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The Mount Balfour Mining Field

BY

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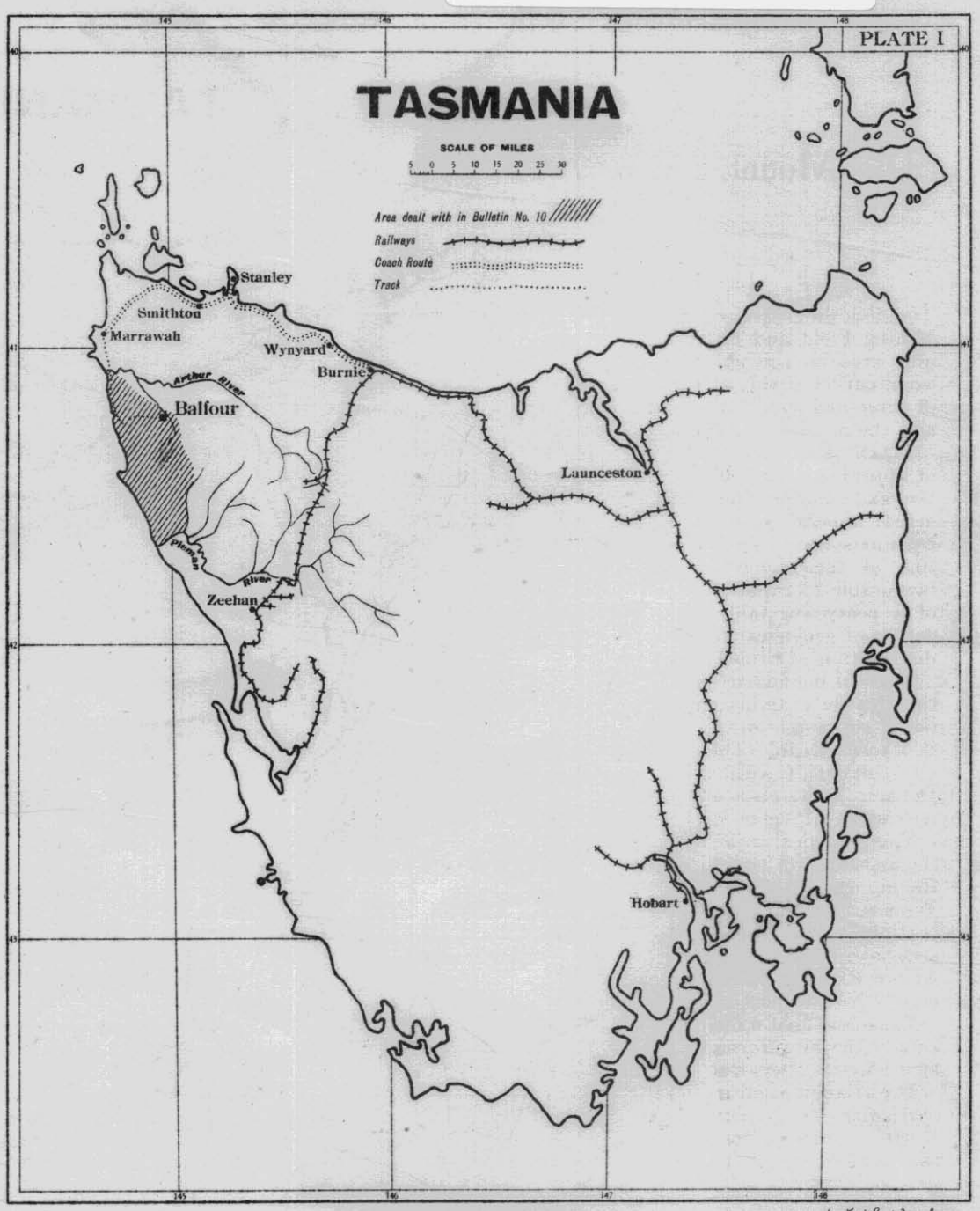

LOCALITY PLAN

L. Keith Ward
Assistant Government Geologist
27th June 1911.

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The Mount Balfour Mining Field.

I.—INTRODUCTION.

The following account of the geology of the Mt. Balfour Mining Field and its surroundings deals with a considerable area on the north-western coast of Tasmania. The examination of this area occupied the writer for the period of three and a half months between the beginning of May and the middle of August, 1910.

When it is seen that this bulletin deals with an area of approximately 400 square miles, it will be evident that the examination was, as regards the areas beyond the actual mineral leases, of the nature of a rapid geological reconnaissance. The absence of timber from a large portion of the region covered during this examination is favourable to rapid movement, but the universal presence of a peaty vegetable cover obscures most effectively the details of geological structure, and to some extent also the distribution of lithological types.

Natural boundaries were observed in the delimitation of the area for examination. The Arthur and Pieman Rivers lie on the north and south respectively. On the west is the Southern Ocean. The selected eastern limits are practically coincident with the channels of the Frankland and Donaldson Rivers, which are main tributaries of the Arthur and Pieman Rivers.

The geological survey of this region was carried out with the assistance of the charts of the various areas comprising the mineral leases. Thus the districts which surround Temma, Balfour, and the northern and north-eastern portions of the Norfolk Range are delineated with some accuracy. The remaining groups of mineral leases on the Nelson River and the Interview River are located approximately with respect to these others.

The areas held under grazing leases are shown in accordance with the information obtained from the charts published by the Department of Lands.

The triangulation survey of 1856 was appealed to in one particular—the location of Sandy Cape with regard to Mt. Norfolk—since on this matter only did it provide information with regard to the large area examined. And here

confusion has arisen. The mountain peak hitherto known on the mineral chart and northern sketch-map of Tasmania as Mt. Norfolk is situated at the head of the Toner River, and on the southern side of that river. Between it and Sandy Cape lies a lofty peak of the western part of the Norfolk Range, which has been named Mt. Edith. On ascending the so-called Mt. Norfolk the writer was surprised to find that the view of Sandy Cape was obscured by the summit of this Mt. Edith. Upon the completion of the plotting of the prismatic compass bearings recorded during the recent geological examination, the writer found that the peak called Mt. Edith occupies precisely the position with regard to Sandy Cape that the peak called Mt. Norfolk does on the old triangulation survey; while the peak called Mt. Norfolk on more recent maps lies to the eastward at a distance of 2·35 miles. The writer has therefore assumed the responsibility of restoring the name of Mt. Norfolk to that peak to which he is confident it belongs (*i.e.*, that lately known as Mt. Edith); and has given the name of Mt. Rosslyn to the peak from which the name of Mt. Norfolk has been taken.

The maps accompanying this bulletin have been prepared with all the care which was possible, but are not of equal accuracy in all portions for the reasons indicated.

Only a small portion of the region examined—the area comprising the mineral leases near the coast line immediately to the northward of the Interview River—has previously been visited by an officer of the Geological Survey of Tasmania. In September, 1901, Mr. G. A. Waller paid a brief visit to this district, and recorded the results of his observations in a publication entitled "Report on some Wolfram Sections near Pieman Heads."

This latter report therefore represents the sum total of the official literature on the field which was in existence before the writer entered upon his investigation. A brief "Preliminary Geological Report upon the Mt. Balfour Mining Field" was prepared by the writer immediately upon his return from the field, and has been issued as Geological Survey Report No. 1—the first of a new series of such publications.

The writer desires to express his sincere appreciation of the hospitality and assistance which he received from numerous mine managers and others in all parts of the field, and to return thanks therefor. He desires also to acknowledge the invaluable field assistance rendered by Mr. M. Donoghue, through whose energy and resource it was possible to cover so large an area in the time available.

II.—THE HISTORY OF THE MT. BALFOUR FIELD.

The history of the region round Mt. Balfour—or Mt. Lyons, as it was first called—runs back to the beginning of the period of systematic prospecting and exploration on the western coast. The first discovery made on the field was that of alluvial tin ore. The exact date of this discovery is unknown, but alluvial workings are known to have been in existence in 1884, and from that time onwards there have been a few men at work on the alluvial deposits.

In March, 1889, a tin reward claim was granted to John Dally for a term of 21 years. This reward lease (No. 694-87M), the term of which has but just expired, was granted for an area of 22 acres on Specimen Hill, near the township of Balfour, which John Dally had held as a prospector's lease since September, 1886.

Prospectors made their way southwards, and the southern part of the area with which this bulletin is concerned received some attention during this earliest period of activity. The alluvial workings on the granite country which lies along the coast to the south of Sandy Cape ultimately led to the discovery of wolframite lodes in the granite. A reward claim for wolfram, now Section 5119-M, was applied for by Alfred Foster, and granted to him in the year 1891. Little work, however, was carried out at this time.

The western part of the district, near Temma—or Whale's Head, as it is usually called—was first prospected at the end of 1898. Shortly afterwards there was a revival of interest in the wolframite-bearing area near the Interview River, which is commonly referred to by prospectors as the "North Pieman district." In 1900 ten mineral sections were taken up in this locality, and a little work was done upon the lodes located in some of them. The scene of operations was visited by Mr. G. A. Waller in September, 1901, and from this visit up to the time of the examination of the field by the writer practically nothing had been done.

During the period at which attention was attracted towards this southern portion of the region there was little activity near the present site of Balfour. Only three men were on the field, and the tin workings were temporarily abandoned. While prospecting in the district, these three men, Messrs. W. W. F. and T. C. Murray and F. H. Smith,

made the first discovery of copper ore in Tin Creek, near the southern boundary of the reward section (123-M). This reward was applied for in December, 1901.

No material progress was made for some years, but the discovery of copper ore on this reward lease led to the prospecting of the country to the northward and southward. The progress of the work of prospecting may to some extent be traced by means of the several reward claims which have been successively granted to prospectors. A. V. Chester's reward section, 2699-M, dates from November, 1906; T. B. Moore's reward on the Toner River, 3484-M, from December, 1907; M. M. McArthur and J. E. Elliott's reward on the Interview River, 3921-M, from January, 1908; and R. J. Henry's silver-lead reward, 4930-M, near the last-mentioned, from July, 1910.

From the year 1908 large areas have been taken up as mineral leases by various owners, and all those that have been held at various times are shown upon the district maps which accompany this report.

Interest in the field attained its maximum intensity during the latter half of 1909; but unfortunately the majority of the mines have not been endowed with the capital necessary for development, and actual mining work has been at no time commensurate with the prominent position which the field has occupied on the share market. It is therefore not a matter for surprise that the whole district has suffered a set-back. Other interests having arisen, the attention of the mining public has been diverted elsewhere; and, for want of adequate capital, the various properties have been unable to command the sustained interest which is felt in mines which are being vigorously prospected. During the writer's examination of the field there was very little actual work being done upon the great majority of the leases.

Those companies which have endeavoured to prove their mines have in the past been hampered to no small degree by want of efficient means of communication with the port at Temma. With the completion of the tramway between Temma and Balfour a new era in the history of mining on the field should begin.

The selection of the agricultural land in the vicinity of Temma first took place in January, 1903.

For very many years the coastal stock route to the southern mining fields of Heemskirk and Zeehan was used. But at the present time there are very few head of cattle taken southwards across the Pieman River.

In past years the belt of timber following the coast between the Pieman and Arthur Rivers has been worked over by hunters for skins. Black opossum, wallaby, and kangaroo were at one time abundant throughout the district, but are now rarely seen, save in the most unfrequented parts.

The sawmills on the field have but just been erected, and no attempt has yet been made to fill any more than local requirements.

III.—PHYSIOGRAPHY.

(1)—Topography.

(*a*) *General Description.*

The broader topographical features of the coastal region which lies between the Arthur and the Pieman Rivers are on the whole well defined and at once perceptible without appeal to detailed measurement. The more minute details await treatment, and cannot be satisfactorily interpreted until an accurate survey of the region has been achieved.

Such hypsometric observations as have been made are only approximate in the great majority of cases. Two trial survey lines for tramways have been run between Temma and Messrs. Murray's Reward Mine. Certain of the altitudes here recorded for various points and surfaces have been ascertained by referring aneroid measurements to points in these lines. Since so few levels have been accurately ascertained, it is apparent that the different measurements here recorded are of unequal value; those to which greatest weight should be attached being situated on the actual survey lines or in their immediate vicinity.

The estimates which are here given of the areas occupied by the several physiographical units are, for the same reasons, only approximate, but every endeavour has been made to make them as accurate as is possible under existing circumstances.

The prominent topographical features of the region under consideration are due to the large extent of country occupied by two physiographical units—on the one hand the Norfolk Range, and on the other hand the broad coastal peneplain.(1) The range rises abruptly to a considerable height above the level of the peneplained surface, a fact which may best be seen from the coast line. In the vicinity of the township of Balfour, and in other parts of the region, there are many smaller hills which are only isolated portions of the peneplain itself, and noticeable only because of the deep dissection of the latter.

The drainage of the region is not very complex in character. The Rivers Arthur and Pieman, which form the northern and southern boundaries of the area under discussion, take their rise in the country lying to the east-

(1) A "peneplain" is a region in which the features of relief are well-nigh obliterated, having been worn down by surface agencies during a long cycle of erosion.

ward, and are already streams of some magnitude when they receive the contributions of this region. The Frankland River plays a similar part to that played by the Donaldson River; each conveying to its main trunk stream the drainage of the eastern front of the Norfolk Range. Another portion of the drainage of the eastern and southern parts of the mountain region finds its way direct to the Southern Ocean along the valleys of the Lagoon and Interview Rivers. The western front of the range is drained by the nearly straight streams which run with the slope of the coastal peneplain direct to the sea. Similar streams drain those portions of the peneplain which extend northwards and southwards beyond the limits of the Norfolk Range. The coast-line between the Arthur and Pieman Rivers is on the whole fairly regular. The rocky reefs which are prominent features at some points are at other places masked by a cover of sand.

The only promontory of noticeable size is that of Sandy Cape. The minor indentations are at no place large, and only one—Whale's Head Boat Harbour—has proved adaptable to commercial requirements.

Some further comments on the several topographical features are necessary, and will be grouped under the headings of the several physiographical forms.

(*b*) *The Norfolk Range.*

The mountains which constitute the Norfolk Range may at first sight appear to belong to different groups, or even in some cases to be independent of each other. The writer would, however, claim that all the high country should be embraced under the name of the Norfolk Range.

Thus constituted the range may be said to be made up of these portions:—

(1) The main portion of the range presenting an almost continuous front to the west, and extending in a direction N. 25° W. (magnetic bearings are given here) from the great bend of the Lagoon River to Mt. Hazelton.

(2) A south-eastern limb comprising Mts. Rosslyn, Hadmar, and Vero, presenting a broken front to the north-east, and extending in a direction E. 15° S.

(3) Meridional ridges stretching southwards from these latter mountains, and terminating abruptly with Mt. Sunday and the Pinnacle.

(4) The isolated residual fragments of the northern end of the range—Mt. Balfour and Mt. Frankland. (In the case of Mt. Balfour a low ridge of hills still remains to mark the connection with the larger portions of the range. The ridge is cut through by Daisy Creek.)

The distribution of these portions of the range has been effected by the operation of the forces which have moulded the general outlines. The range as a whole owes its origin in the main to erosion, and the separation of the range into different ridges or peaks is due to the continued operation of the agents of erosion.

It is a noticeable fact that the highest peaks of all portions of the range rise to altitudes which lie between 2000 and 2600 feet above sea-level. Mt. Rosslyn is apparently the highest, but Mts. Hadmar, Vero, Norfolk, Sunday, and Hazelton are nearly as high.

This uniformity in the height to which so many peaks rise suggests that the present mountain range results from the unequal erosion of a former plateau region. The suggestion obtains a certain amount of support from the facts ascertained with regard to the geological structure of the range. Folding has, in the opinion of the writer, not contributed to the moulding of the range. Neither has faulting been a controlling influence in the framing of the topographical features, as far as can be seen from the structural data recently acquired. The dislocations observable in the mountainous area appear to be quite independent of present topographical features, being, in the opinion of the writer, of much greater geological age than the land forms. This question is referred to below.

The area which is now occupied by the several component portions of the Norfolk Range is approximately 80 square miles.

On the topographical sketch-map printed with this bulletin the only prominences depicted are those which are to be grouped within this physiographical unit.

(c) *The Coastal Peneplain.*

Almost the whole of the region mapped, with the exception of the highland already referred to, has clearly been at one time a region of very low relief. The remarkable regularity of the surface of very large areas at the present day is clear proof of the former approximation of these

surfaces to the base-level of erosion. The surface of the peneplain may be seen from the tops of the ridges near the Balfour township, whence the even sky-line stretching northwards from the base of Mt. Balfour can at once be appreciated. A still better view of this essential feature of the peneplain, and one which extends over a much greater area, is that to be obtained from the tops of Mt. Balfour and Mt. Hazelton. From these points of vantage the eye is at once impressed with the extraordinary uniformity of the slope of the coastal plain towards the sea, and the clear-cut gorges of the few consequent streams which convey the drainage of the plain and mountains to the sea.

North of Possum Creek the slope is almost continuous right down to sea-level at the coast-line, but a few low ridges and residual hills still remain to indicate that the foot of the old gradually-sloping surface was well above sea-level. South of Possum Creek, as far as the Pieman, the surface of the peneplain is bounded on the seaward side by an abrupt and almost continuous scarp, the top of which is usually 200 feet, or nearly so, above sea-level. This scarp is separated from the actual beach by a narrow strip of lower country, over which the coastal dunes have spread.

The peneplaned surface does not slope in one direction only, for the writer's observations indicate a well-marked fall northwards and southwards from the Norfolk Range towards the Arthur and Pieman Rivers in addition to the westward slope towards the Southern Ocean. The westward slope is most pronounced, and is not constant. Between the foot of Mt. Balfour and the sea the grade is approximately 66 feet to the mile, while between the foot of Mt. Hazelton and the mouth of the Thornton River the fall is about 100 feet to the mile. The northward slope of the peneplain from the base of Mt. Balfour towards the Mt. Balfour Copper Mine is approximately at the rate of 25 feet to the mile.

The peneplain attains a height of 800 feet above sea-level near the base of Mt. Balfour, while farther south along the base of the western front of the Norfolk Range it rises to the 900-feet level. From the fact that a well-marked fall in level was observed in both northerly and southerly directions, it would appear that at the time of the formation of the peneplain the drainage of the region was effected by rivers coinciding approximately in position with the present Arthur and Pieman Rivers.

The original peneplain therefore possessed a surface somewhat resembling a very flat cone, above which no important prominences other than those belonging to the Norfolk Range stood out in relief. The only really noticeable projection above the surface of this old piedmont plain is the small flat-topped hillock with gently sloping sides known as the "Little Frenchman." Now, however, the peneplaned surface is broken in all directions, consequent upon the displacement of the strand-line and the resultant initiation of a new cycle of erosion. The rivers and streams of the region have cut up the former even surface so that in places there are only narrow ridges or spurs remaining to mark the existence of the old peneplain.

(*d*) *The River Systems.*

The rivers and their tributaries throughout the whole region exhibit the features of youth and immaturity—being characterised by falls and rapids, and in most cases by well-marked divides and traversing narrow valleys, of which the walls are usually steep. These features in a region for which extensive peneplanation has been claimed are due to the arrest of the cycle of erosion in which the peneplain was developed by some crustal disturbance which displaced the strand-line.

As the result of this displacement the rivers formerly existing have become entrenched, and a number of new streams have been born. The history of the Frankland River is well shown by the meanders in its course, which are developed where the banks are steep and where all traces of a modern flood-plain are absent, as well as by high-level remnants of an ancient flood-plain near the Balfour township and the Mt. Balfour Copper Mine. The present river is evidently entrenched within its former channel, of which almost all traces have been destroyed by erosion.

The Nelson River shows similar features to the Frankland in the lower portions of its channel, and the general direction of the course of each has been determined by the extent of the country rising above the old peneplain.

The Interview River shows somewhat similar features at Elliott's Reward Mine, but at this place there are signs of the development of a small flood-plain of recent date.

The small streams which take their rise on the western front of the Norfolk Range are regular, consequent streams, which convey the drainage to the coast by paths

which are markedly direct as far as the scarp of the old peneplain. There they are in several instances deflected to the northward by the coastal sand dunes. The Thornton and Pedder Rivers show this deflection to a marked degree.

Both the Arthur and the Pieman Rivers, which bound the area under discussion, are confined in narrow gorges with steeply inclined walls. And these features are shown also by the smaller rivers which find their outlet on the coast-line.

From the distribution of the alluvial deposits of tin ore in the valley of Emmett's Creek, the basin of which now carries no stanniferous lodes, it is clear that the head waters of this creek have been captured by Tin Creek. Between these creeks, and also between the head tributaries of the Lindsay and Lagoon Rivers, the divides are ill-defined.

(*e*) *The Coast-line.*

The coast between the Pieman and Arthur Rivers is inhospitable. Numerous shallow reefs jut out into the sea, and isolated rocks occur at a little distance from the land. Islands are few in number, those of notable size occurring only at Sandy Cape and a little to the north of Rebecca Creek. All are close to the land. The jutting reefs seldom acquire the size of promontories. Sandy Cape is much the largest. Ordnance Point is a narrow spit surmounted by a high dune of wind-driven sand.

The coast-line is at no point marked by cliffs of appreciable altitude, though the sand dunes rise very abruptly at different points along the beaches.

The indentations in the coast-line are small, in accordance with the physiographical development of the region. For the region was base-levelled before the occurrence of the disturbances which determined the present position of the strand-line.

Whale's Head Boat Harbour is not large, but appears to be the most suitable port for the district. It possesses the serious disadvantage of facing the west, whence the prevailing winds blow. Somewhat similarly situated are Gannet Harbour at Ordnance Point, and a narrow gulch in the granite at Sandy Cape.

The Pieman River will admit small vessels, but although navigable for some miles, the entrance is rather dangerous from the existence of a bar and a projecting rock.

(2)—The Relation of Topography to Geology.

While the broader physiographical features of the region owe their development to the operation of geological processes, it is necessary to distinguish between the processes which have left their impress upon the topography of to-day and those which either have had no influence in topographical development or of which the effect has been completely obliterated. The earliest traces of structure preserved are those connected with the development of an extremely old peneplain, of which the summits of the Norfolk Range mark the level. Prior to the establishment of this ancient base-level a considerable amount of dislocation of the crust had occurred, the planes of fracture being filled with siliceous lode-matter in a great number of cases. At a slightly earlier period the region was invaded by acidic igneous material, and at a more remote date still by basic dykes, which cut through the great beds of sediment deposited in the earliest epoch of which the field carries evidence.

While the structural features of these earlier dislocations and invasions have disappeared, the products of the invasion of molten materials and solutions remain. But these materials have not influenced the moulding of any of the larger physiographical units.

Coming to the investigation of details, it is noticeable that the dykes exert no control over the physical features. The rate at which they are eroded is not different from that of the sediments invaded by them. The superior structural compactness of the igneous rock is in this case exactly counterbalanced by its tendency to be softened by chemical decay.

On the other hand, the siliceous lodes have in many cases been the controlling cause of the smaller ridges, peaks, and scarps of recent date within the limits of the dissected portions of the great peneplain. Thus there are a number of hog-backed ridges in various parts of the field which have a siliceous lode for a backbone. As examples, may be cited the ridges on the Mt. Balfour Copper Mines lease at the northern end of the field; on the Messrs. Murray's reward section, 123-M; on the Pierpont Morgan section, 3639-M; and on the Mt. Lyell Mining and Railway Company's section, 3686-M, near Mt. Frankland. Yet these cases are far from being of universal occurrence, and many instances may be given where well-defined ridges exist and the siliceous lodes cross them at different angles. As an instance of a small peak accentuated by the occur-

rence of a mass of silica which has resisted erosion with greater success than the surrounding rocks, mention may be made of the Messrs. Murray Bros.' section, 4222-M, to the north-east of Mt. Hazelton. The scarp on the western side of the upper part of the Nelson River Valley, 3 miles to the W.N.W. of Balfour and 1 mile east of the Little Frenchman, coincides with the line of siliceous lodes of that locality.

Yet the general drainage of the region is only controlled to a minor degree by these harder portions of the rock masses. The short valleys which are longitudinal with regard to these hard bars in the country are connected by narrow transverse gorges; but these features, which are characteristic of the tributaries, are not shown by the main streams.

The promontory of Sandy Cape is undoubtedly due in some measure to the superior power of resistance of the granite to the westerly seas, but this granite does not stand in relief above the neighbouring rocks.

The recent dunes on the actual coast-line have in several cases caused the deflection of the rivers at the mouths. Since these dunes are in constant movement, the actual position of the debouchures of the rivers so affected cannot remain constant. It is noticeable that the deflection of the rivers is to the northward.

In the investigation of the relationship of geology to topography one feature is most marked—the lack of coincidence of any physiographical unit (save the sand dunes) with geological boundaries. The three cycles of erosion of which evidence exists, viz., (1) that of which the summits of the Norfolk Range mark the level, (2) that of which the coastal peneplain is witness, and (3) the cycle now in operation, have operated upon the same rocks. There has been practically no protection for the older slates and sandstones by the deposition of any sedimentary material of notable extent. At some few places basalt has afforded temporary protection from erosion to small areas, but even this has been dissected by the erosion of to-day. The coastal peneplain from the border of which the sea has withdrawn has therefore apparently been formed by long-continued erosion which had, before the arrest of the cycle by a negative movement of the strand-line, achieved the base-levelling of the coastal belt, but had not yet reached that stage of maturity in which the bed-rock would have been covered and protected by the deposition of waste from the upland. It is, in short, a "destructional plain."

(3)—Relation of the Topography to that of Adjacent Regions.

The present state of knowledge with respect to the topography of the western coast of Tasmania as a whole is unfortunately not yet far advanced. The lack of any detailed topographical map of the region and the absence of accurate representation of the hypsography both render it unwise to correlate the physiographical units recognisable in the area here mapped with physiographical features beyond this area in any but a general way. However, as the geological examination of Tasmania proceeds, certain general facts with regard to the evolution of the forms of the present day begin to arrange themselves.

In the country lying to the south of the Balfour field it has been found that the present position of the strand-line with regard to certain base-levelled surfaces and the details of the present drainage systems afford clear evidence of the interruption of the conditions of stability during the existence of which extensive peneplanation was achieved.

It is difficult to conceive that the remnants of this old peneplain (correlated by the writer for the North Dundas and Zeehan fields ([1])) could be independent of physiographical relationship with the coastal piedmont peneplain of the Balfour field. It has been indicated above that the Pieman is an old river which has been revived. The old flood-plain now dissected by the Huskisson and Pieman Rivers between Mt. Black and the Parson's Hood, ([2]) and Brown's Plains on the Corinna-Waratah road, belong, in the writer's opinion, to the same physiographical unit, developed at the period of maturity of the old Pieman River, and perhaps in Pleistocene time. ([3]) The piedmont plain surrounding the Heemskirk Range is to be regarded as belonging also to this old base-levelled surface, and occupies a physiographical position precisely similar to that of the coastal piedmont plain lying to the north of the Pieman River.

The close parallelism between these plains suggests a marked regularity in the displacement of the strand-line over a considerable length of coast-line, such as may result from the withdrawal of the sea rather than from a warping of the crust. The same features on the whole are exhibited by the country lying to the north of the Arthur River. The small Marrawah plateau only differs from its sur-

([1]) *Vide* Geol. Surv. Tas. Bulletin No. 8, pp. 11-12. ([2]) *Vide* Geol. Surv. Tas. Bulletin No 6, pp. 6-9. ([3]) *Ibidem*. p. 36.

roundings on account of the considerable local development of basalt.

These areas lying to the north and south of the Balfour field are quite clearly physiographically cognate. But when we turn to the country lying to the eastward difficulty arises for want of hypsometric details. Questions that suggest themselves are these: —

> Does the coastal piedmont plain slope gradually upwards until it attains an altitude of 2000 feet at Waratah, so that the deeply dissected peneplain of that region is really one with that of the coastal belt which has here been described?
>
> Are the Long Plains part of this problematical unit?

A positive answer to both questions, however strong may be the probability of its correctness, is hardly justifiable at the present time.

The other point of physiographical interest to which attention should be drawn is this, that the ridges and peaks of the surrounding country all rise to about the same altitude as the peaks of the Norfolk Range. Mt. Livingstone and the Parson's Hood of the Meredith Range, Mts. Heemskirk and Agnew of the Heemskirk Range, Mt. Bischoff and Mt. Zeehan, all rise to approximately the same altitude, as if they constituted residual fragments of a former base-levelled surface. (1) These mountains mentioned now constitute "monadnocks" or residual prominences standing in relief above the piedmont peneplain.

While the limits of the different physiographical units here mentioned have not yet been clearly defined, it is believed by the writer that they extend more widely than has been indicated by the localities cited. The matter of importance for discussion here is that concerned with the recognition of the different geographical cycles rather than the extent of country affected by each beyond the limits of the Balfour field.

To these matters some reference will be made when the relationship of the oxidised zone of the ore-bodies to the present and past surfaces of the land are being treated of.

(1) The period during which this base-levelled surface was developed would apparently have been that between the Devonian irruption of the granite, and the beginning of Permo-Carboniferous time. For it is known that at the time of the deposition of the basal beds of the Permo-Carboniferous system the region was already deeply dissected below the level of these mountain tops. *Vide* Geol. Surv. Tas. Bulletin No. 8, "The Ore-Bodies of the Zeehan Field," 1910, p. 9. Whether faulting of later date has lowered these Permo-Carboniferous beds to their present position has not been definitely proved.

(4)—The Relation of Topography to Mining.

(*a*) *Prospecting and Exploitation.*

Mention has been made of the existence of narrow ridges in which the mineral lodes often form a core. To such lodes the topographical features have of course drawn attention, and actual discoveries of ore have resulted. However, a number of these ridges between the valleys of tributary streams have hitherto proved barren of ore. Silicification of the country unattended by impregnation with copper-bearing minerals has caused the differences in relief. The relation of the copper-bearing shoots to these ridges is mentioned below.

The transverse creeks which cross these lode ridges have in a few cases afforded exposures of ore near the surface, and thus have aided in the discovery of the ore-shoots.

Adit-mining has been possible on account of the presence of these ridges and valleys at a number of points throughout the Balfour field. But in very few places can it be expected that adit-mining will reach unoxidised ore, on account of the distribution of lode-matter with regard to the higher country. Unfortunately most of those lodes which traverse the highest portions of the field, in the Norfolk Range, have hitherto failed to offer material promise. In the lower ground the adits have not given any appreciable backs. From the principal mines of the field the output must in the future depend wholly upon shaft workings. In making this statement the writer does not refer to the Mt. Balfour Copper Mines nor to the properties almost wholly undeveloped, since insufficient work has been yet done to prove the effect of topographical features upon the lode contents in these cases.

It appears plain, however, that the only points from which any considerable mining by means of tunnelling will be possible in the future are situated on the Frankland River. The gorge of this river at the northern end of the Balfour field approaches very closely to the principal fracture-line of the district, while its depth and the steepness of its walls offer opportunities for cheap mining to the properties advantageously situated.

Preliminary exploratory work can of course be carried on at a number of places still untouched by means of shallow adits. But no conclusive evidence can be afforded by these shallow tunnels, which have little more importance than surface trenches.

(b) Transportation Facilities.

The different features of the topography have on the one hand favoured communication, and on the other hand retarded it. The gradual slope of the piedmont peneplain has given a well-graded road between Balfour and the coast. But the valleys of the streams which dissect the peneplain have proved serious obstacles to transport.

The main road from Balfour to Temma follows the slope of the plain to a point where a gap in the coastal belt of timber occurs, and then crosses the small streams south of Temma in rapid succession. From Temma to the Arthur ferry the grade throughout is good, but the almost universal distribution of peat renders unmade roads rapidly unfit for even the lightest vehicular traffic. The long stretch of beach north of Sundown Point is used whenever the weather permits.

Apart from this main road, no roads over which vehicles of even the strongest description can travel are in existence. A few dray-tracks are used in the most favourable weather, but these are quite impracticable after rain on account of the peat.

The pack-tracks follow as a rule the combs of the available ridges in order to obtain secure footing for the horses.

The main track from Balfour to the Pieman River is of splendid grade as far as the Interview River, since it follows throughout the level of the peneplain, only noticeably descending from that level to cross the head of the Thornton River and the Lagoon River. But that portion of it which lies to the south of the Interview River is very uneven on account of the numerous coastal streams. A deviation might well be effected by turning aside and crossing the Interview River at Elliott's Reward Mine and following the unstaked foot-track to the Pieman River. This route might be converted into a pack-track without great difficulty or expense.

There has been some duplication of tracks between the Pieman River and Balfour, as may be seen from the topographical map. The object of this duplication is not apparent, since it is doubtful if any material advantage has been given by the later track. The expenditure of the money in the improvement of the existing tracks would seem to have been a wiser policy.

On the topographical map a track is marked which affords a short route between the Toner River and the Pieman River, but the ascent over the Vero-Hadmar

saddle from the Toner River valley is precipitous, and the route is not well defined.

At the time of the visit of the writer to the field there was no certain means of taking a pack-horse from Balfour to the Pieman River with a load of stores. The track, where it crosses the Thornton and Lagoon Rivers, requires improving and widening. The ford over the latter river may be impassable if the river is not low.

Such disabilities as these make the prospecting of the outlying portions of the field slow and expensive; while even in the immediate vicinity of Balfour the development of many of the mines has been retarded by the absence of any means of transport for the necessary machinery. The construction of the Government tramway from Temma to Balfour will afford substantial relief from these restrictions to certain of the mines. The outlying properties will still suffer considerably, unless roads are constructed to the tramway.

(5)—Rainfall and Water-supply.

Balfour has only recently become a station for the recording of meteorological observations, and hence there is little available information with regard to the amount and distribution of the rainfall. The tables here given embody all the known data with respect to rainfall for the stations Balfour, Marrawah, and Whale's Head (Temma). These tables have been supplied by the Divisional Officer for Tasmania of the Weather Bureau of the Commonwealth of Australia, for inclusion in this bulletin:—

Distribution of Annual Rainfall (in Inches).

Station.	Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Murrawah	1906...	1·32	1·10	·71	4·57	4·48	12·05	14·47	4·78	5·32	4·24	2·56	·83	56·43
	1907...	1·42	1·79	1·25	6·18	4·71	3·61	8·15	6·64	6·11	5·90	·55	6·23	52·52
	1908...	·76	1·25	4·19	1·83	5·37	5·74	3·73	3·09	5·43	3·10	2·46	1·70	38·65
	1909...	1·23	1·62	3·65	5·14	5·24	6·17	5·8,	6·61	2·78	4·77	3·35	2·49	48 85
	1910...	1·38	1·26	1·62	3·26	9·19	7·45	8·57	6·08	6·81	4·45	2·84	3·98	56·89
	1911...	·79	2·92	2·72	3·87	5·58	...	...	...	...	...	...	...	...
Whale's Head ...	1910...	1·15	·63	1·56	2·07	7·87	4·50	5·37	5·57	5·36	4·56	1.66	4·07	44·37
Mount Balfour.	1910...	1·60	2·38	2.75	5·87	15·97	9·03	7·85	12·10	9·85	8·28	4·44	7·27	87·39
	1911...	1·56	6·00	4·91	...	6·89	...	...	...	...	...	...	...	...

The water-supply for the mines is not likely to be difficult to maintain. The creeks taking their rise on the slopes of Mt. Balfour are utilised at the present, and are capable of supplying the requirements.

The water necessary for the sluicing of the detrital tin deposits is said to fail in the dry season, but was plentiful during the whole of the period occupied by this geological examination. The topography of the stanniferous area is favourable to the introduction of water by means of races cut on the sides of the spurs of Mt. Balfour, with the exception of that of one place—the upper portion of Specimen Hill.

No advantage has yet been taken of the steep grade of the rivers and their tributaries with a view to the development of power.

IV.—GENERAL GEOLOGY.

The Rock Types Represented in the Mt. Balfour Mining Field and Their Mode of Occurrence.

A.—THE IGNEOUS ROCKS.

(1) *The Amphibolite Dykes.*

Included together under this head are a large number of separate occurrences, which are undoubtedly to be regarded as different parts of one complex intrusion. There are some differences in appearance between the various members of the group, but all varieties are readily distinguishable from all the other rocks of the district.

The colour is not quite constant on account of the varying proportions of light and dark constituents. In some varieties a distinct greenish colour is possessed by all parts of the rock, in other varieties a greenish-grey colour obtains. The mottled varieties exhibit pale to dark-green and white or grey minerals.

A distinct schistose structure is uncommon save in immediate proximity to a fault, as in the case of the dyke traversed by the lode-fissure of Elliott's Reward Mine on the Interview River. More usually the rock has the typical massive habit of a basic plutonic rock such as gabbro.

The constituent minerals cannot be accurately determined with the naked eye, except in the case of the magnetite crystals, which sometimes are visible in the weathered rock.

As weathering of these rocks proceeds, there is formed a brown or yellowish-brown crust over the unaltered rock. The final product of decomposition is a soft clay deeply stained with iron oxide. This clayey soil, where it attains any depth, is rich, and supports a dense vegetable cover.

The examination of thin sections of different samples of the rock is rather unsatisfactory, owing to the altered condition of all specimens of the rock available for slicing. Still sufficient information was obtained to confirm belief in the essential unity of type among all varieties.

The felspars present in slices from different rocks are somewhat variable in composition, and more than one species is usually present in any given rock. The plagio-

clase is sometimes lathshaped, but the crystals usually have greater width in proportion to their length than do typical laths. Where the extinction angles of the plagioclase are measurable, they are found to belong to species varying from oligoclase-andesine to andesine-labradorite. Most commonly, however, the whole of this felspathic substance is replaced by a saussuritic aggregate or by kaolin.

Round this plagioclase there is often micropegmatite, the felspathic component of which remains almost invariably clear. Clear albitic felspar is also present in some cases in the form of veinlets, lenses, or aggregates of more irregular form. In a few places doubtful orthoclase, free from intergrowth with quartz, is to be seen occupying interstitial spaces in much the same way as the micropegmatite.

Quartz is in few places prominent save as a constituent of the micropegmatite, but is in some slides to be seen in the form of allotriomorphic granules. It is quite abundant in the dyke outcropping on the south bank of the Pieman River, a mile above the ferry at the mouth, and in the entirely similar dyke lying to the westward of the granite north of the Pieman Heads. Here it contains numerous indeterminable acicular inclusions, the optical character of which is masked by their host.

The ferromagnesian constituents are difficult of determination for the reason that they too have suffered no small amount of superficial alteration. The least altered variety was found to be that obtained from the north-western end of the dyke near the Balfour township in the bed of a small tributary of the Frankland River. In this variety the felspars remain exceptionally fresh, and micropegmatite is absent.

In the rock mentioned the ferromagnesian constituent is augite with hypidiomorphic to anhedral outlines. There is pronounced zonal structure, the centre of the crystals being pale-yellowish and the outer zone yellowish-brown. No pleochroism is noticeable. In several places alteration into chlorite (pennine) is to be observed, but no amphibole could be recognised. The pyroxene surrounds the felspar crystals in such a manner as to produce typical ophitic structure.

In the case of all other specimens which were examined in thin section, no pyroxene could be recognised with definite certainty, although the general appearance of the rock is almost identical with that mentioned above.

Where the ferromagnesian constituent is to be recognised it is hornblende or actinolite. In many cases composite aggregates of almost colourless fibres merge gradually into single strongly-pleochroic plates. The undoubtedly secondary fibrous uralite thus implies a secondary character for the more massive form. It is highly probable that all such amphibole results from the paramorphism of pyroxene, although intermediate stages were not found in the thin sections available. The lack of euhedral outlines in the amphibole crystals or aggregates renders the test of pseudomorphism useless.

The texture of these amphibole-bearing types is similar to that of pyroxene-bearing variety described above, and the ophitic intergrowths are well marked.

A little epidote is sometimes present in anhedral grains, or in narrow veinlets.

In most cases there is a certain amount of chlorite forming at the expense of the hornblende.

Ragged plates of ilmenite are very common in all varieties of the rock, and are always almost completely altered into leucoxene. Rutile in granules or fine rods is occasionally to be seen.

On account of the presence of the hornblende exhibiting secondary characteristics, and of the existence of pyroxene in at least one case, it has been deemed advisable to call the rocks collectively amphibolites.

