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THE TIN FIELD OF NORTH DUNDAS

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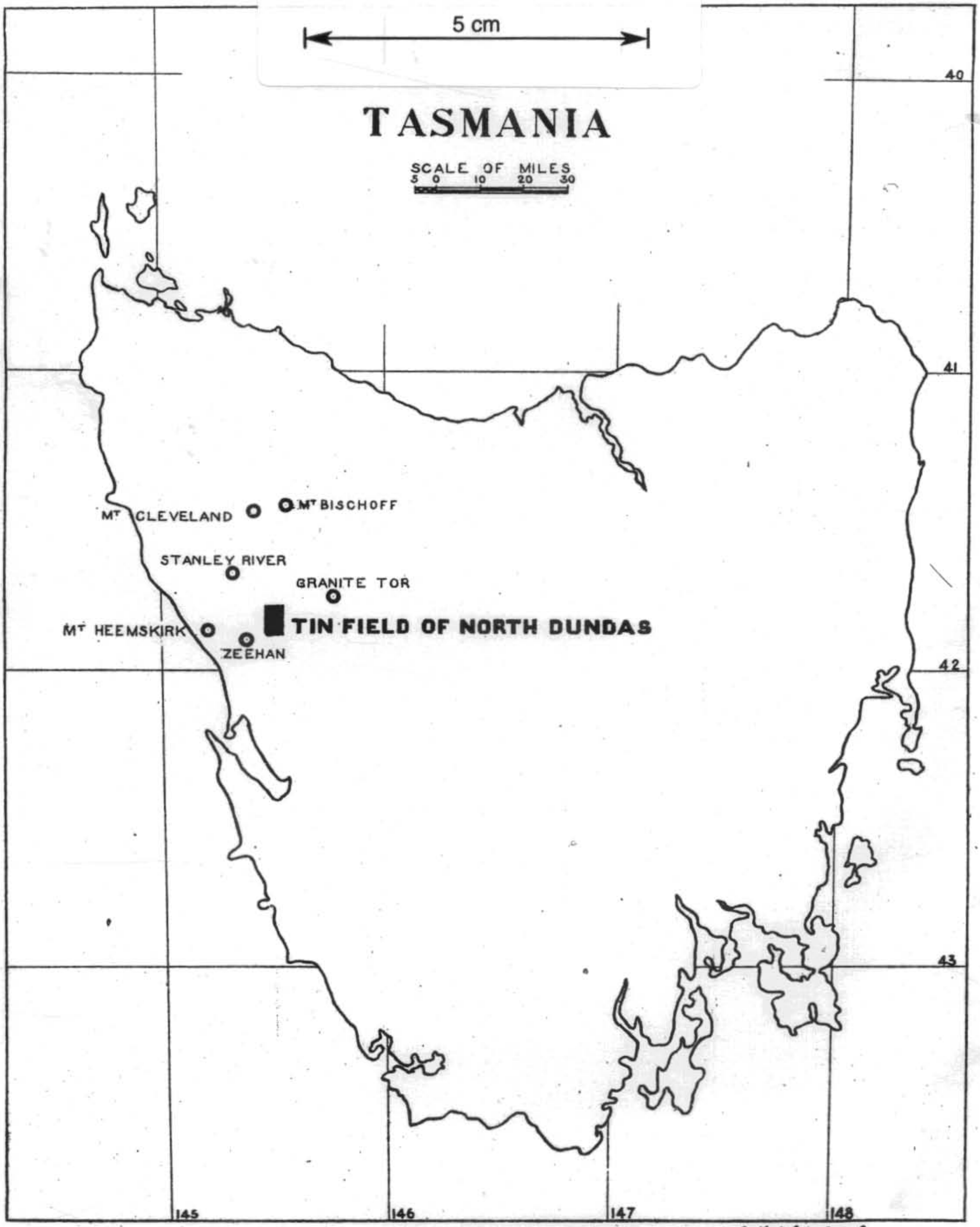

LOCALITY PLAN

L. Keith Ward
Assistant Government Geologist.
12. 2. 1909.

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THE TIN FIELD OF NORTH DUNDAS.

I.—INTRODUCTION.

(1)—General.

The tinfield of North Dundas possesses some features which are not quite normal, and much of the following report has been written with a view to the exposition of those geological features, which are in themselves not quite apparent when any single occurrence is considered apart from its neighbours.

The writer can conscientiously go no further, in many cases, than state what appears to be the probable structure of the ore-body under consideration and its probable relationship to other ore-bodies of the district. The reason of this is that so little systematic development work has been done on the lodes. The present condition of the district as regards development is undoubtedly backward. In some cases, in the centre of the field, the abnormal character of the lode-structure has contributed towards this condition, but in other cases no such excuse can be proffered.

Nevertheless, in spite of the meagre amount of the information to be obtained from many occurrences of ore there are certain generalizations which may be made provisionally. There are, at least, certain features which may be presented to the mining community for consideration in the planning of necessary development work.

It will be noticed, in the course of this report, that in several instances the management have formed an erroneous conception of the structure of the lodes, and that the work which has been done is apparently wasted. These failures to attain the immediate object in view are by no means without their use, and the negative results have a positive value; for the non-productive work has in several cases given definite facts concerning structural details which would otherwise have been unavailable.

The important thing to be kept in mind by the several mining companies called upon to deal with the more complex structural problems is this: every single detail of occurrence (including quantitative details regarding the distribution of ore) should be faithfully recorded and made available for reference on the mine. Unfortunately, this has not been the practice in all cases, and if the progress of the property has not been seriously impaired for want of such information, my examination has at least been to some degree hampered.

In the geological survey of a mining field of this character an officer of the survey must necessarily rely on the management of the companies for full and unreserved information concerning the properties entrusted to their charge. It is neither practicable nor expedient to systematically sample all ore-bodies examined; for the geological survey of a district is not intended to include such matters as the calculation of ore reserves. Yet, by unreservedly placing at the disposal of the geological survey all the information available, any single company may offer information of considerable value.

The immediate application may not be possible to the company affording the information, but assistance may be given in this way towards the solution of other questions in other neighbouring mines. Any benefit that may accrue to any one mine in the district is of indirect, but real, benefit to all the other mines.

The above remarks are not of general application, and I have pleasure in acknowledging the very ready assistance which has been afforded me in almost every instance.

In some cases it has been quite impossible to gain any information whatever concerning abandoned or disused workings. The leases have been held temporarily and abandoned by several different parties in succession. The records have in several such cases become little more than traditions, handed down from one lessee to another, or pieced together from the information afforded by those who were on the field in its earlier days.

Under such circumstances, it is necessary to insist that the views here put forward by the writer must not be considered to be in any way a final judgment. Still, I have had the opportunity of studying the field as a whole in far greater detail than has any member of the geological survey hitherto.

The reasons which have contributed to retard the due recognition of the field are set forth at some length in the following pages, and will be seen to be chiefly these:—

(1) The geographical position of the field.
(2) The unusual mineral composition of many of the lodes, and the consequently abnormal gossans which are the outward manifestations of the presence of many of the lodes.

(3) The complex character of the structure of many of the lodes on the field.

Though these several causes may have for so long a period kept mining development in a backward condition, in no way do they constitute any reasons for future inactivity. The field is now accessible; and it is hoped by the writer that this report may assist to explain some of the features which caused perplexity.

It appears that the interest of investors has now been duly aroused, and that the district will be a centre of progressive mining activity.

(2)—Geographical Position.

The area which may be considered to constitute the tinfield of North Dundas is of very irregular shape, and its boundaries are a little difficult to define. In a later portion of this report it will be seen that there is a considerable development of river-borne alluvial matter forming high-level terraces on either side of the Pieman River. These older river terraces carry a small proportion of tin ore, and it may therefore be expected that from time to time occurrences of tin ore will be reported from localities beyond the area mapped and treated of in this report. It is, however, believed that any such occurrences are not likely to prove of great importance.

The central area of this tinfield, and that from which the greater portion of the tin ore of the old river terraces has been derived, is located in the strip enclosed between the Ring and Argent Rivers. These are two of the main tributaries of the Pieman River.

The outskirts of the field stretch southwards as far as the township of Dundas, and eastwards to the deserted site of Ringville.

On the northern side of the Pieman River, and just below its junction with the Huskisson River, some alluvial tin ore has been found, but so far not in payable amounts.

The most important of the neighbouring mining centres is that of Zeehan, distant some 9 miles to the south-west.

Rosebery and Mt. Read are closer still, and are situated to the eastward.

The western coast-line is 18 miles away, and approaches most nearly to this area at Trial Harbour, near Mt. Heemskirk.

Geographically, the tinfield of North Dundas is seen, therefore, to be located in the centre of the mining fields of Zeehan, Dundas, and Mt. Read, which are areas in which deposits of silver-lead predominate.

On the locality-plan prepared for this report, the positions of the nearest tin-bearing districts are shown; and from the following report it will be seen that the tinfield of North Dundas is genetically related with the other occurrences of tin which are shown on this map. The nature of this genetic relationship is fully discussed below.

The Emu Bay Company's railway-line passes through the northern portion of the field, and forms the main line of communication and transport.

The principal track connecting with the railway-line follows the Renison Bell Creek, and crosses over the saddle between the Renison Bell and Dreadnought Hills. This saddle is a little over 400 feet above the rails, and a much better gradient might well have been secured by starting the track some little distance further to the eastward. At present all material for all the mines other than the Renison Bell has to be dragged on sledges over this steep track, and progress is consequently slow and transport costly. The tin ore is packed out on horses to the railway. Yet the construction of this track by the Government has been of immense service to the mining community, which had been hitherto dependent upon the rough pack-track to the south of the Renison Bell Hill.

The southern portion of the field is much nearer to the North-East Dundas Tramway, and there are two connecting tracks. Of these, that which leads to the Confidence Saddle will be much the more serviceable when the projected repairs have been effected. Deviations which will secure better grades can easily be effected, and facilities for transport will be very greatly improved when this has been done. The principal tracks are shown on the topographical map accompanying this report.

II.—PREVIOUS LITERATURE ON THE FIELD.

The first official report published which makes mention of this field* is that by Mr. A. Montgomery, and is dated from the Geological Surveyor's Office, Launceston, on April 11, 1893. This is an interim report dealing with the state of the mining industry on the West Coast at that period. It contains a mention of the tin-bearing river

* A very brief note concerning the gossan outcrop on the Renison Bell lease is included in Mr. Montgomery's "Report on the Progress of the Mount Zeehan and Mount Dundas Silver-lead Fields," November 25, 1890.

terrace above Star Creek, and of the occurrence of the tourmaline-bearing quartz porphyry.

The detailed report which followed this latter is dated May 20, 1893, and is entitled "Report on the Progress of the Mineral Fields of the County of Montagu." In it mention is made of the general geological features of the district, and a brief account of the workings on the Ring River and Dalcoath Creek.

Mr. Montgomery published a later and more detailed report on May 15, 1895, which deals at some length with the alluvial ground and lodes which were being worked at that time. The mining activity was restricted mainly to the area traversed by Gormanston Creek and the lower portion of Dalcoath Creek. A brief account is given of the Renison Bell Mine, but the country lying between this and the Dalcoath Creek was at this time unprospected.

The next official visit paid to the field was during the early portion of the year 1900, when Mr. Twelvetrees made a brief examination of the Renison Bell Mine. His report, entitled "Report on the Mineral Districts of Zeehan and Neighbourhood," was dated from the Government Geologist's Office on October 27, 1900. The portion of this report which deals with the district is not considerable, but affords an account of the state of development of the Renison Bell Mine at that time.

In the year 1902, Mr. G. A. Waller issued a "Report on the Tin-ore Deposits of North Dundas," which is dated from Zeehan on March 8. This report gives a brief account of the geology of the district, but is concerned mainly with an account of the several mining properties of the field. In the discussion of the features presented by the lodes, Mr. Waller gives a short account of the geology of the areas being worked.

More recently Mr. Twelvetrees paid a short visit to the northern end of the field, and his observations are embodied in the "Report on the Renison Bell Tinfield," which was issued from the Government Geologist's Office on December 18, 1906. Since this visit very little alteration in the state of the Renison Bell Mine has taken place, but other discoveries have been made in the immediate neighbourhood.

The abovementioned reports constitute the officially-published literature on the field.

Besides these, Mr. Waller, in a paper, entitled "Some Modern Theories Concerning Ore-deposits," read before the Australian Association for the Advancement of Science in

1902, makes reference to the pyritic tin-lodes of North Dundas, and discusses their bearing on the general aspects of ore-deposition.

The only other publication which makes mention of these tin deposits is Mr. Donald Clark's "Australian Mining and Metallurgy," 1904.*

III.—PHYSIOGRAPHY.

(1)—Topography.

The topography of the northern portion of the area mapped shows a marked contrast to that of the central and southern portions.

In the north there still remain very well-marked remnants of a broad plain of erosion. On the borders of this plain, now deeply dissected by the rivers of to-day, lie several notable prominences.

Mt. Black, the Colebrook Hill, and the hills indicated on the topographical map published herewith form the principal heights on the southern limit of the plain.

To the north and north-west the dissected plain extends to the base of Mt. Ramsay and the Parson's Hood.

The width of this flat belt is clear proof that the whole region has remained at a constant level for a period sufficiently great for the erosion to have attained a mature stage. The old Pieman River has gradually, by lateral planation, established a broad valley, and as the gradient has diminished it has been unable to remove the detrital material. Thus, a broad plain has become filled with alluvial material, the composition of which shows that the principal tributaries flowed into the old valley from the east and south-east. This latter statement holds true for at least the eastern portion of the old Pieman Valley.

This stage in the physiographical development of the region seems to have been attained at a period during which the action of water has been assisted by that of ice. Few traces now remain, but the occurrence of huge erratics in the alluvial material indicated at the extreme north of the area mapped must be regarded as sure signs of the contribution of glaciation to this stage of erosion.

From the fact that the materials of this period of deposition cover the diabase dyke found in the tinfield, the period of the development of the alluvial deposit on the old valley floor would seem to have been later than Mesozoic.

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* Page 221 *et seq.*

View from Messrs. Duncombe & Maddox's Workings, looking East,
Boulder Co.'s Battery in foreground. [*Ward.*

At a still later period, the whole district has suffered an uplift, and the rejuvenated rivers have cut down their channels deeply into the former alluvial plain.

The latter, therefore, is marked at the present time by disconnected areas, of which the general level is noticeably constant.

The present-day rivers and their tributaries have not yet attained a stage of maturity, and their beds are marked by falls and rapids.

The higher country of the tinfield proper is deeply dissected by the processes which have been continuous in their action from the beginning of the cycle of erosion which culminated in the formation of the older alluvial terraces right up to the present time.

The steep slopes of the present hills and ridges, and the ungraded streams and rivers, have prevented the accumulation of any considerable alluvial deposits of recent date. Those which do occur are shallow and local.

The nature of the warping of the crust which has given rise to the rejuvenated river system of the Pieman cannot be decided by the study of one portion of the basin apart from the others. To determine exactly the sense of the warping the heights of a large number of points on the basin must be accurately obtained. These facts are not yet available.

However, according to the aneroid measurements made during the geological survey of the tinfield, it was found that—

(1) The former elevation of the southern border of the valley of erosion of the Pieman River was about 700 feet above sea-level.

(2) The present level of the river is about 240 feet above sea-level.

We may conclude, therefore, that the warping has caused an uplift of this southern portion of the old flood-plain which amounts to more than 460 feet. (It cannot be the exact 460 feet which make the difference between the present river level and the higher terraces now visible; for the deposition of the terrace gravel took place at a period when the older river system had been duly graded, whereas the present rivers have not yet attained their base level of corrosion. The uplift must, then, be the difference of level now measurable, *plus* the depth to which the Pieman must yet corrode its present bed before reaching the base level.) These figures are based on the assumption that there has been a movement in one direction. No evidence of any other movement than that of an uplift was detected in the area examined. Yet there are clear signs to show that the River Pieman has temporarily attained its base level, only for a further movement to entrench it once more in its levelled floor.

