feet tall are very abundant in the valleys.

### (*b*) *Agriculture and Grazing.*

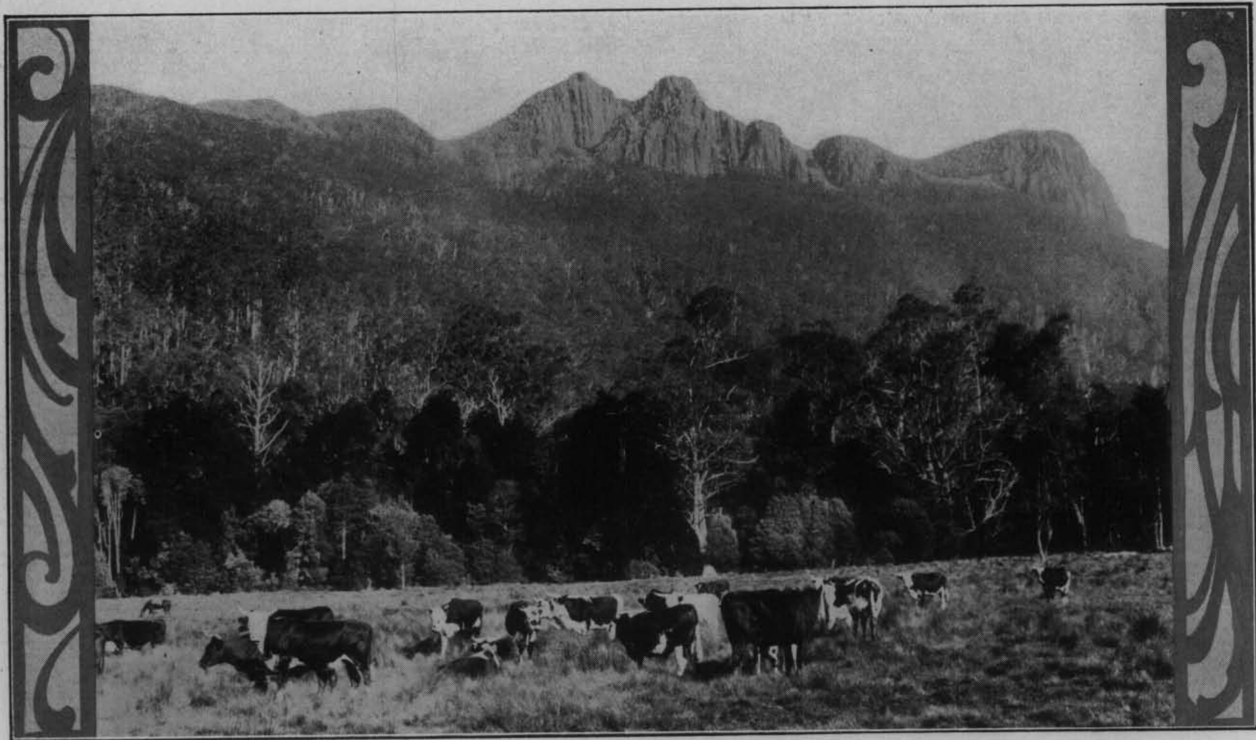
Although the district generally is one of high relief, there are, nevertheless, large tracts of country eminently suitable for agricultural and grazing purposes. Farming possibilities, however, are not likely to operate in a large way in the development of the district until it is made more easily accessible by the construction of well-graded roads.

In the northern areas between 2000 and 3000 acres of agricultural land have been selected in small lots, and these have been greatly improved by the removal of small trees and scrub and the sowing of grass seed. Nearly all of the land is virgin, and is highly productive, but it is now overrun by rabbits, and the destruction of the grasses by them has enabled bracken-fern, fire-weed, and shrubs of many kinds to spread over the surface. Very few selectors reside on their properties, and therefore it is impossible for them to keep this pest in check. The fertile basaltic soils extend along the east bank of the Forth River to a point 11 miles southward of Lorinna. Gisborne's blocks, near the end of this belt, are parts of a particularly fertile area. On the west side of the river basaltic soils are not so extensive, and only a few selections have been taken up.

The soil resulting from the decomposition of diabase is not so fertile as that derived from basalt. Land of this class occupies the plateau between the Forth and Mersey Rivers. The Berriedale, February, and Howell's plains in this country are covered with white-grass, button-grass, and other native grasses and reeds, upon which stock of all kinds are run during the summer and autumn seasons.

Between Brown River and the foot of Mt. Oakleigh, the Forth flood-plain is from ½ to 1 mile wide. The sandy and gravelly fluviatile deposits occupying this area support most luxuriant vegetation, and will provide splendid pasture lands when they are cleared of scrub and grassed.

A considerable portion of the central plateau is covered with boulder clay and erratics largely derived from the diabase rock capping the mountains. This soil supports a heavily matted growth of grasses and reeds which provide, during the period of drought, an abundance of nutritious food for cattle, horses, and sheep. The native grasses of the highlands are in their best condition when the artificial grasses on the lowlands are withered and lacking nutritive value. Of the numerous kinds of grasses that go to make up these natural pastures, water-grass, and white or kangaroo grass are those most favoured by stock. Unlike the European grasses, these contain so much substance in the green state that cattle and horses keep in



*Spurling Photo.*] PHOTO. 3.—PLATEAU GRASS-LANDS AT THE FOOT OF RUGGED MOUNTAIN. To face page 20.

good firm condition. In general the plateau surface is hard and firm, but an appreciable portion of these glaciated areas consist of wet, almost swampy, country. Even in the summer months, the soil keeps in a moist condition. This is due in part to the protection from erosion afforded by the matted growth of grass and the peaty soil, in part to the imperviousness of the boulder clay subsoil, and to the flat nature of the country.

### (c) *Game.*

The well-grassed plains afford an abundant supply of feed for the large numbers of kangaroo and wallaby that frequent the central plateau country. These animals supply the larger portion of the meat food required by prospectors and they are valuable also for their skins, which are readily saleable at 60s. per dozen. Early explorers were thus able to combine the operations of hunting and prospecting to their great advantage. In the valleys, these animals have been considerably reduced in numbers, especially near the mines, but they are fairly plentiful in the more remote, rugged parts. In the heavily timbered areas on the mountain slopes, ring-tail and black and grey brush opossum are abundant. The pelts of these animals are highly prized for the richness and the softness of the fur. The marsupial wolf, tiger cat, and the Tasmanian devil, which prey upon the herbivorous animals, are seldom seen on the plains, but they abound in the mountain areas.

At certain seasons of the year wild duck are plentiful in the lake country, and black swan are occasionally seen. The streams are stocked with mountain trout and black-fish, but English trout have not been seen in the upper waters of the Forth, nor have fish of any kind been seen in the lakes. English trout should do well in the lakes as they contain an abundance of food. Cormorants, which prey upon the fish, were seen on the Forth River near Mt. Pelion on several occasions this summer.

## VI.—GEOLOGY.

### (A)—Geological Maps.

The district has been divided for purpose of description into three parts; two of which, the northern and southern areas, have been carefully examined and mapped. Only salient features of the intervening country have been observed and recorded, and, therefore, it has been considered advisable to confine this discussion solely to those areas examined in detail. In addition to the geological plans, an ideal section through Pelion Range has been inserted, to illustrate the association of the several formations composing the mountain mass. The maps show the boundaries of the sedimentary and igneous formations and their positions relative to one another. In the northern area (Plate III.), it is considered that the hornblende granitite and biotite granites belong to the Devonian intrusives, and that they represent dykes that have partially resorbed the igneous porphyroids through which they penetrate. These dykes, therefore, have been separately delineated on the map. In the southern area, some of the numerous porphyry dykes intruding the quartz schists have been only provisionally assigned to the Devonian, in view of the doubt still existing as to whether or not all of them do not rightly belong to the porphyroid period of volcanism. The Algonkian sediments have been divided into two series (lower and upper), consisting of the crystalline micaceous schists of Dove River and the more heterogeneous quartz, micaceous, and argillaceous schists of the plateau country. The only other sedimentary formations occurring in this district that require special comment are the Quaternary unconsolidated sediments, consisting of Pleistocene and Recent members, which are lithologically nearly identical, and more or less grade into each other. It has been found convenient to separate these formations so that the distributions of the glacial deposits may be followed. The maps show also the economic deposits of tungsten, tin, copper, lead, silver, and coal; the location of the mining properties, and the general physical features of the region.

### (B)—Geological Summary.

The Mt. Pelion district is almost exclusively an area of Palæozoic rocks. The sediments most abundantly developed in this region consist of great thicknesses of highly distorted schists folded in long east and west anticlines. They have been divided into a lower and upper series of the Algonkian system, the former represented by micaceous schists, and the latttr by quartz and argillaceous schists. These formations underlie the whole region and occupy a considerable portion of the present surface. They were intruded by Pre-Silurian porphyroids, of which the extrusive and pyroclastic members cover a considerable extent of the northern area. Overlying these are found tubicolar sandstones and conglomerates occupying Gad's Hill ridge southward to Lemonthyme Creek, and the Five mile Rise. Limestones conformably succeed these strata, but only remnants now exist. In Devonian time all the foregoing were intruded by granites and porphyries in the forms of stocks and dykes. Resting on the upturned edges of the Algonkian quartz schists in the southern area are horizontally bedded, Permo-Carboniferous strata consisting of conglomerates, mudstones, limestones, shales, and sandstones containing seams of cannel coal from 12 to 21 inches thick. Overlying the coal measures are thick sheets of diabase rock of Upper Mesozoic age. It is over comparatively limited areas only, however, that these later beds of sediments and lava sheets remain, denudation having removed them over the greater part of the plateau country. All that remains now of these erstwhile extensive formations which once covered so deeply the whole area are isolated peaks and mountain ranges.

In the late Tertiary local volcanic vents supplied basaltic lavas and tuffs which occupy small isolated areas on the hills near the northern border, and at several points in Forth Valley farther southward.

Deposits of Pleistocene age are very plentiful, and consist of glacial till, boulder clay, gravels, and sands.

## (C)—Sequence of the Sedimentary Rocks.

| System. | Series. | Group or Formation. | Lithological Character. |
|---|---|---|---|
| Archæan | | | Not identified in Tasmania |
| Algonkian | Lower | Dove River | Crystalline mica schists |
| | Upper | Central Plateau | Quartz, mica, and argillaceous schists |
| | Unconformity | | |
| Ordovician | | Dundas | Bluish-black fissile slates |
| | Unconformity | | |
| Silurian | Lower | Tubicolar | Tubicolar sandstones, shales and conglomerates |
| | Middle | Mole Creek | Bluish-grey argillaceous limestones |
| | Unconformity | | |
| Permo-Carboniferous | Lower & Upper Marine | Mersey | Horizontal beds of conglomerates, mudstones, shales, and sandstones containing coal seams |
| | Unconformity | | |
| Quaternary | Pleistocene | Central Plateau | Glacial drift and morainal material |
| | Recent | Forth River | Alluvial and recent gravels |

## (D)—Sequence of Igneous Rocks.

### (1) *Intrusive and Extrusive.*

| | |
|---|---|
| Pre-Silurian ... ... ... | Felsites, keratophyres and porphyries (porphyroids). |
| Devonian ... ... ... ... | Granites and granite porphyries. |
| Upper Mesozoic ... ... | Diabases. |
| Upper Tertiary ... ... | Basalts. |

## (E)—Sedimentary Rocks.

### (1) *Algonkian System.*

The lowest and most prominent sedimentary rocks of this district consist of a great series of micaceous, quartzitic, and argillaceous schists which are apparently conformable throughout. This series has been divided lithologically and stratigraphically into two distinct groups, the older known as the Lower Algonkian mica schists, and the younger as the Upper Algonkian quartz and argillaceous schists. The members of the lower division of this series consist essentially of finely laminated muscovite-biotite schists possessing well-developed crystalline texture. They are highly foliated, brown coloured, medium to coarse-grained rocks made up of muscovite, biotite, and quartz. Near the northern border in the valleys of the Forth and Dove Rivers, the overlying formations have been removed exposing splendid sections for examination. In this part they have a general east-west trend and dip northerly at an inclination of from 60 to 70 degrees.

Quartz schists compose the bulk of the Upper Algonkian. They are usually hard, fine-grained rocks, but in places are sufficiently coarse to be termed grits, and nodular varieties are not uncommon. In some places, especially in the vicinity of sharply-folded anticlines and synclines, a high degree of schistosity is developed in the rock. The appearance generally is that of a greatly contorted, thick-bedded, white opaque coloured rock, the mica component lending a silvery grey shining lustre. Interstratified with the quartz schist members are thinner beds of argillaceous, siliceous, and micaceous slates of various shades from grey to black. All phases contain sericitic mica developed parallel to the bedding-planes and in the argillaceous members especially this mineral is so abundant that the rock has the appearance of a normal mica schist.

Both groups of strata are folded along east-west axes, and they are much faulted.

The strike of the structural axes is from 80 degrees west of north to due east-west. The dip is variable, both in direction and magnitude according to the position in relation to the folds.

### (2) *Ordovician System.*

At several points between Brown River and Gisborne's Blocks hard fissile slates are exposed in road-cuttings and creek beds. In the centre of the district at certain horizons the slate beds are well developed. This is especially noticeable in the ridge leading eastward from Brown Mountain. The slates outcropping just south of Gisborne's are fully 300 feet thick. They strike east-west and dip south at an inclination of 75 degrees. Apparently these slates lie on the southern limbs of synclines in Algonkian strata. The contact of the slates and quartzites is not observable as the outcrop shows only in the bed of a narrow gully. They vary in colour from grey to bluish-black, and have a marked laminated structure.

### (3) *Silurian System.*

#### (*a*) Tubicolar Series.

These strata are found in the northern area of this district in all gradations from fine-grained evenly sorted white sandstones, through grits, to white, water-worn pebbles cemented into conglomerates. The sandstone is made up of subangular to rounded particles cemented principally by siliceous material with also the addition of a little calcite. Intercalated with these beds are narrow bands of felspathic shale. The materials forming these strata were laid down on a porphyroid floor, and were derived from disintegrated quartzites and quartz schists of the Upper Algonkian series. The conglomerate member peters out going southward, and has not been observed at all in this district; showing that these strata did not extend far beyond the northern boundary. A characteristic feature of these strata is the peculiar cylindrical borings which traverse the sandstones at right angles to the bedding-planes. Not all of the layers, however, contain these annelid borings and trails. Tubicolar sandstone occupies the extreme northern part of the district and on the east side of the Forth River it caps Lemonthyme Hill southward to Berriedale Plains. Quartzite of identical habit and tentatively ascribed to the same horizon forms a sharp anticline on the west side of the road northward of Gisborne's.

#### (*b*) Limestone Series.

Conformably succeeding these strata are argillaceous limestones of the Middle Silurian. The nearest outcrop is just over the northern boundary in the neighbouring district.

(4) *Permo-Carboniferous System.*

This group of rocks consists of 1500 feet of conglomerates, mudstones, shales, mudstones with marine fossils, sandstones, shales, sandstones enclosing coal seams, and pebbly sandstones, followed by fine-grained sandstones. They occur over a very large area, and form the bulk of all the mountains rising above the old peneplanated surface of Algonkian strata, and are almost invariably protected by a deep covering of diabase.

(*a*) The basal member is made up of glacial conglomerate and till, fully 100 feet thick in parts, the material of which is derived from the quartz and mica schists beneath. Splendid sections of these strata are exposed on the south and east sides of Barn Bluff, and on the west banks of Lakes McRae and Ellen. In both localities they have been cut through by Pleistocene glaciers and are found occupying erosion troughs in the schists formed by Carboniferous glaciers. They are particularly prominent near Barn Bluff, where they present great perpendicular walls of rock extending several miles. These rocks consist largely of angular to subangular and rounded quarzites and quartz mica schists. The material is very irregular in size varying from the finest particles to blocks several feet in length. The conglomerates form the base of the Permo-Carboniferous system in Tasmania, and these are correlated with similar strata at Adventure Bay, Mersey River, Preolenna, and Port Cygnet.