On the assumption, apparently justifiable, that these intrusive rocks were at the time of their consolidation pyroxene-bearing, it is not an easy matter to say what the rock type, which existed before amphibolitisation, should be called.

The mineralogical composition of the unaltered rocks is that of quartz-augite-diorite rather than that of typical diabase, but the texture is that of typical ophitic diabases. Only one generation of crystals is present, and the rock is invariably holocrystalline.

The usual form assumed by these intrusions of amphibolite is that of a dyke from 30 to 100 feet wide, and at times some miles in length, but there are also present masses the length of which are not so disproportionately greater than the breadth. Their vertical range with respect to the present topography is considerable. But it is noticeable that one persistent dyke which possesses a strike that would carry its outcrop over Mt. Hadmar near the summit cannot be traced at that altitude. It is

nevertheless possible that the outcrop may at that place be masked by vegetation.

The dykes are found to be quite independent of the bedding-planes of the Balfour slates and sandstones which they traverse. They produce no noticeable contact-metamorphic effects upon these intruded rocks.

The dyke on the coast in the south-western portion of the field examined is apparently cut by the granite, but the contact between the two igneous rocks is concealed.

The mineral veins traverse the dykes in a few places, as at the Interview River and in the vicinity of the Toner River.

The orientation of the long axes of the dykes is irregular save in the area lying to the north of Mts. Rosslyn, Hadmar, and Vero, where a north-north-eastern direction is the prevailing one.

It is quite possible that other dykes may exist in the area of which the accompanying sketch map has been prepared. The growth of dense vegetation upon several of the dykes mapped is the sole superficial sign of their existence.

These amphibolite dykes are certainly to be regarded as alteration products of a great series of old igneous rocks abundantly represented in North-Western Tasmania. The various members of the series exhibit great variety of mineralogical composition and texture, and have consolidated under different conditions of environment in different places. As the geological survey of Tasmania proceeds it is being recognised that the series comprises an appreciable number of basic types, in addition to the quartz-porphyries, granite-porphyries, and keratophyres. Descriptions of some of these basic types have already been published in the bulletins of this Survey, wherever they have been investigated.(1)

Other varieties are now known to exist at several points in the north-west of Tasmania, notably at Smithton and West Montagu, where first-class agricultural soil results from their disintegration. A rocktype entirely similar to that obtained near the Balfour township, and described above, is to be found on the track between Mt. Read and the Henty River. A thin section of this rock, obtained by Mr. G. A. Waller, is in the possession of the Geological Survey.

(1) Geol. Surv. Tas. Bulletin No. 5, 1909, pp. 12-14. Geol. Surv. Tas. Bulletin No. 8, 1910, pp. 29-30.

The rocks described by Professor J. W. Gregory in his paper on the Mt. Lyell Mining Field (1) as diabase-porphyrites are probably very closely related in composition, but are different as regards texture from the Balfour types.

The igneous rocks with which the amphibolite dykes are here grouped are known to be contemporaneous with certain of the older sedimentary rocks, to which a Cambro-Ordovician age has been provisionally assigned. The field evidence in the Balfour region shows these igneous rocks only as intrusive into the sediments. But no contradiction to the evidence of other places is necessarily involved, since the slates of Cambro-Ordovician age constitute a group of great thickness, and the horizon of that portion of the group which was being deposited contemporaneously with the igneous effusions has not yet been determined.

(2) *The Coastal Granite Massif.*

The rocks to be here taken into consideration are the types constituting the main mass of the granite *massif*, the minor variants from these types, and the dykes and apophyses which traverse the granite and pass beyond its boundaries into the surrounding rocks.

(*a*) *Granite.*—The prevalent types of granite represented in the region are medium-grained in texture as far as the bulk of the rock is concerned. Not uncommonly, however, there are developed large simple twins of felspar, which are in many cases 1½ inches in length, and in a few cases as much as 4 inches. The presence of these phenocrysts renders the rock strikingly porphyritic, but the matrix in which the phenocrysts are set is of typically granitoid texture.

The colour is usually grey rather than pink. Both light and dark coloured micas can be seen in the majority of samples; and the pale mica appears never to be absent, while biotite, though usually in excess over muscovite, does sometimes entirely retreat.

Within this more normal granite there are segregations possessing very irregular outlines. On the promontory of Sandy Cape, close to the water's edge, several such segregations were observed to be strikingly rich in tourmaline, and to be composed of this mineral, quartz, and felspar without any mica. Other segregations again are

(1) Aust. Inst. Min. Eng. 1905, pp. 56-58.

highly micaceous through the great development of muscovite.

There is practically no soil above any of the granite. The rock is entirely concealed for very large areas by the peat cover, which is itself shallow and almost wholly composed of vegetable material. Where excavations have been made it may be seen that the regolith is shallow, although the surface of the granite is usually very soft and friable. Where the peat cover conceals the boundary between the granite and the members of the slate group it may be determined with close approximation to accuracy by the observation of the small angular fragments of quartz on the peat surface. These are brought up to the surface by small, burrowing crustacea, commonly called "land crabs," which dwell in and below the peat, and build up small conical mounds of waste material at the surface.

The microscopical examination of the muscovite-biotite granite affords a little additional information with regard to the mineralogical composition of the rock. Both triclinic and monoclinic felspars are represented, the former ranging in different cases from oligoclase to albite. The large twinned crystals mentioned above are carlsbad twins of orthoclase. Apatite is usually present in anhedral grains. Tourmaline rods and granules are distributed through the varieties rich in muscovite. The outlines of the tourmaline are in some cases quite devoid of crystallographic lines and angles, but in other cases are characteristic of the mineral. The colour of the tourmaline is not constant, and is irregularly distributed through the same crystal, the tints assumed ranging between deep-brown and pale-yellow, or even colourless. The granite mass, the principal portion of which consists of the rocks thus described, forms a large intrusion extending in a north-westerly direction from the Pieman River to Sandy Cape. The length of this mass at the surface is about 19 miles, and the average width a little over 2 miles. From the geological map it will be seen that it just reaches the Pieman River, and attains its maximum width in the district in which prospecting for wolframite has been carried on. The upper surface of the granite does not stand in relief above the rest of the country, but conforms with it to the general slope of the piedmont peneplain.

These features serve to indicate that the granite *massif* assumes the form of an exceedingly massive dyke, of which the upper limits are but just exposed at the pre-

sent surface. The north-western extremity of the dyke is covered by the Southern Ocean. The south-eastern end appears to dip down below the slates, and cannot be seen on the south bank of the Pieman River. Acidic dykes are said to occur on the coast a few miles south of the Pieman Heads, and are probably connected in depth with the southerly extension of the *massif*.

The disposition of the intrusion is independent of the structure of the invaded slates and sandstones. The latter have suffered some degree of contact-metamorphism by the granite, and the alterations effected are mentioned elsewhere in this report. The relationship of the mineral veins to the *massif* is discussed elsewhere.

(*b*) *Acidic Dykes.*—Rock types which can hardly be classified with any of those mentioned under the head of granite are found very intimately associated with the granitic types. Being, for the most part at least, enclosed within the granite boundaries, and traversing, as they do, the normal granitic rocks, they are usually of slightly later date than the granite itself.

The only possible exception to be noted is that of a pale-coloured granite-porphyry not seen *in situ*. Pebbles of this rock were found at North Pieman Head in the gravels brought down to the beach by the numerous small streams flowing westwards into the ocean. These pebbles may be derived from the border of the *massif* itself, or from apophyses of the undifferentiated magma which protruded into the surrounding rocks.

A notable development of coarse pegmatite occurs on the western edge of the Sandy Cape promontory. The rock is almost wholly composed of quartz and felspar, these minerals being often intimately intergrown. The felspar is exceedingly well developed, and single crystals attain a length of much more than a foot. The pegmatite shows a well-defined "comb-structure," and there are some drusy cavities observable, in which rough crystal terminations are visible. The pegmatite constitutes a floor or flat vein within the granite, and dips at a very low angle towards the north-west. No uncommon minerals were observed enclosed within the pegmatite.

There are numerous aplitic dykes of small size traversing the granite in all directions, and sometimes even passing out into the surrounding slates. These are almost wholly composed of quartz and felspar, but a little mica is sometimes visible in addition. In one case a composite dyke was seen in which the sides are of aplite while the

heart is pure quartz. This rather striking occurrence appears to show the connection between the numerous quartz veins which traverse the granite and the quartzo-felspathic differentiation products. These quartz veins at times carry a little dark-coloured tourmaline.

On the northern shore of Sandy Cape, where the granite outcrops from beneath the cover of loose sand, a dyke 4 inches wide was seen traversing the porphyritic coarse granite. The rock is a fine granular aggregate of grey colour, and proves in thin section to be an aplite rich in tourmaline. The texture is that which is characteristic of the members of the aplite group. The minerals present are quartz, oligoclase-albite, orthoclase, tourmaline, and a little apatite.

The mineralogical composition of the rock shows that it has been derived from some normal segregation centre within the granite *massif;* and that the plutonic consolidation product at that segregation centre to which reference has been made above (the tourmaline-rich and mica-free granite of Sandy Cape) differs only in texture from the hypabyssal type genetically related to it.

The numerous quartz veinlets within the granite boundaries are usually free from metallic constituents. Tourmaline is often seen, and arsenopyrite was observed in one instance at Sandy Cape. The mineral veins carrying tin ore and wolframite are certainly related to these quartz veins, but are not so abundant. The connection between the mineral veins and the granite *massif* is more fully discussed in another part of this report.

With regard to the relationship between the North Pieman *massif* and other developments of granite in Western Tasmania, some remarks are necessary for the proper understanding of both the general and the economic geology of the district.

In all matters relating to mineralogical constitution and texture the coastal granite lying to the north of the Pieman River is very closely allied to that of the Heemskirk Range. Some description of the latter has been given in a recent publication of this Department.[1] The tendency towards the formation of segregations rich in tourmaline and of aplitic and quartz-tourmaline veins is characteristic of both *massifs*, though at Heemskirk the stages in the differentiation are more readily distinguishable.

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[1] Geol. Surv. Tas. Bulletin No. 8, pp. 23 and 24.

There can be no doubt but that the granitic invasion of the North Pieman district was contemporaneous with the invasions of similar material into the Heemskirk district. These, with the plutonic irruptions of lithologically-related igneous matter at Granite Tor, Middlesex, Meredith Range, Heazlewood, Hampshire Hills, and Dial Range, and the intrusions of cognate dykes at Zeehan, North Dundas, Bond's Peak, and Mt. Bischoff, are all judged to be of Devonian age.

The question of the relationship in depth between these Devonian igneous rocks of acidic composition has recently been discussed at some length by the writer, (1) and the opinion has been expressed that they do not constitute portions of a "batholite" continuous at comparatively shallow depths beneath the large area over which the outcrops are distributed. On the assumption of the essential genetic inter-relationship between the ore-deposits of the region and these igneous rocks, it has been claimed that there are at least two zones of coincident mineralisation and igneous invasion, one of which extends from the Heemskirk Range to Mt. Claude, and the other from the Meredith Range to the Dial Range. In other words, the view has been expressed that the different *massifs* of the north-western part of Tasmania are really great irregular bulges along lineal intrusions.

It cannot be said that any connection between either of the nearest granite masses, viz., those of the Heemskirk and Meredith Ranges, with the North Pieman outcrop, has been indicated. It is possible that a connection with Heemskirk may be covered by the ocean. It is nevertheless noteworthy that the North Pieman *massif* itself possesses at the surface outlines which suggest the dyke-like habit of the zones of intrusion which have been mentioned.

(3) *The Basaltic Lava Flows.*

The basalt occurring within the area with which this bulletin is concerned is usually dense and compact in texture. Vesicular varieties occur, but are not the most usual, perhaps for the reason that the vesicular portions have more readily yielded to weathering agencies. To the naked eye felspar laths and blebs of olivine alone are decipherable in a dark-coloured groundmass. In the

(1) Proc. Aust. Assn. Adv. Science, Sydney, 1911: "The Heemskirk Massif; Its Structure and Relationships."

vesicular varieties the grain is usually finer, and olivine (in grains or nests) is the only mineral to be seen.

A brown or red crust forms over the unaltered rock as weathering proceeds, and by gradual stages a red or dark-chocolate soil is produced. The joints affect the progress of the decay, and spheroidal blocks with a core of unaltered basalt and concentric shells of successively more-weathered rock are seen. The only mineral which withstands the decay even temporarily is magnetite. This is always visible on the surface of the thoroughly decomposed soil, and most readily after rain.

The soil resulting from the disintegration of the rock is of first-class quality, and has for the most part been turned to some account for agricultural purposes.

Beneath the decomposed rock there is sometimes found a hard crust of limonite, derived from the overlying rock by the dissolving action of percolating water upon the ferriferous minerals. On the removal of the basaltic soil this limonite crust may be left at the surface.

When a microscopical examination of the basalt is made it is found that the rock differs in no essential particulars from the other Tertiary basalts of Tasmania. The coarse-grained variety from the Balfour township carries two generations of felspars, and is on that account slightly different from the majority of Tasmanian basalts. This, however, is not a matter of great importance, and certainly does not suffice for the establishment of another type.

The basalt is porphyritic through the development of labradorite, augite, and olivine phenocrysts. The augite of these phenocrysts is largely corroded, but the felspar and olivine retain their idiomorphic outlines. The ground-mass consists of granular augite and small laths of labradorite. These crystals are arranged with their long axes in one general direction from the movement of the magma before consolidation was complete. Magnetite occurs in granules or rods between the crystals of the ground-mass.

The basalt is found in the form of residual fragments of lava flows, the original extent of which is not now evident on account of denudation. It is, with the single exception of the unconsolidated material of the sand dunes, the youngest rock in the district, and overlies the fragmental gravel deposits of the former bed of the Frankland River and the Tertiary limestone. Upon the underlying beds it has produced little effect. A slight silicifi-

cation has been caused at a few points, and is chiefly noticeable where the subjacent formation is limestone.

The distribution cannot be clearly explained, for the reason that the conduits whereby the molten lava was enabled to rise to the surface have not been located. The two areas shown on the map at Balfour itself are portions of a single flow, and have been separated by denudation. The small patch near the Mt. Balfour Mine, at the north end of the mining field, is isolated. There may possibly have been one continuous sheet to the eastward of Temma running parallel with the coast; but this is by no means certain. At the present time five distinct areas, separated from each other, are known to occur.

On the beach, between the mouth of Daisy Creek and Ordnance Point, pebbles of basalt are extremely abundant. Since no trace of the massive rock could be found inland in this locality, it appears probable that the shingles have been set free from some occurrence just covered by the ocean.

There is no reason to believe that the basalt found between the Arthur and Pieman Rivers is of different age from the other developments of similar material throughout Tasmania. These basaltic flows are all considered to be of Mid-Tertiary age.

The nearest occurrences to those of the Balfour field are situated at Marawah on the north, Granville Harbour on the south, and in the neighbourhood of Mt. Bischoff on the east.

B.—THE SEDIMENTARY ROCKS.

(1) *The Balfour Slates and Sandstones.*

Until it is possible to correlate, with some greater degree of certainty than can be at present attained, the members of the group of sedimentary rocks which occupy almost the whole of the area that was examined with other recognised sedimentary rocks in Tasmania, it is deemed advisable to assign to them a local name. The members of this group are therefore here referred to collectively as the "Balfour slates and sandstones." This name, employed for convenience, is not intended to preclude the grouping of certain conglomerate beds, together with those of finer grain.

The slate and sandstone members of the group are much the most abundant, and are usually found in mutual association.

The slate is almost always banded, the different bands varying in colour from very dark-grey to white, or in some rare cases green, and in thickness from very small fractions of an inch up to several inches. The thinly-bedded varieties are much the most common. The pale-coloured bands are more siliceous than those of darker hue, which are more argillaceous in composition and finer in grain.

The sandstone is usually of white colour, but is of very variable grain, some beds approaching in coarseness to that of a typical grit, others being almost as fine-grained as the shaly bands.

Cross-bedding is very noticeable in almost every place where exposures are afforded, but no conclusions could be drawn from its presence, on account of the amount of disturbance the sedimentary rocks have undergone since deposition.

Other original characters are in some places preserved in spite of alterations. There are a number of places throughout the district whence excellent samples of ripple-marked sandstones may be obtained from the beds belonging to this group.

Other markings, to which reference is made below, are in the writer's opinion worm-trails originally imprinted upon the ripple-marked beach sands before the consolidation of these.

In very many cases, especially in the layers of sandstone, there are scattered flat pebbles or shingles distributed through the material of finer grain. The materials of which these shingles are constituted are invariably also slate or sandstone—fragments of the already consolidated members of the group.

Such are the characteristics of the rocks forming the great bulk of the group.

The more uncommon members which are classified here with these are conglomerates, which are regarded as local variants of the shingle-bearing slates and sandstones. On Mt. Frankland, at several points along the summit of the ridge, these rocks are to be seen—altered it is true, but clearly constituting members of one group with the more usual types.

At North Pieman Head a conglomerate of rather different type occurs. The pebbles are much larger, the longest diameter being as much as 10 inches in some cases. Many of the pebbles are composed of quartzite, the remainder being of slate. The conglomerate here attains a maximum width of 300 feet.

The various members of this group have been altered by different processes in such a manner that the rock types now show features somewhat different from those which characterised their unaltered condition. Weathering, crustal stresses, impregnation with mineral matter, and contact-metamorphism have all effected changes such that the original characters of the rocks are masked or destroyed.

By weathering, the argillaceous varieties are converted ultimately into a limonite-stained kaolin.

The weathering of the sandstone of the group is, at one place at least, exceptional. This place is the vicinity of the big bend of the Lagoon River, where the sandstone, still *in situ*, assumes spheroidal forms on the weathered surfaces. Such blocks, when released, may simulate the appearance of the waterworn boulders of a stream-bed.

The siliceous members are disintegrated into friable sandstones, in which curiously characteristic cavities exist. The origin of these cavities is well shown by some of the more indurated varieties in which all stages in the formation of the cavities have been preserved. The holes mark the sites of formerly embedded pebbles or shingles of slate and shale, which soften and crumble out of the more enduring sandstone or grit. So complete is the removal of the included shingles, and so clean-cut are resultant cavities on weathered surfaces of the sandstone, that these rocks give one the impression of having been formerly fossiliferous. The form of some of the cavities certainly tends to strengthen this impression, but in no case was the writer successful in finding more than a suggestion of organic outlines for the negative markings under discussion. With some confidence, therefore, the explanation here given, on the evidence afforded by the somewhat altered varieties in both weathered and unweathered conditions, is put forward.

Crustal movements have effected, not only actual dislocations of notable magnitude in various parts of this group of sedimentary rocks, but also an elaborate and minute crumpling or compression of the whole body of the rock. The results of this general compression are seen in the slaty cleavage which is characteristic of all varieties of the group, whether altered or not, by other processes.

In addition to this development of the cleavage there is quite commonly some degree of contortion and even dislocation by overthrusting and faulting. The banded

varieties display these features prominently, but in the homogeneous layers traces of movement are not visible. A very common rock variety throughout the region is a light and dark grey banded slate, in which the darker or more argillaceous bands have parted during the rock movement, and the crevices thus formed (in directions crossing the planes of bedding) have become filled with granules from the coarser layers of paler colour. Yet, in spite of the superimposed cleavages the bedding-planes are almost always decipherable, and in the cases where ripple marks are preserved they are more prominent than the cleavage. The conglomerate at North Pieman Head shows very well the effect of the pressure on the different varieties of pebbles. Those composed of quartz or quartzite have not suffered deformation, although many are cracked in a direction striking N. 70° W. The slate pebbles, on the other hand, have been squeezed into contorted lenses.

The most striking alterations effected in the rocks of this group are those wrought by the impregnation of the rock masses with mineral material introduced in solution. The impregnation is commonly that of silicification, and may be sufficient to cause material induration without otherwise altering the appearance of the rockmass. There are, however, a number of cases in which the silicification is itself prominently shown in the appearance of the rock, or in which mineral material other than silica has also been introduced. Such cases are found most commonly in the vicinity of the normal lodes of the field, where chloritisation may accompany silicification of the wall-rock, as explained in a later part of this report. But in at least one district, viz., on Mt. Frankland, and at a point a mile and a quarter further north (in the south-western part of Section 4274-M), there has been an addition of hematite as well as silica.

The impregnation with hematite is little more than a mere pigmentation, but it produces a rock of characteristically distinct appearance. This rock is a dense pink quartzite, commonly traversed by veinlets of white quartz or a brecciated conglomerate of pink to purplish-pink colour, and with similar white quartz-veinlets. These rocks in almost all respects resemble the typical members of the West Coast Range conglomerate series. The pebbles are, however, more angular, and their character and composition different from those of the latter formation. In drawing attention to this lithological resemblance the

writer desires to insist that, in his opinion, the likeness is accidental. The pink quartzite and conglomerate of Mt. Frankland belong to the group here being discussed.

The relation of these indurated portions to the major fracture-planes of the district could not be definitely ascertained in the majority of cases on account of the vegetable cover. It is, however, in the opinion of the writer, practically certain that the relationship exists, although details are concealed.

The North Pieman granite *massif* has produced certain variations of type, which are noticeable where exposures of the contact metamorphic zone occur. As the granite is approached there first appear a few spots or flecks in certain bands of the slate members of the group, which are at the same places sometimes silicified. These resulting rocks are spotted quartzites and spotted slates or fleck-schiefer. Still nearer to the granite these altered types become more and more abundant till they predominate over the unaltered varieties. The markings become more pronounced, so that the rock acquires the typical appearance of ordinary garbenschiefer.

With regard to the traces of organic life detected in the rocks, very little can be said. Some curious markings were observed in different places, but in no place were there found any traces of recognisable organisms.

In a few places, notably on the summit of Mt. Hazelton, there are markings which certainly suggest that they are worm-trails. While no trace of actual organic structure remains, it seems improbable that these forms have been produced by any inorganic processes.(1) All that now remain are cylindrical columns of sand which coincide with the ripple-marked bedding-planes. The cylinders are oval in section, from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter, the longer diameter coinciding with the bedding-plane; and they may be easily detached from their position in the solid rock, leaving a semi-cylindrical cavity. The tubular ridges or cavities follow an irregular course across the surfaces of the rock layers, and from the main tubes short ones frequently project, sometimes uniting with each other or the main tube, in other cases terminating abruptly.

(1) Note.—These tubular forms resemble to a remarkable degree the markings figured as sun-cracks in A. G. Högbom's "Pre-Cambrian Geology of Sweden." Bulletin of Geol. Instit. University of Upsala, Vol. X., 1910-1911, p. 8, Fig. 3. They are not, however, sun-cracks—in the opinion of the writer—in the case under discussion.

Two and a half miles west of Mt. Hazelton, on the coastal peneplain, there are some rather indefinite marks on the ripple-marked surfaces of bedding-planes of the sandstone belonging to this group. Some of the impressions suggest that they were formed by portions of a spirally-coiled mollusc. Others, still less well-defined, are fan-shaped.

In the absence of recognisable organic remains any attempt at settlement of the age of the group can at best be only provisional. But the evidence acquired in the field is sufficient for approximate correlation with other already recognised groups of sediments in Tasmania. This correlation is based upon evidence to be gathered from the relationship of the group to other sedimentary rocks and to the igneous rocks of the district, and from the lithological resemblance to other sediments.

Unfortunately no sedimentary rocks of definitely determinable age other than the Tertiary have been found in the region. Stratigraphical relationships are therefore of no avail.

The Balfour slates and sandstones are penetrated by the basic dykes and the granite of the North Pieman, and are overlain by the basalt. They are also penetrated by the metalliferous veins. The significance of the evidence of these intersections will be better appreciated from the later pages of this bulletin. The relationship of the sedimentary group to the basalt is evidence of Pre-Tertiary age. The relationship to the granite and the ore-bodies is evidence of Pre-Devonian age, according to the reasoning which is supported by the occurrence of similar ore-bodies and acidic rocks in other parts of the western coastal region. The relationship to the basic dykes is evidence of age that is certainly Pre-Silurian. Whether tuffs are present in the Balfour region as well as dykes is not certain, but it has been definitely ascertained that the dykes traverse some members of the sedimentary group. The dykes are undoubtedly to be grouped with the great series of intrusives and extrusives which are so abundantly distributed throughout North-Western Tasmania, and to which (on the basis of the intercalation of the extrusive members with the slate) a Cambro-Ordovician age is provisionally assigned.

The lithological characteristics of the Balfour slates and sandstones are very similar to those which have been recognised for the slates and sandstones of the Queen Hill at

Zeehan, (1) but the latter appear to contain rather more definite traces of organic remains.

While it is thus impossible to determine with certainty the age of these rocks it is to be noted that they present striking differences in several essential particulars from the Silurian sediments which have now been recognised in several parts of Western Tasmania, and that, in common with some of the Cambro-Ordovician rocks, they are traversed by dykes of the Pre-Silurian period of igneous activity. There are perhaps even some members of the group interbedded with the tuffs derived from the volcanic phases of this igneous invasion.

It therefore appears that the Balfour slates and sandstones are to be regarded as part of the Cambro-Ordovician series.

(2) *Conglomerate of Unknown Age.*

In a number of different parts of the region there are small isolated patches of a conglomerate which is possibly distinct from that which has been referred to the Balfour slate and sandstone group.

The outcrops of this rock are very scattered, and the relationships are seriously concealed from observation by the peat and heath growing over the greater part of the areas in which the rock occurs.

The most extensive development of the rock occurs between Mts. Balfour and Frankland, in Sections 3956-M, 4028-M, and 4343-M, on either side of one of the main branches of Tin Creek.

Lithologically the rock appears to differ from the conglomerate of the Balfour slate and sandstone group. It is more dense and more siliceous, resembling to a marked degree the conglomerate of the West Coast Range.

The matrix in which the pebbles of quartz and quartzite are set is itself quartzose, and cemented into a dense, tough mass by later impregnation with silica. The colour is pinkish.

In this rock, in the form of pebbles, portions of the sandstones and grits belonging to the Balfour slate and sandstone group may be definitely recognised.

The places in which this conglomerate has been found are not many, and in all cases the bulk is so small that it is difficult to decide whether or not the outcrops are remnants of a once more abundantly distributed formation.

(1) *Vide* Geol. Surv. Tas. Bulletin No. 8: "The Ore-Bodies of the Zeehan Field," 1910, pp. 37 and 38.

The strike of the formation could in no instance be ascertained, although the strike of the immediately adjacent sediments of the Balfour slate and sandstone group could be recognised. The impression given certainly is that of one formation resting unconformably upon another. Whether, however, the few occurrences which are known represent the outcrops of materials formed at the spots where they now are seen, or whether they are the sites of deposition of transported material, is not clear. The medium of transportation of the conglomerate can only have been ice, if such transportation did occur.

When first seen the outcrops on the sections mentioned above appeared to the writer to be of the nature of a morainal deposit, but on later investigation this explanation did not appear to be entirely satisfactory. The distribution of the several outcrops throughout the region is hard to reconcile with such a view.

It is noticeable that the observed outcrops are all situated on the level of the piedmont peneplain and at the foot of the Norfolk Range.

The source of the rock was not recognised (assuming for the moment that the several outcrops are those of glacial erratics) unless the silicified conglomerate of Mt. Frankland is to be compared with it lithologically.

The places in which this conglomerate has been observed are the following:—In the valley lying between the north-eastern spurs of Mt. Balfour and Mt. Frankland; at the foot of Mt. Sunday, on the south-west side of that mountain, and a little further north where a tributary of the Lagoon River enters that river to the east of Helen Peak; also at the place where the Balfour-Pieman track descends into the Lagoon River gorge, on the western side of the Norfolk Range, and on the southern bank of the Lagoon River.

In the firstnamed place only is there any appreciable area covered by the formation, the total development being about 80 acres in extent. In all the other cases there is very little indeed, the largest mass being that at the base of Mt. Sunday, where it occupies about an acre.

(3) *Limestone of Unknown Age.*

On the shore-line, at a point about 2 miles north of the mouth of the Pieman River, there is a dense limestone of a slaty-blue colour. The rock is only exposed for a few feet, and appears to strike north and south and dip to the west-

ward. Unfortunately structural details at this spot have little stratigraphical significance, since there is a notable degree of contortion (involving a sharp alteration in the line of strike) of the sedimentary rocks. The limestone lies against the conglomerate, which at that place runs into the sea with a strike of N. 70° W. Dark slate follows on the northern side of this conglomerate, and the next succeeding rock is a broad basic dyke. The granite *massif* outcrops a short distance inland.

Whether this limestone belongs to the old sedimentary series, here called the Balfour slates and sandstones, or not is not easy to decide. The strike appears to differ from that of the immediately adjoining sediments, and the limestone certainly appears to overlie them. The local disturbance of the strata at this very spot is, however, such that definite conclusions cannot be arrived at.

The limestone contains no visible fossils where it is exposed. Lithologically it closely resembles the limestone so commonly found where the Silurian system is represented in Tasmania.

(4) *The Tertiary Limestone.*

A matter of some geological interest is the discovery of a small patch of Tertiary limestone at a distance of 2 miles from Temma, and in the north-western corner of a 99-acre block purchased by Louis Hogg.

The exposure is exceedingly small, for the outcrop appears only on a creek-bank where the removal of the overlying basalt has taken place.

A search for other exposures at the edge of the basaltic sheet proved unavailing near Temma; but entirely parallel information was found to be afforded by an occurrence of the limestone in the vicinity of Marrawah.

Numerous pebbles of the limestone were observed in association with still more abundant pebbles of vesicular or pumiceous olivine basalt along the ocean beach between Ordnance Point and the mouth of Daisy Creek, but neither rock was found *in situ*.

The limestone has commonly a pinkish or yellowish hue, and shows always abundant fossil remains. Parts of the rock are silicified, especially the upper portions upon which the basalt lies.

This limestone is undoubtedly identical with that which has long been known to exist at Cape Grim (the north-

western extremity of Tasmania) and the vicinity.(1) The writer has observed it also on the beach close to Marrawah, south of Mt. Cameron West and east of Green Point.

There can be little doubt but that these exposures of lithologically similar limestone are portions of one essentially continuous horizon, which is persistent far beyond the limits of the region here mentioned.

Specimens of the fossiliferous limestone were forwarded to Mr. W. S. Dun, Government Palæontologist of New South Wales, who has been good enough to forward the following determinations of fossils in samples gathered from A. Wilson's farm east of Marrawah, and from Louis Hogg's farm east of Temma:—

A. Wilson's Farm (Marrawah): Polyzoal limestone containing—

Polyzoa: Retepora, Cellepora, Lepralia, Microporella, Schizoporella (?).
Brachiopoda: Terebratula garibaldiana.

Louis Hogg's Farm (Temma): Polyzoal and shell limestone containing—

Polyzoa: Most of the polyzoa quoted above.
Brachiopoda: A terebratulid which resembles T. garibaldiana.
Gastropoda: Marginella, Calliostoma.

Mr. Dun adds: "There is in my opinion every reason to correlate these beds with the Table Cape beds and Cape Grim beds."

Spines and tests of echinoderms were seen by the writer in the limestone on the beach south of Mt. Cameron West.

Thus we may confidently assign to these marine beds a place at the base of the known Tertiary system.

The extent of the early Tertiary sea is therefore now known to have been greater than was formerly believed.

From the poverty of exposures very little information was to be gathered as to structural conditions during deposition and subsequent changes.

The limestone on Louis Hogg's farm is 250 feet above sea-level, that on A. Wilson's farm 150 feet above sea-level, and that on the beach near Mt. Cameron West lies between high and low water marks; and it certainly seems, from the evidence of the pebbles, that there is a part of

(1) *Vide* R. M. Johnston: "Geology of Tasmania," pp. 244, 268. W. H. Twelvetrees: "Outlines of the Geology of Tasmania," Ann. Rept. Sec. Mines Tas., 1908, p. 157.

the formation below sea-level not far from that part of the shore-line which extends between Ordnance Point and the mouth of Daisy Creek.

While it is not quite certain in all cases what the bed-rock is upon which the limestone rests, that part of it exposed to the east of Temma is lying upon the Balfour slates and sandstones.

In no case could entirely satisfactory evidence regarding the dip be ascertained. The thickness on A. Wilson's farm appears to be some 12 feet, but in the other cases seems to be very much less.

(5) *The Sand Dunes.*

The coastal belt between the Arthur and Pieman Rivers is irregularly strewn with a recent deposit of unconsolidated sand. The width of the sand belt at different points is extremely variable, and probably considerable variations occur at any one point when any long interval of time is taken into account. For within the short period during which the country lying to the north of Marrawah has been occupied by the Van Diemen's Land Company the coastal sand has been found to make notable incursions into the pastoral land. And this has happened despite systematic attempts to check the advance of the sand by planting suitable vegetation. Over the coastal areas, where no artificial checks are placed upon the movement of the sand, it may well happen that the migration takes place much more rapidly.

The largest development of the dunes is that at Sandy Cape, where the sand has drifted across the main body of the promontory. The movement would appear to be almost universally towards the north, if we may judge by the deflection of the rivers at their debouchures.

The material of which the dunes are composed is almost entirely white sand. A few black particles were seen in some places on the beaches. Within the sand dunes are numerous layers, which consist almost entirely of the shells of modern marine mollusca. The steep angle of slope and short horizontal extension of these shell-beds appear to indicate an æolian origin. These beds, the edges of which are exposed here and there on the faces of the dunes, are buried accumulations of the shells, such as are to be seen here and there on the present surfaces of the sand.

Pebbles are at some places visible in the lower portions of the dunes, having probably been deposited there by the creeks, the level of which has been temporarily raised by the action of the sand in damming the mouth. Basalt pebbles were observed to be numerous among these unconsolidated pebble-beds.

These deposits of pebbles and marine shells at many points suggest the former existence of a beach at a higher level than that of to-day; yet the breaks in the continuity are so many that the explanation here offered seems to account more satisfactorily for the facts of occurrence than the idea of a raised beach could do.

Together with the sand and marine shells of the dunes, there are at several points numbers of mammalian bones. Near the northern boundary of the Temma township there have been found numerous rude stone implements belonging to the now extinct Tasmanian aborigines. These implements are for the most part rough chips of the dense quartzite or chert of local derivation, but others are of flint, the source of which is unknown.

In all cases the writer would ascribe a recent age to the dunes.

V.—ECONOMIC GEOLOGY.

(1)—The Relation of Geology to the Mining Industry.

The main object of the present bulletin is to deal with the several particulars in which geological investigation may explain natural phenomena with a view to the assistance of the mining industry. Incidentally, however, there have been noticed certain relationships between the geology of the region and industrial interests not wholly dependent upon mining. The discussion of the geological relationships of these other industries has therefore been separated from that dealing solely with the mining industry.

When the large area of the Mt. Balfour Mining Field is taken into account it is clear that a large number of occurrences of ore must be considered together or separately, according as classification into natural groupings is feasible. In this matter it will be found that in some particulars the whole field may be reviewed collectively, while in others certain portions must be considered apart. Moreover, whereas the discussion of some matters demands little more than the concise presentation of facts the relationship between which is self-evident, the discussion of other matters implies a responsibility on the part of the writer for the grouping and interpretation of apparently disconnected facts. In such cases as those last mentioned indications are given of the grounds upon which it is felt by the author that the assumption of responsibility is justifiable.

A.—THE MINERALOGY OF THE LODES.

Since an attempt will be made here to give an account of the mineralogical constitution of the lodes of the region as they existed at the time of their genesis, and of the subsequent mineralogical changes which have been wrought by secondary processes, the first subdivision of the description will be into primary and secondary products. Here, at the very outset, certain difficulties arise for the reason that no workings on the field may be confidently stated to be beyond the reach of possible secondary alteration. Yet from the study of the deepest workings available, and the comparison of specimens of lode-

matter from all parts of the field, it is possible to affirm with confidence the qualitative character of the primary lode-matter. Quantitative estimates of the lode contents will vary widely from point to point; and no quantitative estimate of the primary contents of any lode or any part of a lode can yet be made.

The primary ore-bodies of the field may readily be subdivided into two main groups—one containing the lodes that carry cupriferous minerals, the other containing cassiterite and wolframite. It will be seen that this subdivision has a geological as well as an economic significance. A number of variants from these two main groups occur through the preponderance of some constituents at certain points. These variations from the normal composition of the lodes are noted under each group.

(1) *The Primary Ore-bodies.*

(*a*) *The Copper Lodes.*—The copper ore from almost any portion of the Mt. Balfour mining field has a remarkably constant character. The ore, however, does not represent the whole of any lode. It is to be regarded as that part of the lode whence it has been taken which has been locally enriched during the period of primary deposition (for reference is here made only to primary ore) in copper-bearing minerals above the other portions of the lode. The constancy of character in the shoots of copper ore by no means implies a constancy of character in the gangue. The gangue material varies considerably from point to point along any lode, and yet this variation is almost always one of degree only. The minerals represented remain the same, but are present in ever-variable proportions. Moreover, certain peculiarities of crystallographic character and association between the constituents of the gangue of the lodes and those of the ore-shoots argue strongly for the consideration of both gangue-minerals and ore-minerals together. The total grouping of all these minerals constitutes the full description of the lodes. The usual association of ore-minerals and gangue-minerals forms the "normal vein-type." The local development of certain constituents in noteworthy proportions produces variants of the normal type.

The minerals which are to be regarded as the primary constituents of the lodes which contain copper ore are the following:—Pyrite, chalcopyrite, galena, sphalerite, stib-

nite, hematite, magnetite, ferriferous dolomite, quartz, chlorite, and sericite, with traces of gold and silver.

Such being the observed species which occur in all the lodes here classified, we proceed to the discussion of their relative importance and distribution.

The normal vein-type of the field is less complex in composition. It contains the following:—

Pyrite, chalcopyrite, quartz, ferriferous dolomite, chlorite, and sericite. Gold and silver appear to be always present in small proportions, but are not known to materially increase the value of the ore at any point.

Galena and blende are only rarely seen, and even then are usually found in traces. Stibnite has been found at only one point, and is not there abundant.

Quartz is by far the most common gangue mineral, chlorite and sericite being usually present only in films. Ferriferous dolomite is invariably present, although it has seldom been recognised in the workings at the shallow levels now existing. This seeming anomaly is explained below.

There are some points worthy of notice with regard to the mineralogy of the lodes, and a brief mineralogical description of characteristics which are especially noticeable is therefore added.

Pyrite is notable throughout the whole region for its constant, although uncommon, crystallographic peculiarities. The most striking features are the widespread occurrence of the octahedral form (111) and the occasional development of the diploid (hkl).

The more common cube (100) and pyritohedron (hko) are abundantly represented; both forms carrying the usual striations. Combinations of the octahedron and pyritohedron are common, and the degree of ascendancy of either form is very variable. The octahedron may exist unmodified or with the points of emergence of the axes bevelled off by the small pairs of triangular faces belonging to the pyritohedron. In other cases the equal development of both pyritohedron and octahedron produces a characteristically equidimensional form. And in other cases again the trigonal coigns of the pyritohedron are bevelled by the small triangular faces of the octahedron.

These are the commonest forms and combinations, but more rarely others occur in which the diploid is to be seen.

The diploid, with curved facets strongly striated by oscillatory combination with the octahedron, was found at a few places, and in others combinations of the pyritohedron and diploid were recognised.

These peculiarities of form are shown, not only by the crystals themselves, but also by the cavities in the quartzose portions of the lodes whence the pyrites has been removed during weathering.

Chalcopyrite exhibits no such features of external form as may serve to distinguish it by form alone. No crystals of this mineral were observed at any point of the field. It is always present in the massive condition, and wraps round the crystals of pyrite.

Quartz is for the most part massive, but the existence of crystal boundaries is shown in the linings of cavities now visible in those portions of the lode that have been leached of part of their contents. This quartz occurring in the empty cavities has all the appearance of being primary in origin. The quartz is found to envelop all the other constituents of the lodes, being apparently the latest component to attain the solid state. The colour of the quartz is, in almost all cases, white.