Remnants of the lastformed terrace are to be seen near the junction of the Argent River with the Pieman. The railway-line to the east of the area shown on the map follows the River Pieman on the level of this terrace. With this evidence may be compared that of the terraces observed by the writer in the valley of the Mackintosh River, at Mt. Farrell.*

Mr. Montgomery, in his report on the Corinna Goldfield, published in 1894, makes mention of the gravels of the West Coast, and their bearing upon the evolution of the physiography of that region. His conclusion that they are of marine origin cannot, in my opinion, be supported by any of the facts yet known. It is by no means necessary to postulate a submergence of the area with which this report deals below sea-level in order to account for the deposition of gravels such as those met with. They would be deposited on the valley bottom of the former river when the gradient of the valley had been so reduced that the diminished velocity was insufficient to maintain the transportation of material to the sea.

A comparison of the topographical with the geological map of the North Dundas tinfield will show how small has been the influence of geological structure in the modification of the physical features by the processes of weathering and degradation. For when we turn from the dissected alluvial plain of the old Pieman River, we find no separate physiographical units coinciding in distribution with particular rock types. The hills and valleys each present a marked variety of geological structure, and the same rock types stretch from hill to hill across the gorges.

The contribution of ice action towards the moulding of the topography of this district has not been great. Formerly there may have been signs of ice action visible in the more elevated portions of the region; but the long continuation of the general processes of weathering has produced surface features which retain no trace of ice action.

Embedded in the gravels of the old Pieman Valley, on the northern side of the present Pieman River, and close

* Geological Survey Bulletin No. 3, "The Mount Farrell Mining Field, 1908," p. 4.

to its junction with the Huskisson River, there are to be seen huge masses composed of blocks of the West Coast conglomerate and the porphyroid so characteristic of the Mt. Read and Mt. Black districts. These cannot, in my opinion, be regarded as of any but glacial origin; and they must be considered in connection with the similar erratics of the Farrell siding, and other points in the Mt. Farrell district.*

The streams which flow northwards into the Argent or Ring Rivers belong to the drainage system of the Pieman River. Those which flow southward join and find their way to the sea by the valley of the Little Henty River. The divide between these two drainage systems passes above the Argent Tunnel along Serpentine Hill to the high ridge which lies to the south-east of the area shown on the map.

In conclusion, the physiography of the region considered is that of one which has passed through a mature cycle of erosion. The nature of the surface before this cycle attained its maturity is not discernible, for there remain no traces of sediments which may have existed in the region in the long period between Early Palæozoic and Late Cainozoic time. The Late Tertiary alluvial terraces rest directly upon Cambro-Ordovician slates.†

The physiography resulting from this erosion cycle has been seriously modified by an uplift of at least 460 feet. The streams, rejuvenated by the latter movement, have cut down deep gorges into the hills and valleys of the older surface, and this cycle still continues in active operation.

(2)—Meteorology.

The rainfall in this district may very reasonably be considered to appproximate closely to that of Zeehan. Mt. Read is not so far distant, but its elevation is greater.

The total rainfall and the distribution of the rainfall for a number of years are shown in the following tables:—

The Rainfall, 1st October to 30th September (in inches).

	1899–1900.	1900-1.	1901-2.	1902-3.	1906-7.	1907-8.
Mt. Read	..	..	77·91	83·61	126·95	122·28
Zeehan	101·33	106·00	94·50	105·31	100·33	100·33

* Geol. Surv. Bulletin No. 3, "The Mount Farrell Mining Field, 1908," pp. 5 and 26.

† *Vide infra*, p. 32.

Distribution of Annual Rainfall at Zeehan.

Year.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April.	May.	June.	July	Aug.	Sept.
1899–1900..	8·66	15·84	7·27	6·19	5·61	6·96	8·91	7·54	10·95	9·62	9·56	4·22
1900-1901..	13·61	4·29	10·41	8·28	2·35	7·78	9·91	7·80	13·96	7·77	7·02	12·82
1901–1902..	12·48	4·58	4·43	8·92	10·65	3·08	5·86	8·94	7·19	9·23	8·07	11·07
1902–1903..	5·71	6·07	5·28	8·04	7·30	8·79	12·49	10·68	10·78	11·79	13·04	5·34
1906-1907..	10·90	8·36	3·49	3·04	2·71	6·18	11·14	5·87	5·30	13·72	12·89	16·73
1907–1908..	10·02	2 63	11·17	3·74	5·11	11·15	5·74	14·74	9·96	8·99	9·53	7·55

Assuming that these figures may be applied to the neighbouring area of North Dundas it will be apparent that the rainfall is heavy, and that it is not negligible in any single month of the year. The greatest precipitation takes place between June and October, while December, January, and February are comparatively dry months.

This question of the distribution of the rainfall is one which should attract the careful attention of the several mining companies on the tinfield. The slopes of the high ground are very steep, and the rain will rapidly leave the hill sides. Yet an appreciable quantity can always be relied upon throughout the year.

Snow falls occasionally, but only the higher part of the region is seriously affected by a fall. The slow melting of the snow gives a more steady supply of water to the streams than is obtained from a mere fall of rain, and on that account is, on the whole, of benefit to the mining community.

The degradation of the higher country by the operation of the surface water is materially hampered by the very dense vegetation with which almost the whole region is clothed.

Only in a few small areas, on the old alluvial plain of the Pieman River, is the denser vegetation replaced by button-grass.

The timber obtainable in the district includes many useful varieties. This is being ruthlessly destroyed in the endeavour to open up the mineral-bearing country. There is some splendid pine on Pine Hill and its vicinity, and on both the banks of the Ring River, near Star Creek, there is a notable growth of blackwood. The destruction of these is certain and unavoidable with the expansion of the mining industry. It seems a pity that the timber should be wasted for lack of enterprise, for it is at present being burnt by the fires necessary for clearing off the scrub round the centres of mining operations.

(3)—The Effect of the Topographical Features on Mining.

Prospecting and Exploitation.—The Ring River and its tributaries have played a most important part in the discovery and development of the mining field. It was in the Ring River in 1890 that tin ore was first discovered, and in the prospecting of the contributing streams the alluvial deposits of the eastern portion of the field were first found. Of these tributaries, the Dalcoath and Gormanston Creeks have been the most continuously and systematically worked. The Ring River itself has one lode exposed upon its banks,* but otherwise has not yet proved to be of any material assistance to mining.

A considerable portion of the Great Northern Creek has been worked for alluvial tin. This fact has led to the location of the parent lode, just as the discovery of tin in the Dalcoath Creek has led prospectors southward, until the lode-bearing zone round Pine Hill has been found.

The other tributaries of the Ring River which have been worked for tin ore, viz., Star Creek and Isaacson's Creek, have not indicated the position of any lode-matter, since they have derived their tin ore from formations which were already of a secondary nature.

The Argent River cannot be said to have materially assisted prospectors. It cuts through one large lode-system, which is more noticeable for its gossan than for the river-bed exposures.

A small tributary of the Argent which flows into the river from the west at a point distant some 25 chains north-west of the Renison Bell Siding contains tin ore, and the lode-formation which has shed the tin ore has undoubtedly been located, but no further prospecting has been done.

The same remarks may apply to the lode running southwards over the high ground which forms the southern limit of the Melba Flat. This was discovered as a result of prospecting for the source of the alluvial tin recovered from the vicinity of the sawmill on the Melba Flat.

In Dundas the tin ore was first found in the shallow alluvial ground forming the banks of the Dundas Rivulet.

The creeks have therefore played an important part in prospecting operations.

In actual exploitation the gorges carved out by various members of the river systems have served to afford convenient low-level sites for the mouths of tunnels. Thus, the Argent River bed has been of great assistance to the Renison Bell Company in the work of attacking their main lode-system in depth.

In the case of Dalcoath Creek, also, the depth of the gorge has been a very great incentive towards the exploration of the lodes by low-level tunnels. Unfortunately these latter commendable efforts have not yet been

* *Vide infra*, p. 150.

attended by successful discoveries of lodes which are likely to give adequate returns for the expenditure incurred.

The discussion of the structure of a large number of the occurrences of ore in this district will show how the mere driving of tunnels is quite insufficient to give any idea of the amount of ore available.* In fact, in some cases the tunnel exposures of ore are extremely meagre. Yet, in other cases it has been possible to make great use of tunnels, where the slopes are steep and the lode-structure is more normal, or at least more adapted towards development by adit levels. In some cases the amount of possible backs available from adit drives of reasonable length is remarkable.

So little actual work has yet been achieved in the mining area that it can hardly be granted that the irregularities of the surface offer facilities for mining which may outweigh the difficulties placed in the way of transport. More feasible routes from the central mineral sections to the railway-line can be marked out, and the transport difficulties thus minimised.

The dissection of the old Pieman Plain has placed serious obstacles across an area which is nevertheless, on the whole, markedly level.

Yet in the creeks which traverse the dissected plain occur the secondary concentrations of ore which have been worked.† The greater portion of the alluvial deposit, though carrying a certain amount of ore, has hitherto proved unworkable.

Water-supply.—The stage attained by the cycle of erosion in the mining field has resulted in a fairly uniform distribution of the rainfall among the several streams.

The fact that the principal occurrences of ore have been found on the higher ground has in some measure lessened the possible uses to be made of the water.

In the earlier days of the field the stream-beds only were worked, and the water question was not vital. At the present stage of development of the field the different mines are very differently situated as regards their requirements.

On the Pine Hill the necessity for the removal of the widespread overburden of quartz porphyry talus makes the question of water-supply most important.

As regards the central block of sections, where the surface detrital deposits of tin ore are being worked by

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* *Vide infra*, p. 66., and Plate V., Fig. V. † *Vide infra*, p. 75.

sluicing methods,* the question of water-supply for sluicing is more important to-day than it will be after a few months; for the amount of ore which can be treated in this way cannot be expected to be large.

The mines which are carrying on sluicing operations cannot obtain large supplies, although, as shown on the topographical map, the races are of considerable length. The hills and ridges have no large areas at high levels available for the catchment of rainwater, with the one exception of the Commonwealth Hill. Part of the catchment on this latter hill is being utilized by the Montana Company.

From the statistics given above with regard to the amount and distribution of the rainfall it will be seen that a race round the upper portion of this hill would supply a large amount of water to the mining companies. It is the only readily available source of water to the high country around Pine Hill. In connection with a reservoir excavated at the saddle between Pine Hill and the Commonwealth Hill, such a race would be of great value.

The ore-bodies on the eastern fall of the Dreadnought and Stebbins' Hills are not adapted to sluicing methods. Nor can water be conveniently introduced in quantity by way of the high saddle connecting these hills with the Renison Bell Hill.

Any scheme for introducing water from the south over this saddle must involve very long race-cutting to avoid interference with present water-rights, and a high-level intake. The ore can be more advantageously carried to the Ring River and concentrated there.

The new discoveries of tin ore near the town site of Dundas are partly at a low level—on the banks of the Dundas rivulet, partly at a considerable elevation above this stream. The working of the higher ground has been seriously hampered by lack of water, which has been obtained from the slopes of the Razorback ridge. Here a very considerable length of race will be necessary to obtain a larger supply, and the work will not be of much use unless there is a larger excavation made for a reservoir.

Power.—Up to the present practically no advantage has been taken of the configuration of the district in order to obtain a supply of water at a high pressure for the purposes of either sluicing or motive-power.

The Argent River possesses a bed which is far from graded, and offers special facilities for the development of a power

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* *Vide infra*, p. 93.

scheme. From the topographical map it may be seen that the river-bed rises very rapidly between the Argent Tunnel and the eastern extremity of Serpentine Hill. Moreover, at the latter spot the gorge narrows remarkably between two spurs, and above this dam-site there is flat country on both sides of the river. A capacious reservoir may be erected here, and the upper waters of the Argent River temporarily stored.

Lower down the Argent River a considerable fall is obtainable, but it cannot be turned to account with such advantage. Moreover, there seems to be no satisfactory reservoir sites available.

The Ring River, also, has a steep gradient in that portion which came under my examination. Between Star Creek and a point about a mile further up stream there is a difference of level of 200 feet. Thence the grade is gradual to Ringville. This section of the river will be of great service to those companies which decide to treat their ore at the low level.

The only other water-channel which may be considered as a source of power is the Dalcoath Creek. Many portions of its bed are very steep, and at two points there are notable falls.

The upper of these is situated just above the junction of the Gormanston and Penzance Creeks with the main stream. Some short distance above this place a dam could be built, by which a fair quantity of water might be impounded.

The other falls are situated immediately above the workings in Section 496-M. The amount of the drop is about 90 feet, and at this point some use has been made of a portion of the power available. Mr. A. Kemp has a pipe-line carrying the water to the bed of the creek in which his workings are situated.

IV.—GENERAL GEOLOGY.

(1)—The Rock Types Represented in the North Dundas Field.

A.—THE IGNEOUS ROCKS.

The igneous rocks which are represented in the field fall naturally into four separate groups, which are here considered apart.

(1)—*The Porphyroid Group.*

This large group of massive and schistose porphyries is much more abundantly represented in the area which lies a few miles to the east and north-east of the area mapped. A few outlying isolated occurrences were met with at North Dundas.

The areas covered are small, and the importance of the series, from the economic standpoint, is small also.

These occurrences, however, serve to confirm the observations of the writer in the Mt. Farrell field with regard to the conditions under which solidification has taken place.* Moreover, it is important to distinguish clearly between these older porphyroids and the latter intrusions of a more acidic type—the quartz porphyry dykes which are genetically connected with the occurrences of tin ore on the field.

There are both intrusive and effusive types present at North Dundas, as at Mt. Farrell, but no plutonic representatives were met with.

In the north-western corner of Section 1273-M there is a very small outcrop. The rock is of a dark greenish-grey tint, and when weathered has a brown crust. Abundant quartz phenocrysts are distinguishable to the unassisted eye. The rock is obviously much more decomposed than any of the masses of quartz-porphyry described below. Its colour is darker than the average porphyroid, and the constituent minerals less easily distinguishable.

Microscopically it is seen to consist of a thoroughly chloritized ground-mass, in which are set altered phenocrysts of quartz and felspar. The quartz is without crystal outlines, and is deeply embayed by the corrosive action of the magma. The felspars are idiomorphic, and are surrounded in some cases by aureoles of micropegmatite. All the felspathic material is completely replaced by kaolin and chlorite, and no extinction angles could possibly be measured. Ilmenite, now converted into leucoxene, is abundant. Some veins, filled by silica and of secondary origin, penetrate the rock.

A very similar type is present in the larger mass which lies mostly within the boundaries of Section 2212-M. The chief difference noticeable between this rock and that described above is the lack of quartz. The felspars and leucoxene are in this rock the notable minerals. Quartz is sporadic and poorly developed. Nevertheless, the general

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* Geol. Surv. Bulletin No. 3. "The Mount Farrell Mining Field," 1908, pp. 11-17.

character is identical, and decomposition has produced the same kind of alteration.

The two rocks are closely related in origin, and the mere difference between the quartz contents is of no great moment. In other places* the gradual passage from quartz porphyry to quartz-free felspar porphyry has been noticed.

Both the masses which have been mentioned belong to that portion of the igneous magma which has forced its way through the slates, *i.e.*, they are intrusive rocks. Whether any contact metamorphic effects were developed at their borders is not now discernible, since the exposures are so greatly weathered.