(*b*) The basal member is succeeded by considerable thicknesses of bluish-grey, unfossiliferous mudstones. The exact thicknesses of these strata could not be ascertained. Resting on these are grey and yellowish mudstones and shales with limestone rich in fossils, characteristic of the Permo-Carboniferous system. Following is a list of the more important species occurring here:—

Bryozoa—Stenopora, Fenestella, Protoretepôra ampla.
Brachiopoda—Spirifera, Productus.
Pelecypoda—Aviculoptecten.

(*c*) Sandstones and shale, the latter from 20 to 30 feet thick, succeed the mudstones. A very good section is exposed in the valley of Douglas Creek on the north side of Mt. Doris. This is a finely laminated carbonaceous sandy shale, showing a considerable development of mica.

(*d*) These sandstones contain several workable seams of coal. Three seams have been definitely located up to the present time. The coal is of the cannel and semi-cannel types, and occurs in well defined measures between massive sandstone bands which form roof and floor. The roof sandstone is largely made up of quartz pebbles from 5 to 10 millimetres in diameter while that forming the floor of the coal seams is fine-grained. The overlying sandstones are several hundred feet thick, and extend up to the diabase cover.

Plants recorded by Montgomery from the coal shale beds include glossopteris (ovata?), and a noeggerathiopsis.

### (5) *Tertiary System.*

It is possible that the remains of high-level terraces of shingle and drift occurring on the sides of Forth Valley are deposits of this age. Certainly the river at this time followed approximately the course it has to day for there are sheets of Tertiary basaltic lava overlying gravels and sands at several points along the valley. These deposits, however, are nowhere extensive, and they are not of economic importance.

### (6) *Quaternary System.*

#### (*a*) Pleistocene Series.

Deposits of Pleistocene age are widely distributed in the southern area. They consist principally of glacial till, boulder clay, and drift, covering a considerable portion of the glaciated plateau.

#### (*b*) Recent Series.

Alluvium and recent gravels are found along the Forth River and its tributary streams. Between Mts. Oakleigh and Hartnett the river flood-plain is from half to one mile wide, and is covered deeply with gravels and sands. Old river terraces at various elevations are found on both sides of the valley. It is not known whether or not these sediments contain gold and other minerals of economic value.

## (F)—Igneous Rocks.

### (1) *Porphyroid Series.*

The several formations comprising the porphyroid series of igneous rocks are represented here by granites, quartz-porphyries, felspar porphyries, and basaltic felsitic rocks. As a rule, the porphyroids by their much more metamorphosed character, are readily distinguished from the stanniferous porphyries and granites of the Devonian; but in some members there is a remarkable similarity. (5) In the southern area these formations are represented by numerous felsitic dykes, striking west of north obliquely across the strata, which have an east-west trend. They are all more or less mineralised probably in part by solutions emanating from the Devonian intrusives. In the hand specimen they appear extremely dense felsitic rocks that have been considerably altered. Radiating tufts of actinolite have been developed in them, and further alteration to calcite and talc is frequently found. They vary in colour according to the degree of alteration. Usually the rock is dark-grey to black, but green, yellow, and white varieties are common. Weathered rock shows the irregular pitted surfaces characteristic of igneous rocks of this type. Microscopically they seem to be composed chiefly of mica, felspar, and secondary actinolite and calcite. At the Barn Bluff mine this rock has, in certain parts of the dyke, become almost completely chloritised.

### (2) *Devonian Granites.*

The granitic rocks outcropping in the northern area near Five-mile Rise, and in the southern area on the east side of Forth Valley are parts of great masses of igneous magma which did not reach the surface, but cooled slowly underneath the cover of sedimentary rocks.

In this locality the granite was intruded under no great depth of strata, but the surface area exposed by erosion is not great. The exposures are determined by the original irregularity of the upper surface of the great subjacent granite batholith. The nearest outcrops in neighbouring districts are those occupying Mt. Inglis and Granite Tor, 10 and 15 miles westward, at Moina, in the adjacent district, towards the north, and the quartz-porphyry dykes near Black Bluff. Another outcrop worthy of note is exposed in the road-cutting opposite the cemetery between Sheffield and Barrington and there are indications in this vicinity of further occurrences below the mantle of basaltic lava.

(5) The members of this group occurring in the northern area have been carefully described in Bulletins 14 and 29 of the Geological Survey.

The granite intrusion took place during the Devonian period and is contemporaneous with the intrusion of the tin-bearing granites so highly developed in other parts of the island.

The principal petrographic types in the northern area consist of hornblende-biotite and normal biotite granites, while in the southern area muscovite granites prevail.

### (*a*) Muscovite-Biotite Granites.

The composition and texture of this granite varies slightly from point to point. In general it is a light to dark-grey rock, of medium to fine-grained texture, and consists essentially of quartz, orthoclase, and muscovite. Biotite in a lesser degree accompanies the muscovite, and in certain places is the dominant mica component. In the porphyritic phases the rock is studded with large phenocrysts of white or pink-white felspar and quartz. The rock has a decidedly fresh appearance, but partial kaolinisation of the felspar has set in and the micas show a slight alteration; aplitic and pegmatitic phases occur, and greisenisation of the granite wall-rock is common to all the veins. With the granite are associated dykes of fine-grained porphyry, and numerous quartz veins, almost invariably containing metallic minerals.

The main outcrop rises eastward from the bed of Forth River to a point 1200 feet higher up the hill whence it becomes obscured by the diabase cover. The degree of metamorphism of the quartz schist contact rock effected by the granite is not great; and, apparently there has been little or no assimilation of the quartzose rock by the invading magma.

### (*b*) Hornblende-Biotite and Biotite Granites.

These are dark-grey to almost black coarse-grained rocks consisting of hornblende, biotite, felspar, and quartz. Hornblende, which with felspar is the most abundant component, occurs in lath-shaped, idiomorphic crystals from 2 to 10 millimetres long. Quartz and biotite are quite subordinate and are phenocrystic, while the felspar is mainly interstitial. Apatite in idiomorphic form is a constant accessory component. The rock appears remarkably fresh showing alteration only of the plagioclase felspar which is partly kaolinised.

*Spurling Photo.*] PHOTO. 4.—BARN BLUFF AND LAKE WILL, SHOWING GLACIATED MOUNTAIN SLOPES. To face page 31.

Associated with this rock is a biotite granite composed of felspar, mica, and quartz. The felspars are orthoclase and plagioclase in about equal proportions, the latter variety belonging to the oligoclase-andesine series. They have suffered partial kaolinisation, and the mica component, although usually unaltered, shows slight chloritisation.

These rocks occur in the form of dykes intruding the older schistose porphyroids, which have been partly assimilated by the granitic magma in its course through them. The outlines of the dykes are very irregular, but they have a general meridional trend.

### (3) *Diabase.*

Basic intrusions having the forms of dykes and sills are found in very large masses outcropping at surface. The diabase has a wide distribution on the central plateau, but a large portion has been eroded away, leaving remnants only exposed on the hilltops. These rocks stand out as great columnar masses 500 to 800 feet thick capping all the higher mountain peaks and ranges over an area of many hundred square miles. It is evident that these eminences are erosion residuals of a former Mesozoic plateau. The diabase is a dark greenish medium-grained rock, composed essentially of augite and plagioclase with also subsidiary olivine.

It has been suggested that each of these mountains represents a separate sill connected with an internal reservoir by means of a separate volcanic neck. (6) Were such the case, dykes or fissures, or some decided evidence of disturbance, would be noticeable along the well-exposed slopes of the mountains; but the coal measures strata are singularly undisturbed and are not broken through by any eruptive rocks. The sandstones beneath the diabase show only the slightest indications of alteration by the igneous rock.

### (4) *Basalt.*

Volcanic rocks containing plagioclase, augite, and olivine, are found as surface flows on the valley sides of Forth River. The varieties of lava range from tachylyte

(6) *Vide* G. A. Waller: "Report on the Mineral Districts of Bell Mount, Dove River, Five-mile Rise, Mt. Pelion, and Barn Bluff," Geological Survey of Tasmania, 1901.

to normal olivine and olivine-augite basalt. The ferro-magnesian minerals, olivine and augite, are partly phenocrystic in a groundmass composed largely of plagioclase. Both amygdaloidal and vesicular types are represented; and columnar and ball-and-socket jointing are common features of the rock. There is no great thickness of basalt in this district, and only detached masses—the remnants of a former extensive sheet—remain. Effusive and fragmental types containing geodes, filled with zeolites, occur in considerable masses at Gisborne's blocks. A small isolated dyke of basalt, 4 feet in width, is exposed at the Barn Bluff Copper Mine in the bed of Cook Creek. A microscopical examination proves it to be very fresh olivine basalt, and evidently of Tertiary age. Basalt occupies the whole of Gad's Hill and Berriedale Plains, farther than which, it has not been observed southward.

## (G)—Geological History.

### (1) *Pre-Cambrian Conditions.*

The crystalline micaceous schists outcropping in the Dove and Forth Valleys near the southern limits of this district represent the earliest formations found in Tasmania. The Archæan rocks, from which these sediments were derived, have completely vanished. Following the deposition of these sediments, the country was elevated, and schistosity was developed in the rocks as a result of regional metamorphic processes. It is impossible to determine the age of this series by palæontological evidence as it is barren of fossils but on stratigraphical and lithological grounds these rocks have been regarded as Lower Algonkian.

After a short period of stability the land surface was again depressed below sea-level and covered with great thicknesses of the sands and muds that make up the Upper Algonkian strata. The variation in the character of the several members of this formation indicates various phases of deposition brought about by alternate changes of elevation and depression. Littoral to shallow water deposits constitute these sedimentary beds.

These schists and quartzites in the southern area after having been regionally metamorphosed in Pre-Silurian time formed a land surface up to the Carboniferous period and suffered denudation to the base-level of erosion.

## (2) *Palæozoic Conditions.*

### (*a*) The Porphyroid Diastrophism.

The orogenic movements responsible for the uplift of the Algonkian formations were followed by intense igneous activity. Both volcanic and plutonic phases are represented, the former by great thicknesses of lava and accumulations of tuffs and other fragmental ejectamenta; and the latter by numerous acidic and basic dykes some of which intrude the volcanic members. Closely associated and in some cases intercalated with these igneous formations are beds of slate, grit, and quartzose rocks, largely made up of pyroclastic material derived from the several volcanic members. It is quite evident that sedimentation and volcanism were synchronous.

The greater volumes of these sediments, however, were deposited at the close of the igneous invasion. During the last phase of igneous activity these formations were disturbed by local orogenic movements which uplifted them and gave them a regional dip in a north-westerly direction. This action resulted also in the development of the schistose structure characteristic of these igneous rocks, and in the transformation of the shales into hard fissile slates. The formation is identical with the Dundas group which on stratigraphical and palæontological grounds has been assigned to the Ordovician. [7] The finding and identification of graptolite impressions in the Dundas slates fixes their position in this division.

### (*b*) The Silurian Diastrophism.

The land surface occupied by the porphyroid igneous rocks gradually subsided and the accumulation of littoral material derived from Upper Algonkian quartzites and schists, commenced. These littoral deposits are represented in neighbouring districts by conglomerates and sandstones of the West Coast Range series, and in the northern area of this district by tubicolar sandstones and conglomerates. The relation of the tubicolar group to the West Coast Range formations is that of slight unconformity since the basal member of the former group is a conglomerate that contains pebbles derived from the latter.

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[7] *Vide* T. S. Hall: "Evidence of Graptolites in Tasmania," Royal Society Paper, 1901.

Following a short period of rest a further submergence took place, and the calcareous sediments that formed the limestone were deposited on the ocean floor. The Silurian limestone is especially notable as being the most useful horizon-marker in the Palæozoic formations. This formation undoubtedly belongs to the Middle Silurian. The Silurian system has been subdivided into Lower, Middle, and Upper divisions according to recognisable differences in sedimentation and the accompanying faunal changes. The faunal changes are not profound, and there seems to be some divergence of opinion as to the disposition of the several species of the more characteristic fauna. The limestone and the immediately succeeding beds occurring in the vicinity are fairly fossiliferous, but the tubicolar sandstones and conglomerate, apart from the tubicolæ, contain few fossils. One of the most important of recent discoveries is that of the rhynchonella fossil in tubicolar sandstones at the Thistle Mine near Lorinna. Specimens were submitted for identification to Mr. F. Chapman, Palæontologist to the National Museum, Melbourne, who reports as follows:—

> "I have examined the fossils in grey sandstone from Lorinna, and conclude that they belong to a species near to *rhynchotreta cuneata*, Dalman sp.; but may be new. It differs from *rhynchonella borealis*, already provisionally recorded by Etheridge from Zeehan, in having a more acutely trihedral shell, more numerous costae and concentric surface ornament, tending to become microscopically tegulate. It also differs from the typical *R. cuneata* in its thinner and more numerous costate structure. These beds, if it is fair to judge by a limited fauna, show age affinity to the Wenlockian. I do not think they can be older, but it would not be safe to positively affirm this without seeing other fossils."

*Rhynchonella cuneata*, Johnson sp., has been identified by R. Etheridge, Jr., in bluish-grey slates conformably overlying Silurian limestone at Zeehan, and impressions of *R. borealis* and *R. capax*, var. meridionalis, have been observed in the greyish-white schist (sandstone) of the same series. These are not regarded as essentially characteristic fossils of the period, and, therefore, are not of absolute diagnostic value; nevertheless, they suggest a Silurian facies.

As the limestone is only slightly unconformable with, and directly succeeds the tubicolar strata, which in turn have a like relationship to the older sandstones and conglomerates, it seems natural to infer from this and the palæontological evidence that the tubicolar strata belong to the Lower Silurian, and that the West Coast Range conglomerates lie at the base of that system.

### (c) The Devonian Diastrophism.

Before the intrusion of the granite and the several kinds of rock that are believed to have been derived from the same magma, the earlier Palæozoic formations had been elevated. The local effect of the granitic intrusion is shown in the complete dislocation of the strata, and the anticlinal folding of the older formations is directly attributable to the effects of this irruption. With the Devonian ends the last great period of diastrophism. The most extensive ore-deposits occurring in Tasmania are coincident with the Devonian granitic irruption.

### (d) The Permo-Carboniferous Sedimentation.

At the beginning of this system glacial conditions prevailed as exemplified by the great thicknesses of glacial till composing the basal member. On top of these mudstones, sandstones and shales were laid down. The submergence of this surface brought about marine conditions with the deposition of mudstones, arenaceous limestones, rich in marine fauna, and sandstones, the whole constituting the lower formations of the Permo-Carboniferous series. A subsequent uplift brought about lacustrine or estuarine conditions with the deposition of sands and muds, carbonaceous shales, and coals. Following this a sudden depression restored marine conditions when the upper formations were laid down on the shallow ocean floor. Later an emergence took place, and sedimentation continued with the deposition of the sands.

## (3) *Mesozoic Conditions.*

Immediately following the Permo-Carboniferous, the Trias-Jura sediments were laid down, the transition from one to the other being almost imperceptible. No sedimentary deposits of this age have been observed in this district, but in neighbouring districts they are found con formably overlying the Permo-Carboniferous.

Igneous activity broke forth on a grand scale in the late Mesozoic, and great sheets of diabase were injected into the sediments. The distribution of these rocks is very extensive, covering, as they do, very large portions of the Midland and Northern counties. These deposits cap all the high mountain peaks and ranges, and form a highly protective covering to the soft Permo-Carboniferous strata beneath.