Ferriferous Dolomite is the name given here to an ever-present constituent of the lodes, which appears to be of slightly variable composition. The mineral is a carbonate of lime, magnesia, and iron, and the proportion in which the bases exist is variable. Pure dolomite does not occur, nor does pure siderite, as far as can be ascertained without chemical analysis. The name "ferriferous dolomite" has been selected to express this variability of composition, rather than that of "ankerite," which implies a certain constancy. The formula may be written (Ca, Mg, Fe) CO_3.

The mineral in its unoxidised form is white or cream-coloured, but on weathering assumes a yellowish-brown tint on exposed surfaces, owing to the oxidation of the iron. It is invariably well crystallised, and encloses all the other minerals save quartz. The weathered portions of the lodes throughout the field show the characteristic cavities left by the solution and removal of the rhombohedral crystals.

Chlorite is present in the form of films or aggregates of small scales throughout all portions of the lode-filling, and frequently occurs also as an impregnation in the wall-rocks alongside the lode. The films are often exceedingly

tenuous, and the scales are always very small. The mineral is best developed where the lodes traverse the basic dykes, but is by no means restricted to these localities.

Sericite is sometimes to be seen in films in the lode-matter, but is more commonly found in the wall-rocks, or in the broad mineralised zones.

The gold and silver contents of the lode are, in all probability, due to inclusions of these metals in the pyrites, since assays made of non-cupriferous portions of the lode-matter in all parts of the field have shown their presence. It is noteworthy that the gold content does not appear to rise much above 3 dwt. per ton in those samples which have been obtained from widely separated localities. And the very general absence of gold from the alluvial deposits of the field indicates that there have been no important enrichments of the lodes in this metal.

The galena when seen in this type is usually found in the form of blebs, and the sphalerite is, as a rule, resinous.

The single known occurrence of stibnite is in a lode which is situated a little distance outside the south-western corner of Section 3483-M. The lode at this point is very siliceous, and, contrary to the usual mode of occurrence, distinctly banded. Pyrite is present in addition to the stibnite, and entirely takes the place of the latter a few feet below the surface. The stibnite forms radiating crusts, most of which are about half an inch in width.

A description follows of the mineral aggregates which, although closely related to these of normal habit, differ by the unusual abundance of one or more constituents.

Variants of the Normal Type.—

(1) There is a variety of lode-matter which is especially characterised by the presence of abundant ferriferous dolomite, and by the addition of magnetite and hematite as well. Quartz is a constituent of the gangue, and both pyrite and chalcopyrite are present.

The magnetite occurs in well-formed octahedra of small size, the outlines of which become apparent on weathered surfaces. The hematite is fine-grained, and not visibly crystallised. It is most intimately associated with the magnetite.

This variant occurs on the Balfour South Copper Mines lease, 3676-M, a little to the east-

ward of the main ore-shoot. It is also to be seen on Lease 4279-M, situated 4½ miles to the south-east of Temma.

(2) More important in bulk, and of more common occurrence, are lodes which contain a relative abundance of hematite and magnetite. These two minerals may appear as minor ingredients of the normal type, as on Lease 4197-M, in the Norfolk Range, between Mt. Lily and Mt. Mabel. Or they may occur as the major constituents of some lodes, as in several cases in the vicinity of Elliott's Reward Mine on the Interview River. Again, the magnetite and hematite may so completely take the place of the other constituents that a massive iron lode results. This has occurred on the Nelson River, 6 miles north of Temma.

(3) A lode occurring to the eastward of Elliott's Reward Mine shows yet another variety. At this place a small exposure shows a lode which consists of galena and chalcopyrite in a gangue of quartz and chlorite. The local abundance of galena at this place has led to the hope that a silver-lead lode of commercial value will be opened up. While it is possible that the lode may be proved to be of value, it appears to the writer clear that the galena ore is in reality only a local variant of the more normal copper lodes.

(*b*) *The Tin and Tungsten Lodes.*—The tin and tungsten bearing lodes are grouped together for the reason that they cannot be considered to be distinct, when the unweathered primary ore is examined. The tin ore and tungsten minerals may be found together in weathered and even disintegrated lode-matter, although it is perhaps more usual to regard them as belonging to different types.

The primary ore has only just been exposed in the two localities where the type has been recognised, viz., at the south end of Specimen Hill, to the south-west of the Balfour township; and on the mineral leases lying between the Interview River and the Lagoon River.

The lode-matter at the two localities differs only with respect to the tourmaline content. The more southerly lodes, situated within the granite boundaries, carry abun-

dant tourmaline, while the northerly lodes have shown no sign of this mineral.

The minerals constituting the type are:—Pyrite, arsenopyrite, cassiterite, wolframite, and scheelite, occasionally chalcopyrite and molybdenite, in a gangue chiefly consisting of quartz, with which are found white mica and (within the boundaries of the granite) tourmaline.

The pyrite exhibits the tendency to develop the octahedral form which was observed for this mineral in the copper lodes. Few actual crystals were observed, for there is little unoxidised ore exposed, but the octahedral form was seen in these, and was detected in the hollows left by the removal of pyrite in solution by weathering processes.

Arsenopyrite was seen wherever the unoxidised ore occurs, and always in massive form.

Cassiterite is crystallised, usually in complex groups, and has in almost all cases a resinous appearance, although sometimes it is nearly black. The unoxidised ore carrying cassiterite may well have its tin ore content unrecognised in the presence of the more massive metallic minerals of other composition. Thus, the alluvial tin ore near the Interview River has been traced right up to the known lodes, which do not carry much visible cassiterite. There is no doubt but that this tin ore has been set free from the lodes which carry more readily recognised tungsten minerals. It may be actually seen in this ore, but hitherto there has been felt some uncertainty as to whether it was derived from the tungsten lodes. The distribution of cassiterite is not regular.

Wolframite and scheelite sometimes occur together in this lode-stuff; more frequently wolframite alone is found. The wolframite crystals are tabular, with strongly striated faces in the prism zone, and terminated by clinodome faces. The scheelite is usually intergrown with the more massive pieces of wolframite, and shows no well-defined crystal forms.

Chalcopyrite and molybdenite are not important constituents.

The quartz is massive and white in colour, usually occurring in the form of long crystals where the veins are narrow, and very commonly filling the central portion of the veins.

The white mica is not important in bulk, but is very widely distributed and very characteristic of the veins belonging to this class. It is found throughout the vein-matter, and also occurs along the selvage of the veins.

The tourmaline is dark-coloured—brown to black—and occurs in stout rods, which are often grouped in divergent bunches. The rods are striated along the direction of elongation, and are in cross section trigonal.

The varieties of this type of vein-matter which carry tin ore are more common than those which carry tungsten minerals. Both cassiterite and wolframite occur together in some places, but the shoots of these metals are more usually distinct.

(*c*) *The Mineralogical Relationship between the Primary Types.*—A noticeable feature of the distribution of the lodes classified in the two main groupings described above is the fact that they do not overlap. There are no known examples of the copper lodes among the primary tin deposits, nor any of tin lodes among the copper deposits. At the same time it must be remembered that copper pyrites has been seen in the tin-ore deposits. No tin ore has been seen in the lodes belonging to the group in which the copper ore deposits are classified. Whether it is completely absent from these lodes cannot be decided without systematic and minute examination.

The most prominent metallic constituent of both groups—pyrite—shows well-marked crystallographic features common to both classes.

The most prominent non-metallic constituent of the two groups is quartz.

At one point immediately to the south of Specimen Hill, on Mineral Lease 4132-M, a little work has been done upon a complex lode-formation, which appears to carry vein-matter of type intermediate between the two main groups. The small amount of ore exposed in these workings shows the presence of pyrite, arsenopyrite, wolframite, chalcopyrite, magnetite, and small quantities of gold and silver, in a gangue of quartz and garnet. Such a combination was not observed in any other part of the region. It appears to be a true passage-type, rather than to constitute an essentially different type. The brown garnet, which was observed in small quantities, is the only mineral unrecognised in other groupings.

(2) *The Minerals Produced by the Secondary Alteration of the Lodes.*

(*a*) *The Copper Lodes.*—The lodes of which the primary composition has been described have all suffered some alteration at or near the surface, and as a result have

either lost some portion of their primary contents or acquired some new minerals in the place of those of primary origin.

The Outcrops.—The actual surface outcrops of a copper lode may show no copper-bearing minerals whatever, even though an actual shoot of ore may have originally occuppied the position of the present outcrop. This phenomenon is caused by the somewhat ready solubility of the copper ores in surface waters as soon as the sulphides are oxidised to sulphates. The pyrite is also removed by the operation of these processes from the majority of the lodes.

In some cases, where pyrite has been more than usually abundant, a gossan has been formed; but the bulk of such residual masses of limonite is in every instance small.

The chlorite, even when abundant in the unweathered ore, is completely bleached in the outcrops, and cannot be recognised.

The former presence of the ferriferous dolomite and pyrite in the lodes is shown by the forms of the cavities remaining in the quartz, which is, of all the vein constituents, the most resistant to chemical and mechanical disintegrating processes.

The quartz outcrops are therefore usually quite white in colour and cavernous in texture in the cases where the original lode has contained metallic ingredients. The careful investigation of the form of the pores or cavities in the quartz will in most cases enable a decision to be found as to whether the dissolved minerals possessed crystal boundaries or not. Where the negative moulds of crystals are well preserved it is to be noted that these are in no case the traces of original cupriferous minerals, since these minerals have not been observed to be present in crystal forms in any part of the field, nor are the forms assumed by the crystallised copper minerals those which correspond to the cavities preserved in the quartz.

The outcrops of those lodes, or portions of lodes, which have held no considerable proportion of metallic ingredients are dense massive quartz or quartzite, according as the vein-matter constitutes the filling of a fissure or the intimate impregnation of a belt of shattered country.

These differences between the outcrops of metalliferous and non-metalliferous lodes need careful attention from prospectors and companies planning work upon unprospected lodes. There is no reason to expect that a massive

quartzose lode in which there are a few cavities bearing evidence of the former existence of pyrite will, at a depth of a few feet below the surface, become rich in copper.

Still less probability exists of a sudden rise in the value of a lode which consists solely of massive quartz or quartzite and carries no solution cavities at all. While it must be remembered that at any time a primary ore-shoot or one which has been enriched by secondary processes may be encountered within the limits of such lodes, it is absurd to regard every outcrop of quartz as the leached capping of a copper-bearing lode.

Where actual shoots of copper ore are found, these extend practically to the surface, although partial leaching of the lode-contents may extent downwards for over a hundred feet. The completely-leached zone is always shallow.

New Minerals Produced.—The metallic contents of the lodes are gradually oxidised and pass into solution in the surface waters. Some portion of the dissolved matter undoubtedly thus finds its way by more or less direct surface channels to the sea. Part of the surface waters, however, having taken some mineral material into solution gradually seep downwards through the upper portion of the lode and the neighbouring country-rock. The paths followed are either channels already dissolved in the metallic portions of the lodes or the numerous fracture-planes and crevices which extend downwards to shallow depths. The principal part of this descending meteoric water would seem to have been restricted to the channels of solution within the lodes themselves. Within these channels the metallic contents leached from the upper portions of the lodes have been redeposited at greater depths. Oxidation, solution, and redisposition have been constantly in progress at the same time. The humidity of the climate is such that any accumulation of oxidised ore has been prevented. Solution has continually proceeded *pari passu* with oxidation. At the same time the dissolved matter has not been entirely transported away in the seepage water.

Mere traces of minerals characteristic of the uppermost altered zones of copper lodes are found. There is very little native copper present in the upper portion of any lode in the district. It has been seen in rare cases by reliable observers, but the writer was unable to detect any during his visit to the field. No cuprite can be said with

certainty to have been found, although it has been reported to be present. The blue and green carbonates of copper—azurite and malachite—occur only as stains or insignificant encrustations upon other lode constituents. Their value as indications of the presence of copper is great, but they do not at any known point make material contribution to the bulk of the ore.

The forms in which the copper-bearing seepage waters redeposit their mineral matter are not quite constant. The new minerals formed are covellite, chalcocite, and bornite. Perhaps also some of the chalcopyrite is of secondary origin. Covellite is characteristic of the whole field. It is almost invariably found in thin films or veinlets in the altered lode-matter, and possesses always the indigo-blue colour which is its most prominent feature. The films are seldom thick enough to separate cleanly from the rest of the lode-matter, but at one place in the Murray Bros.' Reward Mine it has been found massive and apparently pure. This massive covellite shows the characteristic cleavage, but no crystal faces. Chalcocite is found at a number of places in small quantities, and is readily visible in the ore obtained from the Balfour Mines Development Company's lease, 3566-M. Both here and in the Messrs. Murray Bros.' Reward Mine it forms veins in the lodes which also carry chalcopyrite and covellite. Some of the ore obtained from the Development Mine and containing traces of chalcocite displays little other sign of the operation of secondary processes.

Bornite has been observed in traces in the workings of the Mt. Balfour Copper Mines.

How far chalcopyrite represents the primary copper contents of the lodes in which it occurs cannot be quite definitely determined until at several points workings have exposed ore which is unquestionably of primary origin. Chalcopyrite is known to occur in some parts of the world as a secondary constituent of copper lodes. In the opinion of the writer at least the greater part of the visible chalcopyrite in the lodes of the Mt. Balfour copper field is primary. This opinion is based on observations upon the mineral constitution and texture of those exposed portions of the copper lodes which are apparently the furthest removed from superficial alteration, and on the comparison of this apparent primary ore with that which clearly shows signs of secondary modification.

The chalcopyrite seems to have been present in almost every specimen which now shows covellite. The majority

of covellite-bearing lodes carry this mineral as a coating or replacement of chalcopyrite, which may almost invariably be found beneath the thin veneer of covellite. In the high-grade lode-stuff of the ore-shoot which has been worked on the Murray Bros.' Reward Mine the copper contents are for the most part contained in this chalcopyrite-covellite admixture, which results from the incomplete alteration of chalcopyrite. These remarks apply also to the ore won from the Central Mt. Balfour Copper Mines, the Balfour South Copper Mines, and the Balfour Consolidated Copper Mines.

In one or two cases the writer observed the apparent partial replacement of crystallised pyrite by covellite; but these occurrences are quite exceptional. The pyrite remains quite unaltered in the majority of cases, and the complex crystals of yellow pyrite retain their outlines in the midst of chalcopyrite, which has been largely converted into covellite. The yellow rounded forms of the pyrite in the deep-blue copper ore give the ore hitherto obtained in the Balfour district a characteristic appearance.

Should these expressed opinions of the writer with regard to the primary origin of the most part of the chalcopyrite be correct, development work at deeper levels than any hitherto obtained may be confidently projected by those companies which have located ore-shoots. For the writer holds the view that the shoots of secondarily-enriched ore contain a basis of primary ore which itself carries appreciable copper values; the change from the primary into the secondary character being most often that involved in the transformation of chalcopyrite into covellite.

No little interest will be taken in the development of the present mines at greater depths, for the information thus to be gained with respect to the depth to which enrichment of the lodes has been effected will be of importance to the rest of the field. The character of the ore obtained from a depth of 50 feet below the level of the button-grass on the Messrs. Murray Bros.' Reward Mine is identical with that from higher levels. It is, of course, not exceptional to find secondarily enriched ore for some distance below the surface. Copper lodes are commonly found to exhibit a zonal distribution of their constituent minerals. Beneath the superficial gossan or leached capping usually lie the oxidised ores—carbonates and oxides—which give place to secondary sulphides at

or about the level of the ground-water. This ground-water surface is by no means a plane surface. It may be defined as the surface including the points to which surface or meteoric water will rise in any opening which exists or is made. The upper portion of the earth's crust is a much-fractured region, and the fractures, fissures, and joints of all kinds, together with the pores or interstitial spaces between the rock constituents form a complex basin through which the meteoric water circulates. Hence the ground-water in the deeper parts of this basin is effecting the same alterations as are in progress in the more shallow parts, though more probably at a slower rate. The secondary sulphides are therefore found both at and below the ground-water level, and may extend downwards as far as any crevices, joints, solution cavities, or other superficial openings will permit the meteoric water to descend.

The rainfall on the Mt. Balfour field is sufficient to maintain the water-level almost at the surface, and for this reason alone the oxidised ores are not developed to any degree. The deepening of the main channels whereby the rainfall is carried off to the sea tends to lower the water-level throughout a region which is undergoing dissection. The denudation of the lode-bearing areas, on the other hand, tends to reduce the interval between the surface and the water-level.

The surface of the ground-water is found in most cases to follow approximately the topographic contours of a district, but to approach more nearly to a plane surface than do the actual outlines of the region. Thus, the water-level is closer to the surface at any point in a valley than it is beneath a hill or ridge.

Hence, on the Mt. Balfour field, the outcrops which follow the ridges may be leached at the very surface, but it is invariably found that the water-level is not far below, and shallow workings encounter the ore which has undergone secondary enrichment, rather than ore which has undergone impoverishment. Undoubtedly in the course of time the relations of the water-level and the zones of ore to the surface vary. This will take place in such regions as that of Mt. Balfour, where dissection is partly selective, so that the lode ridges tend ever to stand out more prominently in relief above the less-resistant country-rocks. At the present time, however, dissection is not sufficiently far advanced in the peneplain region, nor has the period during which the existing inequalities have been developed in this region been of sufficient duration

for the water-level to sink deeply below the crest of the lode outcrops. In the case of the lodes which are situated above the level of the piedmont peneplain, progressive denudation has prevented the accumulation of secondary ores.

The gaps and gorges carved in the lode outcrops may in some cases reveal primary ore, but judgment on this matter should be reserved until more is known of the character of the primary lode-matter.

(*b*) *The Tin and Tungsten Lodes.*—The secondary alteration of these lodes is not of such importance as that which has effected the copper lodes. There are, however, a few matters worthy of attention.

The Outcrops.—At the surface the vein-matter is markedly cellular in texture from the removal of the most abundant primary constituent—pyrite—by oxidation and solution. The lode-formation at Balfour, as will be seen from the description in a later part of this report, consists of large numbers of narrow veins. These do not make an imposing outcrop which will compare with those of the lodes belonging to the copper-bearing group. There is loose quartz carrying tin ore and wolframite in the surface soil, and a few inches below this the narrow veins are to be seen *in situ*. The cavities in the oxidised veins left by the removal of pyrite are in many instances filled with kaolin and vegetable matter, but are sometimes empty. The metallic minerals remaining are only cassiterite and wolframite. These two minerals are with difficulty attacked by natural solvents, and remain with the quartz and white mica after the other metallic minerals disappear. Of the two the wolframite is decidedly the more friable. It possesses a good cleavage, and, occurring in tabular crystals, readily breaks up into cuboidal fragments bounded on two sides by cleavage-planes and on the remaining faces by parting-planes or irregular fracture surfaces.

In the vicinity of the Interview River there is practically no development of oxidised ore. The primary lode-matter is visible practically at the surface. The outcrops are concealed, and the presence of lodes can be determined only by the existence of the tourmaline-bearing quartz at the surface. The surface soil is shallow, and the ore occurs almost unaltered immediately below this thin cover. The mineral known as tungstite or tungstic ochre is to be seen upon the surfaces of some specimens of wolframite and scheelite, but is insignificant in amount.

The shoots of ore in the tin and tungsten lodes in the Mt. Balfour field are therefore not due to the secondary transference of any material part of the minerals constituting the ores of these metals from upper portions of the lodes, as in the case of the covellite ore of the copper group.

There may be a relative enrichment in tin ore or wolframite in a given weight of ore at the surface, owing to the removal of other heavy metallic minerals such as pyrite, but the valuable metals themselves undergo no chemical concentration. They are notably stable under normal conditions of weathering, and mechanical disintegration of the lodes has intervened before any marked oxidation of the wolframite has taken place.

(3) *The Alteration of the Wall-rock of the Lodes by the Mineral-bearing Solutions.*

It has been found, by means of prospecting operations upon the lodes beneath the surface, that the country-rocks immediately adjacent to the lodes have acquired characteristics which they do not possess at a distance from such lodes. It is confidently inferred that the acquisition of these characters is due to the chemical activity of the mineralising solutions at the time of primary ore-deposition. Through the operation of these solutions changes have been wrought which entirely alter the appearance of the rocks through which the veins pass. The alteration is not constant in extent, but varies to no small degree along a single vein, and different kinds of alterations are effected at various points along lodes which are in all other respects similar.

The most common alterations are marked by the addition of silica and chlorite to the slates. This kind of altered country-rock is that to which reference has been made above as being itself closely related in character to the lodes carrying copper ore, and even merging into them.

The silicification of one or of both walls is very common wherever the copper-bearing lodes occur, and in many cases there is no accompanying development of chlorite.

Sericitisation of the slate is very marked at quite a number of points. The soft sericitic aggregate has caused a little trouble in mining, since it is sometimes so incoherent as to run when penetrated by the workings.

Hematite, in a small number of instances, is disseminated through the country rock. The best example occurs in Section 2700-M, held by the Mt. Balfour Copper Mines, where the workings on the smaller south-western lode show the footwall side of the lode to be so heavily charged with hematite as to possess a deep-red colour. The same characteristics are shown by the country-rock enclosing the main lode on Section 3922-M, on the Interview River.

Graphite is occasionally present to a notable extent in the country-rock enclosed within the broader portions of the lode-fissures, to which reference has been made above, and less frequently in the country adjoining the more compact lodes. The presence of graphite does not bear any relationship to the amount of copper present in the lode. Thus, notable graphitisation has taken place where copper ore is present in the principal underground workings of the Mt. Balfour Copper Mines and on the Pierpont Morgan lease, 3639-M; and where copper ore is absent on the Mt. Balfour Extended Copper Mines Section 4214-M, and the Mt. Balfour United Syndicate's Section 4268-M.

The country-rock of the tin and tungsten lodes does not show such variability of character. Where these lodes traverse the slate country silicification of a narrow strip in immediate proximity to the veins is usually to be noticed. With the silica pale mica is sometimes associated. This mica is occasionally found in spheroidal or ellipsoidal aggregates in the quartzite.

The granite enclosing the veins in the neighbourhood of the Interview River is always considerably altered. The felspar is replaced by pale-coloured mica, which, with quartz, forms the bulk of the rock. Stellate aggregates or rods and needles of tourmaline are distributed through this altered granite. The extent of this alteration into greisen could not be ascertained in any single case for want of exposures. It appears, however, to be considerable, and unequal on the opposite sides of the vein-fissures.

(4) *Comparison between the Mineralogical Composition of the Lodes of the Mt. Balfour Field and that of Lodes in other Western Tasmanian Mining Fields.*

It is a matter of no little interest to find that the mineralogical features of the copper lodes of the Mt. Balfour field are reproduced in a number of other mineral fields in the western portion of Tasmania.

The principal feature which attracts attention in this way is the recurrence of copper ores in association with hematite and magnetite. These aggregates of copper and iron-bearing minerals are peculiarly characteristic of the whole of Western Tasmania. They are best developed along the mineralised zone which coincides with the West Coast Range, and are found from Mt. Farrell to Mt. Darwin. The grouping of these minerals in the same areas is well marked, even if, as happens in some cases, they are found in separate lodes or shoots.

The association of copper ores with hematite or magnetite, or both, has been officially recorded by the Geological Survey from the following localities:—Mt. Farrell (1), Red Hills (2), Mt. Lyell (3), Mt. Huxley (4), Mt. Jukes (4), and Mt. Darwin (4), and even in the vicinity of Point Hibbs (5). It is also to be noted that in the Dial Range there is the same close association of lodes carrying copper with those carrying iron (a). And again in the Blythe Mineral Field (b) the hematite and copper-bearing lodes are closely associated.

Stibnite has been found in association with copper ores at Port Davey, on the south-west coast; and some stibnite has been found also at Hall's Creek, near Lynchford (c).

Wolframite has been found in small amount in a number of places in Western Tasmania accompanying the stanniferous veins. Thus, it has been recorded from the vicinity of Mayne's Mine, and of the Federation Mine, at Heemskirk (d), from the Oonah Mine at Zeehan (d), the Mt. Bischoff Extended Mine at Waratah, and the Mt. Black Proprietary Mine (e) at Rosebery. In the Middle-

(1) *Vide* W. H. Twelvetrees: "Report on the Mt. Farrell District," 1900, pp. 22-23; also Geol. Surv. Tas. Bulletin No. 3, pp. 51 and 53.

(2) *Vide* W. H. Twelvetrees: "Report on the Mineral Districts of Zeehan and Neighbourhood," 1900, pp. 98-103.

(3) *Vide* A. Montgomery: "Report on the Mt. Lyell Mine, County of Montagu," 1893.

(4) *Vide* W. H. Twelvetrees: "Report on the Mineral Districts of Mounts Huxley, Jukes, and Darwin."

(5) *Vide* G. A. Waller: "Report on some discoveries of Copper Ore in the Vicinity of Point Hibbs," 1902, p. 2.

(a) *Vide* W. H. Twelvetrees: "Report on the Dial Range and some other Mineral Districts on the North-West Coast of Tasmania," 1903.

(b) *Vide* W. H. Twelvetrees: Report on the North West Coast Mineral Deposits," 1905, pp. 35-47.

(c) *Vide* "The Progress of the Mineral Industry of Tasmania," Reports for the Quarters ending March 31st and June 30th, 19 7.

(d) Geol. Surv. Tas. Bulletin No. 8, 1910, Plate II.

(e) *Vide* G. A. Waller: "Report on the Ore Deposits (other than those of Tin) of North Dundas," 1902.

sex district wolframite has been mined at the All Nations (now Lady Barron) and the Shepherd and Murphy Mines (1).

B.—THE GEOLOGY OF THE LODES.

(1) *The Distribution of the Primary Ore-deposits.*

When the copper lodes of the field are reviewed in a group it is found that they are all enclosed within walls of either the Balfour slates and sandstones or the amphibolite dykes. None of the lodes of this type are known to occur within the granite, and the basaltic lava flows and the sand dunes can be seen to overlie portions of the lodes thus classified.

The copper lodes do not occur within the areas in which tin ore and wolframite veins are found. Chalcopyrite may occur within such areas, but in such cases it occurs only as an accessory constituent of a vein-type distinct from the normal copper-bearing type and the variants of this type, which have been mentioned above.

The veins thus grouped are distributed over an exceedingly large area, the northern limits of which are, according to the present state of our knowledge, the sections on the Nelson River and those adjoining the North Mt. Balfour Mine on the Frankland River. On the west the copper-bearing region extends to the coast-line, in the vicinity of Temma, and on the east it reaches almost to the Donaldson River. The interval between the lodes located in the Norfolk Range and those on the Interview River is not absolute, since a number of quartz reefs, similar to those in the immediate vicinity of Balfour and, as has been explained, genetically related to the copper lodes, are to be seen in the intervening country.

Beyond Elliott's Reward these lodes with strong quartz outcrops extend eastwards and southwards for a short distance, but disappear as the Donaldson and Pieman Rivers are approached.

These are a few scattered reefs of white quartz between the western front of the Norfolk Range and the sea. These do not offer any inducement to prospectors.

It cannot be said that the distribution of the majority of the copper lodes corresponds in any more than a general way with the direction of orientation of the granite *massif* at the present surface. A rough parallelism between the

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

area mineralised with copper and the great dyke-like mass of granite is all that can be said to exist. The orientation of the separate copper lodes or groups of lodes does not correspond in any manner with this general direction.

The cassiterite and wolframite lodes occur in two localities, one of which lies within the boundaries of the granite and the other within the Balfour slates and sandstones. It is noticeable, in view of the latter occurrence, that the lodes found in the North Pieman granite in the vicinity of the Interview River have not been traced out into the surrounding sedimentary rocks. It is true that very little prospecting has been carried on in this area, and there are not known to be any alluvial deposits in the streams which traverse this country which lies to the east of the granite. Search for vein-matter to the east of the granite is desirable.

The absence of granite or granite-porphyry from the stanniferous area at Balfour is noteworthy, but is not without parallel.

This latter area lies to the west and south-west of the Balfour township, and is distant from it a quarter of a mile to a mile. The nearest outcrop of granite, at Sandy Cape, is 12½ miles away.

(2) *Comparison between the Mode of Occurrence of these Ore-deposits and that of Other Similar Ore-deposits in North-Western Tasmania.*

The general association of copper-bearing lodes with lodes of iron ore in the vicinity of an outcrop of Devonian granite is not restricted to the Balfour field alone.

A precisely similar association is known to exist in the neighbourhood of the Dial Range. The Devonian granite *massif* which outcrops at the southern end of the Dial Range lies in close proximity to the Blythe Iron and Copper Mines (1), Rutherford's Copper Mine (2), the Penguin and Dial Range (3) iron mines, and the copper mines at the Dial Range (3) and Gunn's Plains (2).

It is also noticeable that all of these latter ore-bodies are found within the boundaries of the Cambro-Ordovician

(1) W. H. Twelvetrees: "Report on the Blyth River Iron Ore Deposit," 1901.

(2) Geol. Surv. Tas. Bulletin No. 5.

(3) W. H. Twelvetrees: "Report on the Dial Range and some other Mineral Districts on the North-West Coast of Tasmania," 1903; and W. H. Twelvetrees: "Report on North-West Coast Mineral Deposits," 1905.

rocks. But there is a marked difference between the Cambro-Ordovician group at Balfour, in which igneous rocks are not well represented, and the group of like age in the Dial Range district, where the igneous types are abundant and varied.

The general geological features of the Balfour Field and the mineralised belt extending from Mt. Farrell to Macquarie Harbour along the axis of the West Coast Range cannot be closely compared, as far as the distribution of ore-bodies and lithological types is concerned. There are, however, reasons to believe that the Devonian granite may yet be found at some point or points along the line of the West Coast Range. No detailed examination of the area has yet been undertaken, save at a few localities.

As regards the tin and tungsten lodes, many occurrences similar to those which have been found within the limits of the granite *massif* of the Interview River district are known where other outcrops of the Devonian granite or its apophyses are situated. There are not, however, parallel cases in which tin ore and wolframite are situated so far from the visible acidic igneous rocks as they are at Balfour. The only occurrence which may be in any way compared with that of Balfour is that mentioned above, of wolframite at the Mt. Black Proprietary Mine, at Rosebery. At the latter place acidic dyke rocks are reported to have been recently discovered, but the news has not yet been officially confirmed.

(3) *The Structural Features of the Lodes.*

There are some striking differences of structure between the copper lodes and those in which tin ore and wolframite occur, and it will be found convenient to consider the two groups apart.

(*a*) *The Copper Lodes.*—These lodes constitute the filling of fissures or fractures in the rocks in which they occur, and are commonly tabular in form, after the manner of those which are usually referred to as "fissure veins."

The following description of the structural features contains an account of all the lodes which are believed to belong to the copper-bearing type, whether they have been actually proved to carry shoots of copper ore or not. The adoption of this course does not imply any generalisation other than that which has been made with regard to

the mineralogy of the vein-type. And, since no relation between the physical features of the lodes and their copper contents can be traced, there can be no objection to the consideration of the structure of the copper-bearing portions of the lodes at the same time with that of the non-cupriferous gangue.

The fissures utilised by the mineralising solutions at the time of ore-deposition are planes of fracture and actual dislocation. Where simple fractures have been made in the slates correspondingly simple lodes result. But in a number of different places the crustal fracturing has affected a broad zone. The simple fissure has in such instances been replaced by a broad sheeted zone, and the impregnation with vein-matter has followed the course of the many component fractures of the zone. These broad fracture-zones may carry cupriferous minerals, or they may contain only gangue minerals. In no case has the relationship between the fracture-zones and the more simple portions of the fissures in which they lie been exposed by underground workings. As examples of these zones, mention may be made of the vein-matter encountered in the tunnel driven westwards in the north-western portion of Messrs. Murray Bros.' section 2149-M, and of the lode which is being opened up at the principal workings of the Mt. Balfour Copper Mines. In addition to these cases, in which the filling of actual fractures has taken place, there are a very large number of instances of the impregnation of the country-rock, and especially of the sandstone beds. The mineralisation of these beds has been achieved by the addition of the constituents of the veins. The country-rock has been silicified and chloritised, and impregnated with pyrite throughout its entire mass in such a manner that a dense green quartzite studded with crystals of pyrite has been produced. These bands of impregnated country possess in many cases prominent outcrops, which are usually bleached white and are pitted with cavities formed by the solution and removal of the pyrite. In some instances these broad indefinite zones of altered country-rock merge into well-defined veins. No cases have yet been found in which copper is associated with the silica, pyrite, and chlorite of the quartzites produced in the manner explained. Traces of gold and silver have been obtained by assay, probably from the pyrites of the quartzite. Veins which represent the actual filling of fissures do certainly occur within the zones of impregnation, but are usually quite insignificant in size and importance.

The vein-fissures, in the majority of cases, traverse the bedding-planes of the slates and sandstones at an oblique angle. The angle is at times small, but when any fissure is followed for any distance it is clear that there is no coincidence with the bedding. In the cases of the impregnated zones of country, bedding-planes do exert a controlling influence, since the cavities occupied by the mineral matter introduced in solution have been the pores or interstitial spaces between the component grains of the coarser beds.

In very many instances, where there is apparent conformity between the dip of the vein and that of the country on one side of it, there is marked discordance when the dip of the opposite wall is examined. This want of agreement in dip, and sometimes also in strike, between the country-rock forming the two walls shows clearly that these fractures now filled by the vein-matter are actual planes of dislocation. Fragments with angular outlines, formed by the rubbing of one wall on the other during dislocation, are often to be seen cemented into the vein-matter.

When the endeavour is made to follow a given lode along its strike for any considerable distance no little difficulty is experienced. Some of the smaller lodes do not possess very prominent outcrops, and cannot be traced far on account of the surface cover of peat. These appear to be either branches of the principal lodes or to be entirely distinct from them.

Nor are the larger outcrops less perplexing, for it is characteristic of the field that abrupt changes in the line of strike of the principal lodes take place, and that where the change of strike occurs there is a break in the continuity of the lode. These characteristic breaks and bends are nevertheless not of such magnitude or importance that the several portions thus separated may not confidently be referred to one general direction of fracture. At the breaks, in one or two places, some work has already been done, but not enough to determine the details of structure. These matters will more readily be understood when the main ore-shoot of the Messrs. Murray Bros.' Reward Mine has been further opened up, and when more exploratory work has been done at both ends of this shoot. Small and apparently disconnected bunches or lenses of ore have been found where these breaks occur, and have rendered the task of prospecting an exceedingly trying one. The workings at the south end of the Central Mt. Balfour Copper Mines Section 2177-M have partly exposed a number of these lenses, the discontinuity of which has

been the cause of great disappointment. Beyond the area in which the breaks occur the lode maintains regular structural conditions.. It is to be borne in mind that, in such cases as have been mentioned, the length over which such irregularities of structure prevail is in all cases small when compared with the length of the continuous lode-matter. In the prospecting of lodes which possess these characteristics it will be best to conduct exploratory work in the larger members of the lode-systems and to establish connections through the zone in which the breaks occur at a later date. Otherwise much time and energy may be wasted in the attempt to determine the course of the continuation of a lode which has given place, in the broken zone, to several lenses the extent of which is unknown.

In a few other cases there are found discontinuous lines of lodes, in which the several component parts along the general direction of fracture are arranged *en échelon*. This is the predominant feature of the unprospected lodes which outcrop along the scarp of the dissected peneplain to the west of the upper Nelson River, notably in Sections 4437-M, 4171-M, 4172-M.

With these reservations regarding the absolute continuity, mention may be made of the actual length of the known lines of fracture in the Balfour field. The longest is that on which the principal lodes worked on the Messrs. Murray Bros.' Reward Mine, the Central Mt. Balfour Copper Mines, the Mt. Balfour No. 2 Mine, the Murray Bros.' Section 3955-M, the Mt. Balfour Copper Mines, and the North Mt. Balfour Mine are situated. Between its furthest proved extremities this line extends for a length of 6½ miles. There are other lines which are of notable length in addition to this one. The lode-matter on the escarpment of the peneplain to the west of the upper Nelson River occurs in overlapping lenses for a length of 2½ miles. The line of lode upon which the Mt. Lyell Company is working in the vicinity of Doherty's Pimple appears to be practically continuous for a length of 3 miles. The Poseidon line of lode, at the head of the Lindsay River, extends for 1½ mile. There are many others which transgress the boundaries of single leases.

The direction of strike of the lodes is far from constant throughout the field. Each lode must be treated apart, and, as has been already indicated, variations take place on a single line of lode. Nevertheless, by reference to the maps, it will be seen that the majority of the lodes in the northern and central portions of the field have a tendency

to strike in directions lying between north-north-west and west-north-west. In the district drained by the Toner River the strike is usually between 10 and 25 degrees south of east and north of west. Round Elliott's Reward Mine, on the Interview River, no general uniformity of strike can be recognised.

In the same way the dip is always a matter for determination with regard to each lode separately, and in the majority of cases it is impossible to say what the dip is for want of underground workings. In those cases in which observations have been possible the prevailing dip has been to the south-west or south, according to the strike of the lodes. The variations from this general direction appear to be only local. The lodes are steeply inclined, usually at an angle of from 75 to 85 degrees from the horizontal.

No single instance was observed of one vein intersecting another, though in several places veins with very different directions of strike abut against one another. The most noteworthy examples occur in the area worked by the Mt. Lyell Company on the Lindsay River, in Sections 3483-M and 3605-M, in the principal underground workings of the Mt. Balfour Copper Mines on Section 2698-M, and on the north-eastern slopes of Mt. Balfour within Section 4238-M.

These phenomena appear to imply that there was one main period of earth-fracturing, during which the yielding of the crust in some places took place along two or more directions at the same time. The identical character of the material filling the fissures, of which the strike directions are different, strongly supports the view that mineralisation has taken place at one period only.

In several instances a shoot of ore or mineralised quartz vein has been located within the boundaries of formations which have very different strikes from that of the shoot or vein. This feature is shown by a vein followed in the tunnel workings situated in the north-western portion of Messrs. Murray Bros.' Section 2149-M; and also, in all probability, by the shoot of rich ore worked on the Balfour South Copper Mines' Section 3676-M.

(*b*) *The Tin and Tungsten Lodes.*—Very little work has been done upon the lode-matter containing tin and tungsten, almost all the prospecting carried out having been directed towards the discovery of alluvial material. This alluvial ore has been followed till it gave place to detrital ore, and the weathered outcrops of the lodes themselves have been broken in a few cases. Beyond this no system-

atic work had been done to prospect the lodes at the time when the writer visited the field.

Since there are some differences between the structural features of those lodes which are enclosed within the granite boundaries and those which occur in the slate at Balfour, the discussion of the two occurrences is separated. Within the boundaries of the granite *massif*, in the district lying to the north of the Interview River, very little information could be gathered at the time of the writer's visit. Old workings had fallen into disrepair and been overgrown with scrub. Such excavations as are available for examination are quite small, and have never sufficed to reveal the extent of the shoots of ore which have been prospected. The principal exposures lie on Section 5121-M. At this place the principal shoot has a strike direction of N. 35° E., and other smaller bodies in its vicinity are approximately parallel to it. The different makes of ore constitute a series of imbricated lenses. The orientation of the series is not perfectly certain, but apparently lies along a direction striking a few degrees west of north. Along a line with this direction, at least, there are a number of occurrences of similar lode-matter for a total distance of $1\frac{3}{4}$ mile. From information received with regard to the results of further prospecting operations since the writer's visit to the locality, the structural features obtaining in the most northerly section, 5120-M, are similar to those mentioned for Section 5121-M.

The lodes carrying tin ore and wolframite, in the neighbourhood of Balfour, are small but numerous, and are distributed over a wide area. Together they constitute a great stockwork, in some parts of which the veinlets are closely crowded together, and in other parts more widely spaced. The exposed veins are all narrow, one with a width of 9 inches being exceptional; and those from $\frac{1}{2}$-inch to 3 inches in width being common.

The number of these veinlets, of which the angle of dip is under 20 degrees, is large, and many are almost horizontal. In quite a number of instances these flat veins branch into two or three smaller veins.

There is no agreement between veins and the bedding-planes of the slate or sandstone which they traverse. The sedimentary rocks have been shattered, and the broken blocks dip in all directions. The veins have no constant direction of dip, yet a number of them dip to the south and south-east.

The more nearly vertical components of this complex stockwork have not yet been followed to any depth below

the surface. There cannot be any doubt about the vertical continuation of the lode-matter downwards. Mining operations have, however, ceased as soon as pyrites has made its appearance.