The other rock-mass included in this group is entirely different in appearance and structure. It crosses the Penzance track from Section 1178-M to Section 774-M. To the unassisted eye it is a dark compact rock, which is noticeably different from the slate in which it occurs. The weathered surface is clean and hard, while the surrounding slate is converted to kaolin. The only mineral which can be distinguished in it is quartz, in the form of irregular glassy blebs. In thin section the true character is apparent. The rock is at first sight a porphyry, since there appears to be a ground-mass studded with phenocrysts. But the larger crystals have not crystallized in their present positions, nor are they idiomorphic. The most notable feature revealed by the microscope is the presence of numerous rounded fragments of an igneous rock constituted of glass, in which are set numerous microlites possessing a straight extinction.

These rock fragments, together with the fragments of quartz and oligoclase felspar, are set in a sericite-chlorite aggregate.

The whole mass constitutes a consolidated tuff, to which the term 'clastoporphyroid' may be given.† There is no doubt whatever but that this particular rock must have been formed during the period of sedimentation of the the Dundas slate series.

That is to say, the porphyroid intrusion was contemporaneous with portion of the period of sedimentation, and later than another portion of that period, inasmuch as both *intrusive* and *effusive* types are represented.

This evidence is of value in establishing firmly the age of the porphyroid group, and in confirming the observa-

* *Ibidem*, p. 11. † *Ibidem*, p. 17.

tions recently made by Mr. Twelvetrees in the Leven Gorge,* and by the writer at Mt. Farrell.

The period of this intrusion is to be referred to that which preceded the deposition of the Gordon River limestone, and until further evidence is available should be termed Cambro-Ordovician.

(2)—*The Basic Group.*

The most important, in the matter of bulk, of the igneous rock groups present in the North Dundas tinfield is also the most variable. The one constant character is that of the uniformly low percentage of silica and the predominance of the ferro-magnesian constituents.

Although isolated masses, which are to be referred to this group, may consist of only one rock-type, in other cases (especially in the larger outcrops) there are a number of different rock-types represented in the one geological unit.

The variability of type is due either to the relative increase or decrease of felspar, olivine, orthorhombic, or monoclinic pyroxenes, or to the effect of secondary processes by which the original types have become considerably modified. No hard and fast lines can be drawn between the types, yet it is convenient to look upon them here as—

(*a*) Gabbros and norites, the modifications of which are gabbro-amphibolite and saussurite norite.

(*b*) Pyroxenites and peridotites from which the serpentines have been derived.

(*a*) *The Gabbro Group.*—The gabbro proper is seen in its freshest form at the south-eastern corner of Section 3370-M, near the junction of Dalcoath Creek with the Ring River. The rock is coarse in grain and remarkable, even to the unaided eye, for the development of large areas (up to three-quarters of an inch in diameter) of the ferro-magnesian constituent as a continuous crystalline growth about the other minerals.

From the mode of occurrence the exposures here seem to be the upper limits of a deep-seated mass, the exact shape of which is not discernible. The work of the denudation of the overlying slate has not reached a further stage than that necessary to barely uncover the uppermost portions of the intrusion.†

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* Geol. Surv. Bulletin No. 5, "Gunn's Plains, Alma, and Other Mining Fields, North-West Coast," 1909.

† See Plate III.

Microscopically, the rock does not prove as fresh as it appears. The texture is holocrystalline and coarse, and there is a marked poikilitic growth of diallage about the felspars. The latter are all clouded by kaolin, and the extinction angles are not recognizable. There are both orthorhombic and monoclinic pyroxenes present. Of these, the earlier crystals are orthorhombic, and are either partially or wholly surrounded by the larger areas of diallage.

The orthorhombic forms are much altered, and for the most part are represented by areas of serpentine and uralitic hornblende. This is the case even when there is a complete envelope of unaltered diallage surrounding the crystals. The serpentine is faintly tinted green, and the secondary amphibole pale yellow to light bluish green. Brown biotite is also present.

Of the iron ores, ilmenite in patches, which show the characteristic partial decomposition into leucoxene, is abundant.

This same type of rock is found in the area which occupies the western portion of the crown of Commonwealth Hill. It also constitutes the southern portion of the dyke which crosses the Argent River, and is cut several times by the Montana Company's water-race. The northern extremity of the dyke is constituted of a finely-grained rock which is, in all but texture, similar to that described.

Other portions of the basic masses are very similar to the gabbro described above, notably the area lying to the west of the Emu Bay Railway-line, near the Melba Flat, the area lying to the north-west of Section 453-M, and the area between Pine Hill and the Confidence Saddle.

The monoclinic pyroxene is not so well developed as in the exposure near the Ring River and Dalcoath Creek, and the rocks are strictly norites, rather than gabbros. Yet they are to be regarded as part of the gabbro family.

Modifications of these rocks are formed by the further progress of the alteration of the pyroxenes into amphibole. In the rock described above, this process was in its incipient stages. In other cases the alteration has been so complete as to produce a rock which may best be termed a "gabbro-amphibolite."

An excellent example of this rock is the mass which constitutes a broad dyke-like intrusion along the course of Dead Man's Creek. The alteration from a gabbro is best marked at the point where the Government track crosses the intrusion. The character is not outwardly altered in the least degree, and the paramorphic change from pyroxene into amphibole is only to be determined with the assistance of the microscope.

The hornblende occurs in two forms. The massive crystal plates are coloured green to greenish yellow. The smaller scales and tufts appear bluish green, green, or greenish yellow, according to the direction in which the light traverses the crystals.

In several cases it is possible to find the centres of large plates unaltered diallage, while the outer portions are completely converted into massive hornblende. When the orthorhombic pyroxene has been replaced by hornblende the character of the unaltered mineral is indicated by the existence of the numerous inclusions which are so characteristic of bronzite. The diallage of these rocks appears to be free from such inclusions.

The more fibrous forms of amphibole are associated with almost colourless chlorite and epidote.

The felspars are almost completely replaced by the mineral aggregate termed saussurite. Ilmenite, with its usual decomposition product, leucoxene, is abundant.

Near the Emu Bay Railway line, and about a quarter of a mile south of the Argent Tunnel, there is a type which appears different from any of those described, as it possesses a high proportion of a pale-coloured constituent, which is the more noticeable on account of the coarseness of grain.

Microscopically, the rock proves to be a saussurite-norite rather than a saussurite-gabbro, since the orthorhombic pyroxenes are largely in excess over the monoclinic.

The distribution of the ferro-magnesian constituents and the saussurite aggregate indicates that the former were later in the order of crystallization. The pyroxenes are very fresh in this rock.

There is yet another rock type which seems to belong to this group. The area covered by it is large, for it extends from the Gormanston Creek right over the high spur lying to the eastward and across the Ring River.

Macroscopically the rock has the appearance of a diabase, on which a limonite-stained crust is produced by weathering. Its mode of occurrence is not readily determined on account of the vegetable cover and the poverty of outcrops.

As far as could be ascertained it forms the outer fringe and most easterly extremity of the gabbro proper.

In thin section the rock is seen to differ considerably from the gabbro, both in mineral constitution and structure.

The structure resembles that of some of the finer-grained diabases of Tasmania, but the constituent minerals are amphibole, plagioclase (with high extinction angles), and abundant interstitial quartz.

The felspars are partly enclosed in the hornblende. The latter is markedly devoid of crystal boundaries, and has every appearance of being secondary. It is strongly pleochroic, the tints assumed being green, bluish-green, and greenish-yellow. The quartz contains numerous acicular inclusions, which have an oblique extinction, but the exact character of which could not be ascertained.

Epidote is present in scattered grains, and as the filling of cracks. Magnetite is abundant in the form of equidimensional grains.

The reasons for classifying this apparently more acidic type with the gabbros are based on the signs of secondary processes (notably that of the paramorphism of some pyroxene into hornblende) and the close association in the field with the normal members of the gabbro group.

The rock closely resembles that obtained from the Whyte River Mine, where, too, it is associated with a member of the basic series—serpentine.

The relation of this rock to the other members of the group is discussed below.

(*b*) *The Pyroxenites and Peridotites.*—With the progressive decrease of the felspathic constituent the gabbros become rocks consisting only of ferro-magnesian minerals. Those in which only pyroxenes are present are termed pyroxenites, and where olivine occurs they are called peridotites.

A notable development of the pyroxenite facies is present near the south end of the Argent Tunnel, on Serpentine Hill.

In some specimens a few sporadic patches of an opaque mineral, resulting from the alteration of the felspathic constituent, remain, and mark the passage between these rocks and the norites. The rocks possess the characteristic bronze-like lustre which results from the high proportion of the orthorhombic pyroxene present.

Microscopically the types represented are seen to be either websterites or bronzitites, according as they consist of both bronzite and diallage or bronzite alone.

The websterite varieties show the usual phenomena regarding the relative rate of weathering of the two pyroxenes; the diallage remaining almost entirely fresh, while the bronzite is converted into bastite and serpentine. This latter change may have been the cause which led to the distortion of some of the crystals of diallage, and the fracture and dislocation of the crystals of chromite; for the passage into the hydrous condition would be accompanied by an increase of bulk. Numerous cracks filled with serpentine occur, and there is often relative displacement of the walls of the cracks.

The pyroxenes are often intergrown with one another, but diallage is frequently wholly enclosed in the bronzite. This order of crystallization, therefore, differs from that observed in the gabbros described above.

There are numerous granules of chromite scattered through these pyroxenites. Most of them are wholly enclosed in the bronzite, but a few crystals of chromite have a serpentinous core. This would appear to be due to the alteration of enclosed crystals of olivine or pyroxenes within the chromite.

Intermediate between these pyroxenite rocks and the serpentines, which show no trace of the original constituent minerals, there are varieties which exhibit a markedly banded structure.

There are few signs of the banding on freshly broken surfaces, but the weathered faces of the rock show bands in which large crystals of altered pyroxene (from one quarter up to three-quarters of an inch in diameter) are studded in a homogenous mass of serpentine, alternating with bands quite devoid of these larger crystals. In other varieties the banding is shown by differences in the number and size of the pyroxene crystals or the proportion of these crystals present in the successive zones.

These phenomena are exhibited by a portion of the basic mass outcropping at the southern end of the Argent Tunnel. The best development of the banding, however, occurs at the northern extremity of the mass extending from Dundas towards the Melba Flat.

With microscopic assistance little more information can be gathered. The nature of the serpentine, which forms, as it were, a groundmass with respect to the defined crystals of pyroxene, is not to be definitely determined.

The original mineral, which is now converted to serpentine, may have been olivine, in which case the rock would be a serpentinized hartzburgite; or it may have been pyroxene. The bastite-serpentine which replaces the large crystals of orthorhombic pyroxenes has retained its characteristic structure, and the crystal outlines are fairly well defined. Hence it would appear that the other serpentine results from the hydration of some different mineral. Chromite crystals are abundant, and much fine-grained magnetite of secondary origin is present in the serpentine.

The banding of these rocks seems to the writer to be due, in all probability, to fractional crystallization. It was not possible to gather any data which might serve to support this hypothesis. Yet the variations appear to be due, not so much to variations in the composition of the magma, as to variations in the physical conditions under which solidification has proceeded.

The rocks, which certainly appear to have been peridotites before their conversion into serpentine, are closely associated in the field with those just described. In colour they are usually dark green on freshly broken surfaces, like the varieties carrying the bastite crystals. They differ in being homogenous and massive, or in appearing schistose. This latter phenomenon is due apparently to the expansion of the rock as hydration has proceeded. Wavy parting planes with smoothly polished surfaces of serpentine are frequent. The only mineral other than serpentine to be detected with the unaided eye is chromite.

This type is visible in the railway-cutting at the south end of the Argent Tunnel, on the Confidence Track, to the south-east of Pine Hill, and at Dundas.

Microscopically the rock is seen to be constituted of serpentine for the most part. A little pale chlorite is present in tufted aggregates. Crystals of chromite are prominent, and much magnetite dust, resulting from the process of serpentinization, is present.

In many cases there are a number of small grey specks in the serpentine, which are seen in thin section to be small aggregates of calcite and dolomite.

The serpentine is usually dark in colour, but at one point on the North Dundas-road, close to the Melba Flat, the yellow translucent variety occurs.

It is reported that the peach-blossom-coloured chlorite mineral kämmererite is present in the serpentine near the Argent Tunnel. I did not observe any at this place, but found it abundant near the Adelaide Mine in Dundas, a little to the southward of the area mapped, but within the boundaries of the same mass of serpentine as that shown on the geological map.

The kämmererite occurs irregularly distributed through the serpentine, and is built up of a number of scales with a pearly lustre.

In thin section it is seen to form tufted aggregates, and in many cases the tufts are disposed radially about nuclei of chromite.

Reviewing the basic group as a whole the characteristic features are the variability of the different types and the close interassociation of different types in the field. Variations are most commonly caused by differences in mineral composition, but are also marked by changes of texture, while the mineral components remain the same.

The intrusion was in almost all instances unaccompanied by any great shattering of the surrounding rock. Only one well-marked dyke was detected.

The contact metamorphic effects produced were very slight, being restricted to a slight silicification of the slate. This can be seen at the southern entrance of the Argent Tunnel.

One noticeable point about the intrusion is the variable height above present sea-level at which the exposures of portions of the basic mass are to be found. For instance, there is gabbro at the top of the Commonwealth Hill, and a similar type exists near the junction of the Ring River and Dalcoath Creek. In the latter case the surface of the igneous rock is barely exposed. In the former case there has already been some loss of material through denudation, so that the present height may be considerably lower than at an earlier stage in the erosion cycle.

Between the two outcrops there is a difference in altitude of 1300 feet. The difference may be due in part to subsequent warping of the crust, but when other outcrops are taken into account beside the two cited, it becomes apparent that the upper surface of the original intrusion must have been an extremely irregular one; and the irregularities have been reduced rather than accentuated by the progress of denudation. The several exposures of the basic rocks must necessarily be regarded as possessing continuity in depth; and the slate of the greater portion of the field is therefore resting upon an igneous foundation, the upper portions of which are exposed at the surface here and there.

There are considerable developments here and there of iron ores in connection with the serpentines. These are due to the progress of weathering, and are mentioned again below.*

* *Vide infra*, p. 78.

(3)—*The Acidic Group.*

The acidic igneous rocks which are represented at North Dundas are hardly so varied as the basic; yet if a wide view be taken of the limits which may be allowed for the definition of an "igneous rock" there is a considerable variety of types represented. It would thus be found that, not only are there the types of rocks which are usually found as dykes, but there are, in addition, mineral aggregates which are usually regarded as vein-stuff rather than as the typical products of consolidation of an igneous magma. The difficulty arises from the absolute impossibility of distinguishing between a *vein* and a *dyke* in such cases as those under discussion.

Here, however, only the types which are more usually regarded as dyke-rocks are considered, and the varieties which have not hitherto become quite familiar as dyke-rocks are left over for discussion in the chapter on the economic geology of the district.

The typical dyke-rock, which is derived from a granitic magma, is termed a "granite-porphyry," and it is this rock which is the principal representative of the acidic group in the tinfield of North Dundas. The most typical development of the rock, and that which is most free from subsequent alteration, is to be found on the northern slopes of the high saddle between Commonwealth Hill and Pine Hill.

It is essentially a porphyritic rock, in which the phenocrysts consist of quartz, felspar, muscovite, and biotite, while the groundmass is a crystalline mixture of quartz and felspar. The mica crystals are less prominent than those of quartz or felspar. The idiomorphism of the quartz can easily be detected in weathered specimens without microscopic aid.

In thin sections it became apparent that the groundmass varies considerably in grain. In a few cases it is microgranitic, but more usually it is cryptocrystalline, and the rock assumes the habit of a quartz porphyry.

The long dykes which have been charted on the geological map herewith are almost wholly constituted of this quartz porphyry facies of the granite porphyry. It is only near the larger exposures of the acidic mass that the typical granite porphyry habit predominates.

The felspars are in all cases altered to some degree. Orthoclase, in the form of carlsbad twins, can still be recognized, and in addition to it there are crystals with the outlines of felspars, but completely converted into pinite.