### (4) *Cainozoic Conditions.*

Following this, crustal disturbances took place uplifting the whole surface. This orogenic movement brought about further vigorous erosion and great volumes of the Mesozoic and Permo-Carboniferous were swept away. The great drainage channels existing to-day came into being, and the rivers became entrenched within the older erosion surface. During late Tertiary volcanic eruptions broke forth at several points in this district, resulting in the accumulation of deep deposits of basaltic tuffs and lavas. The long-continued emission of basalt involved much disturbance of the drainage system. The river channels were choked, streams were diverted, and deep leads were completely buried. The ensuing quiescence was followed by Pleistocene glacial conditions, and an era of intense erosion supervened. The full effect of this glacial and subsequent fluvial erosion have already been described. Elevated river terraces in Forth Valley show evidence of Pleistocene and recent warping. An examination of these terraces shows that the greater uplift took place near the coast line, for in that direction the river is deeply entrenched in the bedrock, while in the upper reaches it has not passed through its old bed.

## VII.—STRUCTURAL GEOLOGY.

The importance of a knowledge of the structural geology of the district will be conceded when it is recognised how intimately associated therewith is the distribution of the various kinds of ore deposits. The general geology is simple, but the structural features are rather difficult to decipher. Occupying the greater part of the surface are the Algonkian formations which underlie all other sediments occurring here. An examination of the structure of these formations shows that the strata are folded in a series of long, roughly parallel, anticlines and synclines which have been truncated by Pre-Carboniferous erosion, and also by the action of Pleistocene glaciers. The axes of these folds extend in a general east-west direction, but in the south-east area they have been interrupted by faulting, and now assume a north-north-west course. Sharper folds are found in the alternating thinly stratified quartzose, micaceous, and argillaceous beds, while the thick-bedded massive quartzites, offering greater resistance to the compressive stresses applied to them, have suffered lesser deformation. In many places the more plastic argillaceous schist members are converted into highly foliated crystalline mica schists of a prevalent dark-green hue. In some nodular varieties they assume almost gneissose appearance. At the apices of the anticlines in the crystalline schists tensional strains have resulted in lateral openings, and, where these have been intersected by transverse fissures, ore-deposits have been formed. The old strata were invaded by numerous dykes of diverse character at widely separated periods. They consist of Pre-Silurian porphyroids, Devonian granites and porphyries, Mesozoic diabases, and Tertiary basalts. Mineralisation on an economic scale accompanied only the granitic invasion, and the ore-bodies are quite unaffected by the latter irruptives.

All of these dykes have a general north-west trend. This concordance in strike suggests a structural affinity. The intrusions were accompanied by slight dislocations of the sedimentary formations. Faulting is only of local character, and nowhere has displacement on any considerable scale taken place. The most prominent fault has determined the remarkably straight course of Forth River. Near Mt. Oakleigh another fault of considerable magnitude cuts the Forth fault, and at the point of intersection a scarp of great height is presented. The latter fault has been traced in a north-westerly direction through Ward Pinnacle and the Barn Bluff sections. Several lesser faults were observed parallel to this one.

In addition to the folding and faulting produced in the rocks numerous tranverse fissures have resulted from Devonian diastrophic movements.

## VIII.—ECONOMIC GEOLOGY.

### (A)—MINERALOGY OF THE ORE DEPOSITS.

The principal useful metals that have been found here are tungsten, tin, copper, lead, zinc, silver, and gold. Besides the metals enumerated coal gives promise of commercial importance. A list of the most important minerals occurring in the district follows:—

| *Metallic Minerals.* | *Rock-forming Minerals.* |
|---|---|
| Arsenopyrite. | Actinolite. |
| Cassiterite. | Biotite. |
| Chalcopyrite. | Calcite. |
| Galena. | Chabazite. |
| Gold. | Chlorite. |
| Hæmatite. | Dolomite. |
| Molybdenite. | Epidote |
| Pyrite. | Fluorspar. |
| Pyrrhotite. | Gilbertite. |
| Sphalerite. | Hornblende. |
| Wolfram. | Magnetite. |
| | Muscovite. |
| | Quartz. |
| | Topaz. |
| | Tourmaline. |

*Non-Metallic Minerals.*

| | |
|---|---|
| Pelionite. | Cannel Coal. |

Brief descriptions of some of these minerals follow:—

*Wolfram*—Tungstate of iron and manganese—$FeMnWO_4$. It contains theoretically 76·3 to 76·6 per cent tungstic acid ($WO_3$), and 23·4 per cent. iron and manganese oxides. Wolfram crystallises in tabular forms of the monoclinic system. It occurs massive, in chisel-shaped and spear-head forms, and in divergent groups of plates or needles. It is brown to black in colour and possesses a single direction of very perfect cleavage. The chief sources of wolfram in this district are the Mt. Pelion Mine, Douglas Prospect, Lone Pine, and Hartnett claims.

*Molybdenite*—Disulphide of molybdenum—$MoS_2$—contains 59·95 per cent. of molybdenum and 40·05 per cent. of sulphur. It is a soft lead-grey mineral with a metallic lustre and greasy feel. It commonly occurs in flakes or scales having a highly developed basal cleavage. Hardness is 1 to 1·5; specific gravity 4·7 to 4·8. The greatest development of molybdenite is in the lodes of Douglas Prospect; it occurs plentifully also at the Mt. Pelion Mine, and in much lesser quantities in several other lodes.

*Cassiterite*—Tinstone—$SnO_2$. Tin = 78·38; oxygen, 21·62. After wolfram this is the most important mineral of economic value in the district. It is a hard (H = 6 to 7), heavy (S.G. = 6·4 to 7·1) mineral usually of black or brown colour, and occurs here in well developed crystallised form. In this locality it occupies the central parts of the lodes showing that it was formed later than the vein material. It is of considerable importance as a constituent of the ore-bodies on the Mt. Pelion and Hartnett properties.

*Arsenopyrite*—Sulpharsenide of iron—Fe As S. Arsenic = 46·0; sulphur, 19·7, iron, 34·3. Hardness is 5 to 6; specific gravity 5·9 to 6·2. Occurs in greatest abundance at Pelion Mine, especially in the Cliff lodes; at Douglas Prospect and Lone Pine. It is one of the latest minerals deposited from solution.

*Pyrrhotite*—Composition uncertain, varying from $Fe_7S_8$ to $Fe_{11}S_{12}$. Specific gravity, 4.6. Colour, bronze-yellow to copper-red; lustre, metallic. Magnetic. Hardness, 3·5 to 4·5. A common constituent of the copper lodes.

*Actinolite*—$Ca(Mg,Fe)_3\ (SiO_4)_3$. A common component of the Barn Bluff, Mt. Pelion, and Windermere copper deposits. It is a light to dark-green mineral of secondary origin, and derived from schistose rocks in the localties named.

*Talc*—$H_2Mg_3(SiO_3)_4$—An alteration product of actinolite and epidote. It is not abundantly developed.

*Epidote*—A calcium-aluminium-iron silicate—abundantly developed in association with chlorite at Mt. Pelion and Barn Bluff.

*Tourmaline*—A complex borosilicate of aluminium and other bases. Colour, usually green to black. It forms at the contact between the schists and granite and commonly occurs also in greisen veins. Highly developed on all the wolfram lodes.

*Fluorspar*—$CaF_2$. Specific gravity, 3·8. Hardness, 4. Colourless, yellow, blue, green, purple, and violet. Occurs abundantly and frequently found in perfectly developed cubes in the wolfram lodes.

## (B)—Mineral Deposits.

Several kinds of mineral deposits are found in this district. Nearly all of them are more or less genetically related to the intrusive granite. There are however, indications of an earlier mineral epoch believed to be concomitant with the porphyroid irruption. It has been found convenient to divide the several kinds of deposits into groups according to the nature of their occurrence and to their mineralogical composition. Thus the deposits are placed in the following classes:—

(1) Tungsten—Tin Veins.
(2) Copper Ore-bodies.
(3) Silver-lead deposits.

In addition to the metalliferous deposits several workable coal seams of considerable extent have been exposed in the southern area. A description of these appears in a later chapter.

The information contained in the following pages on the nature of the ore-bodies is amplified by the more detailed remarks given under the descriptions of the mines.

### (1) *Tungsten—Tin Veins.*

These metals are usually found in close association. Wolfram and cassiterite especially are frequent companions, having developed in much the same way. They are found in quartz veins contained in quartz schist or in quartz-tourmaline veins in greisenised granite.

The former are the more important from an economic point of view. The gangue is chiefly quartz, fluorspar, topaz, tourmaline, and gilbertite and contains pyrite, chalcopyrite, arsenopyrite, and gold, as common associates of the commercially more important metallic minerals. The most important occurrences of tungsten-tin veins are at the Pelion Mine, Douglas Prospect, Lone Pine, and Hartnett Prospect.

### (2) *Copper Ore-bodies.*

The name "Copper Ore-bodies" has been applied to these deposits not because copper is the dominant metallic component, but because it is commercially the most important. Pyrite is the most abundant of the metallic minerals; pyrrhotite and hæmatite are plentiful; while chalcopyrite, galena, sphalerite, arsenopyrite, and magnetite are quite subordinate. All the deposits of ore occur in direct association with fissures traversing the schistose country rock in directions opposed to the strike of the strata. Most of these fissures are occupied by felsitic material of a decidedly basic type, and in these cases the ore-bodies occur as hydrothermal metasomatic replacements of the igneous rock. In some parts the igneous rock remains almost unaltered, while in others its nature is recognisable only by the metamorphic minerals resulting from the alteration. The rock-forming minerals constituting these ore-bodies are:—actinolite, chlorite, epidote, talc, calcite, dolomite, magnetite, and quartz. All of them are secondary minerals resulting from the metamorphism of basic rocks. Chloritisation of lime-bearing ferromagnesian minerals results in the production of epidote, which may undergo further change into talc and clay. Actinolite alters readily into talc and calcite. Hornblende is not only a constituent of the igneous dyke rock, but also of the schistose bands intercalated with the quartzites. These schistose rocks on both sides of the fissures suffered considerable alteration and partial replacement by metallic minerals. The alteration brought about by hydrothermal solutions resulted in the formation of actinolite, calcite, chlorite, quartz, siderite, and epidote. Chlorite predominates in the fissures and actinolite in the lateral replacement formations. The mergence of actinolite into crystalline schists is commonly noted. The constant association of pyrrhotite, arsenopyrite, and other high temperature minerals with chalcopyrite indicates that the solutions were very hot at the time of deposition. Extensive concentrations of copper ores are rarely found under such conditions.

### (3) *Silver-lead Deposits.*

The most important of these are those of the Devon group in the northern area. They are fissure fillings in quartz-felspar porphyry and felsite rocks of the porphyroid series, but replacement of the wall-rock has taken place to some extent. The main component is galena with which occur sphalerite, chalcopyrite, and pyrite, the whole contained in a siderite and quartz gangue. Gold and silver are present in considerable amounts, and add greatly to the value of the ore. The lodes strike parallel to the structural planes of the older rock formations.

## (C)—Source of the Mineralising Solutions.

The metalliferous solutions responsible for the deposition of the several kinds of ores contained in the lodes of this district were directly derived from the granitic magma of which they were originally component parts. During the processes of rock consolidation and cooling, these solutions were released from the magma, found their way into fissures in the sedimentary rocks resulting from the effects of the irruption, and into contraction fractures in the granite itself, and deposited their mineral-bearing contents in the forms of metal-bearing veins. The original gaseous solutions in their passage through these fissures experienced a gradual reduction in temperature and pressure proportionate to the extent of their migration from the magma. It has been established that the variation in the constitution of the minerals formed by deposition from gaseous or liquid solutions depends upon the temperature and pressure under which the deposition took place.

From the foregoing it follows that minerals formed under high temperature and pressure are in certain cases quite distinct from those formed under low temperature and pressure, and the nature of the mineral development may be regarded as an expression of the vertical range of the minerals, and of the distance the solutions have migrated from their source. This condition is known as the zonal distribution of minerals. Those formed under high temperature and pressure are termed pneumatolytic minerals, and those deposited from hot aqueous solutions are termed hydatogenetic. Typical minerals of the former are cassiterite, wolfram, and molybdenum, with their associated minerals fluorspar, topaz, and tourmaline while arsenopyrite, pyrrhotite, chalcopyrite, although often found accompanying the pneumatolytic minerals usually occupy the intermediate zone; and galena, sphalerite, and pyrite are characteristic of the hydatogenetic condition. The transition from one phase to another is gradual. Thus tourmaline and fluorspar, boron, and fluorine-bearing minerals, characteristic of pneumatolytic deposits, are found in the Big Blow lode accompanying galena, sphalerite, chalcopyrite, arsenopyrite, pyrrhotite, hæmatite, and pyrite; farther removed from the granite, tourmaline and fluorspar are absent, but arsenopyrite and pyrrhotite, common associates of pneumatolytic minerals, are prominent. Analyses of the sulphidic ores of the Barn Bluff, Mt. Pelion, and Windermere copper mines show the presence of tin.

From the evidence set forth it appears that the hot ascending solutions were originally contained in the granitic magma, and released from it by decreasing pressure, due to its irruption into the upper part of the lithosphere; and that the mineralisation began during the final processes of rock solidification subsequent to intrusion, the residual solutions resulting therefrom having been the agents which produced the mineralisation.

There is no absolute evidence in support of the suggestion that an earlier mineralisation, synchronous with the intrusion of the basic dykes, was responsible for the ore-deposits at the Barn Bluff, Windermere, and Mt. Pelion copper mines.

### (D)—Nature of the Ore-deposits.

Almost all the lodes of this district belong to the contact metamorphic type. They consist of:—(1) quartz veins containing wolfram, cassiterite, molybdenite, with arsenopyrite, pyrite, and chalcopyrite, and associated with fluorspar, tourmaline, calcite, gilbertite, and topaz; (2) chalcopyrite and galena ore-bodies contained in fractures and dykes coursing generally diagonally across the trend of the encasing strata; (3) silver-lead deposits in porphyroid igneous rocks.

The most important factor to be considered in connection with the ore-deposits is the nature of the encasing rocks, both as to physical character and chemical composition. The massive Algonkian quartzites, and quartz-schists are much more easily fractured than the softer, finer-grained, composite, micaceous schists, and consequently they provide more suitable loci for the deposition of ores. These fractures are very irregular but remarkably continuous, and they occur generally near the borders of the granite stock. Farther removed, the fracturing is less intense, and the deposits are found as metasomatic replacements of the hornblendic and micaceous schists, and also of narrow basic dyke rocks, which strike diagonally across the strata in conformity with the gentral trend of the later fissures connected with the granite irruption. The hydrothermal solutions found their way through the fissures occupied by the basic dyke rocks, completely transformed them, and replaced the soluble portion with metallic minerals. They then attacked the crystalline schists intruded by the dyke and deposited therein the remainder of their metallic content. The bands of quartzite in the actinolite lodes represent the insoluble quartz schists and quartzites occurring intercalated with the crystalline schists. Thus the chloritic formation represents the dyke rock and the actinolite the altered crystalline schists.

## IX.—THE MINING PROPERTIES.

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

Wolfram-bearing lodes which are the most important commercially, were discovered in the upper part of Forth Valley in 1916. The mining of these lodes is not yet an established industry; but developmental work shows most encouraging results, and preparations are now being made for their active exploitation.

### (1) *Mt. Pelion Mining Company, No Liability.*

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

The properties of this Company now consist of the wolfram mines, situate in the Forth Valley, two miles north of Mt. Oakleigh, comprising mineral leases 7885-M of 20 acres, 8228-M of 5 acres, 7492-M, 7493-M, and 7777-M, each of 80 acres; the copper and lead mines on the plateau between Mt. Oakleigh and the Pelion Range, comprising sections 7429-M, 7311-M, and 7269-M, each of 80 acres; coal mining lease 7355-M of 200 acres at Mt. Thetis; and water-right 2039-W.