C.—THE SECONDARY ORE-DEPOSITS.

These ore-deposits result from the disintegration of the primary deposits and the subsequent concentration of their metallic contents. Only such constituents of the primary lodes may be found in the secondary deposits as are at the same time not easily dissolved in surface waters, sufficiently heavy to be separated by the natural processes of sorting from the associated gangue minerals, hard enough to withstand attrition, and free from those partings or cleavages which assist the work of disintegration.

None of the constituents of the copper-bearing lodes of normal type satisfy these conditions. The magnetite, which is found in a few cases in abundance, is not known to contribute largely to the alluvial deposits.

The tin and tungsten lodes, however, do contain normal constituents which fulfil the requirements to different degrees. Cassiterite is notably endowed with the properties stated, and therefore appears as the most abundant metallic constituent of the secondary deposits. Wolframite is as heavy, but is not so hard nor so resistant to chemical alteration. Moreover, it is friable, and hence apt to be reduced to a condition of the finest slime, which is certainly the state in which its chemical alteration is most rapidly effected.

The alluvial deposits, wherein the durable constituents of the lodes have been transported from their source and deposited in the creek beds, contain cassiterite at points which are distant from the lodes.

These alluvial deposits merge on the hill-sides into residual or detrital deposits, from which the lighter gangue minerals have been washed away. There remain in the detrital deposits both cassiterite and wolframite, where both minerals have been present in the original lodes. It is noticeable that the wolframite does not survive to contribute to the alluvial deposits, and the tin concentrates obtained in mining are remarkably pure in consequence.

None of the sulphides are found in the true alluvial or detrital deposits, but are found as soon as the cappings of the lodes are broken into.

These remarks apply equally to the tin and tungsten lodes, which occur in either the slate or granite country.

The alluvial deposits worked in the vicinity of Balfour are invariably shallow, a depth of 7 feet being unusual in most of the workings. The tin ore is not evenly distributed, the richer patches being found in pot-holes and gutters in the uneven floor of the creek-bed. The wash on the higher ground above the present creek-beds is firmly cemented, but that occurring at a lower level is not firmly compacted.

There are no features with regard to these deposits which call for special mention. The tin ore of the wash is in almost all cases very pure, but in the neighbourhood of the lodes there are numerous subangular fragments of vein-stuff, in which the cassiterite is associated with quartz. This material appears among the forkings, where it is stacked as waste, since there is no means of dealing with it at the present time.

The principal alluvial workings are to be found in the valley of Tin Creek, where mining has been in progress for 20 years. Some tin ore has been won from Emmett's Creek, which does not now contain within its watershed any ground bearing tin lodes. This seeming anomaly is due to the fact that there has been within comparatively recent times a movement of the divides between the creek basins, and Tin Creek now drains the whole of the area within which the tin lodes occur.

Remnants of older river gravels, in which some tin ore occurs, are preserved in the vicinity of the Balfour township beneath the basalt. These deposits, however, have not been profitably worked.

In the Interview River district the alluvial tin ore deposits worked are restricted to the small creeks which run towards the sea. These have not been worked to any great extent. At the time of the writer's visit to the district there was no one there engaged in mining of any kind. The inspection of old workings gives the impression that the shallow alluvial deposits are restricted to the immediate vicinity of the lodes.

D.—THE GENESIS OF THE ORE-DEPOSITS.

In the discussion of the source of the ore-bodies of the Mt. Balfour mining field it is essential that the genesis of those ore-bodies which are mineralogically and geologically cognate be kept constantly in view. The conclusions which may be drawn with regard to one field are more likely to be accurate if they prove adequate to explain the cognate occurrences elsewhere, due allowance being, of course, made for

variations of different kinds due to local causes. And, while the phenomena presented by the Mt. Balfour mining field may thus serve to explain certain features of other Western Tasmanian mining fields, the information which has been gained with regard to the latter materially assists in the understanding of the occurrences at Mt. Balfour. In other words, the mode of genesis of the lodes in the region under discussion cannot be determined by purely inductive reasoning from the evidence of that restricted area.

The full genetic history of the Balfour lodes cannot be ascertained from that region alone, for the reason that there are so many serious gaps in the record of the geological history of the region. Reference has been made above to these intervals during which no deposition of sedimentary material has taken place in the region. In the absence of a fairly complete succession of such sedimentary deposits the distribution of the ore-bodies in time (*i.e.*, the metallogenetic epoch) cannot be determined without appeal to the surrounding regions. The distribution of the ore-bodies in space is, on the other hand, a matter which is concerned with the geological structure of the particular region itself. Yet, where the geological structure is obscure, the conclusions arrived at for other regions afford valuable assistance towards the solution of difficulties.

It has been already pointed out that there is reason to believe that the tin and tungsten lodes are genetically related to the copper lodes, for there are certain mineralogical characteristics common to both groups, and in at least one place a type intermediate between the two has been exposed. The general principles which govern the separation into different vein-types of metallic compounds emerging from a common source have been already discussed in a publication of the Geological Survey (1). A zonal arrangement of types may result from the operation of the laws controlling precipitation, and this zonal distribution has been claimed for the Heemskirk-Comstock-Zeehan district (2).

The writer would ascribe the distribution of the tin and tungsten lodes relatively to the copper lodes of the Balfour field (3) to the operation of the principles which

(1) Geol. Surv. Tas. Bulletin No. 8, 1910, pp. 56-60.
(2) *Ibidem*, pp. 63-67.
(3) Cf. the distribution of tin-ore and copper-ore in Cornwall. H. H. Thomas and D. A. McAlister: "The Geology of Ore Deposits," 1909, Fig. 18, p. 89.

apparently caused the zonal distribution of the ores of the Heemskirk-Zeehan district. In the case under discussion, however, the manner of distribution is not so obvious.

In the vicinity of the Interview River it is at once seen that the tin and tungsten lodes are situated within the granite, while the cupriferous lodes lie beyond the igneous boundaries. This small district appears to the writer to afford the key to the occurrence near the township of Balfour, where the area containing the tin and tungsten lodes is enclosed within the larger area in which the copper lodes occur. It appears to the writer probable that there is some subterranean igneous rock mass of granitic type below the site of "Specimen Hill" (*i.e.*, below the area containing the tin and tungsten lodes) which has not been exposed by the sum total of the effects of erosion.

The distance of the exposed *massif* at Sandy Cape is such that it appears necessary to account for the ore-bodies (whether containing copper or tin and tungsten) of that part of the field which lies between Mt. Norfolk on the south and the North Mt. Balfour Copper Mine on the north by postulating the existence of another, but concealed, *massif*. This supposed *massif* may extend between the limits indicated, and possess some of the characteristics of a dyke, as does the exposed *massif* of the Interview River, yet another such intrusion may possibly lie beneath the Toner River district.

The hypothesis here advanced may at least be provisionally accepted in view of the fact, already briefly mentioned in this bulletin, that the great granitic intrusions of Western Tasmania appear to follow well-defined lineal directions. The writer has suggested that two such lines of intrusion extend, on the one hand, from the Heemskirk Range to Mt. Claude (perhaps even to Beaconsfield), and on the other from the Meredith Range to the Dial Range.

If it be granted that a concealed *massif*, with the outlines of a great dyke, lies beneath the principal field of mining operations at Balfour, and that the uppermost portion of this *massif* attains most nearly to the existing surface in the vicinity of Specimen Hill (three-quarters of a mile to the south-west of the township of Balfour) the relative distribution of the copper and the tin and tungsten lodes does not offer any anomaly. The distribution of the lodes in space is shown approximately by the location of the mineral leases. It will be seen by reference to the geological map that these leased areas extend along fairly well-defined directions, and have a much greater

length than width. The existence of these mineralised bands or zones is so marked in the case of the main portion of the field (*i.e.*, between Mt. Norfolk and the North Mt. Balfour Copper Mine), of the Whale's Head district, and of the Toner River district, that we may reasonably believe that the distribution of the ore-bodies in space is governed by—

(1) The position of certain lines or zones of crustal weakness.

(2) The invasion of these zones by the various consolidation-products of an acidic magma.

In ascribing the mineralisation of the region to the acidic magma (*i.e.*, the magma of which the acidic granite of the Interview River *massif* is in bulk the most important consolidation-product) the writer expresses once more the belief, already stated in other publications of the Geological Survey (1), in the genetic connection between the majority of the ore-deposits of Western Tasmania and this magma.

The mode of derivation of such ore-bodies from the igneous magma and the principles controlling the precipitation of the metallic ores have been fully explained with regard to the Heemskirk-Comstock-Zeehan region (2), and it will serve no useful purpose to repeat them here. It is sufficient to state that the epoch of ore-deposition in the Mt. Balfour mining field, as elsewhere in Tasmania, coincides with the final stages in the consolidation of the acidic magma. This epoch cannot be decided by the evidence afforded by the mining field under discussion, but is known, from field evidence obtained in neighbouring regions (3), to lie within the limits of the Devonian period.

Since that epoch no addition of mineral material has been made to the lodes. On the other hand, the ore-bodies have lost part of their metallic contents by chemical and mechanical agencies during the succeeding cycles of erosion. A small portion of the field may have been protected from erosion since Mid-Tertiary time by a cover of basaltic lava; but the igneous cover has for the most part been removed since the revival of the river-systems by the latest displacement of the strandline.

(1) Geol. Surv. Tas. Bulletin No. 6, 1909, pp. 40-42. Geol. Surv. Tas. Bulletin No. 8, 1910, p. 99.
(2) *Ibidem*, pp. 55-60.
(3) *Ibidem*, pp. 97-99.

(2)—The Relation of Geology to Other Industries.

Some brief discussion of certain economic features of the region other than those connected with the mining industry is here given, since the writer was inevitably brought in touch with these features during the examination of the field.

The areas in which the other industries are interested are as far as possible indicated upon the topographical map issued with this report.

It will be seen that the Government tramway now being constructed will serve these varied interests to the greatest possible advantage, and that it will assist materially in the mutual co-operation of the mining and other industries.

The various points to which passing reference is here here made are reviewed only from the geological aspect.

(*a*) *Agriculture.*—The soil which results from the disintegration of the older sedimentary rocks—the Balfour slates and sandstones—is almost invariably of the poorest description. The vegetation which clothes this region is consequently comparatively scanty. This is the more noticeable on account of the prevailingly dense character of the vegetation in the West Coast mining fields of Tasmania.

The areas in which there is a notable development of timber growing upon the rocks of this series are those in which the argillaceous, rather than the arenaceous, members of the series are developed, or those which are sheltered from the prevailing winds, viz., the gorges of the rivers and their tributaries. To this general statement there are many local exceptions, but the writer believes that the statement is on the whole true.

In marked contradistinction to this soil which covers the areas occupied by the sedimentary rocks is that resulting from the decay of the amphibolite dykes and the basalt.

The change of the vegetation at the boundaries of these igneous rocks is abrupt, and within the boundaries the growth is almost invariably dense.

The natural vegetation on the basaltic land is, without exception, luxuriant, even when the surrounding country is practically destitute of trees. For instance, the clump of big timber growing on the small basalt patch within the Mt. Balfour Copper Mine's lease is a prominent landmark visible for many miles. The development of the larger basaltic areas to the east of Temma has been ren-

dered slow through the necessity for removing this abundant timber. The soil is on the greater part of all such areas rich and deep, and adapted to the needs of the farmer.

At the present time there is little actual farming being done, the cleared and partially-cleared basaltic land being under grass in almost all cases. The basaltic soil at the Balfour township has attracted the population towards that particular part of the district.

The growth of native vegetation on the dykes of amphibolite is singularly pronounced. In the Toner River district, and again between the Interview and Donaldson Rivers, the open heath-clad country is traversed by narrow and continuous bands of heavy timber, which coincide absolutely with the directions of the dykes. In fact, but for the existence of these timber belts it would be almost impossible to follow the course of the dykes.

The soil is of a deep yellow colour where the dykes are decomposed thoroughly, and hence it is difficult to distinguish the soil of this origin from that belonging to the argillaceous members of the slate series. The areas occupied by the dykes are too small to be turned to account for purpose of cultivation, save in some rare places. For instance, the camping-place occupied by the Mt. Lyell Company's staff at the base of Mt. Frankland is situated on one of the weathered outcrops of this amphibolite.

The grazing leases which have been taken up along the coast do not carry much food for cattle, and are utilised chiefly in the winter time for turning out stock. Some 2000 head of cattle run over this coastal strip between the months of February and November. It is found necessary to remove them in the summer.

(*b*) *The Timber Industry.*—No attempt has yet been made to turn to account the timber of the region for any other than immediately local requirements.

It is true that the distribution of the timber is not very favourable to the establishment of export trade, but doubtless a commencement will be made when the Temma-Balfour tramway has been completed.

There is a coastal belt of timber, which varies considerably in width and which is not continuous throughout, along the western portion of the piedmont peneplain. In places along this belt, which includes the principal basaltic areas of the region, the timber appears to be valuable.

Beyond this coastal belt there is very little timber until the gorge of the Frankland River is reached. To the east-

ward of this river the whole of the country is covered with the normal timber of the western coastal region.

Two sawmills have been erected—one near the farm land east of Temma, the other near Balfour.

The timber which has hitherto been used for mining purposes has for the most part been obtained from the Frankland River gorge, where it has been hand-sawn in pits. That used for fuel has also been derived thence and from the valleys of the small tributaries of the Frankland River.

VI.—THE MINING PROPERTIES.

(1)—The Mining Properties near Balfour. (Plate IV.)

(1) *Messrs. Murray Bros.' Reward Mine.*

The mineral sections held in the joint names of Messrs. W. W. F. and T. C. Murray are many in number. On a few of them some active prospecting has been carried out, but a large number have apparently been taken up on account of the presence of prominent outcrops hitherto untouched. Of all these sections much the most important is that for which the earliest reward lease for copper was granted—123-M, of 80 acres.

Through this lease the main Balfour fracture-line passes. It is shown on the chart accompanying this report by a continuous line through the lease. The fracture has been proved to run right through the lease, and is essentially continuous, though it is, in more than one place, represented by two or more component parts, which are not visibly connected in the underground workings.

The first discovery of copper ore took place at the point where Tin Creek traverses the line of lode in the southern portion of the section. While the creek was low a little work done in its bed proved the presence of covellite, copper pyrites, and iron pyrites. A trench was then cut at a distance of a chain from the creek on its northern bank, and quartzose lode-matter carrying copper pyrites and iron pyrites was found. A shaft was then put down between this trench and the creek. The shaft attained a depth of 27 feet before water became too troublesome. Being sunk on the lode the shaft produced a little ore, which contained copper pyrites and a little covellite. Some 2½ tons of ore, carrying 5 per cent. of copper, from these workings were sent away.

The course of the lode was traced northwards along the ridge by the quartz showing at the surface, and a tunnel was driven from the eastern side of the ridge to cut the lode 52 feet below the surface. The No. 1 tunnel, driven westwards on a bearing of W. 16° S., crosses the bedding-planes of the country nearly at right angles. The slate is banded, and dark-grey to black in colour, striking between due north and N. 10° W., and dipping to the west at an angle of 80 degrees. The bedding is on the whole regular, but there is a slight contortion in a few places.

At a distance of 145 feet from the entrance a quartz leader carrying chalcopyrite, covellite, pyrite, and limonite was cut. This vein, which strikes N. 32° W., and dips south-west at 65 degrees, was followed south for 14 feet. It is 12 inches wide and carries both oxidised and semi-oxidised ore, some of which was sent to the smelters. The vein was recognised as being too small for the main lode, and the crosscut was continued westwards.

At a distance of 27 feet from the first vein the main lode was met with. Where cut it proved to be 12 feet wide, the good ore being on the hanging-wall side, and the rest of the lode being very siliceous. To test the full width of the formation the tunnel was continued westwards, and passed through black slate carrying stringers of quartz with which chalcopyrite, covellite, and pyrite are associated. One vein, distant 20 feet from the main lode, was followed northwards for 6 feet and southwards for 27 feet. It varies in width from 4 to 9 inches, and its contents are almost wholly oxidised.

The crosscut was continued still further in black slate carrying similar stringers of mineralised quartz. Work was suspended at this place, when it was determined to put in a low level tunnel from the opposite side of the hill.

The main lode was opened up on both the northern and southern sides of the No. 1 tunnel, and a rise was carried up to the surface from the point of intersection of lode and tunnel.

The north drive on the lode-channel shows the dip of the ore-body to be at 85 degrees to the eastward for a few feet, but thereafter to be to the westward. The lode, as seen in this drive, is in a semi-oxidised condition, and more or less honeycombed in texture, from the leaching away of some of its contents. Limonite, pyrite, chalcopyrite, and a little covellite are to be seen, and the surface of the exposed lode-matter is stained with copper sulphate.

At a distance of 50 feet from the tunnel crosscut some larger pockets of ore occurred with the quartz, and were bagged up for export. A short crosscut of 22 feet was driven eastwards at this place, and traversed quartzose lode-matter carrying small veins of pyrite and copper sulphides for the whole distance.

The next 40 feet of the northern drive show oxidised lode-stuff, from which most of the copper has been removed by leaching. Another easterly crosscut 25 feet in length shows the presence of similar lode-matter. Some 18 feet beyond the latter crosscut the drive terminates,

being apparently, at that place, on the hanging-wall boundary of the lode.

The stopes above the No. 1 tunnel are depleted of the better-grade ore, which has been taken out for an average width of 5 feet. Some second-grade ore has been left standing in the unfilled stopes for future removal, when better transport facilities exist on the field. The stope lengths on either side of the rise which connects the tunnel with the surface are as follows:—

Stope.	Stope Length South of Rise		Stope Length North of Rise.
	Feet		Feet.
No. 1...	139	...	12
2...	46	...	10
3...	33	...	10
4...	66	...	31
5...	66	...	14
6...	26	...	—

From these figures it would appear that the shoot of ore is pitching towards the south. But it will be advisable to obtain further information on this matter from deeper workings before assuming a southerly pitch.

The No. 2 tunnel was driven at a later date to obtain all possible advantage from the topography before resorting to sinking. The position chosen lies to the south of the older tunnel, and nearly 6 chains distant from its mouth. The crosscut was driven on a bearing of W. 24° S. through slate, which shows stains of copper sulphate in a few places. The slate has a strike of N. 20°W., and is nearly vertical, with a tendency to dip westwards. This crosscut did not give the anticipated results, and some difficulty was found in locating the main ore-shoot at this level. The lode-matter encountered was met with at a shorter distance from the entrance than was expected, and proved to be almost wholly quartzose, so the crosscut was continued. A drive carried southwards for 46 feet remained in this hanging-wall country, so from the end of this drive a crosscut was put back eastwards for 26 feet until it encountered quartz carrying iron pyrites and copper stains. This was thought to be another ore-body from that on which most work was done on the upper level. Hence the tunnel crosscut was continued another 40 feet west of the south drive, and slate carrying stringers of quartz with chalcopyrite and pyrite was passed through.

Then a beginning was made to drive north along the course of the quartzose body first met in the tunnel, and signs of copper were found all the way. At a distance of 70 feet from the tunnel a short crosscut was driven eastwards. Quartz veins in which copper pyrites and iron pyrites appear were intersected, and the crosscut was discontinued when the footwall was apparently touched. The ore-body appears to have crossed the course of the north drive from this point onwards for 25 feet. The drive was continued into the unmineralised slate, and then crosscutting westwards was begun. There are a number of veins and lenses of quartzose ore carrying a little copper to be seen in this crosscut, which in 64 feet of driving cut the tail end of the main ore-shoot. Even here it was found that the lode-channel is not a simple fracture, and the drive on the lode follows a somewhat serpentine course northwards, and yet another short crosscut was necessary before the more massive portion of the main shoot was located. From the intersection of this crosscut with the shoot the stopes begin. Here, too, only the highest grade of ore has been selected and stoped for export, the remainder being left standing. The first stope on this level is 198 feet in length and the second stope 132 feet.

A winze was sunk at a point 82 feet north of the place where stoping was begun on this level, and at the time of the writer's visit the bottom was 52 feet below the drive. Another winze was being started at a point 90 feet further north. The drive on the lode was continued northwards beyond the stoped ground for a short distance, and discontinued when the veins of sulphides contracted and signs of oxidation were found.

The ore has been taken out in the stopes above the level for a width of from 3 to 9 feet. A pillar of unstoped ore available for examination shows the width at that point to be 7 feet 6 inches. Of this, the first foot, on the footwall side, consists of quartzose material with a little unreplaced slate and numerous lenses and veins of chalcopyrite, covellite and pyrite. The succeeding 2 feet 6 inches are of massive, clean ore, chalcopyrite, chalcocite, covellite, pyrite, and a little quartz. The remaining 4 feet of the lode on the hanging-wall side resemble the footwall band of quartzose ore.

The first winze was sunk at a point 20 feet north of the widest part of the shoot on the No. 2 level, where the drive was opened out to a width of 11 feet 6 inches. Being carried downwards on the band of good ore it has

produced high-grade material for export. The dimensions of the winze are 8 feet by 4 feet 6 inches, and the latter width is not so great as the width of the shoot of rich ore in some places. The ore is of the usual variety—pyrite, chalcopyrite, covellite, and in some places chalcocite in veins being the component minerals. The dip of the shoot is 75 degrees to the westward. There are still signs of leaching at the full depth attained, and there is a strong flow of water issuing from the crevices in the high-grade ore.

The second winze, 90 feet to the northward, shows characteristics identical with those noted for the first to a depth of 15 feet below the No. 2 level. This was the depth attained at the date of the latest visit of the writer to the property.

A third tunnel was driven from the western side of the ridge to cut the lode 500 feet north of the No. 1 tunnel workings. The direction of this tunnel crosscut bears N. 47° E. The slate near the entrance is much fractured and displaced, and appears on the whole to dip eastwards, but on the eastern side of the lode it is more regular, and has the normal strike of N. 15° W., and dips westwards.

Black slate with veins of quartz honeycombed by leaching was found on the western side of the lode, as in the No. 1 tunnel workings. The lode, however, is much less well-defined, for the veins of which it is composed extend across the formation for a width of 60 feet, being separated by bands of slate. Some of these veins are of quartz from which all metallic minerals have been leached. Others have retained pyrite, chalcopyrite, and covellite, but there is almost invariably some limonite to bear testimony of oxidation.

Upon the strongest of these veins a commencement was being made to open up by driving north-west and south-east. In the south-eastern drive a band of good ore from 6 to 12 inches in width was showing at the time of the writer's visit. This ore is to a certain extent cavernous, and stained with limonite.

On the southern bank of Tin Creek some trenching proved the continuation of the lode, and a fourth tunnel was driven southwards on the lode slightly above the level of the creek. This tunnel was driven for 113 feet, and for the whole of this distance the whole of the quartzose matter shows signs of leaching, and is stained with limonite. At a distance of 90 feet from the entrance a crosscut was driven westwards for 12 feet

through mineralised slate. The slate of the wall-rock is partly sericitised. These workings serve only to prove the continuity of the lode, being too shallow to afford information as to value.

Since the visit of the writer further work has been carried on at a greater depth than that of any workings described above. The assistance of winding and pumping machinery was obtained, and the development of the mine should now be more rapid.

The writer regards the several makes of ore mentioned above as components of what is essentially one lode-formation. The main shoot has all the appearance of a simple "fissure-vein," but the work already carried out in both the No. 2 Tunnel and the Western Tunnel points to the necessity of crosscutting at several points at different levels to prospect for possible parallel veins.

The zone of secondarily-enriched ore had not been passed through in depth at the point to which the first winze had been sunk when the writer visited the mine. How much greater will be the vertical extent of the ore showing covellite and chalcocite cannot be told before deeper prospecting work has been accomplished. It has, however, been pointed out that there are good reasons to believe that the change in the character of the ore which will be experienced in depth will be principally the disappearance of chalcocite and covellite and the existence of unaltered chalcopyrite in their stead.

The copper ore exported from this mine up to the end of June, 1910, amounted to 1286 tons, worth £16,000. Several of the parcels of ore sold had an assay value of over 30 per cent. of copper, and many parcels contained more than 25 per cent.

There are a few small veinlets of tin ore to be seen on the western boundary of the section where a road-cutting has been made. No attempt has been made to prospect the occurrence. Alluvial tin ore is known to occur in the low-lying part of the section through which Tin Creek runs; but, owing to the liability of the ground to be flooded, prospectors avoided the area in the early days of the field.

The Reward lease, held by the Messrs. Murray Bros., is a valuable property, which has reached only an early stage in its development, and appears to possess a very promising future. From this mine the only considerable output of ore has been derived, and to it the other copper mines in the district in a great measure owe their existence.

(2) *The Central Mt. Balfour Copper Mines, No Liability.*

The Central Mt. Balfour Copper Mines property consists of two sections—No. 2090-M, of 40 acres; and No. 2177-M, of 80 acres. They are situated on the principal line of lode in the district, and are immediately to the northward of Messrs. Murray Bros.' Reward Mine. The energy of the company has been expended upon the prospecting of this lode-formation in both of the sections. The outcrop may be traced, almost without interruption, through the two sections, and several short tunnels and trenches were put in by former owners of the property to expose the lode-matter at very shallow depths. These early prospecting operations met with results which gave every encouragement to the present proprietors to proceed with the work of opening up the lode in depth.

Of the surface workings those which gave the most promising results are situated near the northern boundary of the Messrs. Murray Bros.' reward lease. At a distance of 95 feet from this boundary, and in the Section No. 2177-M, a trench was cut across the lode, which consists of cavernous quartz. The quartz itself carries no values at this place, but copper was found on assay to be present in the sericitised slate alongside the quartz. A shaft sunk to a depth of 20 feet at this place showed that the copper continued down for that distance.

A second shaft sunk at a point 20 feet further westwards met with much more satisfactory results. At a point 20 feet below the surface the hangingwall of the lode was cut, and at a distance of 45 feet from the surface the quartz gave place to good ore consisting of chalcopyrite and covellite, with pyrite and quartz. The orebody was followed northwards for 9 feet and southwards for 27 feet, and short crosscuts were driven eastwards and westwards at this level, and it was then decided to drive a low-level adit to test the lode at a greater depth. The ore obtained at this place is of excellent character, but in all cases exhibits signs of having been leached of part of its metallic contents.

The No. 1 tunnel was driven on a bearing of N. 65° E. to come under these workings, and was carried for a total length of 420 feet. Of this total distance the first 70 feet are in country-rock—slate, which is vertical and has a strike of N. 30° W. The next 100 feet show proof of mineralisation to different degrees, and in the remainder of the crosscut only a few quartz veins carrying pyrites are to be seen in slate, which has a westerly dip. From a point

70 feet distant from the entrance signs of sericitisation of the slate begin, and a number of small bands of ore, consisting of quartz with pyrite, chalcopyrite, and covellite, appear. A very strong vein was encountered, and at 115 feet from the entrance what was at first thought to be the footwall of the formation was met. At this point a main drive northwards on the lode was begun, and a short drive was also carried southwards.

On the resumption of the tunnel crosscut it was found that ore of good value lies to the east of the supposed footwall of the formation. The mineralised slate to the eastward carries excellent ore in strong lenses. Then, after passing through a width of 15 feet of pale slate, the tunnel met with 12 feet of mineralised slate carrying pyrite and a small proportion of copper. This gave place to good ore again, and a second drive was begun northwards and southwards. To the eastward of this point small stringers of ore were seen for 30 feet, but the portion of the adit crosscut beyond this distance carries no vein-matter indicative of value. The slate dips to the westward, and in places quartzose veins with a little pyrites are to be seen.

The first drive on the lode, at a point, 115 feet from the entrance of the tunnel, met with very promising results in the neighbourhood of the tunnel. The south drive, 21 feet in length, shows the lode-matter to be quartzose and of high grade on the footwall side. The country-rock on the hanging-wall side carries lenses of good ore also. The north drive was carried for a total distance of 352 feet from the main adit. At a distance of 20 feet from the tunnel a winze was sunk to a depth of 32 feet, beyond which it was found impossible to get down on account of the water which made its way into the opening. At the time of the writer's visit these workings were full of water. There was a crosscut driven both east and west from a depth of 30 feet for distances of 47 feet eastwards and 49 feet westwards, and good ore is reported to have been intersected in both directions. The results obtained at this place certainly gave every reason to hope for the development of at least equally rich ore at still greater depths.

The main north drive continues to follow the ore, and at a distance of 52 feet from the adit crosscuts were driven westwards for 12 feet and eastwards for 18 feet. The western crosscut shows friable ore of good grade. The eastern crosscut penetrated only slate dipping steeply to the west.

At a distance of 116 feet from the adit another crosscut was driven westwards for 12 feet. The first 5 feet of this crosscut are in friable ore of good quality, and the remaining 7 feet are in slate impregnated with pyrite.

At a point 162 feet distant from the tunnel a rise was put through to the surface, and is reported to have encountered good ore for the whole of that distance.

At a distance of 180 feet from the adit the lode begins to bend to the eastward. At 183 feet a crosscut driven eastwards for 168 feet gave no indication of any other ore-body to the east. When the face was 54 feet distant from the north drive traces of copper were found, but not in amounts to justify more work at that place. At a point 140 feet from the drive dense quartzite was encountered. It is vertical, and has a strike of N. 5° E., and is interlaminated with slate. Quartz veins are visible in this indurated rock, but carry only sporadic traces of pyrites.

The lode which was being followed in the main north drive changes in character where it bends round to the east. The ore up to this point had been found to be continuous, and it is estimated that 250 tons were obtained from the north drive workings. Beyond the eastern crosscut soft dig made its appearance in the lode-channel, at first in the back of the drive, and then gradually for the whole height, as if the shoot of ore were pitching northwards. The course of the fissure, as determined by the presence of the dig, bends round to as much as N. 30° E., but returns gradually till at the end of the drive it is nearly north and south.

At the end of the drive crosscuts were driven, eastwards for 26 feet in barren slate, and westwards for 19 feet in slate carrying veinlets of quartz, with which pyrite is associated.

Here work was suspended and the energies of the company were concentrated on the shaft workings.

The second drive from the main tunnel crosscut was carried northwards for 30 feet in cavernous quartz, obviously leached of most of its metallic contents, carrying pyrite and some patches of chalcopyrite. The drive splits in the face and the eastern branch shows a small vein of good ore. The south drive from the adit was carried to within 60 feet of the southern boundary of the lease, and met with good ore in lenses and pockets. A connection was effected between this drive and the shaft on the hill above. At a distance of 50 feet from the adit a crosscut was driven eastwards and lode-matter was traversed for

the whole distance. When driven 30 feet, a drive was begun on a band of ironstained and cavernous quartz, and was carried southwards to within 30 feet of the boundary of the section. A vein of chalcopyrite largely converted into covellite 9 inches wide is to be seen in the face of this drive. It dips to the west at an angle of 40 degrees.

The drive back northwards towards the main adit follows a strong vein of quartz full of cavities and stained with limonite, but carrying pockets and veinlets of rich ccpper sulphides. This vein tapers out very suddenly and ceases altogether. The drive continues and opens out into the main adit.

These comparatively shallow workings were temporarily abandoned in order to prospect the lode-formation from a shaft. The site chosen was opposite the present end of the main north drive, and was selected before the tunnel workings had reached that point. The shaft was sunk for 182 feet, and a commencement was made to drive for the lode at 150 feet. The country rock through which the shaft is sunk is almost vertical slate, striking from 20 to 30 degrees west of north. The general tendency is to dip to the west. The crosscut at the 150-feet level has a bearing of N. 89° E., and was driven for a total distance of 240 feet from the plat. A small quartz vein was cut at a point distant 153 feet from the plat, and after 20 more feet of driving had been done the pug seam followed in the No. 1 tunnel workings was cut. The crosscut was continued for some distance, and finally abandoned in slate country. A south drive was begun on the pug seam, and at the time of the writer's latest visit to the property had advanced 136 feet from the main crosscut. At a distance of 82 feet a short crosscut was driven westwards for a distance of 35 feet and cut a small vein of siliceous ore rich in copper pyrites but only a foot in width.

Should there be obtained no more satisfactory results from the extension of the south drive it would be advisable to connect with the ore-body met in the tunnel above, and then to endeavour to ascertain the pitch of that shoot of ore.

The writer has no doubt but that the existing south drive is on the main fissure traversing this portion of the property. Crosscuts at intervals are necessary to probe for possible parallel shoots or lenses of ore. The deeper prospecting has certainly not been rewarded by the encouraging results that were to be anticipated from the

tunnel workings above; but it is quite possible that a blank portion of the fissure may have been intercepted, and that operations at still greater depths may meet with success.

In the centre of this same mineral lease the No. 2 tunnel was driven to prospect the lode beneath a trench on the hill from which good ore was obtained. The total length of the crosscut driven at this place is 240 feet. The mouth of the tunnel is in normal slate, which strikes in a direction bearing N. 20° W., and dips to the westward at 85 degrees. The tunnel encountered mineralised country for a total width of 40 feet, and at a point 110 feet distant from the entrance a drive was put in southwards. The bearing of the drive lies between S. 40° E., and S. 60° E., and the length is 90 feet.

The nature of the formation changes as followed southwards from mineralised slate carrying chalcopyrite into a strong quartz body. A short crosscut on a north-easterly bearing proves this quartz to be at least 12 feet wide.

The drive of 20 feet northwards from the crosscut disclosed a continuation of the mineralised slate with a little copper pyrites.

To the eastward of the mineralised zone the tunnel shows only slate country.

Still further north a tunnel, known as McGowan's tunnel, was driven eastwards for 450 feet. It crosses the northern boundary of the section at a small angle. At the time of the writer's visit it was inaccessible, the mouth having been dammed up to gather water for the use of a diamond-drilling plant then at work at a point immediately in front of the tunnel entrance. There is a considerable amount of quartz on the tip outside the tunnel, and in parts of it disseminated chalcopyrite and covellite are visible.

In the central portion of the northern section No. 2090-M, another tunnel, known as Harper's tunnel, has been driven in an easterly direction for 200 feet. At a distance of 33 feet from the entrance an indefinite formation 5 feet wide was cut. This lode-matter consists of soft altered slate with quartz, pyrite, and stains of copper sulphate irregularly distributed through it. Beyond this lode-matter 11 feet of slate were passed through, and then 15 feet more of lode-stuff similar to but rather more siliceous than the first. Beyond this place there are numerous quartz veins of small size, in which pyrite

occurs; and at some places stains of copper sulphate may be seen on the exposed surfaces of the veins.

At a distance of 170 feet from the entrance a band of soft chloritised slate carrying veins of quartz and pyrites was driven on southwards for 60 feet. This part of the formation does not show much promise. To the eastward the main tunnel intersected nothing but slate, which in the face strikes N. 50° W., and dips N.E. at 55 degrees.

In the creek bed, at a distance of 2 chains northwards from the mouth of the lastmentioned tunnel, a shaft has been sunk and 85 feet of crosscutting done at a depth of 30 feet. These workings were inaccessible to the writer. Some good ore obtained from them is now at the surface. On the eastern bank of the creek there is an outcrop of gossan which is obviously the oxidised capping of the lode, which is at this place noticeably poor in silica. On the northern side of the creek, however, it resumes its normal quartzose character.

Some attempts have been made to test the value of the lode both at this place and opposite the mouths of Harper's and McGowan's tunnels by drilling. The results of the bores were in all cases unsatisfactory, and little information was derived from them on account of the failure to secure cores.

Apart from the single copper lode which has been attacked at the points mentioned there are a number of points in the vicinity of Emmett's Creek at which shallow alluvial ground has been worked for tin ore.

The results of the systematic prospecting of the lode-channel within this lease have certainly been disappointing, since the deeper workings have hitherto failed to locate any material bodies of ore, such as may be expected to occur along the course of a lode which has been proved to contain several shoots of high-grade material immediately below the grass roots. There is no reason to believe that no other shoots of ore exist; but no positive indication could be found by the writer of the presence of such bodies. It is a matter to be proved by continued driving on the lode-channel and crosscutting at frequent intervals for possible parallel makes of ore. The length over which the lode had been opened up at the 150-feet level was, at the time of the geological examination, short in comparison with the distance over which the shoots of good ore have been located at the surface. Moreover, the deeper prospecting has been carried on only at the 150-feet level

There is a fair quantity of ore of excellent grade stacked at the mouth of the main adit. None has yet been sent away from the mine to the smelters, the material that has been stacked being the product of the development work, and not of actual stoping.

(3) *Messrs. Murray Bros.' Section*, 2149-M.

This section, of 80 acres, adjoins the lease of the Central Mt. Balfour Copper Mines, and through it runs the continuation of the same lode which has been prospected at the places described above.

The outcrop is a prominent one in the southern part of the section, where the ground rises rapidly from the gorge of Emmett's Creek. The white quartz of the lode forms the capping of a well-defined ridge which runs through the section. A number of attempts have been made to prove the lode, and it is doubtful whether any have gone far enough to afford conclusive information as to the value of the lode. The physical configuration of the part of the section in which the lode is situated is favourable to the operation of leaching.

A trench 4 chains from the south boundary shows only cavernous quartz in altered slate country. A little further north, where a break occurs in the ridge, a trench was cut, and then a shallow tunnel driven westwards to intersect the lode-matter. The tunnel passed through chloritised slate with stringers of quartz, and then a massive body of quartz. Beyond this some cavernous quartz with limonite was met, and a drive northwards begun. The gossan and quartz give place to mineralised slate. A little copper was seen, and at this level little could be expected. It would be well to continue the north drive under the rising country ahead and crosscut eastwards.

As the outcrop is traced northwards it becomes apparently wider; but no work has been done here, and it is impossible to tell whether some of the ironstained quartz and gossan are *in situ* or not.

Hematite makes its appearance in the northern part of the section in the chloritised country-rock alongside the lode. A trench cut across the lode proves the width of this zone of altered country-rock carrying quartz to be at least 70 feet. A hole put down to a depth of 10 feet at the western end of the trench gave no results of value.

At a point 6 chains to the south-east of the north-western corner of the section a shaft has been sunk some 63 feet. At the surface at this place the lode consists of honeycombed quartz and chloritised slate carrying pyrites. Thirty feet from the collar of the shaft a small opening in the lode shows quartz with pyrites and numerous cavities. The lower part of the shaft was full of water at the time of the visit of the writer, and inaccessible.

A tunnel was driven from the eastern side of the ridge to come under this portion of the lode. The bearing of the drive is W. 14° S. The slate in the entrance dips to the eastward, but seems to be abnormal. The rest of the tunnel shows a westerly dip, and in the face the dip is at 80 degrees to the west and the strike N. 15° W.

At a distance of 60 feet from the opening set the lode-formation was first entered, and proved to have a total width of 260 feet. Successive bands of mineralised slate with veins of quartz more or less leached of its metallic contents and friable pyrites veins constitute the formation. One strong vein was followed in the direction of its strike, which is N. 30° E., and therefore different from the strike of the lode as a whole. The vein consists of honeycombed quartz with stains of limonite, and even containing pyrites in places. Copper-bearing minerals are reported to have been seen at this place.

The most promising portion of the lode in this section appears to be that in the vicinity of the shallow southern tunnel. From the existing tunnel, or from an extension of it, it would be advantageous to sink a winze and drive a crosscut through the formation for the purpose of ascertaining whether the signs of leaching at the surface are due to the removal of copper ore, which might possibly be redeposited below.

(4) *Section* 4078-M.

This section, now charted in the name of H. C. Daniel, comprises 80 acres, and was being prospected during the visit of the writer to the field by the Balfour Premier Copper Mines, No Liability.

On the top of the ridge between Tin Creek and Emmett's Creek there are some rather indefinite outcrops of a highly siliceous character. The positions of these are shown on the chart of the Balfour district (Plate IV.) by broken lines.

A tunnel was driven from a convenient point in the valley of Tin Creek on a bearing of N. 67° E. to cut the formation in depth below that part of the outcrop which is close to the south-western corner of Section 2149-M.

At a distance of 300 feet from the entrance the tunnel entered a hard belt of quartzite. This rock is sometimes grey in colour, but more usually green, from the presence of chlorite, and is studded with cubical crystals of iron pyrites. It is clearly formed by the impregnation of the slate country. Some rather softer bands of slate were encountered in the next 100 feet of crosscutting, but the formation as a whole is very dense and siliceous for all of that distance. There are a few veins of gossanous material between points distant 360 feet and 370 feet from the tunnel mouth. A few quartz veins are visible in the quartzitic formation, but no sign of cupriferous minerals may be detected.