The difference between these and the orthoclase suggests that they were originally plagioclase.

The biotite crystals are chloritized; muscovite is not abundant.

Besides these constituents there is often a certain amount of tourmaline present, as well as fluorite, sericite, cassiterite, and pyrite, in various portions of the dykes. These minerals, however, must be regarded as of secondary rather than primary origin, and the changes effected in the rock by the lode-forming processes are dealt with below.*

The granite porphyry (and the quartz porphyry facies thereof) must be very closely connected with some narrow dykes of pegmatite on Pine Hill. These were not observed *in sitû* on account of the cover of the talus of quartz porphyry which conceals the bedrock in that area.

There are a fair number of fragments among the talus of these narrow dykes, the constituents of which are quartz and felspar in crystalline intergrowth. The longer axes of the crystals stretch transversely across these dykes from wall to wall (the dykes or veins are up to 4 inches in width).

The other closely connected dykes of quartz-tourmaline rock are treated of in connection with the economic geology.

The distribution of these rocks through the tinfield is not very regular.

The central area from which the main dykes radiate is situated a little to the north of the apex of Pine Hill.

The longest dyke crosses over the Renison Bell Hill almost at its highest point, and can be traced to a point in the creek near the north-eastern corner of Section 2765-M. Here it becomes lost to sight, but an entirely similar dyke-rock is visible in the creek bed near the northern boundary of Section 3240-M. This outcrop may be connected with the other, or again it may be a faulted portion of the other large dyke.

There is a shorter dyke crossing the southern boundary of the Montana Company's Section No. 1342-M, near the south-eastern corner. It can be traced from the creek through the stripped ground in 1963-M, but not beyond that point. However, the similar rock found alongside the pyritic cassiterite lode in Dead Man's Creek is very probably a continuation of the same dyke, or at least connected with it.

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* *Vide infra*, p 60.

The third main dyke runs in a direction about S. 35° E. from Pine Hill, and can be seen at a number of points along the track which lies immediately below the North-East Dundas Tramway, but appears to die out before Great Northern Creek is reached.

The dip of all of these dykes cannot be ascertained for want of the necessary sections. The longest one would not, however, appear to depart widely from the vertical position, since there are no notable deflections introduced by variations in the topography.

The direction of these dykes varies between 28° and 45° west of north.

On the northern slopes of Pine Hill—the locality whence these dykes radiate—there is a more complicated system of intrusions. Here the talus formed by the disintegration of the rock conceals the dip. But the workings, especially those on the eastern bank of Penzance Creek, prove that there is a dip in a south-easterly direction. The strike is variable and hard to determine, as there appears to be several intrusions connected with each other. One main dyke which runs down the spur strikes in a N.E.-S.W. direction.

This structural feature is the more noticeable on account of the resemblance offered to the structure of some of the lodes themselves in the district. The lode system on the boundary between Sections 271-M and 5101-93M exhibits entirely similar structural characters to the system of dykes in the vicinity of Penzance Creek. The longest dykes runs north-west, and is more or less vertical, and joins almost at right angles with a stouter dyke dipping to the south-east. If we compare with this the structure of the lode system described below* the resemblance is extraordinarily marked.

(4)—*The Diabase Dyke.*

The remaining igneous rock-type present in the field is quite distinct from any of those mentioned above, and also younger than any of the other igneous rocks.

Three main outcrops are shown on the geological map, and it is more than probable that all three are one and the same dyke. In the centre of the field the main outcrop can be traced almost without a break from the hill slope to the east of Dalcoath Creek to the junction of the

* *Vide infra*, p. 113.

Dalcoath and Gormanston Creeks. Thence it can be traced without serious gaps through the battery site of the Boulder Mine to a point near the centre of the Montana Company's section. Here it disappears, to be seen again on the western slope of the Dreadnought Hill. Although it apparently died out at this spot, it reappears on the northern side of the button-grass plain, not far from the north-western corner of Section 3621-M.

The typical specimens from this dyke have a greenish-grey colour, and the cryptocrystalline groundmass carries soft black phenocrysts of biotite.

The rock is fairly fresh in most places, but near the Boulder Company's battery it has weathered into a soft condition, and exhibits spheroidal structure.

At the point where the dyke is crossed by the Government track in the Montana section, the texture is much finer, and the dark phenocrysts of biotite are not visible.

The normal type when microscopically examined exhibits a texture resembling that of other Tasmanian diabases, which are found in dyke form. The main portion of the rock is constituted of a felted aggregate of plagioclase and augite. There is a fair proportion of residual glass. The augite crystals in some cases partly enclose the felspars, but the typical ophitic structure of our diabases is absent.

The phenocrysts are a strongly pleochroic biotite (green to yellow), and a mineral which was probably felspar, but now is replaced by the secondary aggregate known as pinite.

The finer-grained variety also contains residual glass, and a felted aggregate of augite and plagioclase in the base. But the felspars are in an embryonic stage of development in the groundmass.

The phenocrysts in this variety are felspars, converted into pinite as in the coarser rock, and olivine. A little pyrite is present here and there.

The rock, as a whole, presents characters most closely resembling those of the dykes of diabase found in various parts of the island.

It is, therefore, presumably of Upper Mesozoic age, if we may regard it as a portion of the diabase, which covers a large area in Tasmania. The nearest outcrops of the massive form of the diabase are at Mt. Dundas, where it forms the capping of the mount; and in the area lying to the north-east of Mt. Heemskirk.

(5)—*The Sequence and Relationships of the Igneous Rocks.*

The four main groups of igneous rocks thus described as occurring in this one field attained their respective positions in the order in which they have been described, but the intervals between the periods of invasion were very unequal.

After the Cambro-Ordovician eruption of the porphyroid, with both intrusive and effusive phases, there was an absence of igneous activity until the close of the Silurian period, or perhaps even some portions of the Devonian.

At this period the basic rocks were erupted, and the acidic ones followed closely upon them. The relation between these two groups requires special investigation, on account of the great importance of both when considered from the economic aspect.

It is now known that in several different localities in Tasmania the outcrops of granite, granite porphyry, quartz porphyry, or aplite, are accompanied by a fringe of basic or ultra-basic types—gabbro, pyroxenite, norite, peridotite, or derivative serpentines.

The granite *massif* of Mt. Heemskirk has two such marginal developments of basic material—one at Trial Harbour, and the other a little further to the north-east, in the Comstock district.

The granitic area of the Meredith Range shows a development of serpentine at its south-eastern extremity. To the northward, at the Magnet Range, and in the Heazlewood district, the basic types are well developed.

In the North Dundas tinfield the geological map herewith shows that the same two rock groups are present; but here the basic types cover a much larger area than the acidic ones which penetrate them.

Elsewhere in the island, also, the same association has been observed. At Anderson's Creek, near Beaconsfield, rocks wth granitic affinities have been observed to be intrusive into the serpentine.* Mr. Twelvetrees draws attention to the fact, and suggests magmatic differentiation as the cause of the juxtaposition of acid and basic types.†

Where any differences in age between the members of the acidic and basic groups have been definitely deter-

* W. H. Twelvetrees, "Report on the Mineral Resources of the Districts of Beaconsfield and Salisbury," 1903, pp. 7-9.

† *Ibidem*, p. 54.

mined the acidic rocks are the younger. The localities (in addition to that of Pine Hill, North Dundas) in which the rocks derived from a granite magma have been observed to penetrate the serpentines and gabbros are Trial Harbour and Anderson's Creek.

Yet no case has yet been recorded in which the acidic rock that penetrates the basic types is itself a typical plutonic type. On the other hand the dyke-rocks of granitic origin have been observed cutting through the serpentine.

Now, it is known that a granitic mass is itself often traversed by dykes of acidic composition, viz., by granite porphyries and aplites.

The intersection, therefore, of the serpentine or other basic rock by an acidic dyke-rock does not prove that the basic rock is older than the accompanying granite.

It remains to be stated that both acidic and basic groups exhibit within their own borders characters which, in the case of groups so closely associated in the field, cannot but suggest a common origin, through the operation of the processes of differentiation.

For, to take the acidic group first, it is recorded that the granite masses of Mt. Heemskirk and of the Heazlewood district are characterised by a more basic aureole. It is, of course, possible that the granite is younger, and that during its intrusion a certain proportion of the basic rocks now occurring at the margin of the granite has been assimilated, with the production of a rock of intermediate character. But no evidence of this granitic intrusion has yet been adduced.

The characters of the several rock-masses which occur at Anderson's Creek, and which are thought to have been derived from a granitic magma, are strikingly peculiar. These rocks seem to be products of the crystallization of several sub-magmas rather than the consolidation products of a single undifferentiated magma.

Further, the process of differentiation in the case of the acidic rocks has not ceased with the extrusion of the normal dyke-rocks, but has continued until a quartz-tourmaline rock has been produced. These phenomena are presented by the acidic rocks which occur both at Heemskirk* and at Pine Hill†, North Dundas.

* G. A. Waller, "Report on the Tin-ore Deposits of Mount Heemskirk," 1902, pp. 5-8.

† *Vide infra*, p. 53.

The complex character of the group of basic rocks is well marked at each locality, where large exposures are to be found. The group invariably includes several types which are distinct from each other. Yet types of intermediate character exist to mark the inter-relationship.

Microscopic examination affords more satisfactory evidence than does macroscopic. Yet even in the field the absence of defined boundaries between dissimilar rock types is noticeable, though the progress of serpentinization has in some cases masked the original character of the rocks.

This differentiation is always visible over and above the minor variations of mineral character, which would seem to be due to fractional crystallization under varying physical conditions.

Certain modifications of the gabbroid varieties have been effected by the conversion of the pyroxene into amphibole, but this alteration has nothing to do with the processes of differentiation. It is commonly effected by dynamic metamorphism, but in the present case there has been very little, if any, actual crustal deformation. In seeking for the cause of the transformation of the pyroxene to hornblende, the writer has come to the conclusion that the stresses have their origin within the rock-mass itself. It seems, therefore, that the explanation may possibly be found in the processes of alteration which have gradually converted considerable masses of basic igneous rocks into serpentine. This serpentinization would be attended with a considerable increase in bulk, and the rocks associated with the serpentine would share in the small differential movements which occur within the basic mass.

This explanation would account for the presence of the gabbro-amphibolite with the serpentine on the borders of the granite areas, whatever be the relation of the granite to the basic types.

The exposures on the Trial Harbour-road and at Dead Man's Creek, North Dundas, appear to the writer to prove conclusively that the gabbro-amphibolite belongs in origin to the basic group, and is only a secondary modification of the gabbro proper.

In attributing, therefore, these phenomena to the operation of the process known as magmatic differentiation, the writer is influenced by the following considerations:—

(1) The constant recurrence of the association of acidic and basic types.

(2) The small difference in age between the two types.

(3) The fact that, where one type intersects the other, the acidic is of later date.

(4) The areas in which the rocks are found together contain undoubted evidence of some change in the composition of the magma at different stages during the process of solidification.

All these signs point to the operation of some definite and regular process or processes along similar lines. Accidental groupings could not be expected to produce such uniformity of character in widely separated localities.

The diabase which occurs in the dyke crossing the centre of the field is not related to any of the other igneous rocks of the district.

B.—THE SEDIMENTARY ROCKS.

There are several groups of sedimentary rocks present in the North Dundas field, but only one of these forms a consolidated rock-mass.

(1)—*The Dundas Slates.*

The greater part of the North Dundas tinfield consists of slate, together with the coarser-grained sediments—sandstone, grit, and conglomerate. The whole are to be considered as one series, and to them the term "Dundas slates" has been applied, since the typical rock-type is a slate.

Lithologically there is a considerable variation in the series from point to point, but the slaty cleavage is prominent in all varieties.

The slates themselves are green or purple where fresh surfaces can be examined, and all varieties weather to a brownish clay.

The coarser and more siliceous varieties are various tints of brown, and weather white.

The original bedding-planes can very often be seen, and the evidence, when collected together, is very conflicting. No regular angle of dip or direction of strike can be assigned to the formation as a whole.

It appears rather that the original bedding-planes have been disturbed by the operation of external forces irregularly applied. Doubtless the great invasion of the igneous material has had much to do with the crumpling of the slates. But a still greater effect was produced at an earlier date by the crustal movements which must have preceded the main igneous invasion of basic and acidic material, since these are free from all signs of dynamic metamorphism.

The age of the slate series cannot be determined from the stratigraphical evidence of the Dundas field alone. There it can be shown that the slate is partly intruded by the porphyroid, partly imbedded with the clastoporphyroid; so that the time of the invasion of the porphyroid group coincided with part of the period of sedimentation. Beyond this nothing definite can be adduced to show either the lower or the upper limits of age.

The floor upon which the slates were laid down is not visible in any part of the field.

The next succeeding sediments above the slate series are those of the old Pieman terraces, which are post-Mesozoic, since they cover the diabase dyke.

Palæontological evidence concerning the age of the series has been obtained and recorded in the proceedings of the Royal Society of Tasmania.*

One of the localities whence the graptolites were obtained was examined, but no trace of the fossils was found on this occasion.

The age of the formation, on the graptolite evidence, must be regarded as Early Palæozoic, but no more can be deduced than this.

However, if it be granted that the Dundas slates are part and parcel of the slates which are found in the gorge of the Leven River on the North Coast of Tasmania, we can arrive at a much closer approximation to the age of the series. The slates in the Leven Gorge are lithologically similar to those of Dundas, and are associated in the field with the intrusive and effusive members of the porphyroid family. Hence we may, in my opinion, with safety regard them as formed during the same period of sedimentation as those round Dundas. Mr. Twelvetrees has recently obtained proofs of the age of the slates in the Leven Gorge, having found that they underlie the Ordovician limestone of that district.†

The Dundas slates may therefore be of Upper Cambrian or Lower Ordovician age, and until further evidence is available may be referred to as Cambro-Ordovician.

Their exact relationship to the West Coast conglomerate still remains to be determined.

* T. S. Hall, "Evidence of Graptolites in Tasmania," 1902.

† Geol. Surv. Bulletin, No. 5, "Gunn's Plains, Alma, and other Mining Fields, North-West Coast," 1909.

There are certain peculiarities which are noticeable in certain portions of the formation, and which are not characteristic of the series as a whole.

The effect of the intrusion of the igneous rocks has been very slight. There has been, of course, a shattering of the rock-mass, and in some places new minerals have been developed. But no sign of appreciable metamorphism of the slate by contact with the heated rocks was detected. The development of new minerals in the contact zone took place only along certain directions, which were probably determined by physical conditions. The rock, as a whole, is not metamorphosed.

Towards the southern limits of the area examined, and represented on the map herewith, a fresh feature is very noticeable. It is the development of very hard siliceous bars or zones in the slate.

No expression of opinion can be given as to the mode of formation of these dense cherty zones, which extend southwards beyond the township of Dundas. Detailed investigation is necessary in that area before their significance and origin can be determined. The only place where the cherty variety of slate occurs *in sitû* in the area here dealt with is in the Section 1897-M.

Some of the more siliceous bands in the slates exposed in the Emu Bay Railway cuttings near the Renison Bell Mine show an impregnation by silica; but the quartzitic bands do not form any considerable proportion of the slate formation at this place.

The coarse-grained sediments of the series are rather varied, and the origin of the several varieties is probably somewhat different.

The grit and conglomerate in the Renison Bell lease and its neighbourhood are typical aqueous sediments, and so too is that conglomerate near the Confidence Saddle.

But the other occurrences, at Ringville and on the high ground between the Melba Flat and Dundas, are, at least in part, distinct. These are especially characterised by the angular shape of the larger fragments; that is, the rock partakes of the character of a breccia.