#### (b) Access.

Heretofore the greatest obstacles to the advancement of these mines have been due to their comparative inaccessibility, and their remoteness from a railway. These disabilities have been largely obviated by the improvements effected on existing roads, and the construction of the Lorinna extension to the wolfram group. From Sheffield, a well-defined public road leads southward, *via* Lorinna for 25 miles, thence to the Pelion Company's wolfram properties, 16 miles farther on. It is one of sharp curves and steep gradients, and only partly formed. The Pelion Company has provided large sums towards the cost of the construction of the southern portion of the road, which is now nearing completion. The copper and lead mines, situate 4 miles farther southward on the central plateau, are reached by means of a pack-track, which follows Forth River for 2 miles, thence it takes a zig-zag course up the western flanks of Mt. Oakleigh to the tableland. The coal mines lie 2 miles still further southward in the heart of the Pelion Range, and are easily accessible by Ewart's route.

### (*c*) General Features.

The wolfram properties of this Company occupy the sidelong country forming the eastern side of Forth Valley. The river in this locality courses through a broad flood-plain into the bed of which it is now entrenched. On the eastern side the country is flat for 15 chains, thence the surface rises steeply up to the level of the old plateau 2000 feet higher. Algonkian quartzites and quartz-schists underlie all the formations, and in these are found the ores of economic importance. Half-way up the hill these schists and the ore bodies encased in them are obscured by sheets of diabase rocks, and the soils from their disintegration. At the north-western corner of the property the lodes are covered with the gravels and shingle of the flood-plain. No attempt has been made to trace them in this direction. All of the veins occur on the steep valley slopes, and consequently the mines are invariably developed by a series of tunnels. Across the strike of the veins the Forth River has cut deeply into the strata exposing the ore-bodies for several hundred feet, and showing that the values have not decreased with depth.

### (*d*) Ore-bodies.

The main lode outcrops strongly up the face of the hill, coursing 5 degrees west of north, and dipping easterly at an inclination of 67 degrees. It consists of wolfram-bearing quartz filling fissures, striking almost at right angles to the quartz schist strata in which it is contained. The fissures are very irregular, but they belong to a main fracture system which is very persistent in a linear direction. These veins are about 12 inches wide, and although they split and coalesce at various points in their course, their aggregate widths show very little variation.

The principal ore mineral is wolfram, with which occur cassiterite, molybdenite, arsenopyrite, chalcopyrite, and pyrite. These minerals are distributed through the quartz gangue in irregular masses, in crystallised individuals, or they fill minute fractures. Associated minerals are fluorspar, topaz, tourmaline, and gilbertite. The valuable contents of the ore are wolfram and cassiterite, the former greatly predominating, and averaging about 4 per cent.

Molybdenite is not an economically important constituent, and bismuth ores are either entirely absent or present only in insignificant amounts. The higher grades of ore are often confined to certain shoots in the vein, and occur frequently on the walls. Rich bunches, however, are found embedded in the quartz gangue, and coarsely crystallised wolfram and cassiterite, especially the latter, are found implanted on, and embedded in, quartz crystals in the centres of the veins. Likewise is found perfectly crystallised cubic fluorspar. The occurrence of perfectly crystallised cassiterite and fluorspar occupying such a position in the lode is a peculiar circumstance, and suggests the probability of a later phase of ore deposition under pneumatolytic conditions; but these minerals may have a hydatogenetic origin. Gilbertite, containing perfectly crystallised pyrite in cubic form embedded in its mass, is a constant accessory constituent, and is usually regarded as indicative of a high wolfram content. The quartz is either white opaque or pellucid, and in the vughy parts of the lode attains a high crystal development.

The Cliff lodes are parallel to, and lie 350 to 400 feet east of the main ore-body. Their dip is almost identical with that of the main fissure. This lode system consists of a number of veins, from 1 to 4 inches wide, with others averaging 8 to 12 inches, occupying sharply-defined fissures exposed in the valley of Reid Creek near the waterfall. The mineralogical constitution of all these veins is dominated by the arsenopyritic component, although the economic minerals, wolfram and cassiterite, are present in appreciable quantities. A higher proportional metallic content is contained in the narrow veins because the greater volume of the ore was deposited before the gangue minerals, and consequently occupies the position on the walls. The chief gangue mineral is quartz, which usually occurs in saccharoidal form, but well-developed crystals exhibiting comb structure are common. Apparently wolfram and cassiterite were two of the first minerals to crystallise out. These were followed by quartz and arsenopyrite, the latter mineral filling interstices, and almost completely encasing its predecessors. Tourmaline is contained in all the veins, and in some reaches a high state of development. It is usually found on or near the walls, but blades of this mineral appear embedded in quartz-gangue at all points in the veins.

In both the main and Cliff ore-bodies the metallic minerals occur in lenses, and have a decided pitch southward. This is not unusual in wolfram lodes.

Ores from the main tunnel workings were submitted for assay to Mr. W. D. Reid, Government Assayer, who reported the metallic contents from:—

| | Per Cent. |
|---|---|
| Selected ore: | |
| Tungstic acid ... ... ... ... ... ... ... | 46·5 |
| Tin ... ... ... ... ... ... ... ... ... ... | 0·22 |
| Average sample: | |
| Tungstic Acid ... ... ... ... ... ... ... | 4·66 |
| Tin... ... ... ... ... ... ... ... ... ... | 0·30 |

The Big Blow lode is exposed in open-cuts on section 7777-M at a point 50 chains southward of the tunnel workings on the main wolfram veins. The outcrop shows up strongly on the eastern slopes of Forth Valley following an almost meridional course with a tendency towards the west. It is difficult to determine the dip, the apparent inclination being towards the west; but this probably is only local. The surrounding country rock has a north-westerly trend here—a considerable alteration from the prevalent east-west strike of the strata farther removed from the source of the disturbance—and the dip appears north-easterly. In many respects these ore-bodies present peculiar structural and mineralogical features. Deposits of this type illustrate the formation of ore-bodies by the transfer of material from igneous (granite) to sedimentary, under such conditions of temperature and pressure that the constituents introduced and those originally present are intergrown together as a result of contemporaneous crystallisation. The minerals are characteristic of the intermediate zone between the typically pneumatolytic and hydatogenetic, and they occur in part as replacements of the country rock, which, at this point, is largely made up of hornblende schist. The schistose nature is partly retained in the minerals composing the ore-body, and all gradations may be seen from the unaltered schist to the completely replaced rock. In addition, the composition of the ore-body indicates the influence of the country rock, the components of which have been chemically changed and deposited in another condition.

The dominant metallic components are sphalerite (zinc blende), pyrite, hæmatite, and galena. Others occurring in subordinate amounts are chalcopyrite, cassiterite (tinstone), ferromanganese, and arsenopyrite. Accessory mineral constituents are actinolite, epidote, calcite, and fluorspar in abundance, and felspar and quartz in subordinate quantity. A small silver content, 3 to 12 dwts. per ton, is fairly constant, while the amount of gold present rarely exceeds 3 dwt. per ton, and in some samples only traces have been detected. Tin was detected in all the samples tested, but never in quantity sufficient to prove of economic importance. Zinc blende occurs in fairly solid form near the centre of the lode; galena only in blebs. A number of samples were tested in the Geological Survey Laboratory, by Mr. W. D. Reid, Government Assayer, who reported as follows:—

| | | | Per Ton. | | |
|---|---|---|---|---|---|
| | | Per Cent. | oz. | dwt. | gr. |
| *Sample No.* 1— | Gold... ... ... ... | — | 0 | 1 | 15 |
| | Silver ... ... ... | — | 0 | 12 | 16 |
| | Tin ... ... ... ... | trace | | | |
| *Sample No.* 2— | Gold... ... ... ... | — | 0 | 2 | 0 |
| | Silver ... ... ... | — | 0 | 16 | 10 |
| | Tin ... ... ... ... | 0·20 | | | |
| *Sample No.* 3— | Gold... ... ... ... | — | 0 | 1 | 5 |
| | Silver ... ... ... | — | 0 | 18 | 7 |
| | Tin ... ... ... ... | 0·35 | | | |
| *Sample No.* 4— | Gold... ... ... ... | — | 0 | 1 | 2 |
| | Silver ... ... ... | — | 0 | 2 | 10 |
| | Tin ... ... ... ... | 0·30 | | | |
| *Sample No.* 5— | Gold... ... ... ... | — | | trace | |
| | Silver ... ... ... | — | 0 | 7 | 6 |
| | Tin ... ... ... ... | 1·0 | | | |
| *Sample No.* 6— | Gold... ... ... ... | — | 0 | 1 | 9 |
| | Silver ... ... ... | — | 0 | 10 | 17 |
| | Tin ... ... ... ... | 1·20 | | | |
| *Sample No.* 7— | Gold... ... ... ... | — | 0 | 2 | 10 |
| | Silver ... ... ... | — | 10 | 15 | 0 |
| | Lead ... ... ... | 9·7 | | | |
| | Copper... ... ... | 0·11 | | | |
| | Zinc... ... ... ... | 5·43 | | | |
| | Tin ... ... ... ... | 0·16 | | | |
| *Sample No.* 8— | Gold... ... ... ... | — | 0 | 2 | 7 |
| | Silver ... ... ... | — | 2 | 4 | 10 |
| | Lead ... ... ... | 1·5 | | | |
| | Copper... ... ... | 0·12 | | | |
| | Zinc... ... ... ... | 4·30 | | | |
| | Tin ... ... ... ... | 0·25 | | | |
| *Sample No.* 9— | Gold... ... ... ... | — | 0 | 1 | 3 |
| | Silver ... ... ... | — | 0 | 9 | 4 |
| | Zinc... ... ... ... | 5·6 | | | |
| | Tin ... ... ... ... | 0·12 | | | |

These analyses show that the ore is of no immediate commercial importance; but there may be richer shoots in the undeveloped portions of the lode, which is fully 10 feet wide, and is remarkably persistent in a linear direction.

(*e*) Development.

The developments accomplished at the Pelion Mine since the commencement of operations two years ago, consist of a tunnel driven 117 feet on the main lode, and numbers of exploratory open-cuts and trenches across the outcrop. The Cliff lode system, which consists of several parallel veins from 3 to 12 inches thick, has also received attention. The work here has been confined to open-cuts and trenches. The present main adit is in a convenient position from which all the known high-grade ore-bodies may be intersected by crosscuts and economically operated. A crosscut should be sent in easterly from the main adit at a point 200 feet from the entrance. It would not be advisable to open out from the surface another series of tunnels to exploit the Cliff lodes.

Present developments have proved the ore-bodies extending over 500 feet on the hillside up to the diabase cover, and have show them existing over a vertical range of 300 feet. At the entrance to the main tunnel the lode is 17 inches wide. This vein was driven on southerly for 50 feet where it cut out, and another commenced parallel to it. As the second lode decreased in size, a third one grew, and shows in the end, 117 feet from the entrance, a vein 12 to 14 inches wide. Rich bunches of ore occur at 5 feet from the entrance, and between 17 and 21 feet, 37 and 41 feet, 97 and 110 feet, and in the face very rich ore is showing.

(*f*) Treatment of the Ore.

The separation of cassiterite and wolfram, and the other metallic minerals from the gangue materials, such as quartz and tourmaline, is very easily accomplished owing to the great differences in the specific gravities of the metallic minerals and those composing the gangue. This is effected by ordinary wet milling processes. The concentrating plant in course of erection consists of a Blake crusher, two sets of rolls, a 4-compartment jig, and elevator for the return of second-grade coarse product of jig to the rolls, a classifier and two Wilfley tables. The machinery is to be driven by water operating a pelton-wheel under a head of 400 feet.

The mixed concentrate resulting from the treatment of the crude ore in this plant will be separated into its component parts by means of a magnetic separator. The absence of bismuth ores renders this separation simple and complete. Owing to its brittleness, due to perfect cleavage wolfram tends to form slime. It is therefore desirable to effect the separation of the wolfram from the gangue material in as coarse condition as possible. In order to lessen the loss by the sliming of the ore recourse is had to hand-sorting in the mine.

### (*g*) Water-supply and Power.

Water for power, one of the most valuable resources of the district, is to be utilised on a limited scale by the impounding of two small streams leading from February Plains. Another project was proposed, and could be carried out at very little additional expense if the prospects of the field warrant it. This relates to the impounding of the waters of Swallow Creek or of Commonwealth Creek on the west side of the river, and the generation of electric power therefrom. The scheme at present under consideration is not one of much promise, as the supply is very greatly reduced during summer, and sufficient only for wash-water for the milling-plant. The supply cannot be augmented from Lake Rosa as this is the source of Oakleigh Creek, the rights to which belong to W. Douglas, of the Birthday Mine. It is doubtful at this stage of development whether or not a large expenditure in this connection is warranted. In considering the question of water-power it is well to bear in mind the fact that the initial cost is usually so great that the interest on the capital outlay would pay the running cost of a modern suction producer gas-plant of equal power in localities where wood supplies are abundant. An 80 horse-power plant using wood for fuel would be suitable for all requirements for some years to come.

### (*h*) Ore Reserves.

Any attempt at forming an estimate of the quantity of ore available for treatment at this stage of development could only be regarded with suspicion. The lodes are certainly persistent in length, and they appear to retain their average size and metallic contents down to the level of Forth Valley, but sufficient actual developmental work has

*Spurling Photo.*]

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PHOTO. 5.—MTS. CRADLE AND BROWN, LAKE McRAE (BASAL CONGLOMERATE IN LEFT-CENTRE).

not been done to provide information upon which a reliable estimate could be formulated. Again, in mining the ore more than twice the quantity of wall-rock is broken with it, thereby diluting the material to this extent. Only coarse lumps of waste are sorted out, the remainder with the ore going to the mill. Thus it will be seen that it is impossible to form an exact estimate of volume, and this refers also to the determination of the average value.

(*i*) General Remarks.

It is impossible to state with any degree of certainty the future prospects of this mine as it is now only in the earliest stage of development, but the geological conditions are decidedly favourable. Although the fissures are irregular, and the metallic contents of the vein material are erratically distributed, it is not anticipated that the average grade will vary greatly above the present working level. Ore-bodies of this kind are remarkable for their continuity, and also for their persistency in depth, their ultimate value depending upon the variation in their metallic content. The developmental work shows the most encouraging results.

### (2)—*Birthday Mine or Douglas' Prospect.*

(Section 7584-M, 78 acres. Lessee W. Douglas.)

(*a*) Situation, &c.

This property is situate 60 chains north of the Pelion-Wolfram Mine. The western boundary of the section abuts on Forth River, while the eastern is 500 feet higher on the steep valley side. Oakleigh Creek, a permanent and valuable stream, flows from Lake Rosa in a westerly direction, and passes over the southern boundary of the section on its course to Forth River. Under lease No. 1833-W, the lessee has secured 5 sluice-heads of the water contained in this stream. The road from Lorinna, at present in course of construction, passes through the western portion of the property. Granite outcrops in the river just over the western sideline, and occupies the greater part of the area encompassed within the boundaries of this section. In the south-east corner a thin cover of quartz schist occupies the surface.

(*b*) Ore-bodies.

The ore consists of the metallic minerals wolfram, molybdenite, cassiterite, chalcopyrite, covellite, pyrite, and arsenopyrite; accompanied by tourmaline, fluorspar, gilbertite, and topaz; the whole set in a gangue of white, pellucid to opaque quartz. Smoky quartz is also commonly found, and frequently occurs in fine crystal development in the cavernous portion of the lodes. These are metal-bearing quartz veins, occupying fissures in muscovite granite. On both sides of the veins the granite has been greisenised by the action of fluorine and boron-bearing solutions on the felspathic component. Wolfram is the only constituent of commercial importance. In many respects these veins greatly resemble those occurring under similar conditions at Tin Spur, but, unlike the latter, they contain abundant tourmaline.

