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PRELIMINARY GEOLOGICAL REPORT
UPON THE

Mt. Balfour Mining Field

BY

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Issued under the authority of
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PRELIMINARY GEOLOGICAL REPORT UPON
THE MT. BALFOUR MINING FIELD.

I.—INTRODUCTION.

THE following brief report upon the geology of the Mt. Balfour copper field and the neighbouring country is prepared with the object of presenting to the public in concise form the results of the recently-completed geological examination.

Having been compiled immediately upon the return of the writer from the field, and before the compilation of the more complete report has been begun, the statements here put forward must necessarily be regarded as provisional, and subject to any alterations that may be required by more minute investigation.

The country which was examined in greatest detail is that portion of the north-western coast of Tasmania which is occupied by the Norfolk Range. This constitutes the central portion of the Mt. Balfour mining field. In order to secure a broader basis for the interpretation of the geological relations of both the central and outlying occurrences of ore a much larger area was traversed than that occupied by the Norfolk Range. A rapid geological reconnaissance was thus made of that part of the western coast which lies between the Arthur and the Pieman Rivers.

The period occupied by the examination extended without interruption from the beginning of May to the middle of August of the current year.

II.—THE GENERAL GEOLOGY OF THE MT. BALFOUR FIELD.

The rocks occurring at the surface over almost the whole of the area which came under examination belong to a great sedimentary group, to which, pending correlation with other stratigraphical groups in Tasmania, the name "Balfour slates and sandstones" may be assigned. The rocks belonging to this group are traversed by basic dykes, more especially in the southern part of the area traversed, and they have been invaded by a granite *massif* which lies partly exposed at the surface along the coast between

Sandy Cape and the Pieman River. The majority of the lodes of the field are contained between walls of these older sediments.

Overlying the Balfour slates and sandstones in a few scattered places is conglomerate, now rendered extremely hard and dense by the complete silicification of its whole mass.

There is evidence of the former existence of a thin layer of Tertiary limestone over a broad coastal strip, but the few remnants of the bed now visible *in situ* occur almost solely at the edges of the small basaltic sheets, which are developed at different places in the district.

The basalt flows are now inconsiderable in extent, but were doubtless formerly much larger.

The outcrops of slate and sandstone or granite along the coastline are in many places concealed beneath a cover of sand, which has accumulated in dunes along the shore, and at a few points been swept inland by the prevalent westerly winds.

The surface cover of peat is almost continuous throughout the region, and its presence entirely obstructs geological observation over considerable areas.

A brief account of the chief characteristics of the principal rock groups follows:—

(a) THE BALFOUR SLATES AND SANDSTONES.

The most important in bulk of the rocks developed throughout the field are these older sediments. The group attains a very great thickness, and is composed of a great number of successive strata of varying grain and thickness. Occasional layers of conglomerate occur, together with the sediments of homogeneous texture, but do not at any point assume very important proportions.

The group consists of a great accumulation of littoral and infra-littoral deposits.

The layers of shale and sandstone have in a great number of places become indurated by silicification, and thus converted into quartzites of varying degrees of purity. In almost every part of the group a slaty cleavage has been developed, but the crushing forces have not been so intense as to obliterate the markings on the surfaces of various layers. Ripple-marks are excellently preserved in many places, and occasional markings, which appear to be worm-trails, are to be met with.

No definite fossils having been observed in any part of this group, it is difficult to assign an age to the rocks.

They are, for reasons which cannot here be discussed, thought to be probably of Cambro-Ordovician age.

There has been extensive rupturing and dislocation of the whole group, and mineral veins occupy the fractures in many places.

Where the members of this group have been invaded by the coastal *massif* of granitic composition there is at the contact a development of spots and small concretionary aggregates in the sedimentary rocks, which show also some degree of silicification.

(b) CONGLOMERATE.

Lying unconformably upon the slate in several different places are small developments of a siliceous conglomerate. The area covered by each of these occurrences is small.

(c) TERTIARY LIMESTONE.

Along the beach from Sandy Cape northwards numerous more or less completely rounded fragments of limestone occur. The rock was not found *in situ* in the vicinity of Sandy Cape, but underlies the basalt sheets on the farm land to the eastward of Whale's Head Boat Harbour, and at Marrawah. It may also be seen on the beach west of Marrawah between Mt. Cameron West and Green Point. It is a limestone composed largely of arborescent *zoaria* of polyzoa, spines and tests of echinoderms, fragments of the shells of gastropods, brachiopods, &c.

Apparently formerly of wide extent, this bed of limestone has only survived where it has been effectively protected from disintegration, as beneath a cover of basaltic lava.

(d) SAND DUNES.

The coastal sand dunes are developed to their greatest extent at Sandy Cape, where almost the whole of the promontory is covered by loose sand. The coast immediately to the south of Whale's Head Boat Harbour, and again near the mouth of the Pieman River, is now almost free from the cover of sand; but remnants of the aeolian accumulations of sand and marine shells are still to be detected. The sand drifts have made notable incursions into the pastoral country lying to the north of Marrawah within the short period of settlement of the district, and a redistribution of the material of the dunes is doubtless continually in progress. The dunes either still exist, or have existed, along the whole length of the coastline between the mouths of the Arthur and Pieman Rivers.

With the sand and shells, of which the dunes are chiefly composed, are to be found in many places mammalian bones; and near the harbour at Whale's Head numerous rude stone implements of the Tasmanian aborigines have been unearthed.

(e) THE BASIC DYKES.

Between Mt. Frankland and the Pieman River there occur a great number of igneous intrusions, which are probably all derivatives from one basic magma.

The form assumed by the majority of these igneous rock-masses is usually that of a dyke, but small developments are found in which the length is not so disproportionate to the breadth of the mass, when the horizontal measurements at the surface are being considered.

The rocks seem to the unaided eye to be gabbros, in which the pyroxenes have been converted into amphiboles, and may, pending microscopical examination, be called amphibolites.