There are always present some rounded or subangular fragments, so that this rock-type may be termed a brecciated conglomerate. Two main varieties occur. In one the fragments are for the most part white, and the cementing material black or dark grey. This is not so common as the variety which has a prevalent greenish tint.

In all cases the fragments are very largely composed of silica; and in the green rock the silica is nearly always tinted green or red. These fragments are sometimes of jasper or chalcedony, but more often are of a cherty nature. Calcite is also present.

Microscopically the rock proves to be an aggregate of fragments of chert, chalcedony, and an igneous rock, which seems to belong to the porphyroid group. The interstitial cement is also of complex composition, and contains fragments of quartz, felspar, and muscovite, together with calcite, chlorite, and kaolin.

The presence of the fragments of porphyroid and of felspar seems to suggest that there has been some contribution to the rock-mass by volcanic action.

The chert may have been derived largely from the hard bands in the slate referred to above.

This green brecciated conglomerate forms all the high-level country examined between Dundas and the Melba Flat, save where denudation has laid bare the igneous intrusion of serpentine.

The conglomerate is covered by no other formation, and its formation may have marked the close of the Cambro-Ordovician period of sedimentation.

Lithologically the rock is very similar to a conglomerate from the Dial Range.

(2)—*The Older River Terraces.*

The unconsolidated river gravels forming the dissected high-level terrace of the Pieman River have been partly dealt with above in the chapter on the physiography of the region.*

The total depth attained by this extremely broad deposit of gravel is not known with certainty, but does not appear likely to prove considerable. Practically no work has been done to prove its thickness, and an estimate can only be formed where a creek has cut its way through on to the slate bottom. Moreover, the bottom over so broad an expanse cannot be expected to be regular. At no point in the area examined does it seem probable that a thickness of 20 feet would be obtained, and in the great majority of cases the slate bottom is less than 6 feet from the surface.

The constituents of the gravel are mainly well-rounded pebbles of quartz, quartzite, quartzitic schist, and porhy-

* *Vide supra*, p. 6.

roid. These have evidently been derived mainly from the country lying to the eastward of that represented on the maps herewith. The many varieties of quartzose pebbles are derived from the West Coast conglomerate, which is well developed in that region.

In addition to these constituents a few pebbles of the tourmalinized quartz porphyry were recognized.

In the lower portions of the gravel bed there is always a certain proportion of chromite present, and with it fine flaky colours of gold, and in some places sporadic colours of iridosmine.

Tin ore is present in small amount in every portion of this gravel formation which was examined.

The huge erratics on the northern side of the Huskisson River, formed of massive blocks of the West Coast conglomerate and porphyroid lie embedded in these gravels, and their presence has led the writer to regard the age of the formation of the gravels as, approximately, Pleistocene.

(3)—*The Recent Alluvial Deposits.*

The more recent deposits of alluvial material are very variable in composition, their constituents being usually of local derivation.

However, at the confluence of the Ring River with Dalcoath Creek there is a recent gravel, which very closely resembles that of the higher terraces. It has no doubt gathered the greater portion of its material from the dissected terraces.

There are a number of pebbles in this gravel which seem peculiar to the Ring River. They are of a much altered lava of basic composition, but the exact character of the rock cannot now be determined. It may be termed an amygdaloidal melaphyre.

On the westward border of the strip of alluvial ground at the junction of the Ring River and Dalcoath Creek the constituent pebbles consist mainly of the characteristic rocks of the Pine Hill area; chiefly acidic igneous rocks carried down by the Gormanston and Penzance Creeks.

The recent gravel benches on the banks of the Pieman River are of similar composition to the older high level gravels.

The alluvial deposit of the Melba Flat carries an entirely different kind of material. The coarser fragments are not so completely rounded, and are mainly formed of the brecciated conglomerate mentioned above.

With them are some rounded boulders of serpentine, but these are not numerous, as the basic rocks seem to have disintegrated completely in almost all cases.

There are many semi-rounded boulders of a quartz-epidote lode-stuff.

The bottom of the alluvial deposit, where visible through sluicing operations, is serpentine.

Much of this alluvial material has been worked for gold and tin, but little now remains untouched in the upper portion of the Melba Creek basin.

(4)—*The Quartz Porphyry Talus.*

On all the slopes of Pine Hill there is a dense cover of angular or subangular blocks of the acidic rock-mass. The blocks and smaller fragments have not moved far from their places of origin, and lie accumulated about the outcrops of massive quartz porphyry.

The depth of this formation is extremely variable, being as much as 20 feet in places. The irregularities in depth are to be explained by the variation in the depths of the gullies carved in the steep slopes of the hill.

The various gullies on the northern slopes have been all filled, and even obliterated, by the gradual downhill creep of the talus, with the exception of Gormanston Creek and Penzance Creek, which have survived.

The spur between these creeks is for the most part covered by the talus, save in places which have been stripped by mining operations.

On the southern slopes of Pine Hill the talus has spread for some distance south of the Penzance boundary.

The variations in the grain and the lack of sorting are characteristic of a talus deposit traversed by minor streams.

Some portions of this talus have been worked for tin ore.

(2)—The General Sequence of Events Leading to the Present Geological Structure.

1. *The First Period of Sedimentation.*—The geological history of the field begins with the period of sedimentation which produced the members of the slate series. This period must needs have been that between Cambrian and the limestone epoch of Ordovician time.

From observations made in other parts of the West Coast region of Tasmania, it may be inferred that these Cambro-

Ordovician sediments were laid down upon a floor of quartzite and quartz-mica schists of Pre-Cambrian age. The bedrock below the slate series is, however, not here visible.

The upper members of the slate series seem to show a tendency to become coarser in grain, so that we may infer that during sedimentation the area was undergoing an uplift. The effect of this has been the covering of the infra-littoral by the littoral deposits.

2. *The First Period of Igneous Invasion.*—During the later stages of this sedimentation igneous activity became very pronounced. The intrusive types were forced between the beds already formed, and the fragmental types became interbedded with the sediments. From the succession of the slates above the horizon of the fragmental igneous rocks we may infer that the clastoporphyroids represent, in part at least, submarine tuffs consolidated by subsequent pressure, and that the conditions of sedimentation were similar both before and after the porphyroid eruption.

The central area of the tinfield appears to have been situated near the western limits of the district invaded by the porphyroid. The central line of this great igneous invasion lies a short distance to the eastward of the area mapped, and the members of the porphyroid group extend for many miles northwards and southwards.

In the neighbourhood of Dundas the slates are capped with a brecciated conglomerate, which seems to have been formed partly by igneous, partly by aqueous, agency. Whether this brecciated conglomerate extended over the district which lies to the north of the Melba Creek cannot now be determined.

3. *The Folding of the Region in Ordovician Time.*—The evidence gathered from several points on the West Coast indicates that the Cambro-Ordovician sediments were seriously affected by dynamic stresses between the time of their formation and that of the deposition of the Silurian sediments.

It is probably at this time that the slaty cleavage was developed in the Dundas slates; and possibly also the folds and fractures in the formation date from this period. Nevertheless, there has been far less deformation of the slates in the area here considered than in other neighbouring districts.

The period of crustal movement appears to have followed closely upon that of the porphyroid eruption; and the district lying to the eastward of that under consideration is apparently more seriously affected by the dynamic stresses.

4. *The Second Period of Igneous Activity.*—There are no rocks representative of the succeeding periods in the tinfield until, ascending the geological column, we come to the Devonian.

The great igneous complex of basic and acidic rocks is assigned to this period on evidence which has been fully stated by the writer elsewhere.*

The texture and structure of these igneous rocks suggest the former presence of some considerable thickness of superincumbent sediments, since removed by weathering agencies.

The igneous material penetrated upwards into these sediments, attaining a varying height in different localities.

This was the period during which the tin ore was introduced into its present position throughout the whole field. The fissures serving as loci for ore-deposition may possibly have been created by the mechanical stresses accompanying the igneous invasion.

The filling of the fissures with vein-matter has taken place during the latter stages of the period, since the igneous rocks themselves form the country enclosing some of the lodes. Whether all the lode-filling was introduced at a later date than that of the consolidation of the youngest member of this igneous group cannot yet be stated.

5. *The Invasion of the Diabase.*—The single dyke of diabase made its appearance during the upper portion of the Mesozoic era. It can be seen to cut through the ore-deposit at one place on the Boulder Company's northern section, and it is covered by the older alluvial terrace gravels.

Little, if any, effect upon the geology of the district has been caused by this rock, which is now of small importance in the field. The upper portions have been completely removed by denudation, and there is nothing left to indicate whether the vertical dyke was connected with any sills such as occur in other portions of the island.

6. *The Development of the old Pieman River Plain.*—A long cycle of erosion must have followed the events chronicled above. This cycle culminated in the development of a broad plain of erosion at the northern end of the field. The southern portion was suffering a continuous

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*** Geol. Surv. Bulletin, No. 3, "The Mount Farrell Mining Field," 1908, pp. 37 and 38.**

dissection and degradation. Ultimately the grade of the older Pieman River became so flat that the material brought into it by the tributary streams could not be carried downwards to the sea. Then the alluvial gravels were formed.

Towards the close of this period there was a contribution of very large boulders to the alluvial deposit by glacial agency.

During the building up of the alluvial gravels the streams entering the Pieman from the tinfield carried in stanniferous material, and distributed it far and wide through the gravels.

Chromite and iridosmine were simultaneously brought in by the streams which traversed the basic igneous rocks. Gold is also present, but its origin was not determined during the present visit to the district.

7. *The Uplift of the Region.*—The district, as a whole, has experienced an uplift after the formation of the alluvial deposit above mentioned. The rejuvenated rivers and streams have cut their way down once more, and a large portion of the alluvial gravels have been removed by the newly formed tributaries and by the River Pieman itself.

The uplift has not been one which consisted of one simple movement, for there are evidences of terraces along the banks of the Pieman River, which mark periods at which the base level of corrosion was attained by the river system.

The principal river systems have, as a rule, cut down their channels deeply into the surface, and the grade of these channels has for the most part prevented the accumulation of recent rock-waste.

V.—ECONOMIC GEOLOGY.

(1)—The General Relationships of the Ore-deposits of North Dundas.

Mention has been made on a previous page* of the geographical relationship of the tinfield of North Dundas to the surrounding mining fields. The explanation of this relationship is given by the geology of these districts.

With regard to the comparison between this field and the other *tinfields* whch are nearest to it in position, the one feature common to all is the presence of the acidic igneous rocks in the immediate neighbourhood of the ores.

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* *Vide supra*, p. 4.

The country-rocks which form the walls of the lodes may be sedimentary rocks of Silurian or of Pre-Silurian age, or they may be themselves of igneous origin. Still, in all cases there will be found the common feature—the presence of acidic intrusions.

The exact acidic type represented is not always the same. The following examples show this variability of type:—

At Granite Tor the tin ore is found in a mass of coarse-grained granite.

The lodes of Mt. Bischoff are associated with dykes of granite porphyry, and within a radius of 5 miles the plutonic type—granite—is to be found.

In the Stanley River field* and at Mt. Heemskirk† both plutonic and dyke-rocks occur together, and their relation to the ores has been described by Mr. G. A. Waller.

The occurrence of tin ore at Zeehan differs in some respects from those in the other fields mentioned. The tin ore is stannite, and is found with sulphides of copper, iron, and bismuth, and sometimes with wolframite in close association with lead ores.‡ Yet there are in the neighbourhood dykes of quartz porphyry§ which are undoubtedly apophyses from a granitic magma.

The granite porphyry and quartz porphyry of the North Dundas tinfield are the local representatives of this group of rocks; and there is a close resemblance between these rocks and the corresponding types from the other localities cited.

There are signs also of a genetic relationship between the tin-ore deposits of North Dundas and the occurrences of *other ores* in the neighbouring mining fields.

The relationship is expressed in several ways:—

(1) There are vein-types common to North Dundas and the outlying districts. As examples, brief mention may be made of—

(*a*) The limuritic vein-type which occurs at the Colebrook Mine and in the Boulder Company's lease at North Dundas.‖

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* Report on the Prospects of the Stanley River Tinfield, 1904, pp. 1-2.

† Report on the Tin-ore Deposits of Mt. Heemskirk, 1902, pp. 2-8.

‡ G. A. Waller, "Report on the Zeehan Silver-Lead Mining Field," 1904, p. 55. H. Conder, "The Occurrence of Stannite in Australia," Aust. Min. Stand., Nov. 18, 1908.

§ G. A. Waller, *loc. cit.*, p. 21.

‖ *Vide infra*, p. 57.

(*b*) The pyritic lead-veins which exist at Zeehan* and Mt. Farrell† and at many different points throughout the North Dundas tinfield.

(2) There are occurrences of mineral groupings which exhibit a character intermediate between well-defined vein-types, and which thus connect the tin ore with ores of other metals, as regards origin.

The occurrence of lode-matter, which appears to be a transitional stage between the pyritic lead veins and the pyritic tin veins is described below.‡

(3) There are gangue minerals in the outlying districts which have certain definite affinities with a granitic magma. The examples which may be cited are:—

(*a*) The axinite, datolite, and danburite, occurring in the limuritic vein-type of the Colebrook Mine.

(*b*) The tourmaline and fluorite in the tourmaline-gold-copper vein-type of the Mt. Black Mine.§

(*c*) The fluorite associated with the lead ore of the Thomas' Blocks Mine at Mt. Farrell.‖

Therefore we cannot but regard both the tin ores and the other ore-deposits of which mention has been made as being in intimate genetic relationship with the acidic igneous rocks.

Neither can we regard these acidic igneous rocks as a separate unit; for, as has been fully discussed above, the acidic rocks are so constantly associated with basic types that a common origin has here been assigned to both groups.

We are compelled, therefore, to refer the ores of tin and the other metals above mentioned to an igneous magma from which both acidic and basic types have resulted by the process of differentiation.

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* G. A. Waller, *loc. cit.*, p. 13.

† Geol. Surv. Bulletin No. 3, "The Mount Farrell Mining Field," 1908, p. 48.

‡ *Vide infra*, p. 55.

§ G. A. Waller, "Report on the Ore-deposits (other than those of Tin) of North Dundas," 1902, pp. 11-15.

‖ Geol. Surv. Bulletin No. 3, "The Mount Farrell Mining Field," 1908, pp. 48 and 101.

The question which naturally presents itself is this: "Are the tin ores and the other genetically-related orès derived from the parent magma by the same processes which have produced the various igneous rock-types?" That is to say, are the ores themselves to be regarded as extreme products of the processes of magmatic differentiation? Much, of course, depends upon the conception which is taken of the legitimate limits of this term "differentiation." Nevertheless, it cannot, in my opinion, be denied but that some of the tin-ore deposits of North Dundas are definite differentiation products. Reference is made to this matter in a later portion of this report.* But the relation of these latter differentiation-ores to the other ore-deposits of the field cannot yet be regarded as fully defined.

However plain may be the fact that the several ores have, speaking generally, a common origin, there yet remain a number of important questions to be solved by later investigations. Some of these problems are:—

- The sequence of the several ores.
- The relation between the vein-type and the proximity to the igneous source, especially with regard to the different types of tin ores.
- The explanation of the distribution of the different ores which may be genetically referred to the same igneous source.

It is as yet too early to formulate any such complete theory regarding the genesis of these ore-deposits of the West Coast of Tasmania as could explain all the problems here indicated.

(2)—The Relationship of the Ore-bodies of North Dundas to the Several Lithological Groups.

The investigation of the geological map of this field will indicate the fact that the primary ore-bodies are distributed through the several rock-groups which are prior in date to the dyke of diabase which crosses the centre of the field.

The members of the Dundas slate series constitute the greater part of the field, and the majority of the ores are to be found enclosed within these slates.