Wolfram and molybdenite are usually found on the walls, but they occur also scattered through the quartz gangue. Arsenopyrite and chalcopyrite are not abundant. Pyrite is always found in well-developed cubic form encased in gilbertite. Tourmaline occurs in abundance near the walls as long laths in the lode-stuff, and also in the greisen; fluorspar, in both purple and brown varieties, is commonly noted in the lode material.

(*c*) Development.

*No.* 1 *Lode System.*—On the hillside, about 8 chains east of the western boundary, a number of wolfram-bearing quartz veinlets from 1 to 3 inches wide contained in muscovite-biotite granite, have been exposed in two cuttings. Three veins show in the small trench, which is 12 feet long, 5 feet wide, and 6 feet deep. Their strike is directed 42 degrees west of north, and their dip 77 degrees north-easterly. The second trench is only a few feet away from the first, and reveals veinlets exactly similar in character to those disclosed therein. Wolfram, cassiterite, arsenopyrite, and pyrite, are metallic mineral components of the ore; topaz and tourmaline are also prominent. Greisen extends 6 inches on both sides of the walls. These veins have been traced 3 chains up the hillside in a south-westerly direction.

*No.* 2 *Lode.*—This is a 6-inch quartz-vein carrying a fairly high wolfram content, and also subordinate quantities of molybdenite, chalcopyrite, and arsenopyrite. It has been exposed in a trench 60 feet long, and 12 feet deep, about 3 chains north-eastward of the workings on No. 1 lode. This lode has been proved to extend up the hill south 35 degrees east for over 5 chains. The dip is north-east at 72 degrees. Sixty feet south-eastward from the end of the main trench another cutting has been made along the course of the vein. Here it is 9 inches wide, with 9 to 12 inches of greisen beyond the walls.

*No.* 3 *Lode.*—This strikes north 30 degrees west, and dips north-easterly at 70 degrees. It lies only 20 feet north-east of No. 2. The width at this point is 6 to 8 inches. It has been explored by a long, narrow trench, showing the usual constituent minerals with wolfram predominating. Here the greisen contains an unusual amount of chalcopyrite.

### (*d*) Conclusion.

It is not possible to predict with any degree of certainty the future of this undeveloped prospect. Lodes of this kind are remarkably persistent as a rule. If the wolfram content remain constant, and the lodes continue for any considerable distance south-eastward, there should be little doubt of their successful operation. The facilities provided here for economical mining will prove of very great advantage in the future development and exploitation of the lodes. The ore may be attacked by means of adits driven on the lodes from the surface; an abundant water-supply for both power and milling purposes is at hand; timber is plentiful; and the property is easily accessible by road.

The lodes are very small, and insufficient in themselves to warrant the erection of a costly milling-plant; it is advisable, therefore, for the holders to amalgamate their interests with those of other owners of mining claims of similar character in the vicinity.

### (3) *Section* 8336-M, 80 *acres. (Lessees: Hancock, Hartnett, and Atkins).*

This section is situate east and adjoining Douglas' Prospect at altitudes from 500 to 1000 feet above the river. It has been pegged recently, following the discovery of a small wolfram-bearing quartz vein contained in greisen. Loose blocks of quartzite enclosing wolfram in quartz have been found strewn over the surface.

(4) *Section* 8230-M, 80 *acres. (Lessees: Hancock, Hartnett, and Atkins).*

This lies north of and adjoining Douglas' Prospect, and is almost wholly occupied by granite rocks. Numerous tourmaline-bearing greisen veins occur, but no metallic mineral deposits have as yet been discovered.

Both these sections possess a certain prospective value, situate as they are in the centre of the wolfram area. Only superficial exploratory work has been undertaken up to the present time, and this has been ineffective in certain parts because the bedrock is obscured by fragmental materials and soils.

(5) *The Lone Pine Prospect.*

(Section 8151-M, 80 acres. Lessees: Hancock, Hartnett, and Atkins.)

Situate 1½ mile north of Douglas' Prospect on the right bank of Forth River, this property occupies steep sidelong country below February plateau. The slope of the surface eastward is at the rate of 1 in 1·5 up to the level of the trenches into the lode outcrop 300 feet above the level of the flood-plain.

The surface is largely occupied by quartzitic schists, the strike of which is directed north of west. These sediments on the lower hillside and valley-floor are covered with alluvial material, and at the foot of the hill in a road-cutting the intruding granite juts out above the surface. Eastward of this section, high up on the hillside, a porphyry dyke penetrates the sediments, and 1 mile northward white porphyry shows again in an excavation on the roadside.

The ore-body consists of numerous wolfram and cassiterite-bearing quartz veinlets coursing in a direction north 48 degrees east, and dipping apparently at an inclination of 75 degrees south-west. Deposition of metallic minerals has taken place not only in the fissures, but also along bedding and cleavage planes, and joints in the rock. In addition to wolfram and cassiterite, the metallic minerals arsenopyrite and pyrite are abundant, and fluorspar, tourmaline, and topaz are common accessory components of the ore. Cassiterite and wolfram occur usually on or near the walls; arsenopyrite almost invariably occupies the centre of the veins. Fluorspar, both green and purple, occurs in massive form, but also in pellucid crystals perfectly developed.

The exploratory work consists of two shallow open-cuts. On the hill the larger vein is 3 to 5 inches wide, and contains a fair proportion of wolfram. South-eastwards it has not been traced far, but down the hill near the river it has been exposed in the road-cutting at a point 4 chains away. Here, two veins, 4 and 8 inches wide, showing high-grade ore have been revealed. The best method of exploring these lodes is to drive on them south-eastward from road-level.

The outlook for this prospect is very promising. The lodes can be developed at a very small cost, the conditions for economical mining being almost ideal.

### (6) *Hartnett Prospect.*

(Section 8303-M, 80 acres. Lessees: Hancock, Hartnett, and Atkins.)

On this section a quartz vein containing cassiterite (tinstone) was discovered during the present examination. It is situate a little over a mile south-west of Lone Pine Prospect on the west side of Forth River. The discovery was made in a small watercourse on the eastern slope of Mt. Hartnett. Quartzitic schists occupy the whole surface of this locality. They are fractured along north-west and south-east lines, and the fissures thus formed are filled with mineral-bearing quartz. The ore consists of white opaque quartz, studded with well-developed crystals of cassiterite. In almost all cases the cassiterite has been implanted either on quartz crystals near the centre of the vein, or else on the walls of cavities.

No developmental work at all has been attempted. It is conveniently situated, and is worthy of much attention.

### (7) *Brook Prospect.*

Crossing the zig-zag track high up on the western flank of Mt. Oakleigh is a large pyritic ore-body contained in quartz schist. This lode has been known for many years, having been discovered by H. Andrews during one of his early expeditions to the district. The ore-body conforms in strike and dip to the general run of wolfram-bearing lodes in the locality. The lode, which is partly oxidised, outcrops strongly over 4 chains in a southerly direction.

This is essentially a fissure vein, but the wall-rock on both sides has been strongly attacked by mineral-bearing solutions which have decomposed the rock, and deposed in its place metallic minerals. The ore consists dominantly of pyrite, pyrrhotite, and arsenopyrite which are traversed by quartz veinlets containing a high percentage of wolfram.

No developmental work has been attempted. This prospect is worthy of attention.

### (B)—Copper Mines.

Copper deposits were discovered many years ago near Mt. Pelion West, and in the vicinity of Lakes McRae and Windermere. Several attempts, in one case on a considerable scale, have been made from time to time to develop these ore-bodies, but the operations have led to no important results. The most promising of the several deposits is that known as the Barn Bluff Mine, near Lake McRae. Here an enormous body of low-grade copper ore has been developed by means of open-cuts and tunnels. The copper content of the ore, however, is too sparsely distributed through the lode matrix to be profitably exploited under prevailing economic condtions.

#### (1) *The Mount Pelion Copper Mines.*

These mines are now owned and operated by the Mt. Pelion Company, No Liability. All the important workings are included in the three sections, 7311-M, 7429-M, and 7269-M, leased by this Company.

Since the discovery of these lodes in 1892 by H. Andrews, spasmodic attempts have been made from time to time by prospectors and mining syndicates to discover richer deposits or payable shoots in the known ore-bodies. The first operations were conducted here under the direction of John Field and R. P. Furmage, of Deloraine. After prospecting the several lodes at shallow levels, and finding no improvement in the metallic content, the mines were abandoned. Some years later a little further development was performed by F. A. Gisborne. Recently the leases were secured by the present owners, who have undertaken extensive devolopmental works with the object of determining the prospective value of the deposits.

There are several almost parallel sulphidic lodes, coursing from 10 degrees west of north to 10 degrees east of north, and dipping south of west at angles varying from 45 to 60 degrees, exposed in open-cuts, trenches, tunnels, and shafts on this property. Near the western boundary of 7269-M a tunnel has been driven 185 feet on one of these in a direction 10 degrees west of south. This a galena-pyrites lode formation, 4 feet wide, contained in quartz-mica schist. On the footwall, 80 feet from the entrance, a band of mixed galena and pyrite, 9 inches thick comes in and continues to 140 feet. The latter portion of the tunnel and the face are almost barren of minerals, but iron oxide and carbonate of copper seepage appear on the roof and walls. This tunnel is only 30 to 40 feet below the surface. Tourmaline is a common constituent, and tin has been detected in the ore though it is not visible. Two inches of selvage show on the footwall, and intense silicification of the wall-rock has taken place on both sides. This is a typical fissure lode, exhibiting also features characteristic of replacement deposits.

Samples of selected galena and mixed ore submitted to Mr. W. D. Reid, Government Assayer, for analyses, were found to contain:—

| | | | Per Ton. | | |
|---|---|---|---|---|---|
| | | Per Cent. | oz. | dwt. | gr. |
| *Sample No.* 1— | Gold... ... ... ... | — | 0 | 1 | 7 |
| | Silver ... ... ... | — | 20 | 18 | 9 |
| | Lead ... ... ... | 20·2 | | | |
| | Zinc... ... ... ... | 11·16 | | | |
| *Sample No.* 2— | Gold... ... ... ... | — | 0 | 1 | 20 |
| | Silver ... ... ... | — | 2 | 17 | 4 |
| | Lead ... ... ... | 8·0 | | | |
| | Copper... ... ... | 0·53 | | | |

Three chains east of the main tunnel entrance is an open-cut into another lode exposed in the southern bank of Forth River. This lode consists of several feet of altered quartzose and argillaceous schists containing numerous quartz veinlets and impregnations of chalcopyrite and sphalerite. The strike here is north-east, and the dip south-east, apparently in conformity with the bedding-planes of the schists. A short tunnel has been driven into this ore-body from river flood-level.

A few chains eastward are a number of narrow veins in the joints of the country rock, composed of the same minerals as before. Southward of this outcrop, towards the centre of the section, a fairly well-defined lode from 1 to 2 feet wide has been opened by a surface-cutting, and a shallow shaft sunk on the underlay. The lode strikes north 5 degrees east, and dips at an inclination of 45 degrees westward. It consists of quartz, limonite, pyrite, magnetite, a little chalcopyrite, considerable sphalerite (zinc blende), and occasional specks of galena. Average samples of this ore were found to contain 6 oz. of silver per ton. Three chains westward a 6-inch vein of zinc blende and oxides of iron, with quartz, pyrite, and chalcopyrite, outcrops on a low ridge. It is parallel to that just described, and is almost exactly similar in every characteristic.

Section 7429-M lies north of and adjoining 7269-M. In 1893 considerable work was performed here by the Mole Creek and Zeehan Mineral Prospecting and Exploration Company Limited. Since then no serious attempt has been made to develop the lodes. The country changes from argillaceous and micaceous schists south of the river to hard quartzites and quartz schists on this section. These quartzites and quartz schists have been subjected to great compressive stresses appearing now distorted into all manner of shapes. They show here a change in strike to northwest. At the centre of the section a hole 13 feet deep has been sunk on an outcrop of quartz heavily impregnated with pyrite, chalcopyrite, arsenopyrite, and sphalerite, pyrite and sphalerite predominating, though there is considerable chalcopyrite in the ore. It was found impossible to determine the width of the lode, and its strike and dip could not be definitely ascertained; however, the course is roughly meridional, and the lode appears fully 4 feet wide. The richer ore occurs on the hanging-wall, forming a vein from 4 to 8 inches wide. Some of this material contained up to 14 oz. of silver per ton, and a selected piece of chalcopyrite was found to contain:—Gold 3 dwt. 15 grains, silver 4 dwt. 19 grains, per ton; and 17·07 per cent. of copper.

From the description given it will be seen that the lodes do not contain economic minerals in sufficient quantities to prove of commercial value. However, the occurrences are sufficiently promising to encourage further prospecting in the vicinity.

### (2) *Section* 3140-M, 80 *acres*.

This property lies one mile east of the Windermere, and two miles south-west of the Barn Bluff Copper Mines. These are known as the Crade Mountain Copper Mines.

This section was originally charted in the names of Lord, Swallow, and Erickson. In 1907 it was leased by the Derwent Prospecting Association, No Liability, who in the following year forfeited their mining rights to the property, and since then it has remained vacant.

The physical features are essentially those of a glaciated area. Morainal material occupies the greater part of the surface, but the bed-rock of Algonkian schists containing the ore-bodies is exposed by subsequent erosion in the valleys of Swallow and Curran Creeks. Swallow Creek is joined by the smaller stream near the centre of the section, and flows south-eastward to Forth River. There is a striking similarity, both in the mode of occurrence and the constitution of this ore-body, to those of Windermere and Barn Bluff. They are all contained in quartzose and micaceous schists, which have a general east-west trend; they occupy north-south fractures in these schists, and east-west beds of the crystalline rocks traversed by the fissures; and they are, mineralogically, almost identical.

### (*a*) The North-south Vein (Hawson's).

This a small vein of copper pyrites, 4 to 9 inches wide, contained in a 2-feet formation outcropping on the east side of Curran Creek, and near the eastern boundary of the section. It has been exposed at several points along its course over a distance of 400 feet by means of deep trenches and shallow pits. These works show the strike to be 15 degrees west of north, and the dip 77 degrees easterly. The lode is contained in hard quartzitic rock, and varies greatly in size from point to point.

The ore is largely composed of chalcopyrite contained in quartzite gangue. Arsenopyrite and pyrite usually accompany the chalcopyrite, and chlorite is also a constant component. Gold and silver are present in appreciable quantity, and appear to be related to the copper component, for an increase or decrease in the latter shows a corresponding proportion in the former.

Samples of selected ore were found to contain:—Copper, 12·61 per cent.; silver 11 oz. 12 dwt., and gold 22 gr., per ton. A sample of arsenopyrite showed the presence of silver at the rate of 1 oz. 15 dwt. 6 gr. per ton, and a trace of gold.

### (*b*) The Northern Actinolite Lode.

About 12 chains from the north-east corner, and 1 chain from the northern boundary, a short open-cut has been sent into a fairly strong lode 6 feet wide. The lode consists of two bands of ore, the larger 3 feet and the smaller 2 feet in width, separated by a 1-foot band of mineralised actinolite. This is a metasomatic deposit replacing beds of crystalline schist, which strike east-west, and dip north at an inclination of 70 degrees. Actinolite occurs on the hanging-wall, and quartzite with actinolite on the footwall. Average samples of this ore contained:—1·8 per cent. copper; 1 oz. 12 dwt. 4 gr. silver, and trace of gold per ton. Selected ore contains as much as 7 per cent. copper; and 7 oz. silver, and 1 dwt. gold, per ton.

(*c*) Southern Actinolite Ore-body.

Another locality where copper-bearing actinolite-rock has been found is farther southward near the creek. The formation here consists of a large mass of actinolite rock sparsely impregnated with chalcopyrite. Here the lode dips south, and apparently it forms portion of the southern limb of an anticline, the axis of which lies between the two exposures. But a little farther downhill the actinolite rock appears almost horizontal, indicating a sharp synclinal fold succeeding the anticline. The outcrops are so few here that it is impossible to interpret the structural relations of these ore-bodies with any degree of certainty. This is a very low-grade ore-body, and of no commercial importance. The copper content ranges from 0·1 to 0·6 per cent.; silver is fairly constant at 1 oz. per ton; while the amount of gold present is insignificant.