The slate of the tunnel has an easterly dip at 75 degrees, and a strike bearing N. 20° W.

The siliceous outcrop which is prominent on the crest of the ridge is undoubtedly only the weathered and bleached capping of the belt of mineralised quartzite which was passed through by the tunnel crosscut.

The Premier Company's systematic attempt to prove the nature of the formation in depth has been unfruitful of any promising results, and no recommendation can be given to pursue the work of further exploring the known outcrops. The test which has been applied is the only one from which satisfaction was to be obtained, and it may be considered to be reasonably conclusive.

(5) *The Balfour Blocks Copper Mines, No Liability.*

The two sections held by the company—4044-M and 4129-M—are of 40 acres each. They lie to the westward of the main fracture-line of the Balfour field. The more important lodes and workings are situated in the northern part of 4044, close to the boundary between it and the Section 3863, held by the Balfour Consolidated Copper Mines.

The most valuable ore-body is one which has a strike of N. 40° W. It was traced in the lease of the Blocks Company by means of trenches, being somewhat exceptional in that it makes no prominent outcrop.

Two shafts have been sunk upon this lode at distances of 80 and 320 feet from the northern boundary of the section. At the bottom of the first one, 35 feet from the surface, a short crosscut was driven eastwards. The second shaft also reached a depth of 35 feet. The water proved too heavy for work to proceed without assistance from machinery, and work was temporarily abandoned at these places, and the workings were permitted to fill with water before the writer's visit to the district. The ore obtained is of good quality, and justifies systematic prospecting in depth.

A third shaft was sunk on the hanging-wall side of another lode which lies to the eastward of that mentioned, and strikes in a direction bearing N. 15° W. This shaft reached a depth of 30 feet, and from this level a crosscut was driven eastwards to cut the lode, which is reported to be 12 feet wide. These workings also were full of water at the time of the writer's visit.

Between the two lodes mentioned a main shaft is being sunk with the help of a winding plant, which was installed with great difficulty. The shaft was begun in dense slate, so silicified as to be almost a quartzite. At a depth of 50 feet this gives place to chloritised and silicified slate carrying quartz veins, which strike diagonally across the shaft and appear to mark the presence of some cross-fracture between the two lodes. The country is traversed by heads between which there is sometimes soft dig carrying crystals of pyrites. When a depth of 70 feet was reached considerable difficulty was encountered through the large amount of water which made its way into the shaft from the sides. At the same time the water standing in the shallow surface workings began to drain slowly away.

There had been no progress beyond the 70-feet level at the time of the last visit of the writer to the property.

The work of prospecting these lodes from the shaft should include the driving of crosscuts across the whole width of the mineralised country.

Some systematic attempts have been made to prove a formation which outcrops on the bank of Tin Creek. At the surface gossan and quartz are visible for a total distance of some chains A tunnel driven in a north-easterly direction cuts across the formation at a shallow depth. Black slate, apparently graphitised, with narrow seams of pyrites and a little quartz, was intersected, but no sign of copper was found.

Further south a tunnel was driven in the country-rock of the lode-formation on a bearing of S. 39° E. for a distance of 84 feet. At this point a short crosscut intersecting the lode gave no encouraging results.

The value of the property undoubtedly lies almost wholly in the northern section; and on the future development of the lode, which has been found to be ore-bearing for a considerable distance within this lease, as well as that of the Balfour Consolidated Copper Mines, the ultimate prosperity of the mine will chiefly depend.

(6) *The Balfour Consolidated Copper Mines, No Liability.*

This company holds a large number of mineral leases, the most important of which is 3863-M, of 78 acres, north and adjoining the section in which the Balfour Blocks Copper Mines are conducting their prospecting operations.

The principal lode on this section lies in the southern portion, and has a strike of N. 40° W. A trench on the lode at a point 50 feet from the southern boundary of the section shows the formation to be 8 feet wide, and to dip to the west at 65 degrees. The lode-matter is well defined in the centre and merges gradually into country-rock on the walls. A small proportion of covellite is present in the lode-matter. The adjoining country is impregnated with silica and studded with crystals of pyrite.

At a point 200 feet north-west of this trench a shaft was sunk on the lode to a depth of 31 feet. This work produced a heap of ore of splendid quality, and very little mullock. The ore is siliceous, and carries, irregularly distributed through the quartz, pyrites, chalcopyrite partly converted to covellite, chlorites. Covellite appears on all the heads and joints, and sericite is sometimes visible. The shaft was inaccessible, having been allowed to fill with water to within 16 feet of the surface. The main shaft on the Blocks Mine, although 450 feet distant, was reported to be draining this shaft at the time when the writer was leaving the district.

There has been some trenching done upon the north-western continuation of this lode at a distance of 160 feet from the shaft. The lode is exposed, and is 4 feet 6 inches wide. At this point it is soft and decomposed, but carries small quantities of copper. The quartz of the lode carries fragments of undigested slate, which have softened. Both covellite and chalcopyrite are present. A trench situ-

ated still further north-west shows only the capping of a formation, not having been carried down to a sufficient depth. At a distance of 40 feet from this trench a hole sunk to a depth of 6 feet shows the presence of a quartzose lode carrying copper 5 feet wide and dipping south-west at an angle of 75 degrees. The connection of this lode-matter with the other exposures cannot yet be determined.

To the west of the shaft and a chain away a long trench cut a quartzose body 6 feet below the surface. This lode-matter appears to be part of a formation marked by an outcrop of quartz which extends southwards into the section held by the Balfour Blocks Company. The strike of the formation is N. 18° W.

Some further trenching has been done in the northern portion of the section, and two trenches have been continued underground as tunnels. Country-rock carrying veins of quartz and a little pyrites for a width of 25 feet has thus been exposed, but no discovery of any promise has been made there.

The Balfour Consolidated Company holds several other sections—viz., 3856-M, 40 acres; 4079-M, 10 acres; 3855-M, 40 acres—in the same part of the field. There are several outcrops of quartzite rather than quartz on these sections, which are situated to the westward of the main fracture-line of this part of the field. The work that has been done upon these outcrops has not been attended with success, and it is doubtful whether any further development work is justifiable.

The inactivity upon the northern section, 3863-M, is to be regretted. The most valuable lode is that which is now about to be worked by the Balfour Blocks Copper Mines, and it may well be prospected from the shaft now being sunk by the latter company. Under these circumstances an amalgamation of the interests of the two companies appears desirable.

(7) *The Balfour Mines Development Company, No Liability.*

The four mineral leases held by the development company—viz., 3387-M, 80 acres; 3397-M, 80 acres; 3569-M, 20 acres; 3566-M, 80 acres—comprise the outcrops along the course of the main fracture-line of the Balfour field for a distance of over a mile, and also some lodes which do not belong to this line of fracturing.

The principal line of lode is marked by a continuous siliceous outcrop, which can be traced from the southern portion of Section 3387-M into the most northerly section, 3566-M. Practically nothing has been done upon the outcrops along this line. The few trenches are all shallow. Advantage has been taken of the existence of three creeks which cross the lode to strip off the leached part of the outcrop and expose the pyritic lode below. Traces of copper have thus been seen, but not sufficient to justify deeper workings.

In the south-eastern portion of the most northerly section there is some interruption in the continuity of the principal fracture-line, which appears to be marked by two almost parallel lodes at that point.

Prospecting operations to the westward of this line have revealed at least one important body of ore. This is situated in the north-western part of the section, and is being opened up by means of a tunnel from the lowest available level.

Some trenches, full of water at the time of the writer's visit, had cut the outcrop in a few places. The ore from these workings is quartzose, and carries both chalcopyrite and covellite. As the lode was followed up the hill it was found to bend round suddenly towards the west. A shaft was sunk here to a depth of 46 feet, and a drive southwards on the lode is said to have found a similar bend in the strike of the lode. These workings were full of water and inaccessible. The ore derived thence has clearly suffered some alteration. Leaching is evidenced by the cavernous nature of the quartz, which is very apt to break into splinters with jagged edges. Chalcocite is distributed through this ore rather more abundantly than in any other part of the field.

The tunnel driven to cut this lode achieved its purpose at a distance of 72 feet from the entrance. The average width of the lode which was followed south is 5 feet. Its strike at this place is N. 18° W., and it dips to the south-west at an angle of 55 degrees. The lode-matter is quite massive and free from signs of leaching. Yet chalcocite is present in small proportions in this ore, which consists principally of quartz, ferriferous dolomite, pyrite, and chalcopyrite. Fragments of chloritised slate are present in some parts of the lode.

This ore is probably almost entirely free from all secondary alteration, and may be expected to maintain its char-

acter in depth as far as the limits of the shoot extend. It is concentrating ore of good grade, and if found in sufficient quantity will provide material which can be profitably handled.

Should the main fracture-line of the field be traceable through this section it may be expected to be located on the eastward side of the lode last mentioned, and about 8 chains away from it. On the northern side of the lease it has been traced as far as Tin Creek, and on the southern side has been followed up to a point within the south-eastern corner of the section.

A number of long trenches have been cut with a view to proving the continuity of the lode-matter already located, but cannot be said to have been successful in attaining their object. One trench in the southern part of the section, and 6 chains distant from the boundary between this lease and that of the Balfour Consolidated Mine, shows copper pyrites in ore of a nature similar to that exposed in the tunnel at the northern end of the section. Traces of copper have been found in another trench a little further north.

Again, at one point on the lode which crosses the southern boundary at a distance of 8 chains from the south-eastern corner of the section, a trace of copper has been found. Here, however, the lode-matter consists of small veins, which merge into impregnated country-rock, and there is not much encouragement to prospect further at this place.

The future of the property depends upon the manner in which the lode-matter now being prospected opens up in length and depth, and upon the possible discovery of other ore-bodies to the eastward.

(8) *Section* 4214-M.

Upon this section, which comprises 80 acres, some work has been done by the Mt. Balfour Extended Copper Mines, No Liability, but without successful results.

In the bed of the creek which crosses the section diagonally an indefinite formation has been located at a distance of 5½ chains from the western boundary. For a width of 5 feet the slate carries veinlets of quartz, with which pyrite is associated, and traces of copper have been seen.

In the north-eastern portion of the section a gossanous capping has been found on the north-western bank of the creek. A trench shows only quartz and limonite, but a

hole sunk to a depth of 10 feet at a point south-east of the trench has exposed a siliceous body in which copper pyrites is said to have been seen.

On the eastern boundary-line there is a broad formation exposed for a distance of 2 chains in the creek-bed. The formation consists of graphitic slate carrying pyrites in veinlets, and also disseminated through the body of the slate. Quartz veinlets also are numerous. No copper-bearing minerals have been seen at this place, but the pyrites is said to show a trace of copper on assay. A cut put into the hillside for a distance of 30 feet offers no sign of encouragement. The western wall of the formation appears to dip westwards at 75 degrees. The graphitic slate with the veinlets of quartz and pyrite dips eastwards, and strikes in a direction bearing N. 18° W.

The occurrence does not seem to justify the expenditure of further capital to open it up.

(9) *Sections* 3807-M, 4104-M, 3168-M, 4128-M, and 3955-M.

These sections are located upon what appears to be the lineal extension of the main fracture-line of the Balfour district, which can be definitely traced as far as the south-eastern corner of Section 3566-M, but not through that section.

In the bed of Tin Creek, in Section 3807-M, the outcrop of the line of lode has been cut by a shallow trench, and pyrite, chalcopyrite, with covellite, are visible in the quartz. On the southern side of the creek the outcrop rises very abruptly, but cannot be traced with certainty in the higher ground.

The steep slope on the northern side of Tin Creek is densely timbered, but the outcrop may be traced into the adjoining section, 4104-M. Here, on the crest of the hill between the two tributaries of the Frankland River, a small excavation has been made, but it is of insufficient extent to afford information as to the width or dip of the lode. The outcrop is marked by quartz, which carries a certain amount of undigested slate. When broken the quartz usually shows a little fine-grained crystallised pyrites. The fragments of quartzite to be seen along the outcrop seem to imply that there has been silicification of the country-rock alongside the lode.

Near the northern boundary of Section 3168-M, a deep trench has been cut in yellow decomposed lode-matter. Quartz containing pyrite, chlorite, and sporadic chalcopyrite and covellite is present in the lode, but it is usually cavernous in texture and leached of its metallic con-

tents. Work was therefore abandoned here in favour of a tunnel, the approach of which was being cut at the time of the writer's visit. The slope of the hill towards the Frankland River is steep, and the site for a tunnel most favourable. The country-rock at the approach—chloritised slate—is slightly mineralised with iron pyrites.

A few chains further north, in Section 4128-M, a little work has been done on the capping of the lode. A shallow excavation shows the presence of pyrites and a little covellite. A shaft on the lode was begun, but when only 10 feet deep the water proved too much for the prospectors to cope with, and work at that place was abandoned. The ore at this place is quartzose, and carries a little chalcopyrite, and is enclosed within chloritised slate heavily impregnated with iron pyrites.

Still further north along the line of this lode, in Section 3955, and 6 chains from the southern boundary of that section, a short deep trench has been cut in the capping. A width of 6 feet of massive quartzose ore is there exposed. The quartz is mineralised with pyrite and chalcopyrite, and contains a little unreplaced slate and chlorite. Thin films of bornite and covellite are present with the copper pyrites, and the cupriferous minerals extend to the very surface. The encouraging feature about the lode at this place is that it appears to be much more massive than is indicated by the actual outcrop. The intention of the owners is to drive a tunnel to cut the lode at a depth of about 100 feet below the outcrop at this place.

The outcrop may be traced continuously at the surface right through the section. It constitutes the edge of the plateau, and, since the descent to the Frankland River is abrupt, exceptional natural facilities for tunnelling are afforded, especially in the northern part of the section.

The northern boundary of this lease coincides in position with a creek which flows into the Frankland River. On the southern bank of this creek, and a chain south of the boundary-line, another small excavation has been made, and siliceous lode-matter of similar character, carrying small proportions of chalcopyrite and covellite, has been exposed. Here, too, the copper-bearing minerals extend right up to within a few inches of the surface.

The very massive outcrop of the lode within the section is such that material improvement of the dense quartzose portion in depth cannot reasonably be expected. Yet it is imperative that a test should be made of the lode in depth, and that this test should include crosscuts

on either side of the quartzose body to the limits of the mineralised zone.

The general direction of the line of strike of the lode between Tin Creek and the northern boundary of Section 3955-M is N. 13° W. At that boundary it bends abruptly and strikes in a direction bearing at first N. 35° W., and finally N. 56° W.

(10) *The Mt. Balfour Proprietary Copper Mines, No Liability.*

The sections, numbered 4175-M, 4174-M, 4218-M, and 4219-M, comprising in all 318 acres, lie almost entirely on the eastern bank of the Frankland River. They appear to have been pegged out with a view to the inclusion of the extension of the lode worked by the Mt. Balfour Copper Mines Company. As has been indicated above, the direction of the lode alters, and the south-eastern extension runs through the sections mentioned in the last group.

A little work was being done at the time of the writer's visit upon Section 4174-M, at a point on the river bank and 4 chains from the northern boundary. The object of the work being done was to prospect a formation said to be visible in the river-bed when the water is very low. A tunnel was being driven in a direction bearing N. 36° E. to cut this formation, the strike of which is said to be N. 20° W. The slate in which the tunnel was being driven has a strike of N. 10° W., and dips towards the east. Numerous fractures are present in the slate, and the divisional planes between the fractured blocks are marked by pug-seams. A few small veinlets of quartz carrying pyrite and chlorite traverse the slate, and traces of copper are claimed to have been seen.

Even without having seen the outcrop in the river-bed, the writer would suggest that an attempt be made to expose the lode by trenches before proceeding further with the tunnel. The vegetable cover completely masks the surface in this particular spot, but, if it were stripped off and a few trenches were cut to the depth of the bedrock, the expenditure involved would be much less than that demanded by a tunnel, and more ground could be prospected in a given time.

The prospecting of the area had not proceeded far at the time of the writer's visit, and at some later date, before his departure from the district, had been attended by a dis-

covery in the southern portion of Section 4174-M of a cupriferous lode. The management report the discovery of a vein, which was opened up at one spot by a shallow excavation. The vein is reported to have expanded as it was followed downwards. The ore obtained thence is massive quartz, which contains chalcopyrite in small amount, and its existence appears to justify further prospecting operations.

(11) *The Mt. Balfour Copper Mines, No Liability.*

This company holds a number of sections, which include an area of 448 acres, at the northern end of the Balfour district. The leases are numbered 4258-M, 5259-M, 2700-M, 2701-M, 2698-M, 2699-M, 3478-M, and 4397-M.

Some variety in the surface geology of this area is introduced by the occurrence of a small patch of basalt in the northern part of Section 4258-M. The ore-bodies which have been located, and to some extent prospected, are three in number, and are restricted to Sections 2701-M, 2700-M, 2698-M, and 2699-M. The main lode—a portion of the principal lode of the Balfour district—extends throughout the whole length of these sections, as shown on the accompanying chart. The western lode, approximately parallel to the main lode, lies almost wholly within Section 2700-M. An isolated occurrence of ore of which the relationships are not clear, is situated in the centre of Section 2699-M.

The western lode is marked by a low ridge, along the crest of which broken fragments of quartz outcrop here and there. The course of the outcrop is N. 38° W. The trenches show the dip to be to the south-west. The lode-filling consists very largely of quartz, and the adjacent country-rock has suffered silicification. The slate has been brecciated at the period of fracturing, and the quartz of the vein-filling has cemented the angular fragments of chloritised slate into the lode formation. Iron pyrites is usually to be seen in the quartz, and traces of copper-bearing minerals—chalcopyrite and covellite—have been found. A trench situated at a distance of 7 chains from the north-eastern corner of Section 4259-M, and N.N.W. of that corner, shows that the country-rock on the foot-wall side of the lode is heavily charged with finely-divided hematite, while the slate of the hanging-wall appears unmineralised. The country-rock is noticeably distorted near the lode. The angle of dip of the slate at this place is

variable, but is always small; in fact, on the footwall side of the lode the slate lies almost horizontally for the few feet nearest to the lode. At a trench situated 5 chains to the north-west of the latter it is to be seen that the hematite is not restricted to the footwall side of the lode, but causes a deep colouration of both walls.

The width of the lode as revealed by the trenches varies from 2 to 4 feet; but the outcrops to the north-west indicate a much greater width of vein-bearing country. Work on this lode was discontinued after the preliminary trenching had been accomplished, since the development of other parts of the property offered more encouragement.

A shaft was sunk to a depth of 30 feet in the central portion of Section 2699-M, on a lode which cannot with certainty be said to have definite connection with any other lode-matter in the vicinity. The ore obtained at this place is of normal character, the principal constituents being quartz and pyrite, with which are associated sericite, chlorite, and chalcopyrite, sometimes partly altered to covellite. The make of ore possesses a westerly dip, and the shaft passed through it into the footwall country, which also carries veinlets of quartz, chalcopyrite, or some covellite. The dimensions of this shoot of ore are so small that work was abandoned at the shaft for an indefinite period. Should any indication of the existence of a branch lode striking in that direction be discovered in the future prospecting of the main lode in depth, the outcrop at this place should be borne in mind.

The main lode has not a constant strike throughout the property. In Section 2701-M the mean bearing of the strike is N. 35° W., but it alters gradually to N. 43° W. before the lode passes out of this section, and for the greater part of the outcrop through Sections 2698-M and 2699-M the strike is N. 56° W. The existence of this bend causes the western lode to approach the main lode in the centre of Section 2698-M, but whether an actual junction is effected cannot yet be determined.

On the southern end of that part of the lode in this property, just above the creek which runs along the southern boundary of Section 2701-M, a deep cut shows the width to be quite 30 feet. The lode-stuff consists almost wholly of quartz, but pyrites and stains of covellite were found in the silica when the leached surface stone was removed. The total depth from the outcrop attained by these workings is 15 feet. A little to the north-west a tunnel was driven on a bearing of N. 30° E. to cut the

lode at a depth of about 30 feet below the surface. The tunnel is inclined at an angle of about 65 degrees to the strike of the lode, and hence is apt to give an exaggerated idea of the width of the formation, which is nevertheless considerable, for there are quartz-veins over a length of 45 feet in this tunnel, and the face is still in quartz. A few feet back from the face a soft part of the vein was found to contain rich copper ore, and a winze was sunk to a depth of 26 feet on this vein. At this depth the work was stopped by the inflow of water and bad air. Without taking into consideration the smaller quartz-veins in the country on the south-western side of the lode, there is a width of 17 feet of lode-formation at this place, the greater part consisting of quartz. The vein upon which the winze was sunk is 3 feet 6 inches wide. Ore taken from the winze workings and now at the surface contains pyrite, chalcopyrite, and covellite.

A few chains to the northward of this point a trench was cut across the lode outcrop, and proves the existence of massive lode-matter for a width of at least 20 feet. There is no metallic mineral now contained in the quartz of this outcrop, but cubical cavities after pyrite and some empty cavities without crystallographic outlines are visible in it.

Where the lode is crossed by the creek in the south-eastern part of Section 2698-M a little work has been done on both banks. The excavations have proved the presence of lode-matter over a width of 12 feet. The ore is of a quartzose character, and carries pyrite and chalcopyrite as well as a little covellite, which occurs in the form of films coating the copper pyrites and fills cavities in the quartz. The full limits of the lode are not exposed in these excavations, which should be extended in a north-easterly and south-westerly direction. The strike of the ore-shoots cannot yet be determined for want of continuous exposures. Whether the copper contents at this place are richer than at other points on the same level along the lode cannot be decided until more work is done. The creek gorge has afforded an opportunity to expose the ore at a level considerably below that of any existing tunnel or trench across the ridge which has the lode for its backbone, and hence the ore at the creek level has not suffered the leaching experienced by the lode-matter elevated above water-level. Yet, on the other hand, it is possible that the position of the creek gorge may have been determined by the existence at that place of lode-matter which was always

less siliceous and richer in metallic sulphides. The continuity of the lode as a whole is beyond question. The extent of the cupriferous shoots in this lode is yet unproved.

To the north-west of the excavations in the creek gorge there are a few shallow trenches showing semi-leached quartzose ore, in which a little pyrites still remains. On the top of the ridge which coincides in position with the lode outcrops; but the rock material outcropping through stuff along this main ridge is quartz only. Near the centre of Section 2698-M a short spur runs out abruptly in a north-easterly direction. It appears to be a resistant residual prominence, just as is the ridge along which the main lode outcrops; but the rock material outcropping through the vegetation is for the most part unconsolidated river gravel—a portion of a deposit in the bed of the Frankland River when it flowed at a higher level. Through this rounded gravel there are a few outcrops of angular lode quartz, but it cannot be said that these may not have been derived from the main lode. Mention is made of this spur on account of the discovery of a branch lode in the underground workings in such a position that the spur may coincide with its outcrop.

Where the creek traverses the lode, between the Sections 2698-M and 2699-M, there is a gap in which the general level of the ridge is reduced by erosion, but the slopes of this water gap are not so steep as in the case of the creek gorge carved through the lode in the south-eastern part of Section 2698-M.

A trench has been cut for a length of almost a chain beside the creek, to expose the lode-matter, and has proved a considerable width of lode-formation. The south-western portion of the formation is quartzose, and on the north-eastern side of the quartz are a number of successive bands of varying composition. Some of the bands are pyritic, and carry massive chalcopyrite; others again are siliceous, and between them occur bands of graphitic slate. The oxidation and leaching of these bands has been most irregular, some being quite massive and others quite cellular.

To the north-west of this creek the outcrop of the lode is not so prominent as in other parts of the property, yet the ridge continues. At one point on the north-eastern face of this ridge there is a mass of unmineralised quartz, and there are also signs of the lode in the bed of a small

creek which crosses the north-western corner of Section 2699-M.

The principal work on the property has been the underground prospecting of the lode by means of a tunnel which cut it at a depth of 90 feet below the trench in the bed of the creek between Sections 2698-M and 2699-M.

The tunnel crosscut was driven in a south-south-westerly direction for a distance of 266 feet before any sign of lode-matter was encountered. At that point a small vein of ore occurs in slate, which shows the presence of graphite. The ore consists of quartz, ferriferous dolomite, pyrite, and small amounts of chalcopyrite and bornite. The apparent strike is between 50 and 60 degrees west of north, but difficult to determine as the structure is irregular and several smooth cross-fractures are to be seen in the small excavation made at this point. This vein, probably a branch of the main lode and connected with it at some other level, is not of sufficient size to be worth following. The slate, for the next few feet beyond this vein, is considerably altered, and contains ferriferous dolomite and quartz, and shows copper stains on the surfaces exposed in the drive.

At a distance of 321 feet from the mouth of the tunnel the main lode was met. Beyond this point the original crosscut followed a circuitous course for a total distance of 105 feet, gradually acquiring a more westerly trend.

At a later period a rise was put through to the surface from a point situated 75 feet from the north-eastern wall of the lode, and 396 feet from the tunnel mouth. The point of emergence of this rise is beside the trench showing ore at the surface, and at this place machinery was in course of erection during the period of the writer's visit with a view to deeper development by a shaft following the direction of this rise. Little work has been done in a north-westerly direction from the main adit crosscut. A drive for a distance of 38 feet follows the wall of the lode from the point where it was first met in a direction bearing W. 29° N. The vein-matter along this drive consists of shattered slate cemented with silica and carrying splashes of chalcopyrite and pyrite, together with a little ferriferous dolomite. There is no reason why this drive should not be extended further and crosscuts driven across the lode to prospect that portion of the lode which lies to the north-west of the main adit in the manner which has been adopted to the south-east. Another north-western drive on the lode was started from the old adit at a point 73

feet beyond the first, and was carried for a distance of 28 feet on a vein with a brecciated structure and carrying quartz with iron and copper pyrites. This make of ore has a dip towards the north-east at 75 degrees.

Between these two drives the adit traversed a great number of successive bands of ore in various stages of alteration. Most of the lode-matter is quartzose, in some places being almost pure vein quartz, and in others silicified slate. Bands of mineralised and graphitic slate occur through the formation, and copper stains are visible on their weathered surfaces. It was decided to explore the lode to the south-east at this level by means of main drives along the walls and connecting crosscuts at intervals of about 100 feet.

The No. 1 south drive follows the north-eastern wall of the lode for a total distance of 378 feet from the main adit. Of this distance the first 68 feet have a bearing E. 35° S., the next 234 feet a bearing of E. 23° S., and the last 76 feet a bearing of E. 36° S. The drive is in the lode, and follows one of the component portions of the whole formation throughout its length. The structure varies from point to point; on the whole it is irregular. The brecciated slate is recemented with quartz and ferriferous dolomite, and carries both copper pyrites and iron pyrites. The slate showing on the walls of the vein-matter carries a notable amount of graphite. Much of the ore is cavernous; the constituent which has been removed in solution appears to have been ferriferous dolomite in a great number of instances. It is possible under such circumstances that part of the copper contents of the lode has migrated downwards. The ore occurs in a succession of lenses which overlap one another at the ends. As one lens disappears another takes its place. The ferriferous dolomite is sometimes in a pasty or friable condition.

At a distance of 302 feet from the main adit a branch lode was encountered. This lode has a north-easterly strike and north-westerly dip, and projects from the main lode in an abrupt manner at an angle of about 80 degrees. The width of the branch lode is 27 feet. Where first cut this lode carried rich ore, and a drive was carried for 40 feet along its course. The ore along this drive is of good quality, and from a distance of 20 feet from the south drive to the face it is more or less cavernous. In the face the lode appears to be turning away to the eastward, but it is by no means certain that this is so; for the several makes of ore in such a formation may be inclined to the general

strike of the whole lode. Examples of such structural features are to be seen in the main lode of this same mine. At the time of the writer's visit the face of the slate was in graphitic slate, with which unmineralised quartz is associated.

In the No. 1 south drive, to the south-eastward of this drive on the branch lode, there were traversed a number of other veins of like mineralogical composition over a total width of 27 feet, the whole of which together constitute the branch lode which resembles the main lode in structure and composition. It appears to the writer to be of the same age as the main lode, and to have resulted from the simultaneous filling of two fractures produced by a single act of rupturing of the earth's crust. Examples of the relief of crustal stresses by fractures with two such different strikes are noted in this report as occurring in several other parts of the mining field, and it is pointed out that the lodes which have resulted from the filling of these fractures do not intersect or displace one another in the manner in which lodes of different ages often do.

The No. 1 south drive for the last 50 feet is in lode-matter of normal character. The quartz vein in the soft mineralised slate is sometimes massive and sometimes cavernous. The leaching of the lode is irregular, as in all parts of the mine on this level.

The No. 2 south drive is connected with the main adit in the vicinity of the rise to the surface; and at its north-western end is 100 feet from the No. 1 south drive. The drive follows the course of the lode. Near the shaft the lode-matter is dense quartz, with only traces of ferriferous dolomite, pyrites, and some fragments of undigested slate; but the drive follows material of a softer character which has suffered no small amount of secondary alteration. At a distance of 107 feet from the main adit behind the rise a connection with the No. 1 drive has been effected by a crosscut through the lode.

The No. 2 drive continues on a bearing of E. 11° S. for 110 feet in the lode. At first the drive is in soft, friable ore carrying bands of mineralised quartz and lenses of pyrite and chalcopyrite. The soft material is largely composed of altered dolomitised slate, in which undecomposed patches of denser character are visible. The direction of the drive was maintained, though the softer ore gradually passed over on to the south-western side of the drive. The part of the drive furthest from the main adit traverses at a narrow angle the successive bands of the lode. Graphitic

slate and dense quartzose veins heavily mineralised with copper pyrites and iron pyrites succeed each other at this place. The drive appears to be well within the boundary of the lode formation, and at 110 feet from the first crosscut it connects with the second crosscut. The continuation of this drive was begun at a point 29 feet further to the south-south-west, in order to take advantage of the softer ground, from which the drive had been diverted. The course is that of the south-western wall of the formation, along which friable ore showing unmistakable signs of leaching occurs. The total length driven is over 135 feet from the second crosscut, but the last part of the drive where the lode becomes very soft has collapsed. The lode-matter consists of decomposed brecciated slate with iron pyrites, chalcopyrite, and silica in irregular pockets. The slate has been chloritised to a considerable extent. and in addition appears to have undergone secondary decay.

The No. 1 crosscut, which connects the No. 1 and No. 2 drives at a distance of approximately 100 feet from the main adit, is 70 feet in length between these drives, and was continued in a south-westerly direction for another 18 feet. It affords an excellent section of the lode, and shows its composite character. The quartzose bands are in some cases dense in texture, in others full of vughs; sometimes almost free from metallic minerals, and at others densely mineralised. Chalcopyrite is present in the most massive portions. The slate is almost always rich in graphite, especially on the north-eastern side of the formation, and almost in every place carries some ferriferous dolomite. The vughs appear to have resulted from the removal of the more soluble constituents.

At one point in this crosscut there is a strong flow of water, emerging from the sole of the drive. This is undoubtedly water from the surface which has made its way down through the pores and vughs in the lode, and which rises upwards at the point where the workings tap the channel of circulation by reason of the head due to the greater elevation of the intake at the surface. The water is fresh and cold, and in no way resembles the water which in some parts of the world ascends from great depths. A precisely similar occurrence has been noted by the writer in the Mt. Farrell Mine, and similarly explained (see Geol. Surv., Tas. Bulletin No. 3, p. 63).

The crosscut was continued for a distance of 18 feet beyond the No. 2 south drive, and passed through slate containing quartz veins. The face of the crosscut is stained

with a deposit of limonite, and it is possible that there is more vein matter beyond.

The No. 2 crosscut, which traverses the ore-body at a distance of a little over 100 feet to the south-east, and affords a very similar exposure to that given by the first crosscut. The ore-body at this place is 75 feet wide, and the crosscut penetrates beyond this for a distance of 30 feet into the slate country. There are a few small veinlets of quartz and seams of pug along divisional planes for a few feet near the lode, and then the unaltered slate is exposed. The strike at this place is N. 80° W., and the dip north at 50 degrees.

The No. 3 crosscut was started from the No. 1 south drive at a point 105 feet beyond the lastmentioned crosscut and opposite the short drive on the north-eastern branch lode. It was carried for 46 feet only, and does not connect with the No. 2 south drive. The ore traversed certainly belongs structually to the main lode, not to the branch lode, and evidences of irregular leaching are prominent.

The future prospecting of the lode matter in this locality should include the systematic opening up of the main lode to the north-west of the tunnel crosscut, and also of the branch lode striking north-eastwards. In both these cases the method adopted for the prospecting of that part of the lode matter already exposed should be applied.

The deeper prospecting from the main shaft being sunk at the present time may be planned out on the same general lines. The depth to which the apparent partial leaching of the lode has attained can only be determined by actual prospecting. At the lower limit of the leached zone it is probable that the grade of the lode will be found to improve for a restricted depth. Much of the ore already exposed in the underground workings in this part of the mine appears to the writer to be certainly of primary origin, and there is consequently no reason to fear impoverishment of the ore shoot as depth is attained.

The ore obtained from the prospecting operations on the lode has been roughly graded and stacked at the mouth of the tunnel.

It cannot yet be said how far the main shoot of ore extends in a south-easterly or north-westerly direction. The lode is continuous through the property, and it remains to be proved whether those parts of the lode which are

marked by prominent quartz outcrops carry the copper contents which have been found to be present in the breaks in the ridge which marks the outcrop.

The size and continuity of the lode, as well as the results hitherto obtained, should suffice to ensure thorough and systematic prospecting at all points. The present energies of the company are concentrated upon the sinking of a main shaft, a course of action which is certainly sound. Meanwhile the tunnel workings may be advanced in the directions indicated above.

(12) *The North Mt. Balfour Copper Mines, No Liability.*

This company holds four sections, viz.:—2702-M, of 80 acres; and three other sections, 2957-M, 3724-M, and 3725-M, of 10 acres each.

The north-western extension of the main lode which is worked by the Mt. Balfour Company is to be traced through the south-western corner of Section 2957-M, and the greater part of the 80-acre section also. There it terminates. The work done at or near the surface upon this lode has been inconclusive. A trench was cut across the formation at a point 2 chains to the north-west of the south-western corner of Section 2957-M. There are a number of quartz veins in altered slate which carries graphite and hematite. The veins dip in all directions, and vary in size from mere stringers to veins 18 inches wide. The quartz is mineralised, and so is part of the slate of the formation.

It is noticeable that there are slight variations in the strike of different parts of the outcrop of the lode. The mean bearing at this place is N. 59° W. The outcrop follows a ridge broken only by the creeks in the south-eastern part of the property. The slopes of the ridge are gradual, and hence not very advantageous for prospecting by adits.

One shallow tunnel was driven for a distance of 72 feet in a direction bearing due north. Throughout its length lode-matter is present. The slate country has been broken for a considerable width, and the secondary material has recemented the fragments into a breccia or filled the spaces between the roughly parallel fractures. The slate itself is altered by the development of carbonates and graphite. Ten feet from the face of the tunnel a short drive was carried 18 feet in a west-north-westerly direction on the course of honeycombed quartzose vein. All the ore dis-

closed at this place has suffered leaching, and in a few places only have traces of malachite been recognised.

On the north-eastern side of the lode there are a few trenches, in which some small veins of quartz carrying pyrites are visible. These small veins are parallel to the main lode, with which they cannot be compared in bulk or importance.

A long tunnel was driven from the north-eastern portion of the section in a south-westerly direction in order to test the lode at the greatest depth attainable by means of an adit. At the time of the writer's visit to the mine the main lode had not been reached. The slate traversed in the north-eastern portion of the tunnel has a north-westerly strike and a dip to the north-east at 60 degrees. It is traversed by a number of minor fracture planes which have an average dip of about 60 degrees to the south-west. Several small veins were intersected during the course of driving this crosscut. At distances of 287 feet, 296 feet, 391 feet, 394 feet, and 431 feet from the entrance these were cut, but the crosscut was continued, since none offered sufficient encouragement to delay the work of reaching the main lode. The most promising of the veins is that cut at 431 feet from the mouth. Here some 4 feet of quartzose lode-matter and decomposed country-rock was found to carry a small copper content.

The main lode is reported to have been cut at a distance of 540 feet from the entrance. After some difficulty in dealing with a belt of running ground which adjoins the lode the main body was broken into. Some ore of excellent grade from this place was shown to the writer.

The prospecting work to be done upon this lode should include the driving of crosscuts at frequent intervals from the drive on the lode, with a view to testing the width of the formation and the distribution of values across this width.

The ridge, which appears to owe its existence to the presence of the hard lode-matter, dies out in the north-western part of the section, and the lode cannot be traced beyond it.

Some trenching has been done in the south-eastern part of the section, but no discovery of lode-matter *in situ* has been made there. The surface is covered by shallow patches of alluvial wash, and the trenches show the bed-rock to be slate and sandstone of normal character. There are some boulders of lode quartz in this wash.

(13) *Other Occurrences of Lode-matter at the Northern End of the Mt. Balfour Field.*

Sections 4106-M *and* 4758-M.—To the north-west of the North Mt. Balfour Mine there are a number of mineral sections within the boundaries of which very little work has been done.

There are indications of lode-matter in the south-western part of Section 4130-M. The country-rock is slate, which strikes N. 60° W., and dips north-east at 55 degrees. The slate is chloritised, and carries numerous veinlets of quartz, in which pyrite is present. Some trenching has been done in the beds of the creeks a few chains to the east of the south-western corner, and slate irregularly impregnated with pyrites.

To the south-west and in the northern part of Section 4106-M there is a low ridge capped by quartz-limonite lode-matter which has a strike of N. 26° W. No work beyond shallow trenching at one point has been done on the lode in spite of its promising appearance. It does not appear to extend northwards, since a trench on the boundary of Section 4106-M has failed to show the existence of lode stuff. Southwards, however, it may be followed along a low ridge for several chains, and then bifurcates and terminates. All along this outcrop there are strewn blocks of gossan and indurated slate stained with limonite and ribbed with veinlets of quartz. The general direction of the outcrop is maintained, after an interval, by a hog-backed ridge capped with quartz or quartzite and extending south-eastwards into Section 4431-M before it finally disappears.

At a distance of about a mile to the south-south-west of the principal workings on the Mt. Balfour Mine some prospecting has been done within Section 4758-M, which is charted in the names of W. Rainbird and K. Laughton. Three holes had been sunk at the time of the writer's visit upon portions of a lode, the strike of which seems to be N. 20° W. The ore exposed in the three excavations does not run continuously through all three, but occurs in the form of overlapping lenses of variable strike. The ore in these lenses is rather more pyritic than is usual on the field, though it belongs to the same general type. The slate is chloritised and silicified.

The present workings have proved the existence of solid pyritic lode-matter, and it is unlikely that any change in the quality of the ore will take place in depth. The ore

exposed has all the appearance of being primary. That work which has been done may be said to have achieved its object. It now remains to determine with certainty the course of the lode and the extent of the ore-shoot along the lode, and also in depth. On the south-east of the lode and 3 chains distant there is a low hill capped with honeycombed quartz, below which ore may be found. It is advisable to prospect at this place for the continuation of the lode.

(14) *The Outcrops lying to the West of Balfour.*

To the westward of the area drained by Tin Creek there are a number of outcrops which offer many points of resemblance to the outcrops of the lodes mentioned above. Some of these western outcrops have been cut through by trenches, but on the majority no work whatever has been done. The positions of the known outcrops are shown in the detail map, which includes this area at the head of the Nelson River. (Plate IV.)

One very well-defined outcrop extends from a point near the centre of Section 4276-M to the centre of Section 4278-M, constituting the backbone of a low ridge which rises slightly above the level of the valley-floor and forms the eastern bank of the Nelson River.

The outcrop consists of cellular quartz, the cavities showing by their form that pyrite crystals have been dissolved out. These cavities are seldom shaped like hollow cubes, for the pyrite crystals have possessed uncommon and complex forms. As soon as the superficial crust is broken away the presence of pyrites is visible in the quartz along the whole length of the lode. A trench has been cut near the boundary between Sections 4276-M and 4277-M, and the lode-matter there proved to extend over a width of 30 feet. There is a small excavation at the northern extremity of the lode, which has not been sufficient to give very definite information. Future work on the lode should be directed towards the exposure of the flanks of the quartzose parts of the lode in search for any parallel shoots which may carry a higher percentage of metallic minerals, and consequently outcrop less prominently.