Moreover, it is natural that these ores should be usually found in this slate series rather than in the igneous rocks. For, as has been already indicated, the ores owe their posi-

* *Vide infra*, p. 53.

tion to the action of uprising vapours and solutions which have transferred the mineral content from the igneous magma below, and deposited it in certain cavities in the superincumbent slates when the pressure and temperature were lessened to such a degree as to permit of a precipitation.

Nevertheless, in the Pine Hill district, we do find that the tin-ore veins may exist in the igneous rocks. And this may be explained by the fact that the impregnation with tin ore at that place occurred at the very end of the processes of igneous intrusion. In fact, not only had the basic rocks solidified, but also the acidic dyke-rocks described above had become quite solid. Hence it is that we find the tin ore enclosed within walls of gabbro, or even granite porphyry. Doubtless, also, if we could but follow the ore-bodies which now are seen at the surface to be enclosed within members of the slate series, we should find the lode-channels continuous through the upper portion of the igneous *massif*, which seems to underlie the greater part of the tinfield.

In the immediate neighbourhood of all of the tin-ore deposits in the main portion of the field there are acidic intrusives. The "Dreadnought-Federal" line of lode may seem an exception when compared with other portions of the field; but even so, the distance from the quartz-porphyry dyke in the Montana Company's section is not considerable. And, if the surface cover of soil and vegetation were removed, this dyke might possibly be traced still further in the direction of this lode-system.

A much more remarkable occurrence is that of the tin ore near the Dundas township, where the only igneous rock visible is serpentine.

This association of tin ore with serpentine, coupled with the association of the Limuritic ore of the Colebrook Mine with serpentine, is, to my mind, one of the strongest links in the chain of evidence which may be adduced to prove the essential unity of origin of the basic and acidic rocks.

The seemingly anomalous nature of this occurrence is satisfactorily explained by the known relationship of the serpentine to the acidic igneous rocks.

Although these ore deposits are closely associated in the field with the igneous rocks mentioned, they are, nevertheless, not "contact deposits" in the strict sense of that term.

It has been realized by the management of some of the mining properties that there is a close dependence of the ore upon the acidic rocks, and the assumption has been made that, if the planes of contact between the igneous rocks and the sediments be exposed, ore-bodies will be found.

Some little work done on the northern slopes of Pine Hill has proved the inaccuracy of this hypothesis. But this work has been of great value in that it has exposed a considerable face of the quartz porphyry at its junction with the slate, and has shown clearly what the structural characters of the ore-body really are at that point. The veins form a reticulating system, and the principal members of this system cut igneous and sedimentary rocks alike, in a direction perpendicular to the line of contact.

Yet it must not be considered that a "contact deposit" must coincide with the surface of junction between any two dissimilar rock-formations. The term "contact deposit" is now limited in its application, and only employed in the description of certain ore deposits which exhibit the following characteristics.*

They are usually irregular in form. They occur near or along the boundary between plutonic igneous masses and stratified rocks; most commonly where the latter are limestones.

The gangue minerals are characteristic, and are usually garnet, wollastonite, epidote, amphibole, pyroxene, vesuvianite, quartz, and calcite.

The ore minerals are haematite, magnetite, bornite, chalcopyrite, pyrite, pyrrhotite, and sometimes galena and blende.

Thus, it appears that tin-ore deposits do not appear among those which are typical contact deposits. But this does not preclude the possibility of such an occurrence, and one occurrence of tin ore in a contact deposit has been recorded in Tasmania.†

The garnet-actinolite lode, which very nearly coincides in position with Gormanston Creek, is of the nature of a "contact deposit," if the term be extended slightly beyond the limits of the strict definition. This matter is treated of below.‡

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* *Vide* W. Lindgren, "The Character and Genesis of Certain Contact Deposits"; trans. A.I.M.E. 1901. R. Beck, "The Nature of Ore-deposits"; Weed's translation, p. 582.

† G. A. Waller, "Report on the Tin-ore Deposits of Mount Heemskirk," 1902, p. 46.

‡ *Vide infra*, p. 56.

It is quite certain that the country rock has had little or no influence upon the composition of the lodes, since dissimilar lodes are to be seen side by side within the same formations.

The variability of lode-type is due to the alteration in the character of the mineralizing solutions which have traversed the lode-channels at different times.

Moreover, as has been indicated already in this chapter, veins of tin ore can be seen on the northern fall of Pine Hill cutting across the slate and the quartz porphyry without change of character.

Changes in the mineral composition of the pyritic-cassiterite veins are very noticeable when the different lodes are reviewed together; but this is a characteristic displayed by different varieties of veins in every mining field. The presence of " shoots " in which one metal or another predominates is not due to the direct influence of the adjoining country rock in this tinfield.

The positions of the several lode-systems (called " systems " because simple lodes are rather the exception than the rule in this field) have been determined by the presence of fracture-systems which possessed the continuity in depth necessary for the admission of the metalliferous solutions from the magmatic hearth. And the details of the fracturing have determined the form of the lode-systems.

It is not possible to discern any evidence which might disclose an essential change of either composition or structure in the lode-matter when an ore deposit is enclosed in wall-rocks which vary from point to point.

The reticulating veins in the quartz porphyry in the neighbourhood of Pine Hill and Penzance Creek are, perhaps, a special case, where the igneous origin of the rock has influenced the form of the vein-system. For during the cooling of the quartz porphyry a number of contraction fissures have been developed, and the tin ore has been introduced into these joints.

One problem which naturally arises at this point concerns the matter of the differences between the two vein-types which constitute the ores which are being worked for tin on the field. It is important to know whether the differences between the pyritic-cassiterite veins and the quartz-tourmaline-cassiterite veins are due to their proximity to, or remoteness from, the plutonic source.

For it is certain that the two types are derived from one source, and the relation between the two needs investigation.

Unfortunately there is very scanty information to be obtained from the underground workings, and thus far the mineral character cannot be examined with respect to its behaviour as vertical depth is attained.

We may say, regarding the two lode-types, that the quartz-tourmaline veins are restricted to the area which surrounds the main centre of the acidic intrusions at Pine Hill.

Yet, as Pine Hill is approached, there are no lodes which show a gradual passage from the pyritic to the quartz-tourmaline type, nor are any intersections between representatives of the two types available for examination.

For the present, therefore, it is impossible to state the relationship between these types, and the order of their derivation from the plutonic source cannot be settled.

But even if the relationship can never be ascertained at North Dundas, it is possible that the necessary information may be gathered from other mining fields in Tasmania where the same vein-types are represented.

With regard to the ore-deposits which have a secondary origin the proximity of certain rock-types has in some cases an important bearing on the grade of the deposit or the nature of the minerals present. The most marked case is that of the deposits of iridosmine, which are workable only where they lie upon or in immediate proximity to the parent rock—serpentine.

(3)—The Primary Ore-deposits of North Dundas.

While the mineral district of North Dundas is primarily a tinfield, there are to be found within its limits ore-deposits containing other metals.

These are here considered apart. Also, separate mention is made of the different mineral groupings or vein-types which contain the same metal; and these several types are grouped together under the headings of the metals of which they constitute the ores.

A.—TIN ORES.

There are exceedingly few localities in which it is necessary to draw a sharp line of distinction between the different vein-types of tin ore. But at North Dundas there are two well-marked types which are strongly contrasted, and each type is developed independently of the other.

Mr. G. A. Waller has given, in his report on Mt. Heemskirk*, a brief description of the several types of tin veins, and has there established four main classes which he terms "quartz-tourmaline veins," "pinitoid veins," "greisen veins," and "pyritic veins."

Of these groups the first and last mentioned are important in the tinfield of North Dundas, but there are signs of the presence of the "pinitoid" type in several portions of the field. No true greisen was observed.

The Pyritic-Cassiterite Deposits.

The following may be given as a definition of the mineral constitution of these deposits:—

The metallic minerals of the vein-type are pyrrhotite, pyrite, arsenopyrite, chalcopyrite, with a certain amount of galena, sphalerite, and bismuthinite.

Wolframite is present in most deposits.

The tin ore occurring with these is cassiterite, but stannite has been observed in some rare cases.

Of the gangue minerals the most abundant is quartz, and with it occurs dolomite. In smaller proportions the following minerals also are present:—Tourmaline, chlorite, epidote, and fluorite. Apatite has also been recorded.

The prevailing structure of the vein-filling is massive.

In further explanation of this vein-type, which has hitherto not been, as far as the writer is aware, very fully defined, the following detailed account of the North Dundas deposits is given:—

The most abundant of the metallic minerals by far is pyrrhotite, and it is frequently accompanied by a quantity of pyrite. The former is, as in most occurrences of the mineral, massive, but the pyrite is often seen to be well crystallized, especially upon the weathered surfaces of the lode-matter. In some places within the lodes the pyrite predominates.

Arsenopyrite is very irregularly distributed, and was most noticeable in the old "Cornwall" workings on the boundary between the two sections held by the Boulder Company, and in the lode-matter at the junction of Gormanston Creek with Dalcoath Creek.

In the latter place it forms, at one place, the bulk of the lode-matter.

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* G. A. Waller, "Report on the Tin-ore Deposits of Mount Heemskirk," 1902, pp. 8-10.

Chalcopyrite is very widely disseminated, but never becomes so abundant as to entirely displace the other minerals.

Galena and blende are usually to be seen in the vein-matter in most of the lodes. They are most frequently seen where dolomite and fluorite are unusually prominent in the gangue.

Bismuthinite has not been recorded at North Dundas.

Assays made from different portions of the lodes have shown a fairly wide distribution of small quantities of silver. Whether the distribution of silver corresponds to that of the galena is not yet determined.

The presence of gold has been recorded from one or two points, but so little sampling and assaying has been done that it is not yet known whether there is a wide distribution of it.

Wolframite was not observed at North Dundas.

The tin ore present is cassiterite, and the writer found no sign of stannite in the ore which he examined at North Dundas. The cassiterite is usually grey in colour, and in a fine state of division. It is almost always crystalline and granular. But in the old workings of the Cornwall Company the tin oxide is usually of a deep brownish colour, and at one point occurs in the fibrous form, constituting radiating crusts and associated with arsenopyrite.

The distribution of tin ore in the massive lodes is very irregular. Extremely rich pockets and bands occur, and as yet the conditions governing the distribution of these shoots are not known.

Systematic sampling and assaying are wanted, in order to provide the data necessary before a solution of this difficult problem can be attempted.

The reasons which may account for the occurrence of the tin ore as cassiterite rather than stannite, especially in view of the presence of sulphides of iron and copper, are at present undetermined.

Of the gangue minerals, quartz is much the most abundant, and it frequently forms the bulk of the ore which occurs on the Dreadnought-Federal lode-system.

In the typical massive sulphide ore the quartz takes many forms, and occurs most frequently in the form of reticulating acicular crystals, the outlines of which only become apparent on weathering.

Chalcedonic silica is present in several places, notably on the northern side of the Argent River, in the gossan outcrops which appear to result from the oxidation of lodes of this type. A little greenish opal was also observed.

Next in importance to the quartz is dolomite, which in most places is ferriferous. It is always present, even in those compact portions of the lode which appear to the naked eye to be aggregates of quartz and pyrrhotite only. And in places the dolomite predominates over the other lode minerals, notably in the main river tunnel and at the northern end of the "big blow" workings on the Renison Bell lease. It is noticeable that in many cases an increase of the proportion of dolomite in the lode is accompanied by an increase in the proportion of galena and sphalerite.

Tourmaline seems to be invariably present, although it is only visible to the unassisted eye in one or two places. It occurs in some quantities in the ore of the Dreadnought Mine.

Fluorite is not commonly seen. It appears to be most often seen where an unusual proportion of galena and blende occur.

Chlorite is usually present in the form of radiating tufts, but can seldom be seen with the naked eye.

Epidote was found to be abundant in the form of crystalline grains in one slice cut from a specimen rich also in dolomite. It is not common in other specimens, and was never observed without microscopic aid.

Apatite has not yet been recognised on this tinfield.

Where the minerals which have been mentioned were free to crystallize out (*i.e.*, in the more massive portions of the lode-systems rather than in the interstices between the separate constituent grains of the more porous beds in the slate*) the structure of the vein-matter closely resembles that of an igneous rock. This structure seems to indicate that crystallization must have taken place in spaces which were open. The open cavities may have been formed by the action of the lode-bearing solutions rising under conditions of high pressure through the necessary fissures. The pressure under which the solutions ascended may have distended the walls of the fissures, and the deposition of the lode-matter may have filled the cavities and prevented the closing together of the walls when the period of circulation of the mineral solutions was at an end.

The order of crystallization of the principal lode minerals, as determined by a number of thin sections, is—

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* *Vide infra*, p. 65.

tourmaline and epidote; then tin ore, followed by quartz, chlorite, pyrite, pyrrhotite, and dolomite, in the order named.

The internal structure of the lodes varies widely from point to point, according to the conditions of deposition.

Most usually the central portion of the lodes has a massive structure, referred to in the preceding paragraph. On either side of the massive portion there are usually zones showing an ill-defined banded structure. These zones are probably due to the metasomatic replacement of successive strips of the country rock.

This banding is remarkably well defined in the lode situated on the boundary between the two sections of the Boulder Company's lease.

Crustification is sometimes seen, but it is not usually well defined.

One matter regarding the lode-structure requires further investigation, viz., the question whether the lode-structure has a determining influence in any particulars over the mineral constitution of the vein-stuff.

The observations of the writer point to the fact that pyrrhotite is only present in the more massive portions of the lode systems.

Where the mineral-bearing solutions have penetrated the country rock alongside the fractures, the only sulphide of iron deposited by them is pyrite. This observation, however, needs to be checked at all points as development proceeds.*

The greater part of the tin ore now being won at North Dundas is being derived from the oxidised portions of the pyritic-cassiterite lodes described.

The tin lodes of the central mining area are of this character in all cases, although the variations from point to point would appear to mark a change of lode-type. The lode-formation, as a whole, must be taken into consideration in such cases.

Some further mention must be made of these lodes in treating of the secondary alteration which they have suffered. The forms assumed by the ore-bodies are also described below.

*** Note.—A variation of mineral constitution with a variation of lode structure has been recorded with regard to the lead veins of the Mt. Farrell district (Bulletin No. 3, Geol. Surv. Tas., pp. 43, 44, 48, and 79-82). The influence of physical structure upon the mineral constitution of lodes is imperfectly understood.**

There are lodes of this type developed in other tinfields, but at North Dundas the separation from the more usual type is so distinct that the description can be given with special detail and certainty.

The same mineral grouping is quoted by W. Lindgren* from W. von Fircks' description of the Mt. Bischoff ore-deposit.

Mr. Waller has recorded veins of this type in his report on the tinfield of Mount Heemskirk,† and mentions the presence there of antimonial silver ores, stannite, and wolframite, in addition to those mentioned above, as occurring at North Dundas.

Messrs. J. B. Hill and D. A. MacAlister have recorded many instances of this vein-type in the tin mines of Cornwall.‡

The Quartz-Tourmaline-Cassiterite Veins.

This second type of stanniferous veins is by no means so uncommon as that type already described.

At North Dundas the exposures of the vein-matter which should be classified here are restricted to the surface and a few shallow trenches and high-level tunnels around the Pine Hill area.

A full definition of the vein-type is therefore difficult to obtain from the evidence of this tinfield alone, inasmuch as those minerals which can be oxidised, or otherwise altered in such a way as to form soluble compounds, have very probably been removed in solution.

Mr. G. A. Waller, in his report on Mt. Heemskirk,§ defines these stanniferous quartz-tourmaline veins in the following terms:—

"These veins consist essentially of a tabular mass of quartz or quartz-tourmaline, containing in the centre a vein, from which the country on either side has become mineralized. Either the vein-rock or the vein-stone may carry tin, but usually the vein-stone is the richer of the two. Tin appears to be associated with both black and green tourmaline; but I think that, of the two, the green is the more favourable. This is also the case at Mt. Bischoff. A little iron, copper, and arsenical pyrites is often present, either in the vein-stone or in the vein-rock,

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* "Metasomatic Processes in Fissure-veins." Genesis of Ore-deposits, A.I.M.E., p. 543.