The developments are not very encouraging, and further expenditure in this connection is not considered advisable.

(3) *Windermere Copper Mines.*

This group lies about 4 miles south-west of the Barn Bluff Mines, and occupies a long, low ridge dividing two glacier valleys. The ore-bodies, revealed in many deep trenches, open-cuts, and pits, consist of pyrrhotite, chalcopyrite, and pyrite set in a chloritic or actinolitic gangue. The strike of the main body is 40 degrees west of north, and the dip appears easterly at 70 degrees, in this respect being collateral with that of the Cradle Mountain fissure to the eastward. It has been suggested that the east-west actinolite ore-bodies of the Cradle Mountain mines are identical with those of similar character developed here. Apparently both are replacements of the same bed of micaceous schists, but they received their metal-bearing solutions through different channels. It is unlikely that metasomatism has resulted in the deposition of ore for any considerable distance from the fissures.

Near the south-west bank of Lake Windermere a deep trench has been cut into quartz schist and finely-laminated crystalline, mica schists highly inclined, and striking 80 degrees west of south. In the northern end of the trench a dense body of pyrrhotite, 10 to 12 feet wide, heavily charged with chalcopyrite, has been uncovered. About 30 feet south of this another band has been cut through in the same trench, and shows a body similar in character to that just described. Six chains north-westward of these workings, on the west bank of the lake, a trench and open-cut have exposed dense pyrrhotite and chalcopyrite ore contained in chlorite and actinolite associated with apparently unaltered felsitic dyke rock.

Passing up the hill to the north-west, several other bands, all striking with the country, are exposed in shallow trenches; and on the east bank of Lake James a large pyrite-quartz formation outcrops strongly at surface. It is interesting to note that tin has been detected in these ores.

Like the similar occurrences in this district, the grade of the ore here is so low that the lodes could not be profitably exploited even if transport facilities were suitable.

### (4)—*The Barn Bluff Copper Mines.*

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

This is a group of mines situate 4½ miles south-east of Barn Bluff, in the valley of Commonwealth Creek, near the edge of the Central Plateau. The mines are nearly 3000 feet above sea-level, and the average altitude of the plateau is 3400 feet. One half-mile east of the mines, Commonwealth Creek enters Forth Valley, down the steep sides of which it falls in cataracts over 1650 feet in half a mile.

The lodes occupy the greater part of a low spur between the valleys of Cook Creek and that of the main stream. This spur lies in the centre of an older, broader valley, formed by a glacier leading down from Lake McRae.

The Barn Bluff Copper, Gold, and Silver Mining Company originally leased two sections, one enclosing the main ore-deposits, the other the southern extension of the chlorite dyke passing through Ward Pinnacle. These sections are shown on the plan as 5621-M and 5302-93M, the old numbers having been retained for the purpose of reference.

### (b) History.

The Barn Bluff lodes were discovered in 1898 by Henry Andrews, while in the employ of John Field, of Deloraine. A little exploratory work, consisting of several shallow trenches into the outcrop, was performed by this party. The result of this work was not important, and the prospect was abandoned. In 1899 C. P. Smith and Thos. Cook visited the area, and located the large ore-bodies outcropping on the north bank of Commonwealth Creek. Three 80-acre sections were pegged, two in the name of C. P. Smith (the leases of which were ultimately transferred to the Barn Bluff Copper, Gold, and Silver Mining Company), and one in the name of Thos. Cook (later acquired by the North Barn Bluff Copper, Gold, and Silver Mining Company). The operations of these companies were confined to surface-trenching. In December, 1900, P. T. Moore and Reginald Murray, on behalf of the Barn Bluff Options Development Mining Company, of Adelaide, secured an option for the purchase of the mineral rights, and in January, 1901, active operations were resumed. Huts were constructed; a small air-compressor plant, driven by a Pelton wheel supplied with water from Commonwealth Creek, was erected; and developmental work on a considerable scale was undertaken. The operations of this company ceased on April 4, 1903, after the main tunnel had been driven 448 feet; Nos. 2 and 3 tunnels, 25 and 30 feet; and the ore-body had been exposed at surface in 18 open-cuts over a length of 600 feet and a width of 450 feet. No further developmental work has been carried out since. The failure of this enterprise did not discourage Tasmanian investors. The Derwent Prospecting Association was formed in Hobart for the purpose of extending the exploratory work performed by the earlier companies, but their operations did not disclose any richer shoots of ore.

### (c) Geological Features.

The sedimentary rocks occupying this area consist of intercalated bands of quartz and mica schists striking in an east-west direction. Intruding these schists are narrow felsitic dykes of basic character, and numerous quartz-filled fissures traverse them in parallel formation, all striking west of north, and therefore opposed to the structural planes of the sedimentary strata. These sediments are folded in long anticlines with corresponding synclines, the axes of which are directed 80 to 90 degrees west of north. A sharp anticlinal fold has been intersected by Commonwealth Creek near the waterfall beyond the western boundary of the dyke, and a succeeding fold has been observed in the actinolite ore-body. Crossing the main section from the north-west corner to the south-east is the chloritised dyke rock, about 250 feet wide. On the western side it takes the form of chlorite schist, while on the eastern, near the mine workings, it is hard, dense, dark-green rock, partly chloritised, strongly impregnated with pyrite, and containing also a little chalcopyrite. A little farther north-westward it shows up again in its less-altered condition as a greyish-yellow, felsitic rock much softer than, though greatly resembling, the typical quartzitic sediments occurring here. On the south-western side of the chloritic rock large masses of white opaque quartz, containing pyrite, outcrop strongly at several points over a distance of 30 chains. Numerous druses of quartz crystals are common features, and bunches of dark-green mica occur in bands encased in the quartz. On the north side of Commonwealth Creek, and the east side of the chlorite belt, are the actinolite ore-bodies.

The big knob known as Ward Pinnacle is composed of foliated quartz schist, greatly crumpled and distorted, and striking in all directions. This crumpling of the strata has been accentuated by the faulting resulting from the intrusion of the igneous rocks.

### (*d*) Ore-bodies.

In this mine two distinct types of lodes are represented, but they received their mineral content through the same channel. Outside the boundaries of this property, but within the area discussed here, a third type occurs. In order to facilitate description the several kinds are placed under the following headings:—

- (*a*) Chlorite ore-bodies occupying fissures coursing diagonally across the strata.
- (*b*) Actinolite ore-bodies replacing certain strata, and striking in an east-west direction.
- (*c*) Quartz-veins filling north-south fissures.

(*a*) It has already been pointed out that the chlorite ore-bodies occupy the positions of basic rocks intruding the strata, and that the chlorite is regarded as an alteration product of certain constituents of this igneous rock. The schistose structure of the chlorite suggests a pre-Devonian metamorphism, and a consequent porphyroid origin. It is probable than an economically unimportant mineralisation accompanied the irruption of the porphyroid dyke rock. Credence is given to this view by the occurrence of hard, non-schistose chlorite rock, heavily impregnated with perfectly crystallised pyrite, this mineralisation having taken place prior to the complete chloritisation of the original mineral components of the rock. However, the greatest mineral development is undoubtedly due to the agency of hydrothermal solutions emanating from the granite magma. The dip of the dyke is easterly, and it is on this side that the greatest mineralisation has taken place. The ore consists of dense pyrite, arsenopyrite, specularite, and pyrrhotite, with subordinate chalcopyrite and a little silver and gold. These minerals are accompanied by epidote, talc, quartz. and calcite. This is a very low-grade ore-body.

(*b*) The actinolite ore-bodies are more important, and consist essentially of alternating bands of actinolite and quartzite, heavily impregnated with pyrrhotite, pyrite, specularite, arsenopyrite, and, in a much lesser degree, chalcopyrite, galena, and sphalerite. Tin in one form or another has been detected repeatedly in this ore, and gold and silver are constant, though erratic components. The gangue rock is composed almost wholly of secondary minerals. Besides actinolite, there occur epidote, quartz, talc, calcite, magnetite, and chlorite; and tourmaline has been identified in the ore. Actinolite is a mineral of secondary origin metasomatically replacing the crystalline schists. The gradual transition from one to the other is plainly apparent at many points in these ore-bodies. The metallic minerals occur as impregnations in the quartzite, as fillings of joint planes and partings between the strata, as metasomatic replacements of actinolite, and also of the crystalline schists. Mineralisation is much more intense in proximity to the dyke, and does not extend far therefrom. Part of the intrusive rock apparently occupied lateral openings in the strata.

(*c*) About 30 chains east of the Barn Bluff workings, Commonwealth Creek intersects a dyke of granite porphyry. The rock consists of muscovite and kaolinised felspar, and contains considerable specularite. Leading from this dyke are numbers of sharply-defined white opaque quartz reefs, 2 to 4 feet wide, coursing a little west of north. These consist of several parallel fissures connected by smaller intersecting fissures, all of which are barren of economic minerals, but contain tourmaline and specularite. The contrast between the white vein quartz and the dark-grey quartzitic schists is sharply marked, and shows the former standing out prominently on the mountain slopes. Tourmaline, as thin laths, short crystals, and veinlets, is found in the sedimentary rocks in this locality, and down the western side of Forth Valley. The dip of the strata here is almost vertical, the tendency being towards the south.

These veins are of no economic importance, but they are useful in providing a connecting link between the tungsten veins of Forth Valley and the ore-bodies of Barn Bluff.

### (*e*) Development.

The work accomplished by the several companies operating here was largely of an exploratory character. These consist of the main or No. 1 tunnel, driven 448 feet, Nos. 2 and 3 tunnels, driven 25 and 30 feet respectively, and 18 open-cuts and trenches. Many of these open-cuts are mere surface trenches of shallow depth, while others are of considerable extent. Only the most important will be described here.

No. 1 tunnel is driven from the east end of the spur a distance of 250 feet on a bearing 14 degrees west of south, and therefore roughly parallel to the interstratified actinolite veins; thence it takes a zig-zag course for nearly 200 feet in a general north-westerly direction across the strata. It was intended to continue the tunnel westward to intersect the chloritic ore-body, which at that time was considered the main ore channel; but the original plan was altered, and a crosscut was sent out north-westward to explore the several actinolite veins. The first portion of the tunnel passes at an acute angle through alternate bands of mineralised quartzite and more heavily impregnated actinolite rock. The grade of the ore contained in the various formations intersected by this tunnel does not show an increase over that of the ore exposed in the surface-workings. Average samples of this ore contained:—

| | | Per Ton. | | |
|---|---|---|---|---|
| | Per Cent. | oz. | dwt. | gr. |
| Copper... ... ... ... ... ... | 0·16 | | — | |
| Silver... ... ... ... ... ... ... | — | 1 | 4 | 23 |
| Gold... ... ... ... ... ... ... | — | | Trace | |

Samples taken from the crosscut show an average content of :—

| | Per Cent. | Per Ton. oz. dwt. gr. |
|---|---|---|
| Copper ... ... ... ... ... ... | 0·40 | — |
| Silver ... ... ... ... ... ... | — | 0 16 0 |
| Gold ... ... ... ... ... ... ... | — | Trace |

No. 2 tunnel lies 5 chains to the northward of the main adit, and No. 3 is driven into chlorite rock from the bank of Commonwealth Creek. Neither of them reveals richer ore-bodies than those devoloped in the other workings.

Two open-cuts have been sent into a great outcrop of chlorite rock from the northern bank of the creek. These cuts expose 5-feet bands heavily impregnated with pyrite, and containing also filaments of chalcopyrite. Average samples of this ore yielded :—

| | Per Cent. | Per Ton. oz. dwt. gr. |
|---|---|---|
| Copper ... ... ... ... ... ... | 0·10 | — |
| Silver... ... ... ... ... ... ... | — | 0 17 3 |
| Gold ... ... ... ... ... ... ... | — | A Trace |

Several other trenches have been cut into this formation, but everywhere the ore is very poor.

The most extensive mine-openings are in the actinolite ore-body. No. 1 open-cut lies a chain south of No. 2 tunnel. It reveals a 2-feet vein of pyrrhotite, containing pyrite, arsenopyrite, and chalcopyrite interstratified with quartz bands.

No. 2 open-cut is situate 1 chain south-west of No. 1. It is about 12 feet wide, and shows a solid body of pyrrhotite with blebs and filaments of arsenopyrite and chalcopyrite encased in quartzites and actinolite rock.

No. 3 open-cut, 30 feet south of No. 2, discloses an actinolite band containing iron pyrite and a little chalcopyrite.

Open-cuts Nos. 4, 5, and 6 lie 2 chains south-west of No. 3, near the eastern margin of the chlorite belt. They show pyrite and pyrrhotite bands replacing actinolite. The copper content of the ore is very low.

Open-cut No. 7 is on the north side, near the entrance to the main tunnel. The face is 10 feet deep and 20 feet wide. Three veins, 3 to 5 feet wide, are exposed in this cut, separated by bands of dark-green quartzitic rock showing traces of copper pyrites. The ore-veins here contain a fair content of copper. The sulphide is mainly chalcopyrite, and both the carbonates, malachite and azurite, are present. Limonite and specularite, with calcite, epidote, and quartz, complete the list of minerals occurring here. They are found as impregnations and replacements of the schistose rocks.

Analyses of this ore show:—

| | | Per Ton. | | |
|---|---|---|---|---|
| | Per Cent. | oz. | dwt. | gr. |
| Copper ... ... ... ... ... ... | 2·32 | | — | |
| Silver... ... ... ... ... ... ... | — | 2 | 6 | 14 |
| Gold... ... ... ... ... ... ... | — | 0 | 0 | 10 |
| Tin... ... ... ... ... ... ... | 0·22 | | — | |

Open-cut No. 8 is on the south side of main tunnel, and is 15 feet deep and 20 feet wide. A massive ore-body, consisting dominantly of pyrrhotite and pyrite, has been opened up in these workings. The copper content is low, but appears to improve in the bottom of the cut. The ore occurs here again in alternating bands of actinolite and quartzite.

An average sample of this ore contained:—

| | | Per Ton. | | |
|---|---|---|---|---|
| | Per Cent. | oz. | dwt. | gr. |
| Copper ... ... ... ... ... ... | 1·65 | | — | |
| Silver... ... ... ... ... ... ... | — | 3 | 11 | 3 |
| Gold... ... ... ... ... ... ... | — | 0 | 0 | 8 |
| Tin ... ... ... ... ... ... ... | 0·27 | | — | |

### (*f*) Conclusion.

An attempt has been made in the foregoing to give a lucid account of the occurrence and the nature of these enormous low-grade copper-bearing ore-bodies. It is beyond the scope of this report to enter into discussions on quantities, values, methods of mining and treatment, costs in relation to production and treatment, transport. power, water-supply, &c. The details of these subjects are considerations for the mining engineer and metallurgist.

As a summary it is probably safe to say that commercially valuable concentrations of copper ores on any considerable scale do not exist in these deposits. In arriving at this conclusion very careful consideration has been given to the structural conditions existing here, and to the factors governing the deposition of the metallic ores. The confident hope is still held out by many that richer concentrations of ore will be found at greater depth, but no cogent argument has been put forward in favour of such theory.

## (C)—Silver-Lead Deposits.

The only silver-lead deposits of economic importance known to occur in this district are those in the Devon area, near the northern boundary. These lodes have been worked in a desultory manner, with varying success, for nearly 30 years. The original mine, from which the area takes its name, is the only one possessing workable ore-bodies. All the lodes occur either at or near the junction of quartz porphyry and porphyroid. Originally, it appears, the porphyroids partially absorbed the micaceous schists through which they penetrated, and these in their turn were absorbed by Devonian granitic rocks.