Save in the district where the Mt. Lyell Company's most southerly leases are situated (on the Toner River, at the foot of Mt. Norfolk), these dykes do not show any regularity of orientation; and they are in all cases independent of the strike and dip of the sedimentary rocks which they traverse. No contact metamorphic phenomena were observed, and it is doubtful whether any material change has been induced in the sediments by their invasion.

These rocks are traversed by the normal mineral veins of the region, and copper ore has been found in small quantities within the boundaries of more than one dyke. The association of the copper ore with these dykes has no genetic significance.

(f) THE GRANITE.

The south-western portion of the area traversed is largely occupied by a granitic *massif*. The outcrop of granite has an average width of about 2 miles, and extends from the Pieman River to the point of Sandy Cape. The north-western part of the *massif* is actually on the coast, but as the mouth of the Pieman River is approached the slates appear on the western side of the granite.

Away from the coastline the boundaries of the igneous rock are always difficult to ascertain, since outcrops through the peaty vegetable cover are infrequent.

There are a number of different rock varieties within the boundaries of the granite. The most abundant type

is a coarse-grained variety, rendered porphyritic by the presence of large tabular crystals of felspar. Biotite mica is in large excess over muscovite in this type, yet the latter is invariably present. Associated with this variety occurs a paler and more acid type, in which muscovite is much more abundant. This rock is to be found on ~~the~~ properties on which mining operations were once carried on for wolframite.

Tourmaline-rich segregations are to be seen at Sandy Cape in the normal type of granite. At this point also there is a magnificent development of a pegmatitic variety, in which the felspar assumes exceedingly large proportions.

Aplitic and quartzose veins traverse the granite at many points, but only rarely does the aplite extend beyond the boundaries of the granite itself.

It is noticeable that the tourmaline-bearing veins have not been found to extend beyond the boundaries of the granite mass.

(g) THE BASALT.

At two points in the Balfour district proper, viz., at the Balfour township and near the Mt. Balfour Mine, there are small residual portions of some basaltic lava flow. To the westward of the mining centre a number of other small isolated occurrences of the same rock are to be seen. Whether all the separate developments of basalt were at any time connected cannot now be definitely decided. It is possible that several different centres of eruption may have existed, but none of the conduits by which the lava reached the surface have been recognised.

The basalt is an olivine-bearing variety, and in all the occurrences maintains the same general characteristics. It weathers into a deep-red or dark-chocolate soil, and the fresh rock only occurs in the heart of the spheroidal blocks which occur below the deep cover of completely-weathered material.

Water leaching through it has in many cases dissolved some portion of the iron content, and deposited it as limonite below the igneous rock.

Some slight amount of silicification of the underlying rock has been effected by the basalt, and this is chiefly noticeable where the subjacent material is the Tertiary limestone.

At one place near the centre of the township of Balfour the basalt overlies some tin-bearing alluvial ground, which has been worked in the past.

III.—THE ECONOMIC GEOLOGY OF THE MT. BALFOUR FIELD.

As in other mineralised regions in the western portion of Tasmania, there exists some variety in the mineralogical composition of the ore-bodies in the Mt. Balfour field. Viewed singly, any one of these mineral groupings may appear entirely dissimilar from its neighbours in character. In some cases the several gangue minerals associated with the commercially valuable ores of one and the same metal will be so different in their relative abundance that ores which are genetically closely related present an outward semblance of a dissimilarity which cannot be admitted to be real. In other cases the minerals of commercial value are themselves different in different lodes, or the same metalliferous minerals may be present in very widely different proportions.

These variations in the characters of the many ore-bodies of the field necessitate a classification of the lodes and some detailed description of the lode contents. These matters will receive detailed treatment in the full report, while the present preliminary report can take cognisance only of the most prominent features.

There are two main groups of metalliferous lodes in the region under examination.

The most important in bulk, and that to which most attention is being paid at the present time, is the group of copper-bearing lodes.

The other group, comprising the tin-bearing and tungsten-bearing lodes, was for a long time the only one known to be represented. The shallow alluvial and detrital deposits resulting from the disintegration of these lodes have from time to time been worked and have produced a fair quantity of tin ore.

(a) THE COPPER LODES.

(i) *Mineralogy.*

The minerals most commonly visible in the lodes of the cupriferous group are:—Quartz, chlorite, sericite, pyrite, chalcopryrite, ferriferous dolomite, magnetite, and hematite.

Less common are galena, sphalerite, and stibnite.

Traces of gold are usually present, and silver has been found at some points.

By alteration there are developed native copper, chalcocite, covellite, and occasionally traces of malachite and azurite.

Some portions of the lodes are almost wholly quartzose, while at other points so little silica is present that the lode-matter is quite soft and friable. The hematite appears in some cases together with silica, pyrite, chlorite, and sericite; but more often appears to be very free from admixture with the other constituents of the vein-type. Magnetite is sometimes associated with the hematite and sometimes with the ferrous dolomite pyrite and chalcopyrite.

In many instances the proved portions of the lodes of this type show only slight traces of copper, yet it is perfectly certain that such a lode belongs to this type. It is essential to remember that even the most common constituents of this vein-type may, or may not, be present at any given point in a lode.

The distribution of the minor constituents—galena, blende, and stibnite—is exceedingly irregular, and it appears doubtful if any of the occurrences of these minerals yet located is sufficiently large to be of commercial value.

The normal ore is singularly free from deleterious impurities, and as such offers no difficulties to the metallurgist.

The variety in the mineral composition of the lodes produces a like variety in the outward appearance of the outcrops. After a careful study of the physical and mineralogical characters of the different varieties of lode-matter, and the nature of the corresponding outcrops, it is possible, within certain limits, to predict the probable nature of a lode beneath an unprospected outcrop possessing normal features.