† *Loc. cit.*, pp. 9-10.

‡ "The Geology of Falmouth and Camborne." Memoir Geol. Surv. of England and Wales.

§ *Loc. cit.*, pp. 8-9.

and in all probability these minerals will be found in all the veins in depth, their absence from the upper portions of the veins being due to the oxidising and leaching action of surface waters. To this list must be added small quantities of bismuth sulphide, wolframite, and, rarely, molybdenite."

This definition answers very closely to that which might be framed to deal with the North Dundas representatives of the type. There is, however, this difference—that the ore of North Dundas is of simpler composition, *i.e.*, quartz, tourmaline, cassiterite, and pyrite. However, as has been indicated, further prospecting may reveal more variety in the composition.

Another portion of Mr. Waller's definition does not appear to stand true before the evidence given by *all* occurrences, although it is almost universally true—the remarks concerning the mineralization of the country rock alongside the veins.

Where the country rock traversed by the stanniferous quartz-tourmaline veins happens to be granite porphyry, this mineralization of the wall-rocks is admirably shown; but the phenomena do not appear to the writer to be of such general occurrence as to justify inclusion in the definition of the vein-type.

Another striking similarity between the occurrences at North Dundas and those at Mt. Heemskirk is the presence in both places of dykes or veins of quartz-tourmaline rock.

It has recently been urged by many writers on ore deposits that there is no essential difference between "dykes" and "veins" of certain types.

In the case of these quartz-tourmaline intrusions the impossibility of making the distinction is admirably shown.

The criteria by which we judge a tabular mineral aggregate to be a "dyke," rather than a "vein," are not definitely established, nor can they be established in such a way as to limit both classes by hard and fast lines.

In the latter stages of consolidation, the residual portion of the magma from which the acidic rocks are derived becomes progressively more siliceous and more aqueous. And when finally the still liquid material is forced out through the cooler rocks, there results a rock which often possesses the characteristics of material which has crystallized out from *solution*. Thus the phenomena of crustification are visible in these rocks.

At Pine Hill the writer did not find any instances of pegmatite veins *in situ*, but fragments showing this crustification were observed. Moreover, the quartz-tourmaline rock which has been referred to has a marked tendency towards the development of this structure. Intrusions of the quartz-tourmaline rock were observed, the outer portions of which consisted of a granular aggregate of the two minerals, while the central portions of the vein showed marked comb-structure.

Nevertheless, these "dykes" or "veins" show, as a rule, only the granular texture.

While tin ore was not actually observed in the latter quartz-tourmaline rock, the writer is fully convinced that the quartz-tourmaline-cassiterite vein-stuff is precisely the same material with tin ore added. That is to say, the tin-bearing veins of the Pine Hill area are merely special cases of the quartz-tourmaline intrusions.

Precisely this conclusion has been arrived at by Mr. Waller for the very similar veins at Mt. Heemskirk.*

Where the stanniferous veins of this class have penetrated the granite porphyry there has in most cases been a very complete alteration of the porphyry rock, and especially of the felspathic constituents of the rock. The felspars are in many cases replaced by an aggregate of quartz, tourmaline, and cassiterite, with, at times, a little pale mica.

The proportion of quartz to tourmaline in the veins of this class is as variable as the content of cassiterite. At times the veins are predominantly quartzose, and the granite porphyry alongside is silicified. Again, the veins may be almost wholly of tourmaline, and the porphyry walls may be tourmalinized.

There is frequently a little pale mica to be seen in the neighbourhood of these veins, and in one place the adjoining porphyry was found to be almost wholly replaced by a micaceous aggregate.

The mica attacks first the felspar phenocrysts, and then replaces the groundmass in exactly the same way in which the tourmaline acts.

These micaceous varieties mark a passage towards the pinitoid-cassiterite veins of Mr. Waller's classification.

In one place on Pine Hill pyrites was seen in the slate traversed by these veins, but it is not certain that the pyrite belongs to the same period of impregnation. It may belong to the period of the formation of the actinolite veins which are present there.

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* *Loc. cit.*, p. 2.

B.—LEAD AND ZINC ORES.

Pyritic Lead Deposits.

A brief mention is here made of the ore-bodies which contain lead and zinc for the reason that a little prospecting work has been done from time to time upon them.

There has never been any regular output of ore from any of these deposits, which are situated within the limits of the tinfield.

Outcrops which show both galena and sphalerite are quite common, but the bodies of ore appear to be narrow, and to lack continuity.

The ore of these outcrops is usually of a massive character, and the metallic minerals strongly predominate over the non-metallic.

The association of the minerals in these deposits is that characteristic of the "pyritic lead deposits."

In most respects the ore corresponds to R. Beck's definition of that vein-type.* But pyrrhotite is usually an important constituent, and fluorite is always present.

In one case (that of the lode located on the western bank of the Ring River, in Section 3658-M) the texture of the ore is quite identical with that of the average pyritic-cassiterite ore, and the non-metallic gangue minerals are well developed.

It is doubtful whether these ores should be considered apart from the pyritic-cassiterite deposits, which, as has been already indicated, contain a small amount of galena and zinc blende. The ore-body in the Ring River valley just mentioned exhibits to a remarkable degree the characters connecting the pyritic lead deposits with the pyritic cassiterite ones.

This being so, any local increase in the amounts of lead and zinc minerals should be regarded, in my opinion, as a local variation in the character of this type of tin veins, rather than as a separate ore-deposit of different origin and character.

While this view of the origin of this class of ore does not imply the belief that no bodies of lead ore of any size may exist, it may account for the abrupt termination of the lead-bearing ore and the reappearance of the more normal (tin-bearing) type.

*** Bulletin No. 3, Geol. Surv., "The Mount Farrell Mining Field," 1908, p. 48. R. Beck, "The Nature of Ore-deposits"; Weed's translation, Vol. I., pp. 235 and 236.**

The proportion of the metallic minerals present in these lodes is very variable, and those which predominate at the various points are indicated on the geological map.

The Garnet-Actinolite Vein.

There is a rather unusual vein of very large dimensions traversing Gormanston Creek at a narrow angle. It is considered in this place for the reasons that it carries in some places a notable amount of zinc blende, and it may be connected in some way with the axinite-actinolite vein-type, which is the next one treated of here.

The vein does not yet appear to be in itself of commercial importance; but it extends into the tin-bearing region of Pine Hill and the phenomena of vein-formation become rather complicated in consequence.

The mineralogical character of this vein is that of a contact deposit.

The predominant minerals are garnet and actinolite, which show a tendency to separate into bands or zones consisting of one or other of these minerals. Other bands of the lode-matter contain quartz, fluorite, calcite, and epidote. These latter are apparently of slightly later date, and have partly replaced the garnet-rock of the previous crystallization.

There is a fair amount of zinc blende in the actinolite in Section 317-M, and in one place galena was observed enclosed within quartz.

Pyrrhotite is common, and in a few places specular haematite was seen in association with garnet crystals. Copper pyrites is also present in small amount.

The structure of the lode seems to account for the zonal arrangement of the constituent minerals. There appear to have been a series of parallel fractures in the slate country along which the vein-matter has entered. By metasomatic replacement of the walls of these fractures a broad lode-formation has resulted, and bands of slate still remain unreplaced.

The cover of the quartz porphyry talus prevents the detailed examination of this vein occurrence, since the outcrops are not well exposed, save at one point.

In the immediate vicinity of this lode a number of narrow veins and lenses of axinite are to be seen in the slate. These may belong to the lode-formation under discussion, and if so they serve to link this vein with that which is next dealt with. It seems highly probable that the two are very closely related genetically, and they possess one very prominent constituent in common—actinolite.

Before passing on from this description it should be remarked that the slate which forms the walls of this lode does not appear in any way different from the normal slate of the district.

No analysis has been made of this slate, which is usually green in colour, but it certainly does not give the impression of being a highly calcareous variety.

The presence of the silicate minerals which carry a high percentage of lime is therefore striking. The conclusion to be drawn is that a large proportion of lime was introduced in the vein-forming solutions, rather than derived from the wall-rocks.

The chemical composition of the garnet in this lode-formation may prove it to be a manganese-bearing variety. This being so, another connecting link with the axinite veins would be established.

C.—COPPER ORES.

The Axinite Veins.

There are a number of occurrences of vein-matter in the North Dundas tinfield in which the prominent vein-material is axinite. Only one of these veins attains considerable dimensions—that which is located near the southern boundary of the northern section of the Boulder Company's lease.

These veins are here classed as copper ores, for the reason that the type is remarkably well developed at the Colebrook Mine, which is situated at a distance of about 4 miles from the centre of the tinfield, and the metal sought in that mine has been copper.

The occurrence at the Colebrook Mine has been opened up to a considerable extent by mining operations, and, in consequence, the vein-type can best be defined from the information gathered at that place.

This has been done by Mr. G. A. Waller,* and a brief summary is here given of his description.

Of the metallic minerals present the most abundant is pyrrhotite, and with this occur pyrite, arsenopyrite, marcasite, and chalcopyrite. Small quantities of galena, sphalerite, and tetrahedrite have been observed. A small amount of gold and silver is present in the ore.

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* "Report on the Ore-deposits (other than those of Tin) of North Dundas," 1902, pp. 1-5.

The non-metallic minerals are axinite and actinolite in most cases, and with them occur smaller amounts of datolite, danburite, calcite, and quartz.

The structure is usually banded, the ore consisting largely of bands, in which axinite and actinolite alternately predominate.

The locality was visited by the writer for the purposes of comparison with the occurrences in the tinfield of North Dundas, and the information gathered was sufficient to establish the essential identity of the vein-types of the two districts.

In the tinfield, however, the work done has been very little, and there is not so much opportunity of examining different portions of the lode-stuff. Moreover, the only deep workings, beside the Government track at the southern end of the Boulder Company's northern section, are now full of water, and the material on the tip is much weathered.

However, the mineral composition seems to be a little simpler than that of the described type.

Axinite is the main mineral represented, and small radiating tufts and aggregates of actinolite are visible in it. The principal sulphide is pyrrhotite, and a little pyrite, arsenopyrite, and chalcopyrite were observed with it.

Numerous other veinlets of axinite in the slate were observed in other places, viz., in Gormanston Creek, and on the eastern bank of the Ring River these veinlets were seen enclosed in gabbro-amphibolite rock.

There are probably a number of such minor occurrences throughout the district, and they do not appear to be of commercial importance.

In all cases the veins appear to belong (with those mentioned above as garnet-actinolite veins) to the great class of "contact deposits."

In this connection it is of interest to compare the remarks of A. Lacroix upon "The Granite of the Pyrenees, and its Contact Phenomena."† Lacroix gives a full description of these axinite rocks, or "limurites," as they have been termed, and compares the Colebrook rock with that of the Peak of Arbizon.

He also mentions that the limurites sometimes merge, on their borders, into garnet-idocrase rocks.

† Bulletin des Services de la Carte Géologique de la France, No. 71, Tome XI., 1899-1900, pp. 56-61.

There are no available analyses of the country rocks alongside these veins, but from their general aspect the writer has drawn the conclusion that they are likely to prove other than highly calcareous. In fact, it is highly probable that they are richer in lime near the lode by reason of the introduction of lime-bearing minerals by the vein-forming solutions.

This is a question which requires solution by the aid of a series of chemical analyses.

The relation of this axinitic rock to the pyritic-cassiterite veins is shown in the old Cornwall workings. There the tin vein is intersected by the axinite vein, and seems to be even a little displaced by the fracture, which is now filled with axinite. Moreover, the tin vein, which is strongly banded at this place, has apparently been split along the direction of the banding near the cross fracture, and axinite is to be seen forming, as it were, a separate band or zone in the lode.

The other occurrences of copper ores on the tinfield are, in my opinion, to be regarded as merely portions of the pyritic-cassiterite lodes, which are locally rich in copper. Such being the case, there cannot be expected to exist any continuous body of the copper-bearing stone.

(4)—The Alteration of the Wall-rock of the Lodes by the Mineral-bearing Solutions.

The solutions, which have been the means of transporting the metallic contents of the lodes from their plutonic source to the position which they now occupy, have to some extent altered the country rock alongside the lodes.

As will be seen, these solutions have penetrated the country rock for some distance on either side of the actual fissures.

In the case of the ordinary varieties of the slate little alteration has been caused by the introduction of the pyritic-cassiterite ore.

The chief change effected is the development of tourmaline along the planes of the more siliceous, and therefore the more porous, bands of the slate. Pyrite accompanies this tourmalinization, and in many cases tin ore. Pyrrhotite does not appear, except in the actual filled cavities in these slates, its place being taken by pyrite where there is actual replacement along the bedding-planes.

In the case of the grits belonging to the slate series, there is a marked development of sericite in some places at a considerable distance from observed fractures. The sericite penetrates the quartzose pebbles, first in the form of numerous needles with a centripetal disposition, and finally replacing them altogether. It is accompanied by pyrite.

Where the quartz porphyry dykes have been attacked by the solutions which introduced the pyritic-cassiterite ore the alteration is very much more marked.

The prominent feature of the alteration is the development of sericite, accompanied in many cases by tourmaline, fluorspar, pyrite, and sometimes a little blende.

This alteration is noticeable, even where the dykes are some chains distant from the ore-bodies; and is due to the ascent of a portion of the mineralizing solutions along the planes of weakness developed by the igneous intrusions. Tin ore is said to have been recovered by panning crushed specimens of this altered quartz porphyry.

The other type of tin ore, characterized by a quartz-tourmaline gangue, is accompanied by a more complete alteration of the walls.

Where the veins occur in the slate the rock in the neighbourhood of the ore is silicified and tourmalinized. Hence it is very much harder than the unaltered slate.

In the case of the quartz-porphyry the alteration is shown first by the replacement of the felspars. Then the groundmass is attacked, and finally the whole rock may suffer replacement.

Where the alteration has proceeded simultaneously from a number of fissure-planes a broad belt of the rock is altered. Moreover, the alteration in successive bands is not exactly the same, since the mineralizing solutions have varied from point to point.

Thus it is that some bands of the altered porphyry are indurated by silicification only. Others are hard and dense, but carry both green and black tourmaline, in addition to the introduced silica. Others show only a replacement of the felspar by aggregates which consist of quartz and cassiterite, tourmaline cassiterite and mica, tourmaline and mica, or mica alone.

In the case of one prominent vein of this type which was enclosed in the gabbro in Section 3650-M, no alteration of the basic rock was observed.

With regard to the other vein-types and their effect on the wall-rocks little information could be gathered for want of exposures. It was observed, however, that the slate alongside the garnet-actinolite vein carries needles of actinolite.

(5) The Structure of the Lodes.

Taken as a whole, the tinfield is remarkable for the complicated character of the lode-structure.

All of the primary ore-bodies have resulted from the deposition of mineral material by solutions rising along circulation-channels which have been formed at a date prior to that of the period of ore-deposition. These circulation-channels are in reality fracture-planes caused by the actual rupture of the earth's crust. The nature of the fractures depends upon the direction in which the strain is applied, the character of the strain itself (whether it partakes of the nature of tension, torsion, or compression), and the behaviour of the various rock-masses under the strains developed.

The various phenomena presented by the different ore-bodies will first be discussed separately.

(*a*) *The Pyritic-Cassiterite Lodes.*—These are extremely complicated in structure in some places and simple in others. The reasons for the complexity are that the slate has proved somewhat readily fissile, along the bedding-planes, and the fracturing has been itself of a rather complex character. The more intricate structures can best be explained by proceeding from the investigation of the simpler structures to those which show many variations from the simple fractures.