In the valley of the Nelson River, 25 chains to the westward, there is an outcrop of similar cellular quartz stained with limonite and full of cavities after pyrite. It is included within the boundaries of Section 4477-M. No

work has been done on it, and any future attempt to prospect the lode must be carried out in the dry season on account of its low-lying position.

To the westward of this valley lies the broad peneplain from which the descent to the valley is by a short escarpment. The upper part of this escarpment is determined by a long outcrop of composite character. The many component portions are, in mineralogical composition, similar to those described above, and like the latter have remained unprospected. In the southern part of section 4170-M two massive quartz outcrops stand at right angles to each other. The quartz is sometimes stained with limonite, and is cellular through loss of pyrites. The northern lode dies out, and to the westward of its course there is a long line of lenses of similar materials. The lenses in some cases overlap *en échelon*, as in Sections 4171-M, 4172-M, and 4437-M; but this is not a constant feature. The strike of the composite formation varies from point to point, becoming more and more westerly as it is followed northwards. The largest continuous body of the series is one which extends for 20 chains on a bearing of N. 55° W. Beyond this the lode-matter extends as far as Section 4481-M before finally disappearing.

No opportunity for adequately testing this lode-matter by means of tunnels can be said to exist, though the south-eastern termination of the line of lode could be rapidly prospected at shallow levels by means of short tunnels driven from the foot of the scarp which rises from the valley flats.

The quartz outcrops along this line are certainly more worthy of trial than many others which have received attention from prospectors, for much of the quartz is heavily mineralised.

Two 80-acre sections, 4328-M and 4239-M, taking in the gorge of the Upper Nelson River, have been prospected at two points. In the southern part of the northern section and on the eastern bank of the main stream there is an irregularly-shaped outcrop of massive quartz which has been cut into. There is no sign of the presence of any metallic mineral with the quartz. A little work has been done in the southern section on the other side of the river, and mineralised slate has been exposed. No sign of any cupriferous mineral was seen, but pyrite is abundant in graphitic slate which has undergone silicification. The occurrence does not offer any encouraging indications.

(15) *The Balfour United Syndicate's Sections and the Adjoining Sections.*

To the east of Balfour, and for the most part on the eastern side of a small tributary of the Frankland River, are a number of sections on some of which active prospecting work has been carried out by the Balfour United Syndicate. Unfortunately this work has not yet been successful in locating any ore-body which offers promise of proving to be of commercial value.

The syndicate holds three sections, 4267-M, 4268-M, and 4274-M, comprising in all 160 acres. A lode formation has been found running across Section 4268-M, and entering the Section 4274-M. In the northern part of the latter a shaft has been sunk to a depth of 27 feet on a quartz lode carrying pyrites. The country-rock is heavily mineralised slate. The lode appears to have a course bearing N. 35° W. Traces of copper are said to have been seen in the quartz of this lode at a point just outside the northern boundary of Section 4274-M, where an excavation has been made to a depth of 12 feet. At this place the lode-stuff appears to have a brecciated structure. To the northward there are several trenches which give shallow exposures of the northern extension of this lode formation, which consists of graphitic slate charged with pyrites and carrying small quartz veins. One of the trenches on the bank of a creek was continued underground as a short tunnel, but without resulting in the exposure of any further information.

In the northern part of Section 4268-M a trench 3 chains long has been carried up the bed of a small creek, and exposed the bedrock. The northern continuation of what is apparently the same formation as that prospected in the southern part of the section is exposed for a width of 160 feet by this trench. The formation consists of dark quartzite and black indurated slate impregnated with pyrite and containing innumerable veinlets of quartz, with which chlorite and pyrite are associated. The structure is very irregular, the veins and fragments of impregnated country-rock possessing no constant directions of strike or dip. The formation at the south-western end of this trench is said to be cupriferous, though no copper-bearing mineral was visible in that portion of it still *in situ* at the time of the writer's visit. The lode-matter is such that shoots of copper ore may at any time be located within the formation, for it corresponds mineralogically with the non-

productive portions of cupriferous lodes throughout the field. The ore obtained from this lode and shown to the writer cannot have been derived from any shoot of material size, since all traces of its existence have been removed from the solid lode. It does not apear that the prospects at this place are very encouraging. The value of the formation must depend upon any discoveries that may be made in the future.

In the north-western part of Section 4274-M some trenches have been cut in the bed of the creek which crosses the section diagonally. The trenches show disturbed and contorted slate carrying a little graphite and a few small veins of quartz. On the western bank of the creek traces of galena are visible with pyrites in some iron-stained quartz.

To the northward of the Balfour United Syndicate's leases no work had been done at the time of the writer's visit. White quartzite, which marks the bleached outcrop of the northern extension of the formation exposed in the creek near the northern boundary of Section 4268-M, projects here and there through the button-grass in the south-western part of Section 4457-M, charted in the name of J. Reid. No indication of the existence of any more definite or more promising formation can be detected at the surface.

No work has been done on the remaining sections in this district save the cutting of a long shallow trench in an east-and-west direction in the southern part of Section 4283-M. Unmineralised slate only is exposed.

(16) *The Tin and Tungsten Bearing Lodes near Balfour.*

The area which contains the lodes which carry cassiterite and wolframite has been outlined on the detail map of the Balfour district. The lode-matter has hitherto received very little attention, but is now being worked at a few points by tributors on the leases held by the Mt. Balfour Pioneers, No Liability. The separate small veinlets cannot be indicated on the maps furnished with this report, though some of the largest separate veins and the localities in which notable crowding of the veinlets occurs are distinguished. It will be seen that this area includes the small hill known as Specimen Hill (on which are situated the greater part of Sections 1116-M and 1201-M, as well as the southern corner of Section 994-M and the north-western portion of the old reward lease 694-87M). Round

the base of this hill the principal work on the veinlets has been done. The upper parts of the hill are practically untouched on account of the difficulty of bringing any water on to the ground. Beyond the slopes of this hill the stanniferous ground extends into Section 1274-M. Here, below the Temma-Balfour road and to the north of the slaughteryard, several veins are visible *in situ* in the bedrock of the stripped alluvial ground. One vertical vein, 6 inches wide, was followed down for a few feet, but the ore became pyritic immediately below the surface, and the presence of pyrites led to the abandonment of the prospecting of the vein.

The small occurrences of lode-matter in the valley of Tin Creek to the northward of this point are mineralogically related to the copper lodes, and have no connection with the stanniferous veins. The tin ore obtained in the vicinity of these outcrops is of alluvial origin, derived from the upper portions of the Tin Creek basin.

The stanniferous veins are partly exposed in the road-cuttings on the eastern side of Specimen Hill, as far as the western boundary of Messrs. Murray Bros.' Reward Mine, but nothing has yet been done to open them up at this place.

On the south-eastern side of the hill, within the Section 694-87M, a small area has been worked for the superficial oxidised lode-matter. There are at this place a very large number of stringers, some flat, some inclined at low angles, traversing the slate. The cassiterite is accompanied by quartz and sericite in small amount. Pyrites has been present in all cases, and the slate containing the veinlets is pitted with cubical cavities which mark a former impregnation with the same mineral.

Specimen Hill is separated from a small hill to the southward by a small creek which runs diagonally across Section 4047-M. Along the south-eastern bank of this creek the lessee of the section, Mr. W. Bradley, has been working upon the upper part of a small but rich vein of oxidised ore, which dips to the south-east. The country-rock is soft, decomposed slate, which has been removed to a depth of as much as 5 feet in some places.

Another lode, with a strike which is nearly east and west, crosses the creek, and is partially exposed at a few points. It appears to dip southwards. There are some parts of the vein which appear to have suffered no superficial alteration, for they show the following minerals associated together:—quartz, pyrite, arsenopyrite, wolframite,

cassiterite, and chalcopyrite. From this vein several smaller ones branch, and are oxidised near the surface. Cassiterite is the only metallic mineral present in them in the weathered state, though it is probable that most of the other minerals mentioned above will be encountered in depth.

In Section 4659-M, which adjoins the last-mentioned section on the eastward, the alluvial workings have been traced up to a narrow vein, some 8 inches wide, with a north-and-south strike, and exceedingly rich in cassiterite. It is apparently vertical, and, being but little above the button-grass level at its outcrop, will probably become pyritic at no great depth. The friable character and ultimate disintegration of the vein has probably been due to the decomposition and removal in solution of the pyrites. Some work should be done upon the vein in order to ascertain its extent.

In Section 4132-M, south of Specimen Hill, a little work has been done on a small vein which has a strike of N. 47° W., and a south-westerly dip. The lode is not very well defined, and comprises at least two seams. The ore obtained from this place appears to the writer to be of a character intermediate between that of the tin ore and wolframite veins and that of the copper veins; but very little of the lode was actually exposed for examination. Pyrite, arsenopyrite, magnetite, and quartz are present in the lode, which certainly carries a trace of wolframite, and probably also a little cassiterite. Brown garnet is present in some parts of the vein-stuff. Samples of the ore were assayed for gold and silver, and gave returns up to 16 grains of gold and 1 oz. 14 dwt. 15 gr. of silver per ton. In one sample of a narrow seam of ore 4·44 per cent. of copper was found on assay to be present.

Some other quartz outcrops in the vicinity are still less promising, being not visibly mineralised. The ore which has been exposed by the work already done does not appear likely to prove of value for its copper contents, and there is not much inducement to work it for either the precious metals or tin and tungsten.

(17) *The Lodes Lying to the South-west of Balfour.*

A systematic attempt was made by the Balfour Prospecting and Mining Company to prove the value of a lode which lies mostly in Section 4262-M and crosses the north-eastern corner of 4238-M on a strike of N. 35° W.

A shaft has been sunk to a depth of 50 feet in the north-western corner of Section 4262-M. The lode dips to the south-west, and at the bottom of the shaft is said to be 14 feet wide. Gossanous material was encountered for the full depth, but the clean sulphides were just beginning to make their appearance when work was stopped by the inflow of water. The lode-matter, judged from the material on the tip, is of complex structure and composition. The gangue is sericitised and chloritised slate and quartz, and in this occur disseminated pyrite, siderite, chalcopyrite, sphalerite, and galena. An analysis of a picked sample of ore showed the presence of 7·53 per cent. of zinc, 2·69 per cent. of lead, 0·23 per cent. of copper, as well as 2 dwt. 15 gr. of gold and 2 oz. 13 dwt. 14 gr. of silver per ton. The lode-matter appears to be a variant of the copper-bearing type, notable chiefly for the proportion of galena and sphalerite present.

Some 4 chains further south the lode has been exposed in a creek bed, and a shaft put down to a depth of 20 feet. The ore is similar to that from the deeper shaft, but rather more weathered and leached. The country-rock is black slate. After crossing the angle of Section 4238-M the lode returns to Section 4262-M, where some trenches have been cut and another shaft 38 feet deep has been sunk. These workings did not attain a sufficient depth to reach the unaltered lode-matter, but proved the width of to lode to be 9 feet 6 inches. The gossanous material exposed does not offer any indications of value in the lode below.

This lode appears to the writer to have had a reasonable test. It is doubtful whether any shoot of galena or zinc-blende will be found which might prove to be of commercial value, and these are, next to pyrite, the most abundant sulphides in the lode.

To the south of the latter lode in the north-eastern portion of Section 4210-M, charted in the name of J. Donaldson, is the south-eastern end of a massive and continuous quartz lode. On the northern boundary of the section in the bed of a creek the lode has been cut into. The vein-stuff consists of quartz carrying some sericite and chlorite, and a fair amount of pyrite. Galena is said to have been obtained at this place, but none was visible at the time of the writer's visit. The pocket would therefore seem to have been only a small one.

The lode continues in a W.N.W. direction up the slopes of the northern part of Mt. Balfour, where some trenches

have been cut across the outcrop. The actual width of the lode is difficult to estimate on account of the gradual change from lode-quartz into quartzite, yet it is certainly large, and exceeds 50 feet at the surface at some points. The trenches gave no results, for the quartz contains no metallic minerals. Cavities left by the removal of pyrite are present, but not in any quantity.

In the western part of Section 4238-M a short tunnel has been driven in a south-westerly direction across the lode. It was begun in banded slate and sandstone striking N. 50° W., and dipping to the north-east at 48 degrees. In the vicinity of the lode the country-rock is much disturbed, and carries graphite. The lode itself is a broad belt of quartz and silicified country in which crystals of pyrite are common and occasional splashes of chalcopyrite are seen.

From this main quartz-lode run two parallel lodes on a more northerly course. A trench cut across the eastern one, in the vicinity of the tunnel just mentioned, shows it to be at that point a broad and rather indefinite formation consisting of dark slate impregnated with pyrites and veinlets of quartz. As it is followed north the lode becomes better defined, and the veins of quartz and pyrite become larger. In one trench some galena was exposed, but not in large amount. The country-rock carries a notable amount of graphite.

The western branch lode has been prospected by a short tunnel on the lode. Where cut the lode has a width of 4 feet 6 inches, and is a compact body consisting of quartz and quartzite with very massive pyrites. Gold has been found by assay to be present in small amount. A drive carried southwards for 20 feet gave no encouragement, since the ore-body splits into several lenses and shows a smaller proportion of metallic constituents. No copper-bearing mineral was seen in this lode during the work of prospecting. These two branch lodes continue northwards through the north-eastern corner of Section 4263-M into Section 4417-M, where the outcrops are traceable at the surface. The presence of pyrites in the eastern one is noticeable, but no work has been done.

The main lode maintains its course across Sections 4263-M and 4337-M. In the latter section Mr. J. Connors has cut a deep trench across the lode in one of the creek gorges, and has laid bare the solid bedrock. The lode consists of quartzite and quartz with a considerable amount

of pyrites, but without any visible signs of the presence of any copper-bearing mineral. The trench shows the lode-formation to be at this place over 100 feet in width. A tunnel was begun from the lower end of the trench, and follows a course but little different from that of the trench, so that it hardly exposes any more of the lode than is visible in the trench. At a point higher up the hill to the north-west another tunnel has been begun in slate and sandstone, which strikes N. 20° E., and dips to the south-east at 42 degrees. A few veins of quartz were cut, but nothing which offers promise of improvement. The work has not proceeded far enough to give an intersection of the main lode. The outcrop on the crest of the hill is massive, and consists of white quartz, part of which is honey-combed, the cavities having the form of pyrites crystals. Two shallow excavations have been made upon the outcrop at this place. Pyrite has been exposed, but no mineral of value.

The massive quartz lode in this locality does not offer any inducement in itself. It is a dense body in which the percentage of metallic minerals has always been small. As such it cannot be expected to improve in value at depth, and future prospecting operations should be directed towards the search for possible shoots of ore parallel to this dense quartzose lode.

Within the boundaries of Section 4315-M there are two small outcrops of quartzose lode-matter which have not been opened up. They do not show any signs of the presence of metallic minerals. A similar outcrop appears near the top of Mt. Balfour, within Section 4391-M, and what is possibly the continuation of this lode on the eastern boundary of Section 4198-M.

On the western side of Mt. Balfour the Balfour Prospecting and Mining Company has done a little surface work upon a massive quartz outcrop which is half a chain in width. The quartz at the surface contains many holes after pyrites. A little below the surface the quartz shows stains of limonite, and a little deeper still shows unoxidised pyrite. No copper bearing mineral has been seen. The quartz lode has a strike of N. 5° W.; and, being located upon the flank of the mountain, is in a suitable position for inexpensive prospecting by tunnelling. It does not appear, however, that the lode justifies further expenditure, save with a view to the search for mineralised shoots on the flanks of the lode which makes the bold outcrops.

(18) *The Lodes Lying to the South of Balfour.*

The main line of lode of the Balfour field cannot be traced continuously southwards beyond the boundaries of the reward section, 123-M. The surface of the ground in the locality where the outcrop disappears is flat, and is covered with button-grass for some distance. Where a creek has dissected this surface in the eastern part of Section 3156-M, a trench cut in the eastern bank of the creek shows a large number of quartz veins of small size over a considerable width. No metallic minerals are visible, and no further work was carried out.

There are, however, outcrops which appear certainly to be southern extensions of this same line of lode in the Section 4142-M, where some prospecting work has been carried out by the South Murray Balfour Copper Company, No Liability. The country is for the most part flat within this section, and the only course to follow is that which was adopted by the company. A series of trenches were cut across the supposed line of the lode, and proved successful in locating it. The formation is a composite one, consisting of numerous stringers which extend over a total width of about 60 feet. In the north-western part of the section pyrites is associated with the quartz, and occasional splashes of chalcopyrite were seen while the trenches were being cut. It was decided to sink a shaft on the western side of the lode, in order to expose the lode in depth. The shaft was down to a depth of some 30 feet at the time of the writer's visit. The country-rock at that depth is green slate, in which occur threads of silica and a good deal of pyrite. It is doubtful whether any adequate underground prospecting will be possible on this property without the assistance of machinery, save when weather conditions are most favourable.

To the east of this section and within the boundaries of Section 4212-M some prospecting trenches have been cut by the Balfour Prospecting and Mining Company. No defined formation has been found, though the slate shows impregnation with pyrite, and a few quartz stringers are present. A cut in the eastern bank of Tin Creek, just beyond the northern boundary of the section, shows similar quartz veinlets in slate carrying pyrite and traces of chalcopyrite.

Some prospecting has been done on Section 3763-M by the Balfour Consolidated Copper Mines, No Liability.

There is an outcrop following the crest of a low ridge in the north-western part of the section. The trenches on this outcrop show the presence of a honeycombed quartz lode, in which the cavities have the form of cubes. The country-rock is greenish slate and white quartzite. This quartzite causes to no small degree the prominence of the outcrop, on account of its hard and compact nature. A tunnel has been driven in an east-north-east direction from the western side of the hill through the lode, which is not so prominent in depth as the surface indications would seem to imply. The latter part of the tunnel is in soft black slate carrying crystals of pyrite.

On Section 3639-M, charted in the name of W. Williamson, a hog-backed ridge running through the section is capped by the quartzose and gossanous outcrop of a lode which strikes N. 29° W. Some little work has been done on this property, which is known locally as the "Pierpont Morgan Mine." The trenches on the outcrop show honeycombed quartz with cubical cavities after pyrite, which appears to dip westwards in silicified sandstone which has been stained to a deep-red colour with hematite. A short tunnel has been driven from the north-eastern side of the hill on a bearing of W. 36° S. to cut the lode. The country-rock is much decomposed at the tunnel level, but appears to have suffered also some alteration by the mineralising solutions in the vicinity of the lode. At a distance of 110 feet from the opening set the lode was met. It is 30 feet in width, and consists of well-defined quartzose material with heavily mineralised bands containing pyrite, chalcopyrite, and covellite. A certain amount of oxidation and leaching is evident, and it seems reasonable to hope for an improvement in the grade of the ore at a greater depth. On the western side of the lode graphitic slate is found, with stringers of quartz traversing it at flat angles. The face of the crosscut is in clean graphitic slate. A short drive of 25 feet southwards shows oxidised and leached lode-matter, with occasional bunches of sulphides.

As far as work has gone, the prospecting at this place has been successful in locating an ore-body which appears to offer some promise. Little has been actually proved, but enough to show that ore of good grade exists and that the lode merits a thorough test in depth. The configuration of the country does not admit of tunnelling, and a shaft should be sunk.

To the south-west of the Pierpont Morgan Mine, and in the north-eastern corner of Section 4264-M, there is a rather indefinite lode, which partakes rather of the nature of a band or bar of quartzite formed by the impregnation of a bed of sandstone with silica. In some places there is a great deal of pyrites present, and this gives rise, on weathering, to a gossanous capping. There are several somewhat similar outcrops of quartzite on the ridges which lie to the south and south-west, but practically no signs of pyrites in them.

In the southern portion of Section 4343-M there is a strong outcrop of quartz carrying cavities after pyrite, and stains of limonite beneath the bleached outer crust. The strike of the lode is N. 55° W. Nothing more than the mere knapping of the surface of the outcrop has been done.

(19) *The Properties Situated on the Western Slopes of Mt. Frankland.*

The two sections, 4216-M and 4217-M have apparently been pegged to include a bold outcrop of dense-grained white to pink quartzite which forms the western spur of the mount. This quartzite has a strike of N. 40° W., and dips to the south-west. It is entirely similar in character to the quartzite forming the crest of the mountain a few chains to the south-east. This quartzite has doubtless been formed in a manner similar to that in which the many bars of quartzite which resemble lodes have been made. It has been pointed out in another part of this bulletin that such occurrences have not in any case within the limits of the field proved to be of commercial value.

(20) *The Lodes Lying to the South-east of Mt. Frankland.*

A group of sections, now abandoned, were pegged out to include several small outcrops of lode-matter, but very little work indeed has been done in the whole area.

In the western portion of Section 4359-M, near the north-eastern corner of Section 4300-M, there is an outcrop of silicified sandstone with cubical cavities after pyrite, which has a strike of N. 30° W. In the southern part of the same section there are two outcrops which possibly belong to one lode. The more northerly is in flat country, and is composed of overlapping lenses of dense, flinty

quartzite, in which there are occasional cavities after pyrite. The second is on a hill in the south-eastern part of the section, and consists of material which differs only by the presence of limonite stains from that mentioned above. The cavities in the quartzite are not numerous.

In the northern part of Section 4302-M, on top of the hill above Waratah Creek, there is a small outcrop of honeycombed quartz, which carries pyrites beneath the cellular crust. Limonite present in the outcrop gives it a gossanous appearance. The strike appears to be N. 40° W. from the direction of distribution of some broken fragments of lode-matter. This outcrop should certainly be attacked; and, if preliminary prospecting operations give indications of promise, a tunnel may easily be put in at the bottom of the hill near creek level.

In the southern part of Section 4346-M there is an outcrop of dense quartzite containing a few cavities after pyrite and stains of limonite. There does not appear to be much inducement to work upon this outcrop. As in the case of other such outcrops in this district, the work of prospecting should be mainly restricted to the search for more heavily mineralised shoots in the vicinity of these quartzite bars which make the prominent outcrops. Just outside the south-eastern corner of the latter section and in Section 4358-M there is a small outcrop of slate carrying quartz veinlets and a few stains of limonite.

The best-defined and most promising lode in the area runs diagonally through two 40-acre sections, numbered 4281-M and 4282-M. The outcrop is marked by the presence of quartz, limonite, and hematite. These minerals in Section 4281-M occur in a series of overlapping lenses a few yards in length and 2 feet in width. The strike of the lenses themselves is on the average N. 40° W., but the strike of the whole formation taken collectively appears to be N. 52° W. The lode has a south-westerly dip at an angle of 70 degrees in the trenches which have been cut.

Continuing into Section 4282-M the formation becomes more massive. One trench shows it to be 6 feet wide and vertical, crossing flatly-bedded slate and sandstone which is much weathered. The quartz is much fractured, and in the middle of the formation is an altered pyritic band. The gossan and pyrites is flanked on the east by quartz and on the west by altered slate deeply stained with hematite. The quartz carries either cavities emptied of pyrite or limonite pseudomorphs after that mineral. Small quantities of copper ore were found in this place, and a

tunnel was started to cut the lode at a depth of 30 feet below the outcrop. This object was never attained, since the workings collapsed before the lode was reached. It is to be regretted that this lode has not been explored in depth, since the presence of copper ore at shallow levels has been proved. How far the lode extends to the north-west cannot be definitely determined for the cover of peat. There is, however, a small outcrop in Section 4358-M, just outside the north-western corner of Section 4282-M, where a shallow cut has exposed pyrites beneath a quartz and limonite capping. A similar outcrop is located at the north-eastern corner of Section 4346-M.

(2)—The Mining Properties near Mt. Hazelton.

(Plate V.)

(21) *The Mt. Lyell Mining and Railway Company's Leases.*

A large number of sections are held by the Mt. Lyell Company in a district lying to the south-west of Mt. Frankland, and for the most part to the south of the district comprised in Plate IV. accompanying this bulletin. The area embraced by them is 280 acres. Mineral Sections 3686-M, 3687-M, 3688-M, 3689-M, 3801-M, and 3802-M consist of 40 acres each; and Sections 4367-M and 3690-M each contain 20 acres.

In the most northerly of these sections the small amount of work done has not met with any success, and no definite lode formations can be said to have been located.

There are better-defined outcrops in Section 3688-M. None of these are large, but all are worthy of trial. Prospecting at this point had not been begun at the time of the writer's visit.

In the north-western part of Section 3802-M some underground prospecting was being carried out from a small shaft which had a total depth of 47 feet. A little copper pyrites was found at the bottom of the shaft, and a drive was put in northwards on the lode, which has a strike of N. 20° W. for a distance of 107 feet. This drive was in lode formation for the whole distance, but nothing of value was found. Mineralised quartz veins in mineralised and chloritised slate constitute this lode-matter, and splashes of copper pyrites occur in the quartz veins. The lode is nearly vertical, and has a slight inclination to the westward. At a point 85 feet distant from the shaft a

pocket of good ore was found in this drive, but it gave place rapidly to quartz carrying galena and blende in small quantities in addition to pyrite. A crosscut 24 feet long was driven westwards from the face of the drive at a point 107 feet distant from the shaft. This crosscut exposes a number of small veins of pyrite and mixed quartz and pyrite.

Another drive was carried from the foot of the shaft in an east-north-east direction for a distance of 166 feet. Lode-matter was traversed for the first 6 feet of this drive. The end of the drive is in a soft, friable sandstone impregnated with pyrite, but not indurated by the usual silicification. It is possible that this impregnated zone marks the continuation of the long lode outcropping at the surface to the southwards; but there is no sign of its presence at the surface, and the underground indications are not encouraging. The country-rock shows many signs of disturbance. The strike appears to be in most places a few degrees west of north, and the dip between 25 and 45 degrees to the eastward. In the face of the eastern drive the country-rock assumes a vertical position, and carries a little graphite. Traces of copper pyrites were found in small veinlets cut through by this eastern drive, but none are of such dimensions that they offer inducement to follow them. The lode upon which the shaft has been sunk has been cut by a trench immediately to the north of the shaft. The quartz and gossanous lode-matter exposed have been leached of any copper contents which they may have possessed.

The principal occurrence of lode-matter in this group of sections is one which has a strike of N. 29° W., and extends from the central part of Section 3802-M through Section 3687-M and Section 3686-M, and even beyond the southern limits of the latter. In the lastnamed section the lode outcrop forms the backbone of a hog-backed ridge which rises to a height of 75 feet above the surrounding button-grass flats. The lode has been partially exposed by a number of trenches on the surface, and two small tunnels at very shallow levels. The lode appears to have a dip to the westward. The average width of the lode is about 6 feet. Structurally the formation is rather complex, and it occupies a fracture of irregular form in much-disturbed country, the general dip of which is to the eastward. The lode-stuff consists principally of quartz, in which limonite is common, but from which the metallic minerals have in almost all cases been removed by super-

ficial leaching. However, on the highest part of the hill both pyrite and chalcopyrite are visible in the quartz, and with the copper pyrites occurs a little covellite. At the time of the writer's visit a tunnel was being started to cut the lode at a depth of 70 feet below the point where the copper ore was located. The appearance of the quartzose outcrop is not very encouraging in itself. Those portions of the lode from which the metallic minerals have been leached indicate that the vein-matter has always been highly siliceous, and that no great proportion of metallic ingredients has ever existed in the ore. It is therefore improbable that the barren quartzose ore of the surface will be replaced by copper ore of good grade at a lower level, but the possible existence of shoots of ore not indicated by such a prominent outcrop should be borne in mind. The deeper prospecting from the tunnel mentioned will give valuable information on this matter.

Another group of leases held by the same company is situated at the elbow of the Lindsay River, which is situated 3 miles to the eastward of Mt. Hazelton. The leases comprise in all 460 acres.

Leases 3607-M, 3608-M, 3609-M, and 3610-M contain 10 acres each; those numbered 3603-M, 3604-M, 3605-M, 3606-M, and 3682-M contain 20 acres each; while each of the sections numbered 3483-M, 3602-M, 3680-M, and 3681-M includes 80 acres.

The principal lode situated within this area follows a north-westerly course from Section 3483-M towards Doherty's Pimple, and may be traced at the surface almost without interruption for a mile and a quarter.

Some shallow work has been carried out within Section 3483-M upon the outcrop of this lode. A trench situated upon the northern boundary of that section proves the quartzose vein-stuff to carry pyrite and traces of covellite. The lode is at this point narrow—a little over 3 feet in width—and appears to dip to the north-east. In all other exposures, however, the dip is to the south-west. The country-rock beyond the lode dips at a flat angle towards the east. The slate adjoining the lode is coloured red by hematite. A short distance to the south-east a deeper trench has been cut, and a better section of the lode is afforded. There is at this point a wide belt of impregnated country on the north-eastern side of the lode. The lode itself is 10 feet wide, and consists of quartz which carries some pyrites, or cavities from which pyrites has been leached. Traces of chalcopyrite and covellite are

visible. The iron pyrites occurring at this place has been found by the company to contain half per cent. of copper. The country-rock of the footwall is impregnated irregularly with silica and hematite for a width of 75 feet.

In the south-eastern part of Section 3602-M a few shots have been put into the outcrop of this lode in the bed of a small creek. The lode-matter is here of the nature of altered country-rock--sandstone converted into quartzite and impregnated with pyrite. But in the north-western part of the section the lode resumes a better-defined character. A trench distant a chain and a half from the western boundary of the section gives an exposure of quartz which is full of pyrite and carries a little chalcopyrite and covellite. The lode is at this place 12 feet wide and of massive appearance. A short tunnel was being driven in a south-easterly direction on the course of the lode at this place, and had only penetrated the decomposed portion of the lode at the time of the writer's visit. Only limonite-stained clay and quartz had been encountered, and at that time no sign of copper had been seen.

In the central part of Section 3603-M a deep trench across the lode shows the most promising development of ore which had been found at the time when this examination was made. At the top of the trench the width of the lode is 14 feet, but at the bottom it contracts to 12 feet. The dip is to the south-west, and, while the inclination of the hanging-wall is 73 degrees, that of the footwall is 61 degrees. The slate on the footwall side has been indurated to an extremely dense quartzite, which carries spheroidal or ovoidal concretions of pyrites and dips in an easterly direction. In the hanging-wall side the slate dips with the lode. The ore consists of crystalline pyrites with chalcopyrite and covellite in a non-metallic aggregate consisting of quartz, chlorite, sericite, and undigested slate. The covellite is at this place rather more massive than usual, and materially enhances the value of the ore. The intention of the company to sink upon this shoot of ore is heartily to be commended.

To the north-west of this occurrence the outcrop of the lode is not prominent, though the general course of the lode follows a long ridge which extends in the direction of Doherty's Pimple. In a few places it can be seen outcropping through the peat, and seems to continue as far as the south-eastern corner of Section 3608-M. From the centre of Section 3607-M a tunnel was driven to cut the lode at a depth of 66 feet from the surface. The slate

traversed in the approach is much fractured and disturbed. A formation 16 feet in width and consisting of broken slate and quartz was passed through, and the main lode was encountered at a distance of 80 feet from the opening set. The lode-matter, which was barely exposed in the face of the crosscut at the time of the writer's visit, consists of quartz with pyrite, chalcopyrite, and a little covellite in crushed and sericitised slate. Subsequent work is stated to have proved this lode to be 9 feet in width.

This main lode has not been definitely recognised beyond the limits of Section 3607-M, but a number of other outcrops have been followed in a north-westerly direction for a distance of nearly a mile and a half. These, though not yet known to be continuous, probably constitute the north-westerly extension of the main lode, their relation to which is shown by the chart (Plate V.) accompanying this report. To the south-east of the area discussed the outcrop has not been seen to continue without interruption. The only vein-matter which may be considered to be connected with this lode is to be seen near the south-west corner of Section 4672-M.

There remain to be mentioned several lodes other than the main lode which are situated within the Mt. Lyell Company's leases.

The most northerly of these is a cross lode which follows a course bearing 40 degrees south of west from the centre of Section 3607-M. This lode lies in a position approximately parallel to the course of the tunnel mentioned above, and may readily be prospected from that tunnel. The outcrop consists of iron-stained quartz much pitted with cavities after pyrite. For reasons given in another part of this bulletin it is doubtful whether the intersection of this cross lode with the main lode will be marked by any appreciable difference in the metallic contents of either lode.

On the north-eastern side of the main lode, and a mile to the south-east of the lode just mentioned, is another cross lode which traverses Sections 3605-M and 3606-M in a direction varying from N. 75° E. to N. 60° E. The outcrop in the centre of Section 3605-M has a width of 12 feet, and consists almost wholly of quartz. A tunnel driven southwards to cut this lode 70 feet below the outcrop had, at the date of examination, reached a distance of 65 feet from the entrance, and another 100 feet remained to be driven. The drive is in banded slate, show-

ing considerable crumpling and faulting, and having an average dip of 26 degrees to the east.

The remaining cross lode lies to the south-east of the main lode, and traverses Section 3483-M diagonally on an average course of W. 40° S. Like the other cross lodes, it ceases abruptly at the point where it meets the main lode, and cannot be traced on the further side of the latter. It forms a strong quartzose outcrop which can be traced without interruption through the section to the south-western corner, where it has a width of 14 feet. At the time of the writer's visit a tunnel was being driven towards the point of intersection of this lode and the main lode, in the hope of meeting with a shoot of ore at that point. As already indicated, there is no good reason to expect a concentration of ore at such a point, although such an occurrence may possibly exist. A little work has been done upon the south-western extension of this lode on the bank of the Lindsay River beyond the limits of Section 3483-M. Two small excavations made in the low-lying country on the south bank of the river show quartzose lode-matter, which appears to occur in two distinct veins or lenses, which are not collinear. A portion of the ore at this place carries a notable proportion of stibnite, together with pyrites in massive quartz. The ore is banded, the constituent minerals having been deposited in successive crusts. The stibnite disappeared almost entirely immediately below the surface, and only traces remain at the bottom of a shallow excavation Beyond this place the probable continuation of the same lode may be seen on the northern bank of the river, where it traverses Section 3682-M. The outcrop at this place consists of massive quartz, in which there are cavities from which pyrites has been leached.

The remaining lode which occurs in this group of sections makes a prominent but short outcrop in Section 3483-M, a little to the north-east of the main lode. The outcrop consists of quartz carrying pyrite and silicified slate, which has a somewhat gossanous cap. The strike of the formation is N. 70° W., and it would apparently junction with the main lode at the point where such a wide belt of altered country has been proved by trenching.

The prospects of this group of sections appear to depend upon the success of mining operations on the main lode. The line of lode is apparently continuous for a considerable distance, and there are no serious difficulties to be overcome in prospecting it.

(22) *The Lodes near the Head of Tin Creek.*

To the westward of the block of sections held by the Mt. Lyell Company there are a few outcrops upon which no work has been done. The best-defined of these makes a very prominent outcrop upon a hilltop in Section 4341-M. The lode-stuff is almost wholly quartz, but when the capping is broken limonite stains are visible. A few cavities after pyrites may be seen, but the outcrop does not possess a promising appearance. Entirely similar lode-matter occurs to the southward, in Section 4342-M. Still further south, in Section 4225-M, there is a lot of loose quartz at the surface, but none was seen which is certainly *in situ*. However, there are two strong lodes beyond the limits of the latter section which consist of massive quartz, wnich carries a few cavities after pyrite.

In the north-eastern part of Section 4209-M there is a small outcrop of slate impregnated with quartz and pyrites. This vein is small and not well defined, and its extension along the strike is masked by the surface vegetation.

On the eastern side of the Mt. Lyell Company's leases, and in the south-eastern portion of Section 4266-M, there is a small outcrop of dense quartz, from which metallic minerals are absent. A little distance away from this place, and in the north-western part of Section 4609-M, a small trench has been cut across a siliceous lode which has a strike of N. 40° W., and a dip to the south-west. The lode-matter consists of quartz with sericite and chlorite and cavities after pyrite. The outcrop is short, and is not prominent. No copper-bearing mineral could be seen in the vein-stuff. Immediately to the westward and in Section 4414-M there is a small excavation in which similar lode-matter occurs. The dip of this vein is to the south-west, but in the absence of a continuous outcrop the strike could not be determined.

Beyond the most southerly of the Mt. Lyell Company's sections in this locality the main lode prospected by that company may be traced in a south-south-westerly direction through Section 4270-M and the north-eastern part of Section 3640-M. The topography is unfavourable for tunnelling at this place, and the shallow trenches which have been cut do not afford exposures which give much information. The outcrop is for the most part quartzose, but is in a few places gossanous. The quartz has in some places a rather bluish hue, but is more usually white, and carries

cavities from which some rhombohedral carbonate, such as dolomite, has been dissolved away. To the eastward of the formation is a broad zone of altered country carrying enough hematite to produce a deep-red stain. It would be wise to sink on the gossanous portions of this outcrop to a sufficient depth to penetrate the leached zone, below which copper ore may possibly be found.

To the southward of Section 3640-M this main lode does not continue, its place being taken by a number of outcrops of quartzite, which show that the mineralising solutions have not been restricted to one definite channel, but have effected a general impregnation of certain beds of sandstone. However, after an interval there is one outcrop of vein quartz in the north-eastern part of Section 4120-M. There are signs of the former presence of pyrite in this quartz, but it does not appear promising.

To the south-west of this line of lode, and running diagonally through the centre of Section 3640-M on a bearing of N. 34° W., is a lode which shows, at one point, encouraging results for the work done upon it. Three trenches have been cut, the flat nature of the country not admitting of tunnelling. In two of the trenches no copper ore is to be seen, but in the third, which is 6 chains distant from the southern boundary of the section, chalcopyrite with pyrite is to be seen scattered through the quartz of the lode. The latter has a total width of 5 feet, and consists of two quartzose veins with altered country between them. The exposure of ore at this place is encouraging, and there should be more work done at this point to follow the shoot which has been located.

To the south-west of this lastmentioned lode there is an untried outcrop of quartz, which has a strike of N. 38° W., and lies in the centre of Section 4230-M.

Upon the area embraced by the isolated Section 4419-M a little work has been done. In the eastern part of the lease, immediately to the west of the Balfour-Pieman track, a few trenches have proved the presence of numerous quartz stringers in decomposed slate. These trenches are all too shallow to give any definite information. In the north-western part of the section a well-defined quartz lode having a strike of N. 35° W. is exposed for a short distance by a trench. At the surface the quartz carries no metallic minerals, pyrite having been leached out, but below the superficial capping pyrite is to be seen. No copper-bearing mineral was seen by the writer at the time of his visit.

(23) *The Balfour South Copper Mines, No Liability.*

The property owned by the Balfour South Copper Mines consists of 160 acres, divided among the following sections of 40 acres each—3676-M, 3677-M, 4236-M, and 4237M. There are several outcrops within these leases, and too little work has been done to afford conclusive proof of the relationship between them. There appears to be a lode running southwards through Section 3677-M on a bearing of S. 28° E. The outcrop is not a prominent one, but there are fragments of lode quartz at the surface, and in one place at a distance of 4 chains from the southern boundary of the lease a shallow trench has exposed iron-stained slate and pyritiferous quartz. This lode makes no visible outcrop in the bed of Waratah Creek at the point where it might be expected to be seen. A short tunnel has been driven in a direction bearing W. 14° S. from the western bank of the creek which junctions with Waratah Creek in the northern part of the section. The face of the tunnel is in mineralised and silicified slate, work having been abandoned when the drive had not been sufficiently far advanced to traverse the formation, which is probably identical with that which extends southwards, and to which reference has been made above.