It is noteworthy that the richer portions of the lodes which have hitherto been prospected are not marked by bold outcrops of quartz, although any lode as a whole may be thus characterised. This is a natural result of the action of weathering upon the different parts of the lodes, since those portions largely composed of quartz are not subject to such rapid removal as portions in which metallic minerals predominate.

These matters do not appear to have been duly appreciated on the field, and a wholly erroneous idea has arisen with regard to the significance of massive outcrops of dense quartz. The latter, from their superior power of resist-

ance to weathering, attract the attention, and offer advantages for inexpensive prospecting, but very few of them carry an appreciable amount of copper. The shoots of copper ore may, however, be found on the flank of a bold quartz outcrop; or may be in line with a massive quartz outcrop, constituting the extension of the same lode.

The upper portions of the copper-bearing lodes have suffered chemical alteration, and some portion of the copper contents of the upper parts of the lodes has migrated downwards. The result is that secondary ore of higher grade than the primary ore has been produced. In this secondary enrichment the sulphides, chalcocite, and covellite have been generated from chalcopyrite. In the opinion of the writer, the deposits of the richer sulphides are for the most part replacements of primary chalcopyrite. In other words, the secondary sulphide enrichments have an important primary basis, and do not represent the accumulation of copper ore in portions of the lodes wherein little or no copper primarily existed.

(ii) *Structure and Distribution.*

The lodes belonging to this group are found throughout a very large part of the whole of the area which was examined, and, as may be expected, show great variations in structural details at different places.

The lodes are usually found to occupy planes of actual dislocation of the crust, and fragments of the brecciated wall-rocks are frequently found cemented into the vein-filling. The lodes are, in the majority of cases, tabular in form, and precisely those which are usually referred to as "fissure lodes."

In some cases, however, there are found broad zones of altered country rock—slate or sandstone—showing certain features usually associated with the simple lodes, and even passing over into well-defined veins. These zones of silicified country rock contain pyrites and chlorite disseminated throughout their entire mass, but no cases have yet been found in which they contain veins that assume important proportions.

At certain places there are found to be parts of the better-defined veins, where the simple fissures have disappeared and broad sheeted fracture-zones have taken their place. These are not to be confused with the indefinite impregnations of the country rock. The broad fracture-zones may or may not carry payable ore.

A very noticeable feature of the field, and one which has caused no little perplexity, is the tendency of the line of strike of the lodes to change rather abruptly. At the change of strike there is usually a break in the continuity of the lodes. While it must be claimed that the several disconnected portions are parts of one general direction of fracturing, it cannot be said that any quite continuous lode has yet been proved for any great distance. The small amount of underground work that has been done has certainly proved the existence of breaks in the main fracture-line of the central portion of the field. It remains for future developmental operations to prove the exact character and form of the breaks.

Where such broken lines of lodes occur the outcrops of the component parts along the whole fracture-line are in some places arranged *en échelon*, but at other places the successive portions are irregularly disposed.

With these reservations regarding the absolute continuity, it may be shown that the longest fracture-line in the Balfour field, viz., that on which Murray Bros.' Reward, the Central Mine, the Mt. Balfour Mine, and the North Mt. Balfour Mine are situated, extends for a total distance of $6\frac{1}{2}$ miles. Many other similar lines of fracturing extend for distances of as much as 2 miles along the strike.

With respect to the details of strike and dip each district and lode must be treated separately; yet a general tendency to conform to certain directions of strike is usually perceptible in different districts. Thus, in the district surrounding Mt. Balfour, the lodes have a tendency to strike in directions lying between north-north-west and west-north-west, the southerly portions of the fracture-lines having the more northerly bearing. In the Toner River district, at the foot of Mt. Norfolk, the strike of the lodes is usually between 10 and 25 degrees south of east. But in the vicinity of Elliott's Reward Mine no general uniformity of strike can be recognised.

The veins belonging to this group extend over the whole area embraced between the coast-line near Whale's Head Boat Harbour on the west, and the Frankland River on the east. They have been proved as far north as the North Mt. Balfour Mine, and as far south as Elliott's Reward Mine on the Interview River.

The lodes belonging to this group all lie beyond the limits of the granite *massif* which occupies the south-western portion of the area examined, and traverse both the slate and the basic dyke rocks.

(b) THE TIN AND TUNGSTEN LODES.

(i) *Mineralogy.*

The number of minerals present in the veins belonging to this group is also large, and the proportions in which they are represented in the lodes are very variable.

Quartz and white mica are the most abundant of the non-metallic ingredients. Tourmaline is very common in the veins enclosed within the granite borders, but has not been recognised outside the limits of the granite.

Cassiterite, wolframite, and occasionally scheelite, are the valuable constituents, while the following metallic minerals occur with them:—Pyrite, arsenopyrite, a little chalcopyrite, and sometimes molybdenite.

Pyrite is certainly the most abundant of the metallic minerals in the lodes of this group, before the lode-matter has been subjected to weathering. After prolonged weathering a cavernous quartzose lode-matter results, in which all the metallic minerals save cassiterite and wolframite have been leached out. The wolframite itself suffers weathering, and tungstite results from its alteration. Quartz is the principal gangue mineral in this weathered ore, but a white or pale-yellowish mica is always present, and in the lodes enclosed within the granite *massif* the tourmaline is sometimes preserved.

The distribution of the cassiterite and wolframite through the lode-matter is apparently not very regular, but so little of the lode-matter has been exposed *in situ* that it is difficult to form an accurate judgment on this matter.

(ii) *Structure and Distribution.*

The structural features of these lodes are not yet fully ascertainable, since they present no marked outcrops on the surface, and have hitherto received very little attention from prospectors. The working of the alluvial deposits of tin ore has led to their discovery, and the outcrops of the lodes have been broken at a few points, but no serious systematic attempt has been made to prospect the lodes.