### (1) *Devon Mine*.

(Section 7362-M, 40 acres. Lessee: G. M. Day.)

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

The mine is situate 5 miles south-west of Lorinna, in the valley of the Dove River.

The lodes were discovered in 1892 by Malcom Campbell, a well-known prospector of this neighbourhood, who sold the lease of the mining rights to a Launceston company. The Devon Silver-lead Mining Company was organised in 1898, and developmental work was begun in that year.

For many years the mine has lain idle; but the present lessee has arranged for the resumption of operations on a small scale. The little sulphidic ore remaining unstoped is being excavated, and the gossanous material of commercial value will also be extracted. It is hoped that during the winter months enough water will be available to provide power for draining the shafts. The ore-bodies at the 60-feet and 100-feet shaft levels are reported as being sufficiently rich and large to be profitably exploited.

There is no reliable record of the quantity and value of ore produced from this mine. Up to May, 1899, a total of 172 tons, valued at £2154, had been exported; since then it is estimated that 230 tons, valued at £2800, have been produced.

(*b*) Ore-bodies.

The ore-bodies are composed dominantly of galena; sphalerite and chalcopyrite are abundant; pyrite occurs only in small quantity. Quartz and siderite constitute the gangue minerals. In addition to the base metals, the ore contains considerable quantities of gold and silver, the proportion being 2 gr. of gold and 1·53 oz. of silver per unit of lead. The gold appears to increase in amount with the chalcopyrite component. Partial oxidation of the ore-bodies extends to river-level. A large portion of the galena has been converted into cerussite (carbonate of lead); gossan has been formed by the oxidation of pyrite, siderite, and chalcopyrite, the latter also accounting for the malachite and azurite deposits on the walls. Other evidences of local oxidation are the occurrences of manganese oxides in considerable quantities.

Fahl-ore has been detected in the lodes. In the north shaft the lode is largely composed of calcite, which is partly replaced by chalcopyrite, galena, and sphalerite. The several mineral components exhibit banded structure, showing that they were deposited in open fissures in progressive stages of precipitation. In one instance the order observed was siderite, galena, galena-chalcopyrite-pyrite, and sphalerite-quartz in the centre of the vein. Partial replacement of the porphyry and porphyroid wall-rock is noticeable. The ore occurs in lenses from 50 to 100 feet in length, and the main lode has been proved to extend over 400 feet.

The average width of the main lode is 2 feet, from 20 to 50 per cent. of which is made up of fairly clean galena. In general the trends of the lodes are rather constant, though marked local changes appear in the workings. The average strike is 10 degrees east of north, and the dip is at an inclination of 70 degrees easterly. An exception to the general easterly dip is that of the small vein exposed at the entrances to Nos. 1 and 2 tunnels. Here the dip is westerly, and evidently this small vein is an offshoot of the larger. The main or No. 1 ore-body outcrops about 2 chains west of the river, which here has a due north-south course, and as the lode diverges a little towards the east, the backs decrease going north, and increase going south.

(*c*) Development.

The property is developed by two tunnels and two shafts. No. 1 is an adit-crosscut, 25 feet above river level, driven

170 feet, and directed 80 degrees west of south. At the entrance it intersects a small vein of galena, 2 inches wide, and Nos. 1, 2, and 3 lodes at 45, 90, and 125 feet respectively. From the adit, No. 1 lode has been driven on north a distance of 154 feet, and south a distance of 83 feet. On both sides of the adit good shoots of galena were followed, and the ore above the drive has been stoped out nearly to the surface. The width of the lode-channel is 2 to 3 feet, and is filled with quartz, siderite, and galena ore. The upper portion of the lode is much oxidised, and contains a considerable amount of cerussite. Gossan of fair quality occurs here, but not sufficiently rich to offset the heavy transport and smelting charges. The galena is of excellent quality, and occurs in bands from 3 to 12 inches thick. It is reported that rich ore shows in the floor of the drive nearly all the way. This lode is contained in quartz porphyry.

No. 2 lode was driven on 30 feet south, and 80 feet north, whence it branches. One vein was followed north 10 degrees west for 75 feet, and the other north 25 degrees east for 75 feet. The north-westerly vein shows 2 to 3 inches of mixed ore, and the north-east 2 to 6 inches of good grade galena. A sample from the face was submitted to Mr. W. D. Reid, Government Assayer, who reported as follows:—

Silver—92 oz. 15 dwt. 11 gr. per ton.
Gold—Not determined.
Lead—62·2 per cent.

No stoping has been done on this vein, which has a most promising appearance.

The south drive on this lode exposed a little galena and chalcopyrite in porphyroid rock.

No. 3 lode contained in schistose porphyroid is very poor. It was driven on north and south 20 feet. The gossan outcrop of this lode exposed at the surface in a small cutting contained only 8 dwt. 4 gr. of silver per ton of ore.

No. 2 adit-crosscut was driven at high-water mark from a point about 100 feet north of No. 1 tunnel. The difference in level is only 17 feet. At the entrance the small vein cut in No. 1 workings was exposed here, and No. 1 lode was intersected at 50 feet. Drives were carried north over 100 feet, and over 200 feet south. The lode has pinched out in the south end, the walls having come together. Good grade ore occurred for the first

100 feet, and this shoot has been stoped out overhead and also underfoot. In certain parts of this shoot the gossanous material contains rich cerussite. Northward a little ore shows in bunches overhead and underfoot, but very little is contained in the face of the drive. A fair quantity of rich gossan could be recovered from the stopes and north drive. Samples, assayed by Mr. W. D. Reid, yielded:—

| | | | Per Ton. | | |
|---|---|---|---|---|---|
| | | Per Cent. | oz. | dwt. | gr. |
| *Sample No.* 1—Gossan containing cerussite from stopes above No. 2 adit | Gold ... | — | 0 | 2 | 4 |
| | Silver | — | 50 | 4 | 0 |
| | Lead ... | 17·0 | | | |
| *Sample No.* 2—From stopes 10 feet north of main shaft | Gold ... | — | 0 | 4 | 22 |
| | Silver ... | — | 99 | 7 | 18 |
| | Lead ... | 22·7 | | | |
| *Sample No.* 3—Gossan from end of same stope | Gold ... | — | 0 | 13 | 2 |
| | Silver ... | — | 26 | 2 | 16 |
| | Lead ... | 17·3 | | | |
| *Sample No.* 4—Gossan from same stope over main shaft | Gold ... | — | 0 | 8 | 4 |
| | Silver ... | — | 23 | 13 | 16 |
| | Lead ... | 7·1 | | | |
| *Sample No.* 5—At end of intermediate stope 50 feet north of shaft | Silver ... | — | 3 | 13 | 12 |
| *Sample No.* 6—Main level 40 feet north of shaft | Silver ... | — | 1 | 4 | 12 |
| *Sample No.* 7—End of main north drive | Silver ... | — | 2 | 5 | 18 |

From the end of No. 2 crosscut a main shaft 8 feet by 4 feet in the clear has been sunk 100 feet deep on No. 1 lode, and a ladder-way shaft 35 feet northward has been sunk 70 feet. Drives were sent in north and south from 60 and 100 feet levels. It is reported that a 3 to 8-inch vein of high-grade ore occurs in these workings. (At the time of this examination the shafts were full of water.)

About 150 feet north of these workings a shaft has been sunk 70 feet on the No. 1 lode from the surface. The tip-head shows galena and chalcopyrite contained in calcitic material.

Facilities for operating from the main shaft have been provided by the installation of a pumping and winding-plant. This machinery consists of a 4-inch draw-lift operated by a rope connected to a crank on the main shafting, a 12-inch winding-drum fitted with friction-clutch, also connected to the main shafting, and a 3-feet Pelton wheel operating under a head of 40 feet. This is a strong, compact little plant admirably adapted for the purpose for which it was designed. The 4-inch pump easily controls the inflowing water. Supplies for power purposes are drawn from two creeks on the opposite side of the river. In summer months these streams do not contain sufficient water for continuous operation. It has been suggested that impounding Dove River, which is a fast-flowing stream, subject to floods, and contained between high precipitous walls, would ultimately prove the most economical scheme; but the cost of such an undertaking is not warranted at this stage of development.

### (*d*) Transport and Communication.

The mine is accessible from Lorinna by way of the steep track up Five-mile Rise, which rises 1100 feet in 1¼ mile, thence by a branch track along sidelong country down the Dover River gorge. The grade of this track is very steep, even for a pack-track. Those responsible for the marking out of this route have adhered to the mistaken rule of following the steep ridges, whereas only an elemental knowledge of engineering is required to see the advantages in almost all cases of following the main tributary streams. As the main-road follows the main stream (Forth River), so the branch roads or tracks should follow the tributaries. The Dove River route from the mine affords many advantages. Not only is the distance much shorter, but a descending grade can be had all the way to Lorinna. The cost of carting to Staverton railway-station is £5 per ton, equal to 30 per cent. of the gross value of the ore.

### (*e*) Conclusion.

The future of the mine depends upon the results of developmental work directed from the shaft. It is not anticipated that the ore-bodies will show an increase either in size or richness as operations are carried deeper. If the shoots of ore remain constant in length and width and the grade remains the same, a profitable future for the mine, under present conditions, may be safely anticipated. The most essential undertaking in connection with the future development of the field is the construction of a track along the bank of Dove River to the Lorinna bridge.

### (2) *Other Properties.*

Small veins containing galena, sphalerite, and chalcopyrite occur at many points in the vicinity of Devon Mine. None of them appears to be economically important. However, their occurrence proves the extension of the galena-bearing area southward and eastward. One of the most promising of these is known as Sloane's Prospect. This is a vein coursing parallel to and situate a mile east of the Devon series. It is a 3-inch vein of pyromorphite contained between quartz porphyry and quartzite (silicified micaceous schist). The dip is 65 degrees west, and therefore contrary to those of Devon lodes. A small tunnel, 20 feet into the lode, shows no improvement in the size and value of the ore. This prospect is worthy of further attention.

## (D)—The Coal Fields.

### (*a*) *General Features.*

The coal measures of the Mt. Pelion district are parts of a very extensive formation occupying a considerable portion of the great central tableland. They are prominent in the southern and western areas, and in neighbouring districts they form the bases of Du Cane and Eldon Ranges, Mt. Ossa, and the Western Tiers. (8) Montgomery points out that the search for workable seams of coal in the Eldon and Du Cane Ranges should be attended with greater success than in the Pelion country, because the coal basin appears to be deepening towards the south and south-east. The southerly dip of the basin is apparent from an examination of the western slope of Oakleigh Range; the quartz schist bedrock rises towards the north, and the coal measures strata between it and the overlying diabase become thinner and thinner in that direction until they entirely disappear. Similar conditions prevail on the Cradle Range. In this part of the coal-bearing area the basal conglomerate member, composed of sub-angular to rounded pebbles of quartzitic schist, is up to 100 feet thick.

(8) *Vide* A. Montgomery, M.A.: "Report on the Country between Mole Creek and the Mount Dundas Silver Field, and on the Discovery of Coal at Barn Bluff."

Approaching Pelion Range this stratum gradually decreases in thickness, being largely replaced by mudstones, shales, and sandstones; and in the upper tributaries of the Forth, mudstones and shales are exposed at plateau level.

On the eastern slope of the spur connecting Barn Bluff and Mt. Cradle, a seam of coal is exposed just above the roof of the conglomerate, and about 100 feet only above the quartz schist bedrock, while the lowest known seam at Mt. Pelion is contained in sandstone fully 700 feet above the basal member. As the elevations of these seams are almost identical (about 3450 feet above sea-level) it is natural to infer that there is a decided deepening of the basin southward.

### (*b*) *Nomenclature of the Coals.*

The coals of this district consist of two distinct types. Both are colloquially referred to as "cannel" coals, but although this may be a convenient trade name it is a term of no scientific significance. The more highly bituminous coal has been termed "pelionite" in consequence of its distinctive chemical and physical characters; the other is referred to as "semi-cannel." Pelionite is in a manner analagous to the kerosene shale of Preolenna, kerosene shale of New South Wales, torbanite of Scotland, and albertite of New Brunswick. But although there are characteristics common to all of them, there is nevertheless a marked difference, both in chemical composition and physical properties, between pelionite and the other organic substances mentioned.

### (*c*) *Properties and Composition of Pelionite.*

Colour—Brownish-black to black.

Streak—Black.

Lustre—Pitch-like to vulcanite-like.

Texture—Very fine, almost amorphous, having a very close resemblance to pitch. Massive and unlaminated.

Fracture—Conchoidal, both across and with the planes of bedding. The mineral is tough and very sectile.

Weathering—Practically unaffected by atmospheric agencies.

Specific Gravity—1·13.

Hardness—1 to 2.

Fusibility—When heated, swells and fuses, and bursts into a long smoky flame, giving off an aromatic odour, and continues to burn when removed from the external source of heat. In boiling water it becomes slightly flexible.

Solubility—Slightly soluble in chloroform; almost insoluble in benzine, ether, and alcohol.

W. F. Ward, Government Analyst, obtained in an ultimate analysis:—

| | Per Cent. |
|---|---|
| Carbon | 74·0 |
| Hydrogen | 7·8 |
| Nitrogen and oxygen | 12·8 |
| Sulphur | 0·8 |
| Ash | 4·2 |
| Water | 0·4 |

The following proximate analyses have been made:—

| Description of Coal. | Volatile Hydrocarbons. | Fixed Carbons. | Ash. | Water. | Sulphur. |
|---|---|---|---|---|---|
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| Pelionite | 55·00 | 41·90 | 2·80 | 0·30 | Trace |
| Ditto | 51·10 | 44·30 | 4·20 | 0·40 | 0·8 |
| Ditto | 54·20 | 39·75 | 6·05 | Trace | — |
| Ditto | 50·86 | 43·69 | 4·12 | — | 1·33 |
| Ditto | 52·80 | 42·40 | 4·30 | 0·20 | 0·7 |

The analyses show a fairly high content of hydro-carbons, the ratio of volatile constituents to fixed carbon being 1·24 to 1. There is very little ash, the average content amounting to only 4·3 per cent. Like many other coals of this type it contains pyrites in considerable quantity, but in the samples submitted for analysis very little is present.

Coal of this kind is valuable for gas-making purposes, but of little use for oil-making, as it contains more tar than oils. On distillation, pelionite yields hydro-carbons of the aromatic series (benzene, naphthalene, &c.), and not those of the aliphatic series (olefines, paraffines, &c.), such as are contained in the Preolenna kerosene shale. (9) It is not a cannel, from which oils are not made, and not a shale, from which they are. Its colour, both in mass and powder, and its fracture in mass, are different from either

(9) *Vide* W. A. Dixon: Secretary for Mines Report, 1892-3.

and this difference is emphasised by the coke it yields on rapid heating, neither cannel nor shale yielding a true coke.

### (*d*) *Utilisation of Pelionite.*

A number of practical tests have been made to ascertain the value of pelionite for gas-making purposes. The results given here are taken from the report of the Secretary for Mines, 1892-3:—

No. 1 sample produced 11,200 cubic feet per ton of an illuminating power equal to 50·4 candles corrected for barometer and thermometer. This test was made with Sugg's No. 2 cannel burner. The residue was non-coking, and valueless for fuel purposes. There was a distinct odour of sulphur in the hot coke.

No. 2 sample yielded 12,607 cubic feet per ton. The illuminating power of the gas was equal to 47 standard candles.

No. 3 sample (½-ton) yielded 15,486 cubic feet of gas per ton, the quality of which was equal to 29·44 candles.

The results compare very favourably for gas-production with the best "cannel" coals of other countries. They are all the more pronounced when it is considered that the coal used in the experiments consisted of fragments obtained from glacial morainal material, and which had, therefore, been exposed to atmospheric agencies for very long periods.