To the north of the latter workings, and just inside the boundaries of Section 3676-M, are situated the principal workings. On the western bank of Waratah Creek the first discovery of ore was made, and a short tunnel was driven in a direction bearing W. 25° S. This tunnel cut through a formation from which the copper contents have been, for the most part, leached. Chalcopyrite and covellite may both be seen in siliceous lode-matter, which has a width of 3 feet. The better ore is restricted to a band from 12 to 14 inches wide, the remainder of the lode being of complex structure and containing enclosures of altered slate. There are stains of copper sulphate over a considerable width in these workings. The tunnel penetrated a total width of 40 feet of country, which contains traces of copper. The slate is stained brown with limonite and hematite, and carries veinlets in which the copper values are concentrated. How much of the copper content of this country adjoining the lode has been distributed by secondary processes cannot possibly be ascertained until deeper workings have been opened up for comparison. The lode cut by this tunnel is situated at the entrance, and has a westerly dip at an angle of 73 degrees. Its strike cannot be determined with even approximate certainty from the

work done. Two other cuts have been made in the same bank of the creek a short distance to the northward, but with negative results. A short distance to the southward, however, the work of prospecting has been more successful. A shaft has been sunk to a depth of 26 feet on the lode, and from the excavation some tons of excellent ore have been brought up. These workings were inaccessible to the writer, but the ore obtained thence was available for examination. The character of the ore is identical with that of the ore obtained from the richest shoots on the field. Structurally the lode appears to be complex, as if a sheeted fracture zone were replaced with the vein minerals. The width of the lode at the bottom of the shaft is said to be 6 feet. The strike of this shoot of ore appears to be, at the site of the shaft, very nearly north and south, and the dip is to the westward at an angle of 63 degrees.

Immediately to the southward of this prospecting shaft there is a branch lode, the outcrop of which consists of quartz and limonite. The strike of this lode is N. 34° W., on which bearing it may be followed for a short distance to the north-west before it disappears. It is not yet proved whether either of these two occurrences of lode-matter is connected with the outcrop in Section 3677-M to the southward.

On the eastern side of Waratah Creek and opposite to these lastmentioned workings there is a more massive lode marked at the surface by two parallel reefs of quartz with gossanous material. The strike of the lode is N. 40° W., and it extends as far as the south-eastern corner of Section 3676-M. A short tunnel has been driven along the western side of the formation, and has exposed lode-matter which consists largely of ferriferous dolomite, with which occur quartz, pyrite, magnetite, chalcopyrite, and some covellite. The carbonate weathers out, leaving a honeycombed quartzose ore studded with crystals of magnetite and pyrite. The country is stained green from the development of chlorite, and there is much limonite at the surface.

A main shaft was begun, but the work of sinking was temporarily abandoned when a depth of 32 feet had been attained. From this shaft it will be possible to prospect all the lodes mentioned above; and the work of further sinking should be pushed forward before the necessary crosscuts to the eastward are begun.

The only other occurrence of lode-matter within the boundaries of the company's leases is an isolated patch of limonite in the centre of Section 4236-M.

The future of the property will depend, in the main, upon the manner in which the shoot of ore located by the prospecting shaft behaves in depth. The ore hitherto won is of high grade, and results already obtained should be an incentive to prosecute the active development of the property. The period of inactivity which lasted throughout the writer's visit to the field is much to be regretted.

(24) *The Lodes in the Vicinity of the Balfour South Copper Mines.*

The northerly extension of the Balfour South lode system cannot be definitely traced. In the south-western part of Section 4245-M there are two unprospected outcrops of iron-stained quartz, in one of which copper pyrites and traces of covellite are visible. Both of these outcrops are in low country, and cannot be adequately prospected without sinking a shaft.

To the south-west of the Balfour South Mine a little prospecting work has been done in Section 4228-M. A long ridge runs through this section in a direction bearing N. 18° W., forming the divide between Waratah and Daisy Creeks. The capping of this ridge is indurated sandstone with a few small veins of silica, in some of which the cavities show proof of the former presence of pyrite.

In the north-eastern part of Section 4210-M, which adjoins the lastmentioned, there is an outcrop of limonite-stained quartz, in which there are signs of the former presence of pyrite.

To the southward, on the northern slopes of Mt. Hazelton, a little work has been done on Section 3723-M, owned by Messrs. W. W. F. and T. C. Murray. There is a massive quartz outcrop in the north-eastern part of the section through which a trench has been cut. The results are not promising, and the dimensions of the lode appear to contract below the surface. Pyrite is present both in the lode-stuff and in the silicified country-rock alongside.

There is another unprospected outcrop of similar material in the south-western part of the section; and beyond the southern limits of the lease there are some well-defined veins of quartz, upon which no work has been done.

A number of mineral sections have been pegged out, apparently with the object of securing the southward continuation of the Balfour South lode. It cannot, however,

be claimed that this lode has been proved to extend beyond Section 3677-M. In the adjoining Section 3798-M there is an outcrop of lode-matter, the strike of which appears to be N. 40° E. A trench has been cut across it, and a shallow excavation made, proving the width of the lode to be 3 feet, and the walls to consist of silicified sandstone and slate. Both the quartz and quartzite are heavily charged with pyrite, but no copper-bearing minerals are visible.

At a distance of nearly a mile, and still further to the southward, three sections—numbers 3683-M, 3684-M, and 3685-M—each of 20 acres, are held by the Mt. Lyell Company. The only lode-matter visible at the surface within these leases extends from the most southerly section (No. 3685-M) into that adjoining it. The lode is a complex one of quartzose composition, and merges insensibly into the country-rock. No work has been done, and there is no indication that any work which might be undertaken is likely to meet with reward.

To the eastward of this area there are three small developments of vein-stuff, the structure of which remains undetermined. Two of the outcrops lie within Section 4222-M, leased by Messrs. W. W. F. and T. C. Murray. One lies in the south-western portion of the section, and forms the crown of a very prominent peak. This outcrop is partly vein quartz carrying limonite after pyrite, but this vein-stuff merges into the surrounding quartzite. Near the eastern boundary there is a small patch of gossan which does not appear to be connected with any other lode-matter in the vicinity.

In no case does there appear to be reason to anticipate successful results from the prospecting of these occurrences of ore.

There are several sections lying to the southward of Section 4222-M, but the only outcrops visible consist of silicified sandstone.

(25) *Messrs. J. Hollow and J. Smith's Leases and Vicinity.*

Two sections, numbered 4360-M and 4361-M, of 40 acres each, charted in the names of J. Hollow and J. Smith, have attracted some attention in consequence of the early success of prospecting operations upon the vein-matter discovered. Work was abandoned, however, immediately after the presence of copper had been proved, and nothing of a conclusive character was ascertained.

In the southern portion of the northern section a few shallow trenches have partially exposed a lode striking N. 12° W., and dipping to the west at 70 degrees. In the deepest part of these workings some ore of a promising nature, in which chalcopyrite and covellite are associated with pyrite and quartz, has been disclosed. Pyrite is showing in the other trenches, but no copper-bearing minerals.

A little higher up the hill to the eastward an underlay shaft was begun on a gossan outcrop. The material obtained from this excavation shows a considerable amount of pyrites disseminated through quartz and quartzite. The strike of this vein-stuff is N. 48° W.

In the northern part of the southern section a trench shows the presence of a number of veinlets of quartz, the strike of which is N. 40° W. To the south of this point no definite formation may be traced at the surface; but over a wide stretch of country there are weathered sandstone and quartzite which are quite cellular from the loss of the pyrite with which they have been impregnated. This impregnated country extends southwards beyond the limits of the leases held by Messrs. Hollow and Smith.

To the north of this area and outside the limits of the leased ground there lies a lode on which a little prospecting work has been done. The strike of the lode is N. 57° W., and its dip is towards the south-west at a steep angle (between 70 and 80 degrees, as far as can now be ascertained). The outcrop is composed of cellular iron-stained quartz, and the little work done on it proves the lode to be about 4 feet in width and to carry both chalcopyrite and covellite at a point where a shallow shaft has been sunk. The country-rock alongside the vein shows the usual characteristics of chloritisation and colouration with hematite, and fragments of this altered slate are enclosed within the vein-matter. At one point to the south-east of the shaft there is chalcopyrite, together with a little covellite, in the soft pyritiferous slate of the wall-rock. As is usual throughout the district, ferriferous dolomite is a constituent of the ore, although in all cases its occurrence is only indicated by the form of the cavities in the quartz of the outcrop. This lode can be traced at intervals on the surface for a distance of over a mile in the direction of Doherty's Pimple. It seems highly probable that it is the north-western extension of the lode which is being prospected by the Mt. Lyell Company to the south-east of Doherty's Pimple.

(26) *The Lodes to the East of the Lindsay River.—J. H. Lyons' Leases and Vicinity.*

The area lying to the eastward of the bend in the Lindsay River has been prospected with some degree of success. Four sections, charted in the name of J. H. Lyons, and numbered 4605-M, 4606-M, 4607-M, and 4608-M, of 40 acres each, occupy a position on high ground which is separated from the ridge to the north-west, whereon the Mt. Lyell Company's leases are situated, by the gorge of the Lindsay River.

The westerly section (4605-M) contains no definite lode visible at the surface. The slate and sandstone, however, have been silicified in a number of places, and there are numerous cavities after pyrite in these altered areas. In the southern part of the adjoining section (4606-M) this quartzite is especially noticeable, and a little to the north of it there is a lode, in some places ill-defined, following a course bearing a few degrees north of east. This lode has apparently shed the loose fragments of quartz which are abundant on the surface.

In the adjoining Section 4607-M the lode is strong and well-defined, and follows a course bearing E. 10° N. A few shallow trenches have been cut across it, which afford a little information. The quartz is somewhat cellular, the cavities showing that a rhombohedral carbonate, such as dolomite, has been leached out, and carries pyrite with small quantities of chalcopyrite and covellite in addition. The outcrop may be followed without interruption for 6 chains in an easterly direction before it disappears beneath a cover of peat. This lode appears to be worthy of further attention. The present excavations are very shallow, and can hardly be expected to give definite information as to the copper contents below the zone of superficial leaching.

To the north of this lode and to the east of Section 4672-M, which is charted in the name of F. Noetling, there is a lode striking N. 80° W., upon which a little work had been done at the time of the writer's examination of the district. The lode formation is certainly a broad one, but the width varies considerably from point to point. The structure is not simple, since the outcrop shows a large number of veins with intervening bars of slate, the strike of the component veins varying between 40 degrees and 80 degrees west of north. The lode is cut by a small creek, in the bank of which a small excavation

has been made. The gossanous lode-matter forms only a thin crust, below which the pyritic ore shows the presence of both chalcopyrite and covellite. The lode may be traced from this point for several chains in both an easterly and a westerly direction. As it is followed west the veins become less prominent, though a considerable width of the country-rock is silicified and charged with pyrite. An effort should be made to open up this lode in a systematic manner, since copper ore is already known to exist at one point.

(27) *The Lodes on the Norfolk Range at the Head of the Lagoon River.*

(*a*) *The Poseidon Silver-lead Mining Company's Leases and Sections,* 4442-M *and* 4443-M.—In the valley lying to the eastward of the long western front of the Norfolk Range and at the head of the Lindsay River the Poseidon Silver-lead Mining Company holds an area of 120 acres, of which 80 are included in Section 4450-M, and 40 in Section 4451-M. These two sections are not contiguous, being separated by two 40-acre sections—4442-M and 4443-M. These sections have all been located with a view to the exploitation of one principal lode which extends through them almost continuously.

The most northerly portion of the lode lies just beyond the northern Poseidon lease, 4451-M, where a little prospecting work has been done on it by the Balfour Prospecting and Mining Company. The strike is at this place N. 60° W. The ore consists of quartz, which carries pyrite with small quantities of chalcopyrite and traces of covellite. An effort should be made to expose the deeper portions of the lode at this place, since copper is known to be present almost at the surface.

In the north-western portion of Section 4451-M the lode does not outcrop above the vegetable cover, and the ground is low. On passing, however, into Section 4442-M it may be followed by a fairly massive quartz outcrop which does not project above the surface. In the central part of this section there is a considerable width of vein-matter, the several component veins being spread over a wide belt of altered slate. At this place the quartz is associated with abundant limonite. The lode, as followed in a south-easterly direction, turns more and more to the southward, and

disappears at a point where it meets a creek running across the south-eastern part of the section. The outcrop is massive and bold between the centre of the section and the place where the continuity is broken. A few small excavations have been made in various parts of the formation, but only pyrite and limonite in quartz or chloritised slate has been exposed.

That part of the outcrop which traverses the north-eastern portion of Section 4443-M has not been prospected.

The lode at the north-eastern corner of the Poseidon Section 4450-M outcrops boldly, and forms the capping of a low ridge which extends to the south-east as far as the centre of the section. This portion of the lode consists of quartz containing traces of the former presence of pyrites. Nothing more than the mere knapping of the surface having been accomplished, no trace of copper could be detected in this outcrop. In the central portion of the section, however, the bold quartz outcrop gives place to a less prominent but much more promising outcrop of gossan. Here a little preliminary prospecting had been done at the time of the writer's visit, and most encouraging results had been obtained. Below the capping of gossan a little bleached quartz was found, and beneath the latter lies friable pyritic ore containing chalcopyrite and covellite. The trenches at this place do not give much information with regard to the shoot of ore, which is only partially exposed. The width at the surface appears to be over 20 feet. This spot is therefore one at which a systematic effort should be made to open up the lode, and at which the dimensions of the shoot in depth should be ascertained. The little work already done has proved the existence of a body of ore which gives no little promise.

Towards the south-east the outcrop of the lode is not traceable quite continuously across the low-lying ground, but the lode has been shown to be present below the surface by means of trenching. Here, too, it is wide, though the actual width is unknown, and the ore carries some chalcopyrite and traces of covellite.

The lode may be traced as far as the south-eastern corner of the section.

To the south-west of this lode in the southern part of the section there is another small one which is practically unworked. The strike of this lode varies from N. 40° W. at its northern end to N. 30° W. at its southern end. The vein-matter consists of quartz carrying pyrite and some chlorite.

The value of the Poseidon property depends upon the manner in which the shoot of ore in the main lode between the centre and south-eastern corner of Section 4450-M opens up in depth. The portions of this lode marked at the surface by the more prominent siliceous outcrops do not appear to the writer likely to prove of economic value.

(*b*) *The Lodes in the Vicinity of the Poseidon Lode.*—To the north of the Poseidon section (4451-M) there is a well-defined quartz outcrop running in a direction bearing due north, upon which no work has been done. It does not offer any encouragement.

In Section 4693-M, charted in the name of J. Craze, there is a very prominent outcrop, the strike of which is N. 40° E. It stands up in bold relief above the very steep and high bank of the Lindsay River, which at this place flows in a deep, narrow gorge. The lode consists of massive quartz, which has possessed a small pyritic content, but from which the pyrite has been leached out. No trace of any copper-bearing mineral could be seen. Should any such be discovered the facilities for inexpensive prospecting of the lode from a tunnel are exceptionally good; but no such tunnel can be recommended before some discovery of cupriferous ore has been made.

In the relatively low-lying ground to the south of the Poseidon lease (4450-M) there are a number of scattered outcrops of vein-matter, no one of which attains large dimensions.

The largest is a quartzose lode 2 feet 6 inches wide, which runs in a direction bearing N. 20° E. through the north-eastern portion of Section 4398-M. This quartz lode has evidently carried a certain amount of pyrites, now oxidised to limonite or entirely removed. A large number of small outcrops of similar lode-matter occur in the southern part of the section. The dimensions of all of these are small, but some of them have the characteristics of those lodes which may most reasonably be expected to possess a copper content below the leached capping. In the absence of any exposures of the ore beneath the natural outcrops no more information may be obtained. In the south-western part of the section a more massive formation exists, but one which does not appear so likely to carry copper values. It merges into the quartzite which results from the silicification of sandstone.

In the south-western part of Section 4261-M, charted in the name of A. Babington, there is a quartz lode upon which nothing has been done.

Higher up the range to the westward there are three quartz lodes within the boundaries of Section 4307-M which have not been prospected. Pyrites has been present in the quartz, but no sign of copper-bearing minerals may be detected.

(*c*) *The Lodes on the Crest of the Range.*—One long line of lode crosses the crest of the western front of the Norfolk Range at a narrow angle a little to the north of Mt. Mabel. It cannot be claimed that this line of lode is quite continuous; yet the orientation of the several outcrops is such that it seems certain that there has been one main direction of fracturing along a somewhat curved line, with some minor branch fractures branching from it in a north-westerly direction. The northern part of this lode-system has been prospected by the Balfour Prospecting and Mining Company, in whose possession the leases 4195-M, 4196-M, and 4197-M formerly were.

In the north-western part of Section 4197-M the main lode of the system has a strike of N. 16° W., and a dip of between 80 and 85 degrees to the westward. The outcrop consists of bleached or limonite-stained quartz, and extends over a total width of 16 feet. It is complex in structure, and contains bands of altered slate. Where the vein-stuff has been exposed by the prospecting operations in a creek-bed it is seen that hematite is abundantly present in the quartz, in addition to pyrite. Chlorite and sericite are present in small quantities. Traces of native copper are said to have been seen at this place. On the southern side of the creek a small excavation in the hanging-wall country shows only gossanous material. On the northern bank a shaft has been sunk 17 feet in lode-matter which consists of massive quartz containing crystals of pyrite, but no visible copper-bearing mineral.

Two small branch lodes lie to the westward of the main one in the north-western part of the section. Of these, the more westerly is the more important. It is 4 feet in width, and has a north-westerly strike. The outcrop consists of quartz with limonite stains, and has not been prospected save by the firing of a few shots at various places along the capping. It is certainly doubtful whether any copper ore would be encountered at a greater depth if deeper prospecting work were undertaken.

The main lode traverses the north-eastern portion of Section 4195-M, and may be seen outside the boundaries of

the leased ground where the principal creeks cross the outcrop. At one place to the eastward of Section 4196-M there is pyrite showing in the vein quartz which has been broken into.

The principal branch lode of the system crosses the boundary between Sections 4195-M and 4196-M on a bearing of N. 60° W. The outcrop is exceedingly massive and prominent, being principally composed of dense quartz, in which pyrite is visible. A few reddish patches are probably caused by the presence of finely-divided hematite. The country-rock near the lode has suffered silicification, and is usually converted into quartzite. In the southern part of Section 4195-M, however, there is one spot in which there are numerous small veins of quartz in the greenish silicified slate. The outcrop of the massive branch lode has been broken into in the eastern part of Section 4196-M. At this place it consists largely of quartzite rather than quartz. Pyrite is present in bunches, but as a whole the lode is not heavily mineralised. At no point can it be said that this outcrop shows signs of promise. It is one of the massive quartz lodes in which the copper content cannot be expected to be sufficiently high to give the lode an economic value.

To the south-east of these sections the main lode (of which the lastmentioned lode appears to be a branch) continues along a somewhat curved line across the western ridge of the Norfolk Range, the line of strike gradually assuming a bearing of N. 50° W. The outcrop is in places exceedingly massive, but this appearance is largely due to the fact that the adjoining country-rock has been densely impregnated with silica. Pyrite is present in the lode, and hematite is locally abundant.

At a distance of a mile from the top of Mt. Mabel, and in a south-easterly direction therefrom, there is a bold outcrop of quartz within Section 4325-M. The strike of the lode is N. 50° W., and it appears to occupy a position parallel to the long lode described above rather than to constitute an extension thereof. The vein-stuff is very massive, and similar in character to that of the main lode in Sections 4454-M and 4455-M.

The facilities for mining are exceptionally good at a number of points along this western front of the Norfolk Range, but unfortunately the outcrops do not show the features which would justify the expenditure of capital to open them up in depth.

(3)—The Mining Properties on the Toner River.

(Plate VI.)

(28) *The Mt. Lyell Mining and Railway Company's Leases.*

The whole of the area held under mineral lease, and charted on Plate VI. which accompanies this bulletin, is the property of the Mt. Lyell Mining and Railway Company. A block of sections comprising in all 1116 acres is situated on the Toner River itself; and a block of three 80-acre sections is situated at a short distance to the north-west. The whole area leased comprises 1356 acres.

When geologically considered this district shows a greater complexity of structure than most other parts of the region. It is a district in which there has been very considerable fracturing along two main directions, which are approximately at right angles to each other. The crust-fractures have been invaded and sealed by intrusive materials at two distinct epochs. The first invasion was that of the amphibolite dykes, and the second was that of the mineralising solutions. The actual coincidence of the products of these two invasions along certain fracture-lines is well marked, and even more noticeable is the general parallelism between the lode-filled fractures and the dyke-filled fractures. It is also noteworthy that there is a general parallelism between one set of lode-filled fractures, and the larger topographical features, viz., the course of the main stream of the Toner River and the front presented by Mts. Rosslyn, Hadmar, and Vero. These general features may be observed by a comparison between Plates II., III., and VI. The geological significance of these phenomena is discussed elsewhere in this bulletin, and calls for no further treatment at this point.

On the southern side of the Toner River there is a long line of lode which consists of a number of component parts, and extends over a considerable width. The strike of the formation as a whole is between N. 60° W. and N. 70° W.; the dip is not very apparent, but appears to be towards the north at a steep angle. The outcrop is peculiar, but not without parallel on the field. There is a great deal of iron on the actual capping in the form of both limonite and hematite. But the gossanous appearance is deceptive, for the greater part of the formation consists of altered country-rock, in which a proportion of

pyrite is by no means as high as might be expected from the amount of iron oxide visible at the surface. Beneath the thin iron-stained crust the country-rock proves to be chloritised and silicified slate, sometimes coloured by hematite, and usually carrying disseminated crystals of pyrite. A wide belt of country has undergone this chemical alteration, and, in addition, has been crumpled and fractured. The fractures are cemented by quartz, the veinlets of which project in large numbers above the iron-stained outcrop. They are so narrow that they rapidly disintegrate, and never stand out far in relief. In only a few places do these quartzose components of the formation attain dimensions of any size. There are three approximately parallel lines of lode-matter of this character, the central one of which is the most continuous, and has received the most attention.

The work done on the western end of the formation has afforded disappointing results. A trench cut across the most northerly ore-body, in Section 3486-M, shows only quartz with inclusions of chloritised slate. A tunnel driven through the main line of lode-matter, in the south-eastern part of Section 3487-M, has proved only the presence of quartz chloritised slate and pyrite in slate country which is deeply stained with iron oxide.

A trench in the south-eastern part of Section 3597-M shows similar hematite-stained country sheared and traversed by quartz veinlets.

The principal mining operations carried out in Section 3598-M consist of a tunnel driven in an easterly direction on the northern formation from the bed of a deep creek. The lode was left at the entrance, but a short crosscut a few feet in enabled a drive to be started on each wall of the lode. The ore obtained thence is massive quartz with minor amounts of the usual gangue minerals and chalcopyrite partly converted to covellite. At this place more copper-bearing material is showing than at any other along the whole line; but the best of the ore obtained contains very low values, and cannot possibly give payable returns under any conditions. Indications of the existence of shoots of ore with a higher copper tenor unfortunately do not exist. A few chains further east, within Section 3599-M, a surface cut across the lode shows it to possess the same general characteristics, but not so much chalcopyrite. At this point the lode appears to dip to the south. It is massive for a width of 6 feet, and beyond this quartz stringers occur in the slate

Near the centre of the Section 3599-M a tunnel has been driven southwards across the central line of lode without result. In the south-eastern part of this section the most southerly line of lode-matter is met with, and may be followed eastwards to the limits of the ground held under mineral lease. No work has been done upon it, nor upon either of the more northerly parts of the formation in these easterly sections, 3571-M and 3752-M. It cannot be said that any superficial indications exist which would justify much expenditure there.

On the northern side of the river the outcrops of the lodes are more prominent. They follow, for the most part, two directions, one of which has an average bearing of E. 10° S., and the other an average bearing of N. 18° E. The lodes which have been prospected are those of which the strike is more nearly east and west. There is, however, no sound reason whatever to be given for the neglect of the similar and contemporaneously-formed lodes with a north-and-south strike. There are a few unimportant lodes which differ as regards strike from the two series mentioned, but are in other respects similar. Insignificant veinlets of like character traverse the amphibolite dykes in many places, but do not assume important dimensions, and have not been shown on Plate VI.

The principal lode, striking E. 10° S., extends from the eastern portion of Section 3485-M through the reward section into Section 3593-M. In the centre of the former section, and on the line of the lode, there are some small veinlets of quartz carrying chlorite, sericite, and occasional splashes of chalcopyrite partly converted into covellite. These veinlets which occur in altered slate may mark the western extension of the main lode. At the eastern boundary of the section a trench has been cut, and shows only two narrow veins of quartz stained with iron, and carrying traces of copper-bearing minerals.

On the western bank of the creek which traverses the western part of the reward section, 3484-M, a trench proves the presence of a number of small veinlets, in which chalcopyrite and covellite are present, traversing sericitised slate.

On the slope above the eastern bank of the creek a prospecting shaft has been sunk to a depth of 35 feet, and short crosscuts were driven north and south. These workings were inaccessible at the time of the writer's visit,

being full of water. At the surface the width of the formation is 14 feet at this place, while at the bottom of the shaft it is said to be 21 feet. The formation penetrated by the shaft is soft and friable, consisting of crushed and sericitised slate, in which are bunches of quartz and pyritic ore.

A deep trench on the hill-side above this shaft has been cut across the lode. The southern wall (hanging-wall) is crushed and contorted slate, in which small overthrust faults are visible. There are a little copper pyrites and covellite in small stringers over a width of 3 feet on the hanging-wall side of the lode. This part of the formation is separated by 4 feet of contorted slate from the main portion of the lode, which is some 12 feet wide. There is ore of good value at this place. The vein-matter consists of quartz and sericitised or chloritised slate carrying malachite, azurite, chalcocite, chalcopyrite, and covellite, together with pyrites. This exposure is the most promising one in the district.

To the eastward, on top of the hill, there is an outcrop of massive quartz on which no work has been done. The lode of which it is the outcrop is clearly a branch of the main lode, and possesses a strike of N. 18° W.

A tunnel was driven to cut the main lode at a depth of over 100 feet below the point of intersection of this branch lode with the main lode, but the results were exceedingly disappointing. The tunnel was driven some 230 feet altogether, of which the first 185 feet have a bearing of N. 13° W., and the next 45 feet of N. 36° W. A short drive was carried westwards, at a distance of 207 feet from the entrance, on a small vein in which traces of copper pyrites were seen. Several bands of quartz were passed through, but they carry no ore. The slate is in several places chloritised and impregnated with pyrite.

To the eastward of the tunnel workings some trenching has been done on the main lode, and it has been proved to be copper-bearing both on the western bank of the creek traversing the eastern part of the reward section, and also within the boundaries of Section 3593-M.

The branch lodes which junction with the main lode in the eastern part of the reward section are of massive quartz, and on account of their unpromising appearance have not been attacked. Should work be resumed within this area it would be well to make a test of the fracture-lines indicated by these outcrops at points beyond the prominent outcrops themselves.

A lode approximately parallel to the main lode mentioned above runs from the western boundary of Section 3594-M as far as the creek in Section 4004-M. This lode dips to the south at an angle of 80 degrees. The lode-matter consists of quartz containing pyrite, sericite, and chlorite, and traverses sandstone or slate impregnated with chlorite, hematite, and pyrite. A tunnel has been driven southwards across the lode from a point in the north-western portion of Section 3595-M. No success attended this work, for though the lode was cut and the altered country alongside it was penetrated, no copper-bearing minerals were seen.

There are two cross lodes which cut across the last-mentioned almost at right angles on the quartzose outcrops on which no work has been done.

In the north-western part of Section 3896-M there is a lode the strike of which is N. 15° W., in which both copper pyrites and covellite are visible. It is 2 feet 6 inches wide, and consists mostly of clear white or colourless quartz carrying chlorite and pyrite. A hole has been sunk to a depth of 10 feet on the lode, which is not on the whole a promising one.

In the central part of Section 3600-M there is a small quartz lode striking N. 72° E., on which two trenches 150 feet apart have been cut. Pyrite is present in the quartz of this lode, which is from 2 to 4 feet in width. No copper minerals have been recognised in the excavations hitherto made.

The only other occurrences of lode-matter in this locality are those which are to be found in the form of veinlets and lenses within the boundaries of the amphibolite dykes. One of the lenses has been partly exposed by a hole sunk to a depth of 10 feet at a point in the north-eastern part of Section 3486-M. The lens or vein has a strike of N. 5° E., and easterly dip of 50 degrees. Although 2 feet wide at the surface, it is only a few inches wide at the bottom of the excavation. The ore is of normal character and shows occasional splashes of chalcopyrite and covellite.

A narrow vein has been exposed on the western border of the same dyke a little to the northward of the last-mentioned spot, and within Section 3485-M. No copper minerals were observed in spite of the favourable appearance of the vein, which is more pyritic than others in the district. A shaft was started, but abandoned when some 11 feet had been traversed.

Some prospecting work has been done on or near the surface within the boundaries of the northern group of sections, at a distance of 2 miles from the centre of the Toner River group. A strong outcrop of quartz traverses the south-eastern part of Section 4003-M in a direction bearing N. 12° E. It has not been prospected, and cannot be said to be worth the expenditure of any capital.

The principal lode of the district is nearly at right angles to the lastmentioned, and lies in the northern part of Section 4003-M. The strike is E. 10° S. There are two small branch lodes at its eastern end and two parallel makes of ore to the north of it.

The branch lode lying nearest to the centre of the section contains chalcopyrite and covellite in the normal gangue of quartz, chlorite, and sericite. The vein is 3 feet wide at the surface but dwindles to a few stringers of quartz in sericitised slate at the bottom of an open cut 13 feet in depth.

The principal lode (striking E. 10° S.) is well defined at the surface, and forms the backbone of a low ridge. The outcrop consists of quartz, with chlorite and chloritised slate, and carries numerous cavities after pyrite. Traces of copper have been found in the pyritic portions of this lode, which has been prospected by two short tunnels, but nothing has been found which could justify further work. The small lodes parallel to the main one are not any more promising.

A few lodes lying outside the limits of the leased areas are shown on the chart. They possess prominent outcrops of massive quartz, but show no sign of having contained any metallic mineral other than pyrite. The amphibolite dykes show insignificant veinlets of quartzose lodes at numerous points in the neighbourhood of Mt. Bolton.

(4)—The Mining Properties near Whale's Head.

(Plate VII.)

(29) *The Iron Lode on the Nelson River.*

A group of four mineral sections, through which the Nelson River passes, is shown on Plate VII. to the north-east of Whale's Head Boat Harbour, and approximately 6 miles distant therefrom. These sections, now abandoned, have been the site of some superficial prospecting

operations. The lode which extends from the Nelson River southwards into the central portion of Section 2731-M is the most massive one seen by the writer in the whole field.

In the central portion of Section 2923-M the outcrop is over 100 feet in width and consists of gossanous material containing much hematite. The gossan is siliceous, and as the outcrop is followed northwards to the gorge of the Nelson River more quartz is visible among the rubble of broken fragments of the lode. At a few points close to the river level an attempt has been made to open up the lode, but no conclusion has been reached—the trenches hardly penetrating the superficial detritus. The nature of the vein-matter exposed at this place differs in no respect from that of the lodes throughout the field, which carry quartz, pyrite, and chlorite as their principal constituents. It is therefore not a matter for surprise that the prospecting has been carried on in the expectation of discovering shoots of copper ore.

To the southward of the centre of Section 2923-M, however, the mineral composition of the lode alters materially. The hematite, which further north is hardly visible, becomes rapidly the most abundant constituent as the lode is followed southwards along its course of S. 33° E.

With the increase of the hematite, pyrite appears to decrease, and less limonite is visible along the outcrop which follows the western bank of the Nelson River for several chains in the southern part of Section 2923-M. At this place there is an excellent opportunity for driving a tunnel across the lode at a depth of about 80 feet below the outcrop. At the time when the lode was being prospected a shallow-level tunnel was begun, but this was abandoned when the massive iron lode was met. The wall-rock on the eastern side of the lode penetrated by this short tunnel is sandstone impregnated with chlorite and pyrite.

Through Section 2942-M the outcrop may be traced without interruption. It is here massive, and consists of hematite mixed with crystalline magnetite and a small amount of quartz. The vein-stuff is certainly of considerable value as an ore of iron and for many chains maintains a high degree of purity. There is little limonite at the surface, and from the massive character of the ore it does not appear probable that any appreciable sulphur content exists. The soft gossanous material to be seen at the northern end of the lode is not visible at the southern end.

As an ore of iron this lode merits systematic prospecting. Trenches could be cut across it at regularly-spaced intervals in such a manner that the width could be accurately ascertained at a number of points, and it has been indicated that opportunity exists for a tunnel across the lode from the Nelson River gorge.

The lode outcrop is approximately 300 feet above sea-level, and no engineering difficulties of any magnitude would prevent the ore from being carried by rail to Whale's Head Boat Harbour.

(30) *The Couta Mine—Section* 3669-M

The lease numbered 3669-M occupies a small promontory on the coastline at a distance of about 3 miles from Whale's Head Boat Harbour. This lease was formally worked by a number of residents of Temma, and the mine is known as the Couta Mine.

The lode outcrops on the sea-shore, and runs inland on a course of N. 20° W. It is practically a vertical lode. A trench has been cut across the lode on the shore, and discloses ore deeply stained with blue and green carbonates of copper. The lode at this place consists of a band of quartz a foot wide on the western side, and a broad belt of shattered slate to the east of it. The slate carries veinlets of quartz, chlorite, pyrite, and some chalcopyrite and covellite. The whole lode-formation is 14 feet wide. A smaller parallel body of similar character lies to the eastward of it. The loose sand of the coastal dunes has partly covered the outcrop on the shore, and has prevented the continuous prospecting of the capping.

Further north, however, at a point where less surface cover exists, a shaft has been sunk on the lode to a depth of 50 feet, and a little work was done at this level before the inflow of water proved too great to be coped with by hand-power. The lode-matter brought up and now lying on the surface is certainly of a promising character. It consists of dark slate showing graphite in places and carrying bunches, lenses, or pockets of chalcopyrite, which is partly altered to covellite. Quartz, chlorite, and pyrite accompany the copper-bearing minerals, but do not constitute the bulk of the lode. The workings were unfortunately inaccessible to the writer.

A little trenching has been done to the north of the shaft, and the lode has been thus proved to be continuous

beneath the superficial unconsolidated beach sand and gravel for a distance of some chains, and traces of chalcopyrite have been found almost at the surface in lode-stuff consisting of quartz, pyrite, and sericite.

The proximity of the sea and a small fresh-water lake within a few chains of the shore have seriously hampered mining operations at this place. Further prospecting is justified, since the little work already done has proved the existence of promising ore.

(31) *The Strickland Mine—Section* 3819-M.

The mineral lease numbered 3819-M, of 40 acres, charted in the name of J. Shortall, is known locally as the Strickland Mine. It lies to the eastward of Temma at a distance of about 2 miles. The workings are old, and have fallen into serious disrepair, so that the structural details are difficult to ascertain. The lode which has been prospected runs continuously from the north-western part of Section 3819-M into Section 4339-M, on a bearing of S. 35° E. The ore thrown out round the shafts which have been sunk on the lode is of the same character as that present in all the copper mines on the field; and, as far as can be ascertained, the copper content is well distributed through the lode. The weathered ore is now encrusted with copper sulphate, beneath which some chalcocite may be detected. This material was sorted, and a few bags of picked ore were sent away to the smelters at the end of 1908. This picked ore contained 22·9 per cent. of copper, and afforded a profit to the owners.

There is associated with the lode-matter a certain amount of hematite, which is visible along the outcrop along its whole length. A few patches of gossan are visible, but a quartz-hematite capping is the usual form of outcrop for the lode.

Beyond the limits of the Strickland lease the lode cannot be traced northwards, but it extends southwards as far as Little Eel Creek in Messrs. Murray Bros.' section, 4339-M. The Strickland Mine is a property which merits the expenditure of sufficient capital to give it a fair test by systematic prospecting. Hitherto the workings have been of a character which has ensured their rapid destruction by weathering. The port is close to the mine, which has thus a great advantage over the properties lying to the eastward.

To the north-east of the Strickland Mine, and in the western portion of the purchased block standing in the name of Louis Hogg, there are a number of loose blocks of lode-matter which appear to be of local derivation. The vein-stuff is quartzose, and carries much hematite, with a little magnetite and pyrite. Chlorite is occasionally present, and in some blocks of the lode-matter hematite is almost the only constituent. The occurrence is masked by the cover of basalt, and, at one point, of Tertiary limestone.

(32) *The Lodes in the Vicinity of Whale's Head Boat Harbour.*

To the eastward of the township of Temma, and only a few chains distant therefrom, a few holes have been sunk and trenches cut across a wide belt of silicified slate and sandstone, some portions of which are charged with pyrite. Samples taken from this pyritic stone have shown, it is said, 3 dwt. of gold per ton. In view of the facts that no alluvial gold is recorded from the vicinity and that there are no known cases in the whole field in which the gold content of the lodes rises perceptibly above that of 3 dwt. per ton it does not seem reasonable to hope that success will attend the operations of prospecting for gold at this place. Some distance to the southward, and near the coastline, there are some old workings on an ill-defined formation. There is a belt of brecciated slate and sandstone cemented with quartz-veins, which extend into the walls of the brecciated zone. The strike of the formation appears to be N. 45° W. Pyrite and a little chalcopyrite are present in the quartz. A shaft has been sunk to a depth of a few feet and some trenches cut, but nothing of any promise has been discovered.

Two miles and a quarter from Temma, and 1½ mile south of the Strickland Mine, lies the mineral lease numbered 4375-M, charted in the names of Messrs. Sale and Roberts. A strong lode about 8 feet in width traverses the section on a bearing of N. 38° W. The ore consists principally of hematite, with which a little magnetite and quartz are associated, and is reported to contain also copper pyrites. It may be compared with other similar lodes in the Interview River district, and with the lode at the Strickland Mine and that on the Nelson River. As a source of copper it does not appear promising.

(33) *The Lodes near the Balfour-Temma Road.*

To the northward of the Balfour-Temma-road some prospecting has been done on the banks of Possum Creek. In the abandoned section numbered 3538-93M there are some very old trenches, the sides of which have fallen in. The material thrown out shows siderite and chalcopyrite in splashes. No continuous surface outcrop appears, but there are numerous quartz fragments at the surface which seem to be derived from small scattered stringers.

In the southern part of Section 4438-M, charted in the name of H. Williams, some work has been done. A shaft has been sunk on the northern bank and an excavation made in the creek-bed. The lode-matter revealed is massive quartz studded with pyrite and carrying a quantity of chlorite. Copper-bearing minerals are said to have been observed, but at the time of the writer's visit none were seen. No information as regards either strike or dip could be obtained from these workings. A little prospecting that has been carried out beyond the southern boundary of the section has proved the existence of quartzose lode-matter extending in a direction the bearing of which is S. 65° E. But it is by no means certain that the quartz visible in these places belongs to one and the same formation. In the eastern part of the section there are some old workings—a shaft and a tunnel. The ore at this place is quartz with a certain amount of pyrite enclosed in it. There is nothing to indicate that any success will attend the further development of the lodes hitherto located in this section.

On the southern side of the Balfour-Temma-road there is a well-defined lode, part of which has been covered by the basalt on which the purchased blocks of farm-land are situated. It runs diagonally through the mineral lease numbered 4279-M. The lode is a complex one, in which the constituent minerals are separated into different bands. These constituents are not different from those which appear in the lodes of the Balfour field generally, but they are more cleanly separated from each other than is usually the case. In the central portion of the section the western part of the lode consists chiefly of magnetite, with which some chlorite is present, while the eastern part consists of quartz carrying pyrite. In the south-eastern corner of the section, however, the positions of the magnetitic and quartzose parts of the lode are reversed. The pyrite of the lode has been assayed for copper without success, but it is known to carry small quantities of gold.

The lode-matter has at various times been assayed for tin, but no trace of that metal has been found. The lode may be traced as far south as the centre of Section 4295-M, where it is lost beneath the basalt. It extends northwards beyond the basalt cap which spreads over the western part of Section 4279-M. In the opinion of the writer there is no reason to believe that any portion of this lode hitherto prospected will justify the further expenditure of capital. The lode itself is a massive one, but valuable constituents do not appear to be present in payable proportions.