Where exposed the veins are not large, but very little ground has been stripped of its cover of peat, detrital, and alluvial material. It may well happen that larger veins or more valuable aggregates of small veins lie hidden below the shallow surface cover.

Within the boundaries of the granite *massif*, and a little to the north of the Interview River, the workings on the wolframite shoots have fallen into disrepair, and little can be seen. The width of the veins does not appear to exceed 2 feet in the places where work has been carried on; but the extent of the shoots along the direction of the strike is quite unknown, since the veins have only been exposed for a few feet by shallow trenches or shafts. In one place there are several parallel veins overlapping each other, but the orientation of the remaining occurrences in the district could not be definitely ascertained.

The known veins which occur outside the boundaries of the granite are restricted to an area lying to the west and south-west of the Balfour township, and from a quarter of a mile to a mile distant from it.

The number of these veins is very large, but they are all narrow, and do not continue without interruption for any appreciable distance. The veins are very rich in cassiterite in some places, and at the same time are free from wolframite; in other places cassiterite and wolframite occur together; and at a few points wolframite alone remains in the weathered lode-matter. It is impossible to regard those veins which carry cassiterite as distinct from those which carry wolframite, although the cassiterite-bearing varieties are much the more common.

The narrow veins which contain these minerals form a stockwork, the outcrop of which extends over a fairly large area. The several members of the reticulating system strike and dip in ever-varying directions, and a considerable number of them are inclined at very low angles to the horizon. These flat "floors" of ore do not coincide with the bedding-planes of the slates or sandstones in which they are found.

From the weathering and disintegration of these veins a considerable amount of cassiterite has been supplied to the shallow alluvial deposits which cover parts of the valleys of Tin Creek and its tributaries, and (to a less extent) of Emmett's Creek. The output of tin ore from Balfour has in the past been derived mainly from the alluvial deposits thus formed. At the present time tribute parties have begun to strip the surface of the bedrock, where the flat veins are not covered by any appreciable overburden. Thus, a certain amount of lode-mining is being carried on, although only the thoroughly oxidised capping of the lodes is being attacked.

IV.—THE PRESENT STATUS OF THE MINING INDUSTRY IN THE MT. BALFOUR FIELD.

During my examination of the Mt. Balfour field there was a general lack of mining activity throughout all portions of the field. The prospecting operations of those companies which were actively engaged in proving their properties were apparently considered by other owners to be applicable far beyond the limits of the leases on which the work was being done.

While promising results from the mining operations in one mine may reasonably generate the hope that like success will attend the prospecting of similar lodes on neighbouring leases, it by no means follows that the failure of one company to locate any considerable quantity of payable ore is sufficient reason for the neglect of other properties. So little work has been done up to the present time upon any mine in the whole district that it is quite unsafe for any mine to attempt to generalise in quantitative terms from the experience of its neighbours.

Many causes have contributed to retard the development of the field as a whole. Its geographical position is such that the district is almost completely isolated from other portions of Tasmania. The Arthur and Pieman Rivers form serious obstacles to communication on the north and south. On the west lies the Southern Ocean.

Transport to and from the field has been by way of Whale's Head Boat Harbour, which is situated about 15 miles by road from the Balfour township. The harbour is small, and has the serious disadvantage of being exposed to westerly winds and seas. The road from Whale's Head to the mining field is now being gradually rendered suitable for traffic. It traverses long stretches of country covered with a deep layer of soft, peaty soil, which, when cut up by traffic, becomes transformed into a bog in the wet weather.

Under such circumstances transport between the field and the coast has been costly, and somewhat irregular. The cost of carriage of large and awkward pieces of machinery such as boilers to the field has been very heavy; and no attempt can be made to undertake work of this nature except under the most favourable weather conditions.

Hence it is that there has been long delay in the equipment of the different mines with the machinery necessary for development. The prospecting of the various lodes in the north has been in this way retarded, for progress has been

unavoidably slow in the absence of pumping machinery. With the construction of a tramway from the coast these disabilities will be largely eliminated, and progress on the mines should be accelerated.

The following brief account of the principal mining properties on the field is necessarily curtailed for the purposes of this report. The several mines are classed under the heads of the principal metals which occur within the boundaries of the respective leases.

(a) COPPER MINES.

(i) *The Mines Operative at the Time of my Visit.*

(1) *Murray Bros.' Reward Mine* is that to which the rest of the copper mines at Balfour in a great measure owe their origin, and from which alone any considerable amount of ore has been sent away for treatment. The total amount of ore sold, up to the end of June, 1910, was 1286 tons, worth £16,000. Several of the parcels of ore sold had an assay value of over 30 per cent. of copper, and one parcel of 50 tons proved on assay to carry 35.36 per cent. of copper.

The lode which has produced this ore is situated on the main fracture-line of the Balfour field, and near the southern end of the line. The exact structural features of the lode within the Reward lease yet remain to be determined. The writer, however, feels convinced of the essential unity of the bodies of ore exposed in different parts of the workings. The stope width of the main shoot varies from 3 feet to 11 feet 6 inches, and the length of the first stope above the level of the No. 2 tunnel is 198 feet. The ore is of excellent grade, and the better portion has been selected for export, while ore of lower grade has been left standing. The pitch of the main shoot has not yet been ascertained, but the stope length has increased as the lode has been followed down.

Two winzes, 90 feet apart, sunk from the lower adit level have proved that the ore continues without deterioration for at least 50 feet below that level. The ore hitherto mined is not primary ore, but that in which original chalcocopyrite has been enriched by partial conversion into covellite, and with which veins of secondary chalcocite occur.

Lode-matter has been worked beyond the limits of this main shoot, but not to any great extent. The existing workings constitute no conclusive test of this lode-matter, and operations at a greater depth must embrace the pros-

pecting of this vein-stuff, which lies beyond the limits of the main shoot.

The outlook for the property is bright, and now that machinery has been installed the progress of the development work should be much more rapid.