A distillation test by W. F. Ward, Government Analyst, showed that pelionite contains 92 gallons of crude oil and tar per ton of coal. Investigations have not been made to ascertain its value for the manufacture of oils and tar derivatives.

### (*e*) *Estimate of Quantity of Coal.*

The quantity of pelionite in the Barn Bluff area has been put approximately at 1,700,000 tons; and that of the second-grade "cannel" is estimated at 2,200,000 tons. In the Pelion mountain country there is a very large area extending for many miles in a southerly direction, and 7 to 8 miles from east to west. This central coalfield is one of the most extensive in the State. In the future development of the Pelion district this coal-field has a high potential value.

### (1)—Barn Bluff Coal Field.

(Sections 1298-91M and 1296-91M, each of 320 acres.)

These sections are situate on a spur leading south-eastward from Barn Bluff. The leases of these sections were originally granted as reward claims to the discoverers, F. Holmes and W. Hart, of pelionite in this locality. Loose blocks were found at the foot of the spur scattered through glacial debris made up of fragments of the adjacent rocks. Glaciers have stripped from the basal member the greater part of the upper Permo-Carboniferous strata, leaving the former standing out like great ledges of rock at the base of the mountain range. The seams from which the coal has been derived have not been located. Several holes have been sunk in the morainal material, from some of which large fragments of pelionite were recovered, while in others not any was found. With this coal numerous fragments of black, micaceous shale, containing imprints of glossopteris and other carboniferous flora, are found. Farther north a seam of coal has been found in similar micaceous shale only a few feet above the basal conglomerate, and under marine strata as here. It is evident, therefore, that this shale marks the coal horizon. The northern outcrop, above referred to, is found on the eastern slopes of the spur connecting Barn Bluff and Cradle Mountain, about 2 miles in a north-westerly direction from these sections, and at an elevation of 70 to 80 feet greater. If these seams are identical, the pelionite will be found in the micaceous shale bed. The northern seam is described as being 12 inches thick, of bright, brittle, highly bituminous nature, and free from bands. The seam is well-defined between massive shale bands which form roof and floor.

It is shown by the large blocks of pelionite strewn over the surface that the seam is fully 8 inches thick, and probably it is much greater.

### (2)—Mt. Pelion Coal Field.

In this locality two workable seams have been discovered. The coal is of the cannel and semi-cannel types. The measures are well-defined between two massive sandstone bands which form roof and floor.

#### (a) *Lease* 7355-M, 200 *Acres*.

This section is now included in the holdings of the Mt. Pelion Company. It occupies a considerable portion of

Mt. Thetis and the saddle connecting with Mt. Ossa. The workings consist of a tunnel, 50 feet long, driven on a horizontal seam exposed on the northern slopes of the mountain, over 800 feet above the plateau. At this point it consists of two bands, the upper being 5 inches thick, and the lower 21 inches, separated by 4 inches of carbonaceous shale. The seam is encased in shale, 6 inches on the roof, and nearly 2 feet on the floor, the whole contained in firm sandstone. Above the seam the rock is pebbly sandstone; below it is hard, fine-grained sandstone.

About 20 chains to the eastward another opening, 20 feet in length, has been made into the same seam. Here it is not split, and shows 22 inches of good, firm coal, containing very little pyrites. The floor is composed of shale, and the roof of hard sandstone. This seam has been traced by trenching along the northern slope of the range to the western side of Mt. Pelion East. Here it is 18 inches thick, but of poorer quality than that exposed westwards. This seam is 900 feet above that developed on Mt. Pelion West, and it has not been located yet on the mountain.

A bulk sample was submitted to Mr. W. F. Ward, Government Analyst, for examination. He reported the contents as follows:—

| | Per Cent. |
|---|---|
| Fixed carbon ... ... ... ... ... ... ... | 54·6 |
| Volatile hydrocarbons ... ... ... ... ... | 22·5 |
| Ash ... ... ... ... ... ... ... ... ... ... | 20·2 |
| Sulphur ... ... ... ... ... ... ... ... ... | 0·6 |
| Moisture lost at 212° Fahr. ... ... ... | 2·1 |

(*b*) *Sections* 1853-93M *and* 1854-93M, *each of* 200 *Acres.*

A seam of coal is exposed in several trenches on the east slope of Mt. Pelion West, and in one place a tunnel 20 feet in length has been put in. It is a horizontal seam, 17 inches thick, composed of bright, firm, black coal. The sulphur content is abnormally high, and renders the coal almost useless for economic purposes.

A sample of this coal showed the following:—

| | Per Cent. |
|---|---|
| Fixed carbon ... ... ... ... ... ... ... | 52·0 |
| Volatile hydrocarbons ... ... ... ... ... | 19·6 |
| Ash ... ... ... ... ... ... ... ... ... ... | 17·1 |
| Sulphur... ... ... ... ... ... ... ... ... | 10·5 |
| Moisture lost at 212° Fahr. ... ... ... | 0·8 |

## X.—CONCLUSION.

From the foregoing account it will be perceived that this recently discovered wolfram field is only in the earliest stage of development. The work accomplished has produced results greater than were at first anticipated, and providing the market price of tungsten remains at the present figure, the outlook for the future progress of the district is bright indeed. Exploration has been confined to a small area on the eastern side of the valley; on the western side equally encouraging conditions prevail, and northward a large mineral area remains unexplored.

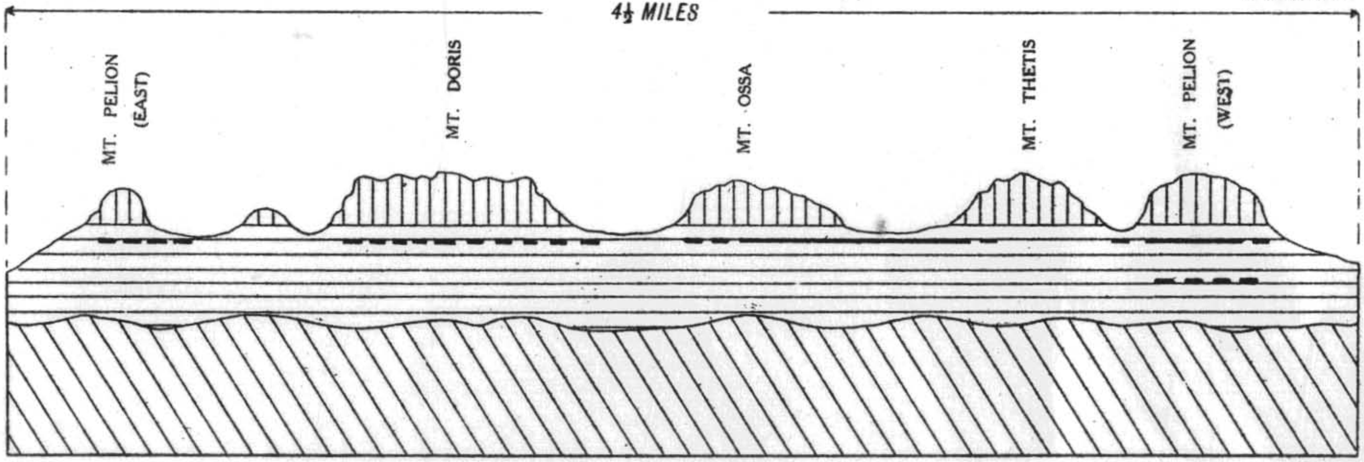
The discovery and development of the wolfram mines are events which led to the extension of the Lorinna road to the edge of the plateau. Ultimately the construction of this road will be carried up to the elevated grass lands, the full value of which have not yet been realised.

Apart altogether from its undoubted mineral and pastoral wealth this region possesses scenery of surpassing beauty. When this magnificent mountain and lake country is connected by road with the main centres of population, it will become one of the most popular tourist resorts in the State.

A. McINTOSH REID,
Assistant Government Geologist.

Geological Survey Office,
Launceston, 20th June, 1919.

Plate II.




UPPER MESOZOIC - *Columnar Diabase* PERMO-CARBONIFEROUS - *Conglomerates, Shales and Sandstones.* *Coal Seams* -

UPPER ALGONKIAN - *Quartz & Micaceous Schists*

**Ideal Section through Pelion Range**

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

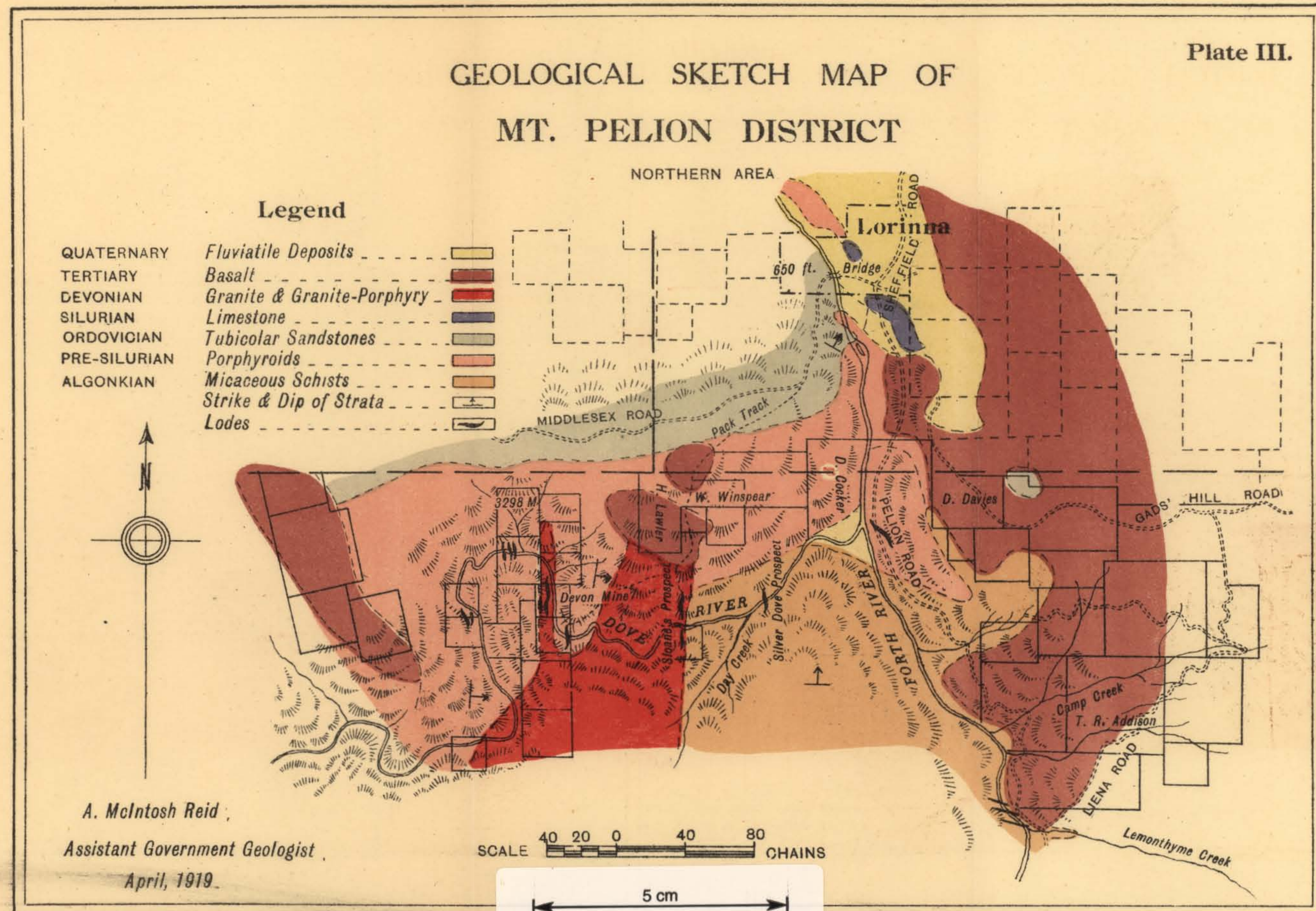



Photo Algraphed by John Vail Government Printer Hobart Tasmania.

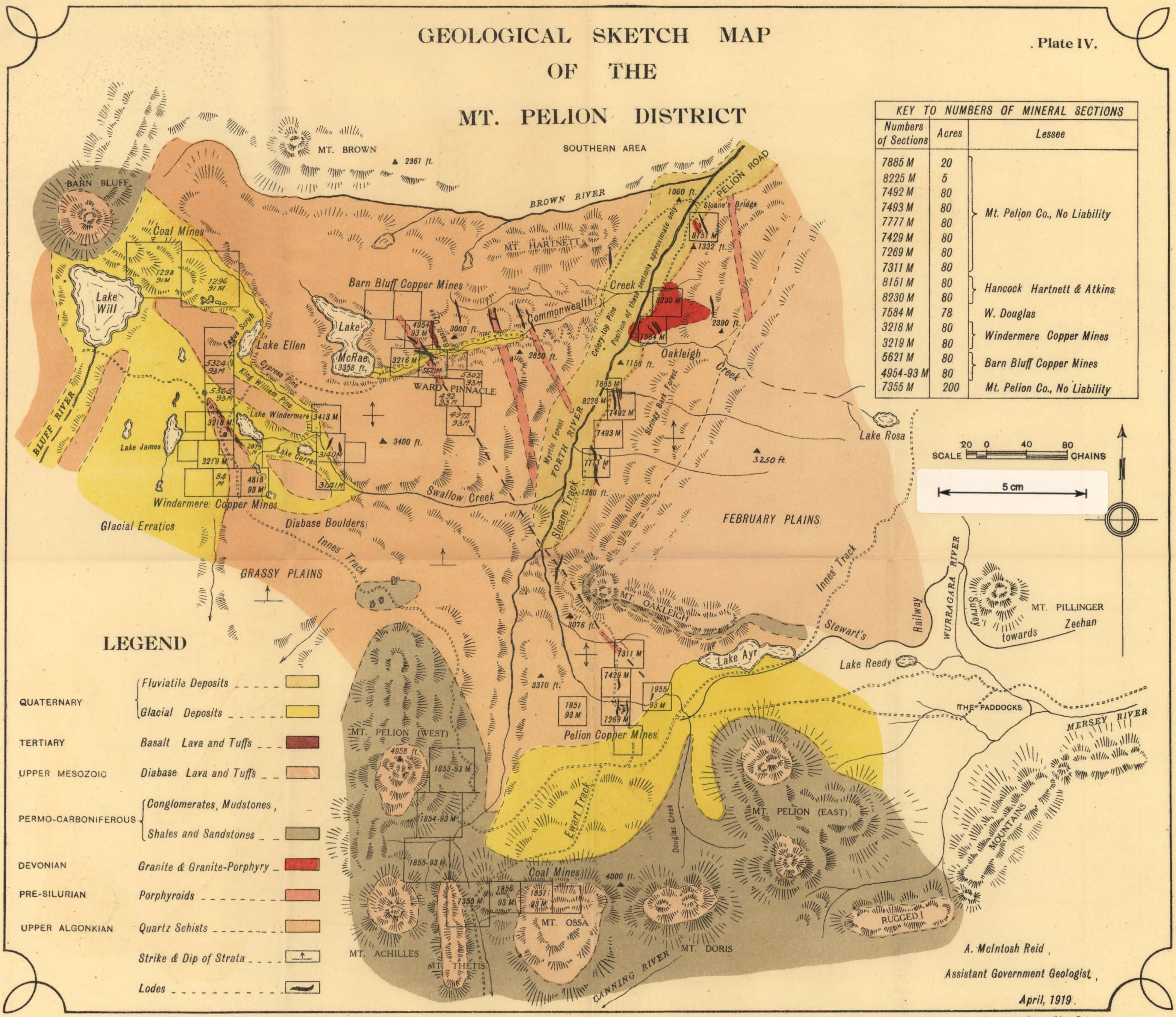


Photo Algraphed by John Vail, Government Printer Hobart Tasmania.