To the south-east of the 50-acre block of agricultural land owned by Mr. S. Symes, and 25 chains distant from the south-eastern corner thereof, a little work has been done on a massive quartzose lode which lies just beyond the area embraced by the map. The strike of the lode is east-and-west, and at the point where the work has been done the width is 20 feet. The lode-matter is principally quartz, with which are associated chlorite, sericite, ferriferous dolomite, and fragments of chloritised slate. The metallic ingredients are pyrite and chalcopyrite, the latter being evenly distributed in small quantities right through the stone. The lode is well worth further attention, and an attempt should be made to discover whether there are any points along its course at which the percentage of metallic minerals is greater than at the spot mentioned. The extremely massive character of the lode and the extremely large proportion of quartz in its composition render unlikely any material improvement in depth at the place where the existing excavation is situated.

The outcrop may be followed eastwards for some distance. Then it joins a quartz lode, the strike of which, at the point of junction, is N. 20° W. The latter lode extends southwards on a course which curves gradually till the strike is N. 40° W. The most southerly part of the outcrop tends to approach quartzite in character.

(5)—The Eastern Group of Mining Properties on the Interview River. (Plate VIII.)

(34) *The Copper Reward Mine—Section* 3921-M.

The most massive lode lying within the Copper Reward lease is that which has a strike of between N. 70° W. and N. 80° W. The most westerly portion of this lode extends as far as the southern part of Section 3939-M. The outcrop may be followed continuously as far as the north-

eastern part of Section 4179-M, where the strike approaches most nearly to an east-and-west direction. The capping throughout this portion of the lode is mainly of quartz with occasional gossanous patches. No work has been done on the lode outside of the Reward section. There is a break in the lode at the eastern boundary of Section 4179-M.

Just inside the western boundary of the Reward lease a creek traverses the lode, which is at this place 10 feet wide. The formation consists largely of silicified and chloritised slate traversed by quartz veinlets and studded with crystals of pyrite. Two feet of the formation on the hanging-wall side (the dip is to the southward at about 80 degrees) carry chalcopyrite, covellite, and traces of malachite. The only exposure of this lode available for examination is an excavation 6 feet deep in the eastern bank of the creek mentioned. Signs of oxidation and leaching of the lode being present, and copper ore having been exposed at so shallow a depth, it is advisable to test the lode at this place by sinking. To the east of the excavation mentioned the lode may be followed on its outcrop, which crowns a low ridge, as far as the Interview River. There it disappears for many chains, to reappear in Section 3965-M, where there is a low ridge formed by the outcrop of pyritiferous quartz. In this place no attempt has been made to prove the value of the lode. Returning to the Copper Reward section, and to the western part thereof, it remains to describe the lode in which copper ore was first located in this district. This lode is apparently a branch of the lode mentioned above. It was located in a bend of the Interview River in summer time, and a trench was cut at that place, disclosing a narrow vein of excellent ore. A shaft was sunk on the northern bank of the river to a depth of 35 feet, immediately on the contact of an amphibolite dyke and slate. The vein at the bottom of the shaft is reported to be 2 feet wide. From these workings some 12 tons of ore have been raised, and now lie on the surface. This ore is remarkably clean, consisting very largely of chalcopyrite with films of covellite. The gangue minerals are pyrite, quartz, chlorite, and fragments of undigested country-rock. The workings were inaccessible to the writer. The course of the lode could not be definitely ascertained for want of the necessary exposures. To the north of the shaft a small excavation in the amphibolite dyke-rock has proved only the presence of quartz-chlorite veinlets. Still

further north a little work has been done in a creek bed, and the presence of chalcopyrite and covellite in small amount has been proved. The formation is a broad one, consisting of altered slate, which is strongly mineralised. From this work it would appear that the vein carrying the high grade ore junctions with the east-and-west lode close to the western boundary of the section. On the south-eastern side of the river the little work that has been done has failed to prove the continuity of the lode in that direction. The future work of prospecting the lease should include the systematic opening-up of the shoot of rich ore, which is itself of a very promising character.

(35) *The Properties Surrounding the Copper Reward Mine.*

The sum total of the prospecting work carried beyond the Copper Reward section is not large. A systematic attempt has been made to open up a strong lode which runs through Section 3922-M, on a bearing of N. 70° W. The outcrop is prominent, and consists of quartz and hematite, the latter predominating. A tunnel has been driven along the hanging-wall of the lode, which dips southwards at an angle of 80 degrees, and a crosscut was carried in a northerly direction across the lode. No cupriferous mineral is observable in the vein-stuff, which consists of hematite, quartz, chlorite, and pyrite. The slate country-rock is stained red with hematite in places.

Similar lode-matter occurs in an unprospected lode which traverses Section 4111-M on the opposite side of the Interview River, and again in the south-western of two lodes traversing Section 4149-M. The other lodes traversing the southern sections, and shown on the chart (Plate VIII.) are almost wholly quartzose. Cavities after pyrite are plentiful in the quartz outcrops, but no sign of any cupriferous mineral has been detected. The only noteworthy feature of the lodes is the curved course of the outcrops.

An exceedingly massive quartz outcrop follows an east-and-west course through the north-eastern part of Section 3966-M and Section 4156-M. The western end of this lode curves round and terminates at the south-eastern corner of the Copper Reward lease. A small parallel outcrop at this place has been prospected by a shaft 40 feet deep. No copper is visible in the vein-stuff, but pyrite is abundant, and a little specular hematite is present.

To the north-east of the Copper Reward Mine there is an exceedingly massive outcrop of quartz in Section 4380-M. Some pyrite is present in this quartz, but the lode shows no sign of the presence of any other metallic mineral.

(36) *The Silver-lead Reward Lease*, 4930-M.

A reward lease of 80 acres has been granted to R. J. Henry for a discovery of argentiferous galena to the eastward of the Copper Reward Mine. The discovery having been made only just before the writer's visit to the locality there had been little opportunity for opening up the find. The vein has a course of N. 48° W., and appears to dip to the south-west. The excavation which had been made showed the lode to be 2 feet wide and to carry a fair proportion of clean ore, free from zinc blende. A portion of the lode was assayed and proved to contain 68·4 per cent. of lead and 34 oz. of silver per ton.

The gangue minerals associated with the silver-lead ore are quartz and chlorite; and there are fragments of silicified and chloritised slate in the vein. These mineral associates, together with the fact that a few blebs of chalcopyrite are visible with the galena, seem to indicate that the silver-lead ore is a local variant of the cupriferous vein-type of the field.

The outcrop of this vein is insignificant, and it cannot be traced more than a few feet. The slate in the vicinity carries stringers of quartz, but no other signs of any continuation of the lode are apparent. An attempt should be made to prove any extension of the ore-shoot by trenching across its supposed course.

(6)—The Western Group of Mining Properties on the Interview River. (Plate IX.)

(37) *The Tin and Tungsten Bearing Lodes.*

The area shown on the chart (Plate IX.) lies entirely within the granite *massif* which extends from Sandy Cape to the Pieman River. All the leases shown were taken up with a view to the development of the tungsten-bearing lodes which were discovered by the miners who were engaged in alluvial tin ore mining. The tin ore has certainly been shed from the lodes which carry the more-readily-recognised wolframite.

Up to the time of the writer's visit very little work had been done upon the lodes, and the condition of the workings was even worse than when Mr. G. A. Waller visited the area in 1901; for no fresh work has been done since that date, and the workings of that period have fallen into disrepair.

The principal lode-workings are situated within the 40-acre lease, 5121-M. There are several trenches and a shaft in this section, but the structural details of the lodes cannot satisfactorily be deciphered. It appears certain that there are several distinct veins approximately parallel to each other and striking in directions the bearings of which lie between N. 30° E. and N. 40° E. Yet the orientation of the veins when considered together seems to be a little west of north.

Some ore which has been located in the centre of Section 5119-M may thus be in some way structurally related to the vein-matter in Section 5121-M. It is not an uncommon thing to find that a composite lode has a general direction of strike different from that of its constituent parts. Moreover, the existence of other vein-matter has been indicated by some shallow trenches in Section 4943-93M, and since the writer's return from the field the discovery of wolframite ore of good grade in the western portion of Section 5120-M has been reported to him.

Still further north, beyond the limits of the leased ground, quartz carrying tourmaline is abundant at the surface at a point which is approximately in line with these other outcrops.

VII.—CONCLUSION.

(1)—The Geology of the Field and Future Mining Operations

From the foregoing account of the geological features of the field and the description of the work that has been carried out on the several leases it is plain that there have been several particulars in which the actual mode of occurrence of the ore has been misinterpreted. While these failures to appreciate the real significance of the details of structure and composition of the ore-bodies must be admitted, it is to be remembered that they are quite inevitable in the early stages of development of a new mining field such as that under discussion. For the benefit of the future mining operations it is essential that the attention of the management of the several mining companies be directed towards the phenomena exhibited by those mines in which success has not followed the prospecting operations equally with those phenomena presented by the more fortunate properties. Thus regarded, the examples attended by apparent failure will prove of real benefit to the mining community.

The most difficult question which the pioneers of the field have been called upon to decide is that which is concerned with the significance of the numerous siliceous outcrops. And it cannot be said that these are yet thoroughly understood. Certain definite facts have been ascertained with regard to some of them; sound deductions with regard to the probable nature of others at a depth below the surface may be drawn; but there remain many cases in which the superficial quartz may possibly represent the physically and chemically resistant portions of cupriferous lodes which possess a complex structure. It remains only for prospecting operations to reveal the value of the latter class.

It is now fully understood that the siliceous outcrops which are constituted of compact granular quartz are the weathered portions of bars of quartzite which may be impregnated with pyrites. No instances are known in this region in which more than a trace of copper may be detected in such formations. Yet the conversion of the walls of the lodes into quartzite is common. Unless signs of some such lode are found in immediate proximity to the

outcrops of granular quartz it does not appear advisable to undertake costly excavations.

The very massive outcrops of almost pure vein quartz are still regarded by some as likely to " turn to copper " in depth. The reasons for this belief are difficult to ascertain. The very denseness of the vein-matter is certainly sufficient to show that in almost every instance no metallic mineral other than sporadic pyrite was present in the unweathered lode. And certainly no general vertical succession of cupriferous ore and barren quartz has been proved to exist in any part of the field. Yet a great amount of energy and capital have been expended in trenching and tunnelling in these massive outcrops. Such work as has been done in traversing the dense quartzose portions of the lode-formations to prospect the flanks thereof is not here criticised adversely. It is the work of which the whole object is to expose in depth only the massive quartz lodes themselves that is to be condemned.

There remain the outcrops which are most commonly marked by a rubble of angular fragments of cavernous quartz in which limonite stains are often seen. These are found upon the flanks of more massive bodies or in line with them, and may represent the leached portions of siliceous shoots of copper ore.

There are other instances in which the course of a fracture is marked partly by massive quartz and partly by gossan free, or almost free, from any content of silica, the latter being the weathered product of the metallic shoots in the same lode which contains in part clean quartz.

It has been pointed out that the study of the quartz itself in the outcrops can give no positive information with regard to the former copper contents of the unleached lodes. The existence of pyrite can be detected by the form of the cavities remaining, but the chalcopyrite does not appear to have assumed crystal outlines in the lodes.

In the prospecting of the outcrops, no less than in the prospecting operations at deeper levels, the several structural features of the lodes discussed in the foregoing pages should be borne in mind. There are many cases in which the lines of strike of portions of a complex lode have been theoretically projected far beyond the actual limits of those particular components. There are noteworthy deviations in the course of several of the longer lines of lode, and these deviations have been disregarded in some parts of the field.

The necessity for crosscutting to the limits of the zone of mineralisation in all the deeper prospecting operations is apparently properly appreciated throughout the field. In those cases in which this work has not been done it should be kept in view by the management of the mines.

In another portion of this bulletin it is stated that all the evidence which may be gathered from the examination of the many lodes of the field supports the view that the fissures utilised by the metalliferous solutions at the period of ore-deposition were formed simultaneously, and that there was but a single period during which these fissures were filled. These conclusions have an important bearing upon certain prospecting problems, and therefore call for some discussion in this place.

It has been observed that in a number of places in different parts of the field, *e.g.*, in the big bend of the Lindsay River to the south-east of Doherty's Pimple, the lodes which have different lines of strike abut against one another. These points of junction of the several members of the lode-systems concerned have apparently been regarded in some instances as actual points of intersection of lodes of different ages. There have, at least, been several attempts made to open up the places where two lodes unite in the hope of finding shoots of ore at such places. The outcrops at the points where two lodes join are not marked in any locality by an extra massive development of vein-matter, and there is no reason to expect that the bulk of the vein-material will prove greater at such places when the downward extensions of the lines of junction of the lodes are laid bare by mining operations. It appears, however, that the hope of an increase in the copper contents of the lodes along the lines of junction has been cherished.

It is recorded that ore-shoots at such junctions do occur in some parts of the world, being apparently caused by physical conditions not well understood. It is, however, much more usual to find that the mineral contents of an older vein have, by chemical interaction, caused the precipitation of certain ingredients of the mineralising solutions occupying the second fissure at some later period. The latter type of occurrence does not appear to be represented within the limits of the Mt. Balfour mining field, and there are no recorded instances in which an improvement in the value of the contemporaneously-formed lodes has been recognised to exist at the places of junction. Hence it is not possible to recommend on geological grounds that prospecting operations be directed towards the open-

ing up of such places rather than of other portions of the lode-systems.

During the writer's examination of the field he was many times asked by prospectors and leaseholders whether the presence of various minerals should not be regarded as a sign favourable for the discovery of copper in the lodes wherein they occur. The answer to this question is provided by the study of the mineralogy of the vein-type—the assemblage of the minerals which may be found in any of a large number of lodes which are very closely related, and which in the majority of cases are almost identical as far as qualitative mineralogical composition is concerned. It has been indicated that neither any particular mineral constituent of a lode, nor any specific mineral developed in the country-rock bounding the lodes, is in itself an attendant of the cupriferous shoots. The writer does not hesitate to deny categorically that any such "indicator" exists in the Balfour field. The only signs of the presence of copper are such as will give a chemical reaction for that metal in the laboratory.

Those comparisons which have been drawn in the earlier portions of this report between the mineralogy of the Balfour lodes and that of lodes in other western Tasmanian mining fields are of a qualitative nature only. That is to say, vein-types are compared, and not ore-shoots. The fallacy inherent in the attempt to make capital of the qualitative resemblances between ore of a new mining field and that of established and successful fields should be apparent alike to mine owners, mine managers, investors, and geologists.

The problems concerned with the prospecting of the lodes which carry tin ore and wolframite are of a different nature from those which centre round the copper-bearing lodes. Outcrops are not prominent, and systematic endeavours should be made to lay bare the solid rock—where possible, by sluicing.

In the vicinity of Balfour the area over which the stockwork extends is large, and leaseholders should try to locate the more-heavily mineralised patches for deeper workings. The country in the neighbourhood of the Interview River presents different details of lode-structure, and is less favourably situated for sluicing methods. There systematic trenching should follow the prospecting of the stream beds. In this region there is much detailed prospecting still to be done.

The lode-mining which is being carried on at Balfour for the recovery of the free tin ore occurring in the flat

oxidised veins of the stockwork which are exposed on or very close to the surface may lead to the rehandling of some ground already worked over for alluvial tin ore. For on some of the stripped ground, flat veinlets carrying visible cassiterite may be seen dipping at low angles into the bed-rock. It seems therefore probable that in such places—for instance, near the slaughteryard on the Balfour-Temma-road—there has been a material addition of locally-derived tin ore to that which has been carried from the more distant portions of the lode-bearing area. Moreover, little attention has yet been given to the possibility of the existence of fine-grained cassiterite in the slate traversed by the numerous veins carrying readily visible cassiterite. In the tinfield of North Dundas no small proportion of the tin ore won from the zones of impregnated slate has been afforded by the cassiterite, which is so exceedingly finely divided as to be quite invisible to the naked eye, even when there is an appreciable percentage disseminated through the slate. This fine-grained tin ore may be recognised by crushing and panning off the slate, but excessive care must be taken lest in the latter process all the ore be lost.

Again, the endeavour should be made to preserve all the forkings and veinstone carrying mixed tin ore and wolframite for future treatment. It appears to have been the practice to throw aside stone in which wolframite is showing, together with the tailings. Mixed ores carrying cassiterite and wolframite are at the present day of material value; and a mixed concentrate of these minerals, whether obtained by the sluicing of alluvial ground or by the crushing and milling of vein-stone, to-day finds a ready market.

(2) The Mineral Resources of the Region.

It is by no means an easy matter to forecast the future of any mining field when there are many mines fully developed for examination and comparison. In the case of the field here under consideration there is no single mine in which the work of development has proceeded to a depth at which the ore exposed for examination is free from all alteration by secondary processes. It has been, however, indicated in the foregoing portions of this bulletin that the shoots of ore, which all show evidence of secondary enrichment, will in all probability merge in depth into shoots which contain valuable proportions of chalcopyrite. In other words, it appears probable that chalcocite and covellite will disappear and the unaltered chalcopyrite will remain.

There is no evidence of the existence of any other primary copper-bearing mineral in the lodes, which may, therefore, be expected to provide ore of a simple character. There is a marked general absence of any ingredient which may cause difficulties in the metallurgical treatment of the copper ore, which is likely to be in practically every case of an acidic nature.

The quantity of secondarily-enriched ore of high grade cannot be guessed at in the present state of development of the field, but there are certainly indications which point to a revenue from this ore which will materially assist in the opening up of the mines in depth.

Hitherto the only output has been from the Messrs. Murray Bros.' Reward Mine, at Balfour. The amelioration of the facilities of transport by the completion of the tramway to Temma will enable several other properties to contribute to the output of the field. Thus the ore already stacked at the Central Mt. Balfour Mine, and the Balfour Consolidated Mine will at once be within easy reach of the port. At greater distances there are already small accumulations of ore at the Mt. Balfour Copper Mine, and the Balfour South Copper Mine. On other potentially productive mines practically nothing more than the mere location of the ore has been achieved; but the existence of the tramway should accelerate the development of these.

It should be borne in mind, when the small total output of the field is considered, that no stoping whatever has been carried on in any mine save the Messrs. Murray Bros.' Reward. All the ore available for export on other properties has been won during actual prospecting. Hence it may be declared with certainty that the past output of copper ore represents but a small fraction of the output to be derived from the field in the future.

The total output of tin ore from the field is not definitely known, nor can it be accurately ascertained. Small parcels have been filtering away for the past 20 years, and it is estimated that thus some 300 tons of tin ore have been sent to the smelters. For even the approximate accuracy of this estimate the writer cannot vouch; yet he is of the opinion that it is not unreasonable.

There is little difficulty in transporting the tin ore from Balfour to Temma at the present time. The output not being large, the ore is readily carried in the waggons returning from Balfour to the port; and the cost of transport is very low, the ore being carried as far as Launceston for 6s. a bag, which is a rate equivalent to £5 10s. to £6 per ton.

From the Interview River district freight charges are very much higher—up to £20 per ton when the ore has to be packed through to Zeehan on horseback.

The era of lode-mining for tin ore has only recently begun at Balfour, and a regular output from the sluicing of the easily disintegrated capping of the veins in the large stockwork should be maintained. These operations may reveal ore-bodies which can be profitably worked on a larger scale.

Wolframite has never received the attention which it merits. The exposures on the slopes of Specimen Hill at Balfour are not large, but no attempt has been made to prospect this variety of lode-matter. All concentrates that may be obtained carrying wolframite, whether other metallic minerals are present or not, may easily be disposed of in Launceston at the present time.

The lodes at the Interview River were prospected at a time (in the year 1901) when wolframite was at its lowest price. The value per unit at that time dropped as low as 5s. At the present time the market rate per unit, for ore containing 70 per cent. of tungstic acid, is in the vicinity of 32s. From the presence of other metallic minerals in the ore at this place it seems probable that mixed concentrates will be obtained, which should be subjected to electro-magnetic separation. The problem does not present great difficulties, and more complex ores are at the present time being successfully treated in Tasmania. The price mentioned above for the carriage of tin ore may seem to be a heavy handicap on any enterprise in this locality, but it should be borne in mind that, in the event of the establishment of a regular output, a steamer service from the Pieman River could be arranged, and the cost of transport correspondingly lowered.

The establishment of an iron-smelting industry on the mainland of Australia is likely to create a demand for high-grade iron ore. There is at least one deposit in the region—that on the Nelson River, about 6 miles to the north-east of Temma—which merits prospecting as a source of iron ore. This is a very large lode, and the quality of the ore appears from surface indications to be excellent. Many other lodes of similar material are known to exist within the boundaries of the field, but none possess the magnitude necessary for exploitation as ores of iron.

L. KEITH WARD, B.A., B.E.,
Assistant Government Geologist.

Launceston, 27th June, 1911.

Plate II GSB10

PLATE II

SKETCH MAP OF THE MOUNT BALFOUR MINING FIELD

LEGEND

Boundaries of Mineral Leases

Boundaries of Agricultural Land Purchased

Boundaries of Grazing Leases

Boundaries of Timber Lease

Boundaries of detailed Charts accompanying this Bulletin

Number of plate of corresponding detailed Chart — IV

Boundaries of Township Reserves

Surveyed Routes for Proposed Tramways

Roads ::::::::::::::::: Tracks ..... Sawmills

AREAS LEASED OR PURCHASED

Mineral leases—17,700 Acres Grazing leases—12,000 Acres

Purchased land—3550 Acres Timber lease—1200 Acres

SCALE OF MILES

0 1 2 3 4 5 6

5 cm

Magnetic North

SOUTHERN OCEAN

Arthur River
Track to Marrawah
Ferry
Boat Harbour Inlet
Alert Creek
Bottle Creek
Sundown Creek
Nelson River
Sundown Point
Sardine Creek
Rebecca Creek
Gaffney's Point
Whale's Head Boat Harbour
Richardson's Point
Temma
Little Eel Creek
Big Eel Creek
No Man's Creek
Possum Creek
Main Balfour-Temma road
Dawson River
South Dawson River
Gannet Harbour
Ordnance Point
Daisy Creek
Native Well Bay
Thornton River
Pedder River
Sandy Cape
The Little Frenchman
Cage
Track to Trowutta
Jim Creek
Bridge
Frankland River
Balfour
Mt. Frankland 1420 Ft.
Mt. Balfour 1350 Ft.
Warratah Creek
Track to Mt. Bischoff
Lindsay River
Doherty's Pimple
Mt. Hazelton 2200 Ft.
Woody Peak
Mt. Lily
Pyramid Hill
Mt. Holloway
Mt. Mabel
Mt. Norfolk
NORFOLK RANGE
Mt. Rosslyn 2600 Ft.
Mt. Hadmar 2500 Ft.
Mt. Bolton 1560 Ft.
Mt. Vero 2300 Ft.
Tarleton River
Lagoon River
Balfour-Pieman Track
Helen Peak
Cage
Mt. Sunday
Pinnacle
Donaldson River
Mt. Donaldson
Interview River
Rocky Creek
Ford Creek
Unnamed Track
Pieman River
Ferry
North Pieman Head

I
II
III
IV
V
VI
VII
VIII
IX

L. Keith Wardle
Assistant Government Geologist
27th June 1911.

B38484

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Plate III G6810

PLATE III

GEOLOGICAL SKETCH MAP OF THE MOUNT BALFOUR MINING FIELD

LEGEND

SEDIMENTARY

RECENT — *Sand dunes*

P — *Conglomerate*

CAMBRO-ORDOVICIAN — *Balfour slates and sandstones*

IGNEOUS

TERTIARY — *Basalt*

DEVONIAN — *Granite*

CAMBRO-ORDOVICIAN — *Amphibolite*

Strike and dip of strata

Geological boundaries

Mineral leases

Arthur River
Alert Creek
Bottle Creek
Sundown Creek
Sundown Point
Nelson River
Sardine Creek
Rebecca Creek
Gaffney's Point
Richardson's Point
Little Eel Creek
Big Eel Creek
No Man's Creek
Possum Creek
Dawson River
South Dawson River
Ordnance Point
Daisy Creek
Thornton River
Pedder River
Sandy Cape
Frankland River
Mt. Balfour
Mt. Frankland
Warratah Creek
Lindsay River
Doherty's Pimple
Mt. Hazelton
Woody Peak
Mt. Lily
Mt. Holloway
Mt. Mabel
Mt. Norfolk
NORFOLK RANGE
Lagoon River
Helen Peak
Mt. Rosslyn
Mt. Bolton
Mt. Hadmar
Mt. Vero
Pyramid Hill
Mt. Sunday
Pinnacle
Donaldson River
Mt. Donaldson
Interview River
Rocky Creek
Ford Creek
Pieman River
Ferry
North Pieman Head

SOUTHERN OCEAN

Magnetic North

SCALE OF MILES
0 1 2 3 4 5 6

5 cm

L. Keith Ward.
Assistant Government Geologist
27th June. 1911.

Photo Lithographed by John Vail Government Printer Hobart Tasmania

GSB10
PLATE IV

CHART OF

MOUNT BALFOUR MINERAL LEASES

SHOWING POSITIONS OF LODES

5 cm

SCALE

0 5 10 20 30 40 50 60 70 80 CHAINS
0 ¼ ½ ¾ 1 MILE

LEGEND

Lodes

Strike and dip of strata

Heights of Mile Posts on Tramway Route — 648 Ft.

L. Keith Ward
Assistant Government Geologist
27th June 1911.

Magnetic North

FRANKLAND RIVER

TRIAL SURVEY FOR PROPOSED TRAM TO WHALES HEAD

LINE FOR TRAMWAY SURVEYED FOR MURRAY BROS: FROM WHALES HEAD

Timber lease—1200 Acres
C. DUNKLEY & OTHERS

TIN

The Little Frenchman

Mt. Balfour

Mt. Frankland

Photo Algraphed by John Vail Government Printer Hobart Tasmania.

PLATE V

CHART OF MOUNT HAZELTON MINERAL LEASES

SHOWING POSITIONS OF LODES

LEGEND

Lodes

Strike and dip of strata

5 cm

SCALE

0 5 0 10 20 30 40 50 60 70 80 CHAINS

0 ¼ ½ ¾ 1 MILE

Magnetic North

L. Keith Ward
Assistant Government Geologist
27th June 1911.

WARATAH CREEK

LINDSAY RIVER (Sketched)

DAISY CK

EIGHTY CK

THORNTON RIVER (Sketched)

LAGOON RIVER (Sketched)

TRACK MT BALFOUR TO WARATAH

24° 00' to Sandy Cape

Mt. Hazelton

Woody Peak

Mt. Lily

Mt. Mabel

Doherty's Pimple

Photo Algraphed by John Vail Government Printer Hobart Tasmania

GSB10
PLATE VI

CHART OF

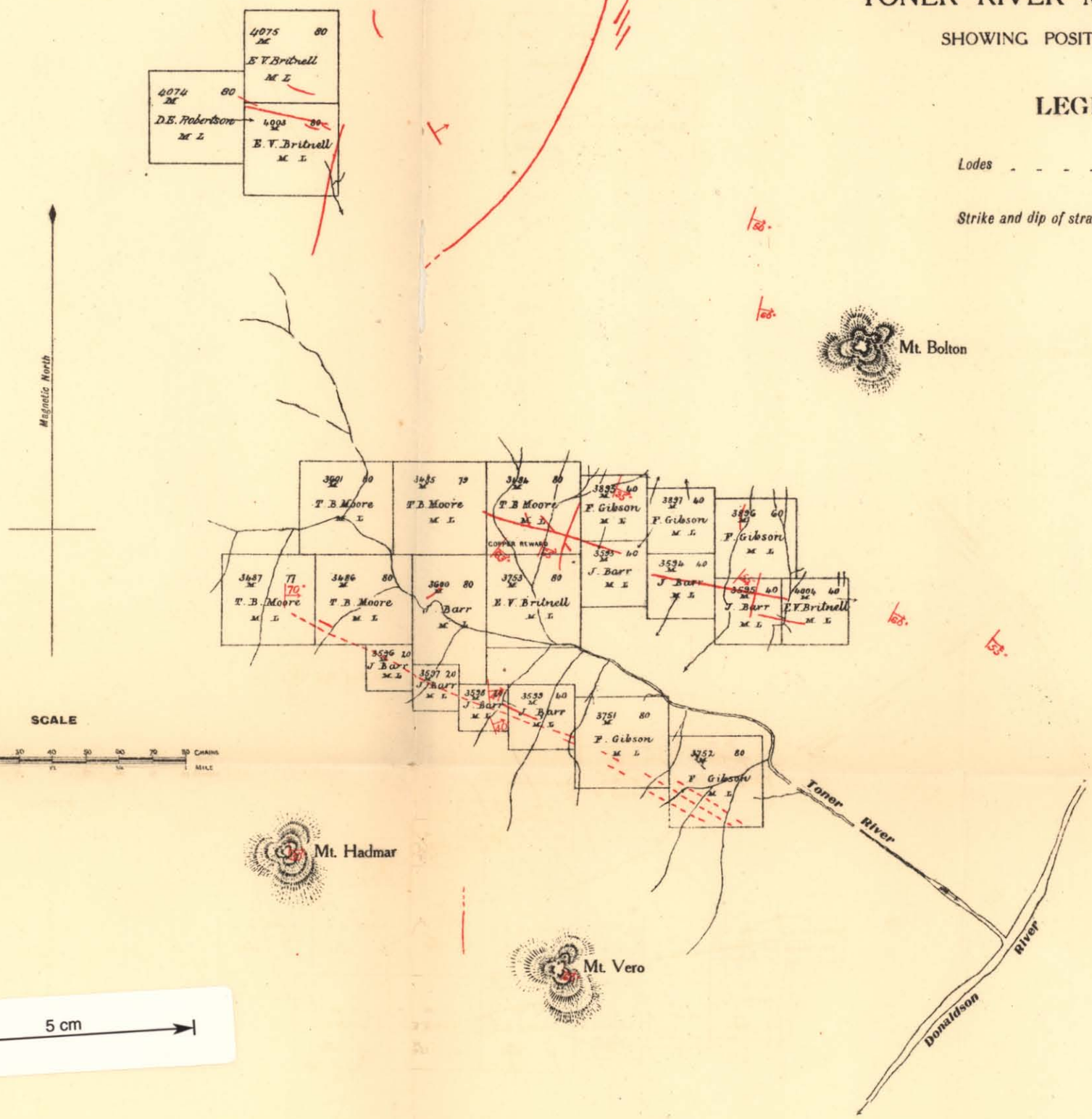
TONER RIVER MINERAL LEASES

SHOWING POSITIONS OF LODES

LEGEND

Lodes - - - - - -

Strike and dip of strata - - - 60°



L. Keith Ward.
Assistant Government Geologist
27th June 1911.

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Plate VII
G6810

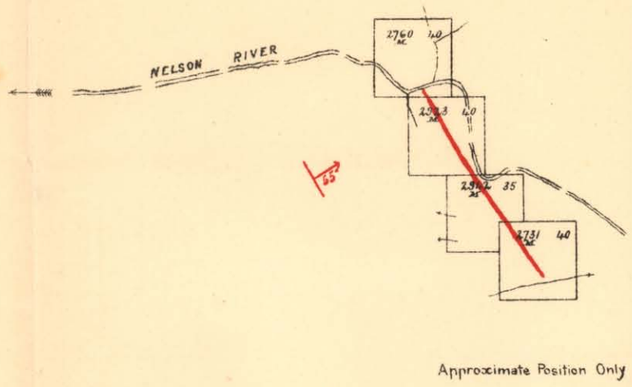

PLATE VII

5 cm

CHART OF

WHALE'S HEAD MINERAL LEASES

SHOWING POSITIONS OF LODES

LEGEND

Lodes _ _ _ _ _ _ _ _ _ _ _

Strike and dip of strata _ _ _ _ _ _ _ 45

Heights of Mile Posts on Tramway Route _ _ _ _ 508 Ft.

SOUTHERN OCEAN

REBECCA CREEK

RACHEL Ck

Magnetic North

SCALE

0 5 10 20 30 40 50 60 70 80 Chains
0 ¼ ½ ¾ 1 Mile

NELSON RIVER

Temma

Gaffney's Point

Whale's Head Boat Harbour

Richardson's Point

13M FROM MURRAY'S REWARD
57 Ft.

12M.
209 Ft.

TRIAL SURVEY FOR PROPOSED TRAM TO MT BALFOUR

10M.
373 Ft.

9M.
401 Ft.

8M.
430 Ft.

7M.
508 Ft.

256 Ft.
11M

LITTLE EEL Ck

BIG EEL CREEK

NO MANS CREEK

OPOSSUM Ck

RIVER

DAWSON

SOUTH DAWSON RIVER

Track to Mt Balfour (Surveyed)

100 . 0 . 0 E. J. Gale Pur.
99 . 3 . 10 W. T. Hanson Pur.
99 . 3 . 35
100 . 0 . 0
99 . 3 . 34 J. Meeve Pur.
99 . 0 . 0 J. Meeve Pur.
99 . 0 . 16 H. E. Hanson Pur.
99 . 3 . 31 R. Rafferty Pur.
99 . 3 . 33 F. Gaffney Pur.
99 . 1 . 33 H. T. Lawson Pur.
99 . 0 . 20 W. E. Hogg Pur.
99 . 1 . 9 S. A. Lawson Pur.
97 . 3 . 26 C. F. Harman Pur.
99 . 3 . 27 M. A. Evans Pur.
98 . 3 . 8 G. H. Saward Pur.
99 . 1 . 25 S. Hogg Pur.
99 . 0 . 15 T. A. Hogg Pur.
99 . 0 . 31 C. S. Gibson Pur.
98 . 1 . 26 E. Lawson Pur.
25 . 0 . 0 J. H. Saward Pur.
24 . 3 . 34 M. J. Saward Pur.
99 . 0 . 17 A. E. Hilder Pur.
99 . 1 . 27 A. W. Ford Pur.
95 . 3 . 28 F. W. Ford Pur.
99 . 1 . 12 H. L. Ford Pur.
99 . 1 . 1 L. Hogg Pur.
25 . 0 . 0 E. A. Cartledge Pur.
41 . 2 . 13
76 . 1 . 34
104 . 3 . 33 E. Rainbird Pur.
104 . 3 . 38 A. M. Austin Pur.
99 . 3 . 31 H. J. Austin Pur.
99 . 3 . 22 J. S. Morgan Pur.
25 . 0 . 0 C. Austin Pur.
25 . 3 . 28 E. G. Austin Pur.
105 . 0 . 0 P. Hurley Pur.
42 . 0 . 0 R. J. A. Evans Pur.
50 . 1 . 20 A. McGuinness Pur.
50 . 0 . 0 S. Symes Pur.
25 . 0 . 0 S. Symes Pur.

J. Shortall M. L.
W. W. F. Murray & F. C. Murray M. L.
H. Williams M. L.
A. McGuinness M. L.

L. Keith Ward.
Assistant Government Geologist
27th June 1911.

5 cm

PLATE VIII

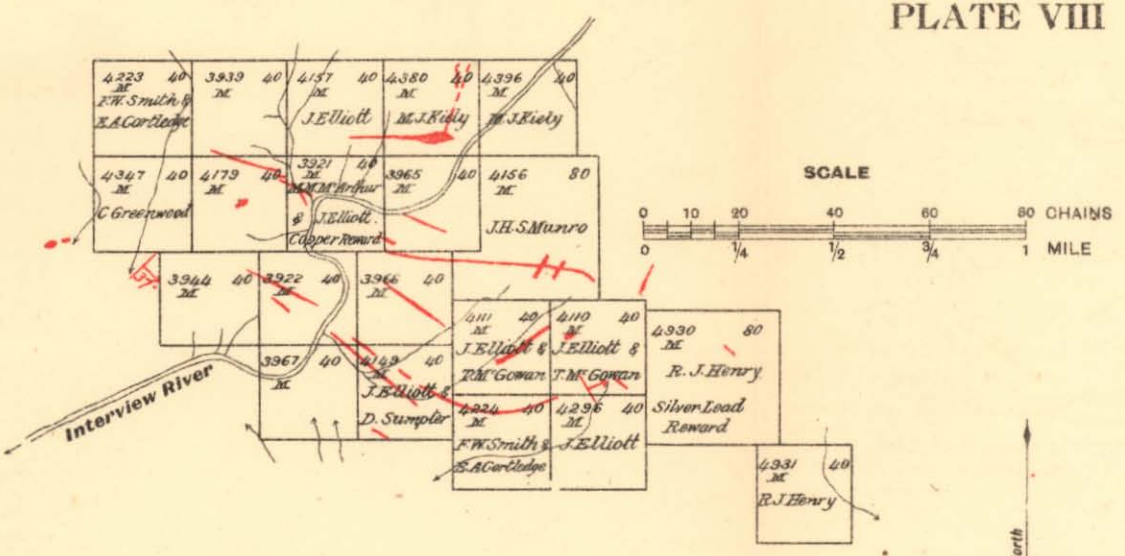

CHART OF THE EASTERN GROUP OF

INTERVIEW RIVER MINERAL LEASES

SHOWING POSITIONS OF LODES

LEGEND

Lodes – – – –

Strike and dip of strata –

L. Keith Ward.
Assistant Government Geologist
27th June 1911.

Photo Mgraphed by John Vail Government Printer Hobart Tasmania

PLATE IX

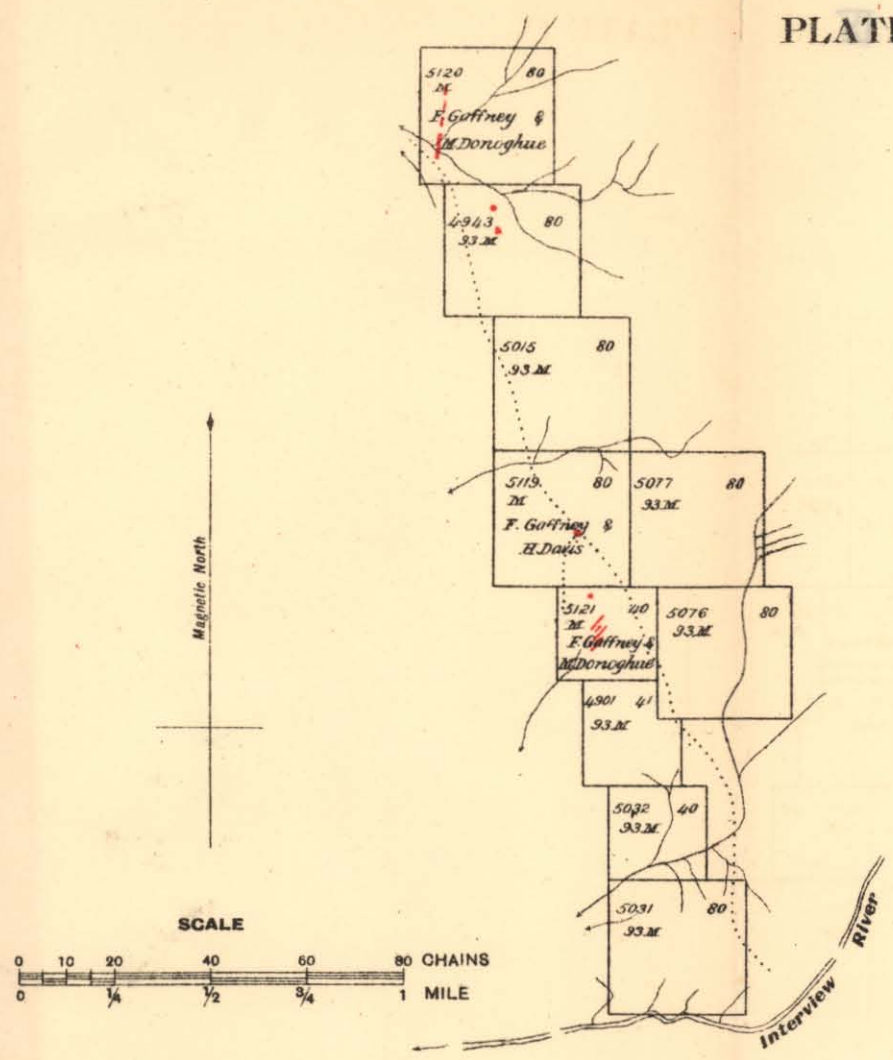

CHART OF THE WESTERN GROUP OF

INTERVIEW RIVER MINERAL LEASES

SHOWING POSITIONS OF LODES

LEGEND

Tin and tungsten lodes - - - ///

L. Keith Ward.
Assistant Government Geologist
27th June 1911.

5 cm

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