(2) *The Central Mt. Balfour Copper Mines*, north of and adjoining Murray Bros.' Reward, are at present engaged in prospecting the northerly extension of the same lode. A number of small bodies of ore have been located on the surface for a distance of half a mile along the strike of the lode, and from the shallow work which has been done upon these, some excellent ore has been won. The most promising ore hitherto obtained in the property has been disclosed near the southern boundary, where a good deal of work has been done from a low-level tunnel. From the level of this tunnel a prospecting winze was sunk, and a little crosscutting was done, with results satisfactory to the management. Some high-grade ore obtained from these workings is stacked for future transport at the mouth of the tunnel.

The prospecting of the property must be carried on at greater depths, and a commencement has already been made. The shaft has been sunk 180 feet, and at 150 feet a crosscut put in to intersect the lode. At a distance of 170 feet from the shaft the lode was cut, and driving on its course was begun. This deeper prospecting had not, at the time of my visit, been attended with very satisfactory results, but so little has been done that it is far too early to make any pronouncement on the results of the testing of the lode at this level.

The known occurrences of ore at the surface extend over a considerable distance along the course of the lode, and the existing underground drive is but short in comparison.

The mere driving on the course of the lode should certainly not be considered a sufficient test, since crosscuts at frequent intervals are required to prove whether parallel bodies exist in the broad channel which marks the lode in this mine.

(3) *The Balfour Blocks Mine*.—The two principal lodes upon which work has been done do not make a prominent outcrop above the general level of that part of the lease in which they occur. They lie to the westward of the main fracture-line of the field, but are not on that account less likely to carry ore of good grade. The most promising ore which has been located is that occurring in the lode

which the Consolidated Company has worked in the adjoining section.

At the present time a main shaft is being sunk with the aid of machinery to prove the lodes at a depth, for earlier attempts to open them up without the help of a pumping-plant have been frustrated by the inflow of water.

In the prospecting of the two lodes which lie on either side of this new main shaft, a sufficient amount of cross-cutting must be done beyond each lode to satisfactorily determine the presence or absence of parallel bodies of ore. No sign of these is visible at the surface, but the presence of even the principal lode (No. 1 lode) could not have been surmised from the surface configuration at places where it has been proved to exist by the trenches or shafts.

(4) *The Balfour Mines Development Company's Workings*.—The principal ore-body located within the leases also lies to the westward of the main fracture-line of the district. It is situated near the northern boundary of the most northerly section, and is now being systematically opened up by a low-level tunnel.

Some trenches and a shallow prospecting shaft had proved the presence of a lode carrying chalcocite and chalcopyrite, but from which the majority of the metallic constituents had been leached. The present tunnel workings show this lode to be 5 feet in width, and to carry a fair content of copper ore throughout. Some chalcocite is present, and it is doubtful if primary ore has yet been reached. Prospecting for possible ore on the line of the main Balfour fracture, which seems to traverse the section a few chains to the eastward of the present workings, can be heartily recommended.

(5) *Mt. Balfour No. 3, and Mt. Balfour No. 2 Mines, and Murray Bros.' Section 3955-M*.—These sections are on the course of the main lode-fracture, and the lode has been uncovered at a number of different places within their boundaries. It appears probable that the fracture continues without interruption throughout this group.

There are copper-bearing minerals showing at several points, but at the time of my visit no underground prospecting had been carried out to a degree sufficient to enable any confident pronouncement to be made upon the prospects of the properties. Tunnels were being commenced with the object of cutting the lodes on both the Mt. Balfour No. 2 and the Murray Bros.' leases; and

from them much information is to be gained. The topography in this part of the field favours tunnelling, since the proximity of the Frankland River gorge to the line of the lode will enable a great many feet of backs (up to nearly 300 feet in some places) to be obtained without excessively long drives.

(6) *The Mt. Balfour Copper Mine* comprises Chester's Reward and a number of other sections, which include within their boundaries more than one lode. The main lode-line of the field runs through the property, outcropping for more than a mile in length. In addition to this lode there is a parallel lode lying to the south-west, and an isolated body of ore in the centre of Chester's Reward section.

The most important ore-body is that portion of the main Balfour line of lode which lies within this lease, and the greater part of the prospecting work accomplished has been done upon it. The results of this work are most encouraging. While it is quite impossible to say whether subsequent development will prove that hitherto unprospected portions of the lode will prove of the same grade as those which have been tested, the extent of the lode-matter indicated by the surface outcrop and underground workings, and the results hitherto obtained should suffice to stimulate the company to redouble their energy.

For some considerable distance the lode outcrops along a ridge, which rises above the level of the surrounding country. Any prospecting of this ridge marked by the lode by means of tunnels cannot give conclusive information regarding the ore-body. It must be opened up at greater depths.

The principal underground workings show the main ore-body in the place where it has been opened up to have a width of some 70 feet, and to consist of a broad belt of somewhat irregularly impregnated country. The drives and crosscuts show that a considerable amount of leaching has taken place in some of the bands which constitute the ore-body at the lowest level attained up to the present time. Under such circumstances it is reasonable to anticipate a relative enrichment at greater depth. The ore which has been obtained consists of quartz, ferrous dolomite, and pyrite, with chalcopyrite either disseminated through the mass or occurring in rather clean bands.

In the future prospecting of this lode it is essential that operations be carried on with a view to testing the north-western continuation of the lode at the adit level. The

existing drives and crosscuts have been put in almost solely with the object of proving that portion of the lode which lies to the south-east of the adit crosscut.

At the present time machinery is especially required in order that deeper prospecting work may be carried on. It is doubtful if any tunnel at a lower level would prove a satisfactory means of attacking deeper portions of the lode. The relief from pumping to be afforded by a tunnel would only be temporary.

(7) *The North Mt. Balfour Mine* adjoins the Mt. Balfour Mine. The lode which is being worked within its boundaries is situated at the north-western end of the long line of lode, which may be traced northwards from Murray Bros.' Reward Mine. The lode at the surface is leached of its metallic contents, and a long tunnel was driven to intersect it at a lower level. The ore-body had only just been reached at the time when I was leaving the field, and I had no opportunity of inspecting it. The ore obtained at this level, and shown to me, is of good quality, and if the ore-body maintains the dimensions which it possesses at the surface, with an enhanced copper value, the outlook will be promising. It should hardly be necessary to add that the main crosscut to the lode can only be considered to be the commencement of prospecting operations. A drive along the course of the lode and crosscuts at many other points will be necessary before any expression of opinion as to the value of the property will be justifiable.

(8) *The Mt. Balfour Proprietary Company* was doing some work on a group of sections which lie on the eastern bank of the Frankland River. These sections were apparently originally pegged with a view to the location of the continuation of the lode which occurs in the Mt. Balfour Company's lease. However, the strike of the latter lode changes abruptly at the southern boundary of the lease, and consequently does not cross the Frankland River. The prospecting which had been done at the time of my visit to the sections had not been productive of any results. However, some quartzose ore carrying pyrites and chalcoppyrite was discovered at a date later than that of my visit, and this clue to the existence of lode-matter should be followed.

(9) *The Balfour Premier Company* has made a systematic attempt to prove the value of the lease, which lies to the westward of the Central Mine, by means of a low-level tunnel. The object of the tunnel was to test at a depth a siliceous outcrop which is prominent on the crest

of the ridge between Emmett's Creek and Tin Creek. The tunnel passed through a broad zone of sandstone so impregnated with silica, chlorite, and pyrite that a dense green quartzite studded with pyrites has been formed. A few insignificant gossanous veins were encountered in this crosscut, but no defined lode of any magnitude. The further prospecting of this ground by an extension of the tunnel workings cannot be recommended, unless some further discoveries are made at the surface to warrant it.

(10) *The South Murray Balfour Company* has done some work upon a lode which seems to be certainly the southern extension of the lode which is being worked by the Murray Bros. on the reward claim. The work which has been possible without the help of machinery has been inconclusive, since copper ore cannot be expected to be found in any quantity right at the surface.

(11) *The Mt. Lyell Mining and Railway Company's Sections*.—Two main groups of sections were being worked, one at the base of Mt. Frankland, and the other further south in the country drained by the Lindsay River.

In the northern group of sections there are several outcrops, the principal one of which has a strike of N. 29° W., and forms the backbone of a low ridge. It is a quartzose lode, from which the metallic contents have been almost completely leached out at the surface. At the time of my visit the only workings in which lode-matter had been exposed were shallow. A little chalcoppyrite had been found and a commencement was being made to drive a tunnel to cut the lode 75 feet below the outcrop on the hill. To the north of this outcrop some work has been done upon lodes less prominently shown at the surface, and a little copper ore has been located. It does not appear possible to obtain conclusive results with regard to these lodes without the aid of pumping machinery, unless perhaps during an exceptionally dry season. The present prospecting alterations can only be regarded as preliminary to workings on a larger scale, when these may be judged to be warranted by the developments.

The other group of sections on the Lindsay River comprises several lodes, upon all of which some work was being done. At two points on the line of strike of the principal lode promising ore has been obtained at no great distance below the surface, and work at deeper levels is planned for the coming summer. The work of prospecting at this place may be carried on without hesitation, for there are

no structural problems awaiting solution. The lodes are known to be continuous for considerable distances. It remains only to determine their copper contents below the leached outcrops.

(ii) *The Mines not now Operative, but on which an Appreciable Amount of Work has been done.*

(1) *The Balfour Consolidated Company* has located some excellent ore on that one of its leases which lies between the sections on which the Blocks and Development Companies are now working. A number of trenches and a shallow shaft have proved this lode to be continuous for some distance. The present inactivity is to be regretted. The lode carrying the good copper values seems to be that which continues through the Blocks Mine, to the west of the shaft which is now being sunk; and the lode on both the Blocks and Consolidated Mines might well be prospected from this shaft.

(2) *The Pierpont Morgan Mine* is situated near the foot of Mt. Frankland, and on the western side of it. A well-defined broad lode-formation runs through the section, forming the backbone of a low ridge. The lode has been prospected by trenches at the surface, and a tunnel from the eastern side of the ridge. The lode is 30 feet wide where intersected in the tunnel, and consists of a number of mineralised bands, which show the presence of chalcopryrite and covellite. The lode has clearly suffered no small amount of leaching, and it is reasonable to look for an improvement in the grade of the ore at a lower level. Sinking is the only course for adoption, and operations should be resumed without delay. The ore-body certainly merits the expenditure of sufficient capital upon it to give it a fair test.

(3) *The Balfour South Mine* ceased operations after actually making a commencement to open up its main lode in a systematic manner at a depth. The principal occurrence of copper ore has had a little work done upon it at the surface, and the presence of high-grade ore has been proved. The strike of the ore-shoot appears from what little has been done to be inclined to the strike of the lode. This matter is one which can only be proved by further work, for the existing trenches and tunnels do not afford conclusive evidence with regard to structure. It appears advisable to push on with the sinking of the main shaft, which is now down 32 feet, and to prospect

the lode-formations at a depth. Other lodes than that which has been mentioned are visible at the surface in the immediate vicinity of the shaft, and may best be prospected from it.

(4) *The Mt. Lyell Mining and Railway Company's Leases*, on the Toner River, at the foot of Mt. Norfolk, have been temporarily abandoned. The locality is difficult of access, and the results are incommensurate with the amount of work that has been done. The prospecting of the lode-formations on the northern side of the Toner River has given more encouraging results than that on the southern side. Some more or less isolated bodies of ore of good grade have been located, but the prospecting of the lodes between these shoots has not met with success. A large area has been tested by shallow workings, and on the Reward section, where the most promising results were obtained, a shaft has been sunk at one place to a depth of 36 feet, and at another place a tunnel driven 230 feet. The ore brought up from the shaft carries copper values, and shows unmistakable signs of leaching. The tunnel intersected quartzose lode-matter, but nothing of value was encountered.

(5) *The Balfour United Syndicate* has actively prospected an ill-defined lode-formation which lies to the east of the Balfour township. The workings are all shallow, but sufficient to indicate the nature of the lode-matter. This lode-matter certainly possesses the same general characteristics as many of the non-productive portions of the copper-bearing lodes throughout the field. Specimens of copper-bearing ore taken from the lode were shown to me, but I was unable to find any cupriferous mineral *in situ* in the lode. There does not appear to be a promising outlook for the property, unless some future discovery of value is made.

(6) *The Strickland Mine*, 2 miles east of Whale's Head Boat Harbour, has been the scene of some active prospecting. The workings are in serious disrepair, and inaccessible, so that the structural details of the lode are difficult to ascertain. However, the lode-matter which has been hauled to the surface and tipped round the several shafts indicates a fairly well-distributed copper content. The grouping of minerals in the lode corresponds to that which prevails throughout the Balfour field. From the lode-stuff at the surface a few bags of picked ore have been profitably exported. The property is one which merits

further attention, possessing, as it does, the additional advantage of being close to the port.

(7) *The Couta Mine* is situated on the coast at a point 3 miles north of Whale's Head Boat Harbour. Within its boundaries a lode has been traced right to the sea-shore. The work of prospecting has been hampered by the existence of the coastal sand dunes. The available points at which the lode could be attacked are either at the coast or some distance inland. The exposure on the shore shows a broad formation, the total width of which is 14 feet, and through which are disseminated copper pyrites and copper carbonates. No work of any importance can be carried on at this place on account of the proximity of the sea. Further inland a shaft has been sunk 50 feet, and some prospecting has been done at that depth with encouraging results. Water, however, ultimately became too heavy, and work was abandoned. The ore obtained at this point is of promising appearance, and the lode should be prospected further.

(8) *Elliott's Reward Mine*, on the Interview River, is one of the most promising properties on the field. The lode which carries the good values runs into the Interview River, and the most encouraging results have been obtained from a shaft put down on the bank. The workings were inaccessible, but there are a few tons of high-grade ore lying on the surface. This ore consists mainly of chalcopryrite, and is exceptionally free from gangue minerals. The lode from which this ore has been won has been located a few chains away from the shaft, where it is crossed by a small tributary of the Interview River, but very little work has been done upon it. In view of the character of the ore which has been proved, the work of prospecting should be proceeded with. The difficulty of access to the mine has undoubtedly been a serious hindrance to its progress.

There are numerous other lodes in the vicinity, but the small amount of prospecting work that has been carried out has hitherto failed to prove the presence of other promising copper lodes.

(iii) *Lodes Located, but Practically Undeveloped.*

In a large number of places prospectors have located copper-bearing lodes, but have not, for different reasons, been able to continue with the work of opening up the ore-bodies. Among these localities where ore of promising

appearance has been uncovered the following call for special mention in this preliminary report:—

(1) On a section applied for by Messrs. Rainbird and Laughton, about a mile to the south of the Mt. Balfour Mine, a few holes have been put down on some lenses of ore, which appear to be components of a lode running 20 degrees west of north. Trenches are wanted on other parts of this lode so that its course may be determined with certainty. Then the ore must be exposed at lower levels. That which has been proved to exist is massive, and perhaps primary.

(2) To the south-east of Mt. Frankland, and close to the Lindsay River, a lode traversing two sections held by Messrs. McKye and Curtain has been found to be copper-bearing. An attempt to prove the lode a few feet below the surface by means of a tunnel failed through the collapse of the side of the hill into which the tunnel was being driven.

(3) About a mile to the south-east of the Mt. Lyell Company's camp on the Lindsay River a promising lode has been uncovered on ground charted in the name of J. H. Lyons. Chalcopryrite and covellite are visible in the ore disclosed by shallow trenches, and since leaching of the lode is indicated by the cellular character of part of the lode-matter, the hope of obtaining better-grade material at a lower level may reasonably be entertained. The outcrop is traceable at the surface for a distance of several chains before it disappears under the peaty cover.

To the north of this ground, and beyond the surveyed leases, a large outcrop has been found by Mr. C. Goldsmith. Where it has been intersected by a small creek a little work has been done, and copper-bearing lode-matter located. The lode may be traced at the surface for some chains.

(4) In the Norfolk Range, near the source of the Lagoon River, and in the centre of the southern of two leases held by the Poseidon Silver-lead Mining Company is one of the most promising ore-bodies in the field. Unfortunately, too little has been done upon it to ascertain even its width with any certainty. At one place where the proportion of copper is highest the width of the ore-body appears to be at least 12 feet. At this point the outcrop is of a gossanous character. The lode may be traced in a north-westerly direction for nearly a mile, its features altering from point to point. The more siliceous portions of the outcrop are almost untouched.

Beyond the northern section held by the Poseidon Company the extension of what appears to be this same lode is being prospected by the Balfour Prospecting and Mining Company. Some copper-bearing lode-matter having been located, the work should be proceeded with.

(5) Three-quarters of a mile to the eastward of the Balfour South Mine some ore of promising appearance has been laid bare in a lease held by Messrs. Hollow and Smith. The work done is of quite insignificant extent, and altogether insufficient to determine either the structure or the value of the lode-matter. The occurrence, however, of ore with the copper contents that parts of the lode-formation are already known to possess should suffice to induce the owners to take more active measures to open it up.

Half a mile north of this latter discovery copper ore of encouraging appearance has been located at several points along the course of a well-defined lode, which has the appearance of being the extension of the principal lode worked by the Mt. Lyell Company in the vicinity of Doherty's Pimple. At the time of my visit this ground was not held under mineral lease.

(6) A similar occurrence of ore has been located at a point $1\frac{1}{4}$ mile north of the Balfour South Mine, on a section held by Mr. F. Gaffney, and is equally deserving of further attention.

(iv) *Lodes which may possibly prove Copper-bearing, but upon which no Work has been done.*

The number of lodes on the field upon which no work has been done is very large. Many of these possess surface characteristics which serve to indicate that the outcrops are possibly the leached cappings of cupriferous lodes. As such, these lodes are worthy of trial.

Among the outcrops which should specially be regarded as those which, though untouched, offer the greatest inducement to lease-holders to proceed with the necessary work of prospecting are those which have a cellular structure or abundant limonite. As examples of such outcrops reference may be made to the following:—

(1) A gossanous outcrop on a section charted as number 4106-m, in the name of E. MacGregor, lying to the north-west of the North Balfour Mine.

(2) A number of cellular quartzose lodes on the western side of the head of the Nelson River, about 4 miles north-north-west of the Balfour township.

(3) A number of small lodes in the upper part of the Lagoon River valley in the Norfolk Range.

(b) TIN WORKINGS.

(i) *Alluvial Workings.*

The output of tin ore from Balfour in the past has been almost entirely maintained by the tin ore won from the alluvial deposits in the several branches of the Frankland River, which head from the north-eastern foothills of Mt. Balfour. The valley of Tin Creek has been the chief producing area, but at present little work is going on there.

An examination of the old workings shows that the alluvial ground is of very variable depth, and that most attention has been paid to the deeper pockets and gutters. No systematic attempt has been made to work deep and shallow ground together.

The workings in the vicinity of the Interview River are also shallow, being situated in small creeks which traverse the coastal granite. No one was working in this area at the time of my visit. There are doubtless future discoveries to be made here, since the district is not one which can be exhaustively prospected in a short time.

(ii) *Lode Workings.*

In the Balfour district the alluvial workings gradually merge into true lode workings. The alluvial ore has been traced up to the detrital ore (*i.e.*, the disintegrated lode-matter still *in situ*), and this in turn has been followed down to the solid lode-matter.

The greater part of the lode-matter which has been located lies within the leases of the Mt. Balfour Pioneers Company. No active steps are being made by the company to lay bare the whole of the area over which the reticulating veins are known to occur. The tributors on the leases are in some places working the flat veins which lie nearest to the surface.

No crushing-plant exists with the help of which the undisintegrated lode-stuff may be treated. Consequently, the output from the vein-matter represents only that portion which has been freed from its mineral associates by the processes of weathering, or which can readily be set free by the crude crushing of the vein-stone by hand.

An organised attempt should be made to expose at least a large portion of the stockwork (*i.e.*, the complex vein-

system in the slate), in order that the company may form an idea of the best place at which to prospect the deeper portions of the veins.

While mention is being made of this superficial lode-matter, it should be remarked that some portion of the tin ore won from the alluvial deposits in the valley of Tin Creek has probably been derived from immediately adjacent lode-matter. There are certainly a number of veins carrying cassiterite visible *in situ* on the stripped bedrock of the alluvial deposits. This being so, it is possible that some portions of the area which has been regarded as worked out may be worked over again for the tin content of the veins in the bedrock.

In the future working of this tin-bearing ground at Balfour it should be remembered that there is always the possibility of an impregnation of the slate between the several veins. In the tinfield of North Dundas much of the output has been maintained by the crushing of impregnated slate; and in many instances this stanniferous slate showed no visible tin ore, even when a fair percentage was present.

(c) WOLFRAMITE WORKINGS.

A small amount of wolframite was sent out from the workings near the Interview River many years ago. Since 1901, when the wolframite-bearing ground was examined by Mr. G. A. Waller, no work has been done.

Recently it has been found that wolframite is present in the cassiterite veins of Balfour. Some of the veins carry wolframite and no cassiterite, while in other cases the two metallic minerals are mingled in a single vein.

It has been the practice to remove the ore carrying wolframite from that carrying tin ore in order to prevent contamination. If this is done it should be borne in mind that the wolframite is itself a valuable ore; and the stone carrying it should be stacked apart, not mingled with tailings.

Search should be made for the alluvial and detrital deposits of wolframite, or mixed wolframite and cassiterite. Tin ore and wolframite are now being successfully separated in Tasmania from a much more complex mineral concentrate than that which would be derived from the working of these veins and the products of their disintegration.

The present market quotation for wolframite carrying 70 per cent. of tungstic acid is at the rate of £1 15s. per unit.

(d) IRON ORE.

The value of one ore-body on the field does not appear to have been properly appreciated. The lode is a large one, and is situated on the Nelson River, to the north-east of Whale's Head Boat Harbour, in leases held by R. Shaw. Hitherto it has been regarded as a copper lode, and prospecting has been carried on with a view to the discovery of that metal. As a source of iron, however, it is undoubtedly worthy of serious attention. The dimensions are large, and some considerable portion at least of the lode consists at the surface of very pure iron ore—a mixture of hematite and magnetite. No attempt having been made to exploit the lode as a source of iron, little more can be said. The full width should be exposed at a number of points. This can be done without difficulty. The topography is very favourable for the driving of a tunnel through the lode at a depth of 80 or 90 feet below the outcrop, since the gorge of the Nelson River runs parallel to the lode for some chains. The lode is not far distant from the seaport, and should be brought under the notice of consumers of iron ore.

Other less massive lodes, containing similar ore to this, occur at several points throughout the field. One is situated to the east of Whale's Head Boat Harbour, on a lease held by Messrs. W. R. Sale and K. Roberts. Many small ones are to be seen round Elliott's Reward Mine, in the Interview River district.

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Launceston, 11th October, 1910.