(1) The simple "fissure-lodes"* are themselves not common. Certain apparently simple fissures are found to be, at some point in their course, slightly complex, and are therefore grouped in the next class.

The examples which may be cited in this group are the gossan lode in the north-western portion of the area mapped, the greater part of the long lode south of the Melba Flat, and perhaps the greater part of the Dundas occurrence.

(2) The branching fissures are common.† They consist of a main fissure, from which one or more branch fissures extend outwards towards the surface.

The main fissure commonly cuts across the bedding-planes of the slates, and the branch or branches conform for the most part to these bedding-planes, as shown in the diagrammatic section.

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* For the sense in which this term is used see Geol. Surv. Bulletin No. 3, "The Mount Farrell Mining Field," 1908, pp. 55-56.

† See Plate V., Fig. I.

As examples of these branching lodes may be cited:—The "big blow" and the more vertical lode associated with it on the Renison Bell lease; the lode situated in Dalcoath Creek (near its junction with Gormanston Creek), and the narrow lodes exposed in the underground workings at that place; the gossanous ore-bodies in the centre of Section 4550-93M; and the lodes on the Renison Bell lease between the Argent River and the railway-line.

The gossanous bodies which cross the boundary-line between the Boulder Company's northern section and the Section 1273-M (known as the Federal Section) are also very probably two more or less parallel branches connected with a more vertical body.

These occurrences are more fully described in a later portion of this report.

Little work of any kind has been done upon several of these branching systems named, but the constant features presented by them has led the writer to describe them thus.

The more vertical member of the branching system is marked by an irregular gossan, which sheds its fragments on either side. The gossans of the more horizontal members of these systems present in all cases a bluff or wall, away from which the fragments have usually rolled. For the dense gossans have exerted some control upon the topographic features, and as a rule follow the course of the spurs.

(3) The complex "lode-systems" are much more difficult problems. The term "lode-system" is employed, for the sake of convenience, to apply to a number of seemingly separate ore-bodies which belong to the same period of ore-deposition and to a single "fracture-system," rather than to a simple fracture. There are two of these lode-systems developed on the field, and the total area embraced by each will be seen, on reference to the geological map, to be large.

The extent of each of these systems is shown on the map, but further work may show that the boundaries should embrace a still greater area.

There appears to be one point of marked structural difference between the two systems—the difference between the relative proportions of the horizontal and vertical components of each system.

In the Dreadnought-Federal system the more vertical components seem to predominate, while in the Renison Bell-Montana-Boulder system the more horizontal components on the whole are the more important.*

* Contrast Figs. II. and V. of Plate V.

The strike of both systems is similar--about north-west and south-east.

The differences between these two lode-systems are due to the differences in the details of the fissuring.

In the Dreadnought-Federal system the separate fractures which constitute the fissure-zone are, for the most part, approximately parallel to the direction of the system as a whole. Between these separate fractures minor cross fractures exist; and the blocks of slate in the shattered zone have been displaced in all directions, so that the bedding-planes of adjacent blocks dip at different angles, or even in opposite directions.*

The lode-system, as a whole, seems to dip to the north-east at a steep angle.

Such being the correct reading of this structure, the prospecting of the system at various points can most advantageously be carried out by a series of tunnels connected by drives on the ore-body.

Both of the present tunnels which have crosscut this lode-system may yet prove to be started from a point inside the north-eastern boundary of the system.

The generalized view here presented of the system as a whole should be always borne in mind by those engaged in the work of opening up the deposits. For the work of mining tends to cause a concentration of attention upon phenomena which may prove to be only locally important.

The Renison Bell-Montana-Boulder lode-system is still more extraordinary, and it is difficult to find examples with which the system may be compared.

In the writer's experience the most closely-related structural features are presented by the gold-quartz "floors" or flat seams of the Red Hill, Kanowna, Western Australia. But the origin of the structure cannot be identical for both cases. In Kanowna the flat seams connected by vertical "feeders" appeared to me to be due to the impregnation of an igneous rock along a series of contraction joints, the most important of which followed the periphery of the igneous rock.†

The somewhat similar structure in the lode-system under discussion has resulted from the operation of forces having their origin outside of the slate mass.

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* See Plate V., Fig. II.

† Compare the cross section through the Zinnwald granite stock shown by R. Beck, "The Nature of Ore-deposits"; Weed's translation, Vol. I., p. 165.

Whether there has been actual torsion or whether a compression of the crust has caused the complicated series of fractures* cannot, in my opinion, be definitely decided. There is actual displacement between the rocks on either side of some of the fractures of the system, and in some places a wrinkling of the bedding-planes was observed in the neighbourhood of fractures.

Whatever may be the origin of the disturbing force the result has been the production of a lode-system which consists of these component parts:—†

(i) Floors or flat seams of variable thickness inclined at angles varying from 0° to 45° from the horizontal. These are of relatively large extent, and carry the bulk of the ore of the system.

The more important ore-bodies which are to be classed here are—the lode of which the surface is being worked at the Renison Bell Mine; the exposure of pyrites at the south end of the railway cutting on the same lease; the several lodes on the slope towards the Renison Bell Creek in the north-western portion of the Montana section; and the lode of which the surface has been worked in the north-western portion of the northern section of the Boulder Company's lease.

There may be more than one of these "floors" in any part of the system, and certainly two (perhaps three) can be seen at the head of the Renison Bell Creek on the Montana lease.

(ii) "Feeders," or more nearly vertical bodies, which must be regarded as the result of the filling of the spaces or channels whereby the mineral-bearing solutions have risen from the lower portions of the crust, and from "floor" to "floor." For these "feeders" comprise, not only the main bodies which fill the more continuous fractures, but they comprise also the minor veins which connect the different "floors."

The continuity of these bodies, which, taken by themselves, seem simple lodes, does not in some cases seem to be great. They terminate

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* *Ibidem*, pp. 170 and 171.

† Illustrated diagrammatically in Plate V., Fig. V., at the end of this report.

abruptly, both as regards length and depth, in the great majority of cases. Moreover, they are small when compared with the bulk of the "floors."

Examples are to be seen in the railway-cutting on the Renison Bell lease; in the north-western portion of the Montana lease between the "floors" mentioned above; in the tunnel driven under the "floor" in the north-western corner of the Boulder lease; and the highly productive lode in the southern portion of the Montana lease.

The relationship of these feeders to the floors is essential since the solutions which have spread laterally along the floors must have ascended along either a single fissure or a number of smaller fissures, which are connected. In short, the continuity of the system, as a whole, in depth must be regarded as certain. The floors may not be succeeded by other floors in many cases, but yet the lode-system must continue downwards in some form.

The visible major feeders may themselves be the main distributing channels, but this can only be ascertained by further work upon the ore-bodies.

The belt of slate impregnated by veins of pyrite in the railway-cutting at the Renison Bell Mine illustrates most excellently the structure of this lode-system. The scale is very small, but the structure is identical.

(iii) The zones of impregnated slate which accompany the feeders and floors, and arranged usually in the form of a fringe about these other members of the system.

Small fissures occur in the walls of the floors and feeders, and run in all directions through the slate. They are usually filled with lode-matter of the same character as that in the major bodies; and from these cracks and crevices the solutions have penetrated the slates themselves.

It is most noticeable that the impregnation has followed the bedding-planes and almost wholly those of the coarser layers. This is, of course, what would be expected, since the interstitial space in the coarse bands would be greater and the solutions would most easily find their way along them.

This impregnated slate has formed, on weathering, a considerable proportion of the detrital ore which has been worked on the Renison Bell, Montana, and Boulder leases.

Moreover, the whole of the face worked by Messrs. Duncombe and Maddox in the north-eastern portion of their lease presents this character. There is as yet little sign of the presence of the more massive ore-bodies in either floors or more vertical feeders at this place.

Between the several small fissures in these zones of impregnation the different blocks of the slate have their bedding-planes dipping at different angles, and in all directions.

The prospecting which has hitherto been carried out upon the several portions of this lode-system serves to show that tunnelling is of very little value. Both on the Renison Bell Mine and on the Boulder lease tunnels have been driven into the hillsides in the direction of the pyritic-cassiterite ore-bodies, but have gone under them, clearly showing the character of these "floors."

Sinking is the only course open for adoption by the companies desiring to prospect for the presence of other possible floors below those which are visible at the surface.

The writer is of the opinion that such floors will be found if sought; but at what depth below the known floors it is impossible to say.

Therefore, the matter of prospecting by diamond-drilling suggests itself. The diamond drill core would serve to indicate the presence or absence of lode-matter along the path followed by the drill.

It has been already indicated that the distribution of cassiterite in the lode-matter of this type is irregular, so that but little reliance could be placed upon assays of possible ore from a bore core. The core might be from a relatively rich or a relatively poor portion of an ore-body.

Again, the dimensions of an ore-body could not be judged from a core which might represent a boring from a "feeder" or a "floor."

Whether it be decided to bore or to sink a shaft at any point on the lode-system, it would be wise, in the opinion of the writer, to work in a direction at right angles to the known floors at the spot where work is started.

In those cases which could be most satisfactorily examined the "floors" of ore are parallel to the bedding-planes of the slate in which they occur. In this respect they resemble the "branches" of the branching-lodes described above, and in fact the direction of the bedding-planes is in both cases the controlling structural factor.

The lode-system of the variety here described is not essentially different in character from one of the branching lodes, it is merely a little more complex in detail.

Both structural types result from the filling of fissures which have been formed in a rock which has been broken by the operation of external forces, and which has simultaneously opened up along the bedding-planes on account of its ready fissibility in those directions.

Another noticeable structural feature is presented by the lodes on the boundary between the two sections of the Boulder lease. There there are two intersecting veins of the same character, and hence probably occupying fissures which are contemporaneous.

One of the veins follows the bedding-planes of the slate, and the other crosses these at right angles. The former is a flat vein, whilst the latter appears to be nearly vertical. The disposition of these two veins is almost exactly that of the long dyke of quartz porphyry and the shorter (but stouter) arms of the same rock which cross it at Pine Hill.

The suggestion offered is that both the acidic igneous rock and the ore-bodies are the fillings of similar planes of weakness caused by the same crustal stresses.

(*b*) *The Quartz-Tourmaline-Cassiterite Veins.*—These are, on the whole, rather more simple in structure, but yet show some points of resemblance to those mentioned above.

The reticulating veins in the porphyry at Pine Hill are due to a fairly regular jointing of the igneous rock during the progress of contraction consequent upon cooling. The vein-matter has been introduced along the joint-planes, and the rock on either side of these has been impregnated by these solutions.* The chief values, certainly, lie in the filled joint-planes, but there are undoubtedly zones of the impregnated rock which would pay for crushing.

The principal lodes of this district run in a north-east—south-west direction, and have thus far been very little

* See Plate V., Fig. III.

prospected. At one point, near the mouth of the tunnel which is being now driven into Pine Hill, there is a suggestion of the existence of a cross-fracture traversing the main one almost at right angles. The slate is certainly indurated along a direction nearly north-west and south-east; while the main vein at that place strikes north-east and south-west.

(c) *The Other Veins.*—The strike of the other lodes is shown where possible on the map. None of the occurrences are of great importance, and very little work has been done upon them.

(6)—The Secondary Alteration of the Lodes.

By the operation of meteoric water upon those portions of the ore-bodies which are at or near the surface of the ground certain chemical changes have been wrought. The result is that the outcrops of the ore-bodies are altered from the above-described primary condition. On the whole, the structure and texture remain, but the mineral composition is altered.

The pyritic-cassiterite ore suffers the most obvious changes. By inspecting the various exposures along the Renison Bell-Montana-Boulder lode-system the processes of alteration can be studied in all their stages.

The chief feature of the early stages of alteration is the change of pyrrhotite into marcasite and limonite. Marcasite is always present on the surface of the exposed "floors" of ore, but the writer failed to recognize any in the primary ore. The conclusion arrived at was that the formation of marcasite marked an intermediate stage in the processes of alteration. Moreover, since pyrrhotite is absent in the crust containing marcasite, and whereas it is the most abundant constituent of much of the primary ore below, the marcasite is formed from the pyrrhotite.

The marcasite itself rapidly decomposes and is carried away in solution, leaving first a honeycombed quartzose lode-stuff in which well-defined cubes of pyrites wrap round many of the quartz crystals.

The pyrite itself finally disappears, and there remains a honeycombed aggregate of acicular quartz crystals, in which tin ore is sometimes visible. Where the quartz crystals are numerous, and to some extent intergrown, the lode-matter retains its original texture, but where the primary ore has been more pyritic and less quartzose there results a friable mass of quartz crystals which readily crumbles away.

The oxidised ore which is sluiced off the surface of these weathered floors consists, then, in part of minute granules of tin ore and small acicular crystals of quartz.

There may result in this way a certain concentration of tin ore, by the gradual removal of those portions of the ore-bodies which are susceptible to alteration. It should, however, be remembered that, as far as the tin ore is concerned, the concentration is entirely of a mechanical nature. The tin ore is not dissolved and reprecipitated upon the horizon where it is now found in the same way as some ores of lead and copper are.

The tin ore in these weathered floors represents (with the exception of that portion of the ore which is carried away by the streams) the tin contents of the disintegrated lode-stuff above it. In many cases the depth of disintegrated ore cannot be large, and yet the returns on sluicing the surface floors have been highly profitable. The conclusion to be drawn is that the tin contents of the yet undecomposed portions of the floors are far from negligible, although no attempts have yet been made to sample the pyritic bodies systematically. This must be done by the present companies working on the oxidised ore, for the oxidised ore cannot be expected to give more than a temporary supply of ore for treatment.

The zones of impregnated slate which occur in the lode-system which has been mentioned, have, in the weathered zone, lost their content of pyrites, and carry, along the bands of coarser grain, cubical cavities after pyrites crystals.

Since these impregnated zones of slate also carry tin ore in places it follows that the unoxidised pyritic slate should be sampled and assayed. There is absolutely no doubt but that this slate, with the cubical cavities distributed along the bedding-planes, has been charged with pyrite. In spite of the statements made to the effect that actual pyrite has not been seen, there is no possibility of doubt; for in some of the larger cavities the characteristic striæ of the pyrite crystals can be seen to have left their imprint upon the walls of the cubical cavities.

While it may be granted that the great bulk of the ore has been undoubtedly of a pyritic character, there is one variety of lode-matter associated with these deposits which has fostered the hope that some of the ore at least has been always free from pyrites. This ore is dense, brown or grey in colour, and has the texture, to the naked eye, of a quartzite. The largest masses of it occur on the Boulder lease, where they have been regarded as boulders derived from some other lode or part of the same lode higher up the hill. There have also been found a few small specimens of similar ore on the Renison Bell lease, to the south-east of the present workings. The ore is valuable, bulking, on the Boulder lease, as much as 53 per cent. of metallic tin, and J am informed that some of this tenor has been broken up and sent to the smelters.

The so-called boulders are not of secondary origin; they have been left standing above the level of the more easily disintegrated lode-stuff by reason of their superior hardness and compact texture.

On microscopical examination the ore proves to be mainly a granular aggregate of quartz tourmaline and tin ore. The tourmaline is not abundant, and the only other constituent is limonite. The latter appears to have been derived from pyrite, which has been present in small amount through the ore. Some limonite-stained cavities remain to mark its former presence.

So the ore cannot be regarded as anything but a local variant of the general type, and it does not appear abundant enough to ever prove important.

The gossans which result from the oxidation of other pyritic-cassiterite bodies in the district may seem to be due to the alteration of another type of vein than that described above. For it has been indicated that the iron content of the "floors" has been not only oxidised, but also completely removed from the surface portions of the formation at least.

The reason for the absence of iron in the form of limonite in the oxidized floors is given by the known interaction between organic acids and the oxidised iron compounds.* The thick growth of vegetation which has covered these deposits has had the effect of rendering the surface-water capable of dissolving out the iron compounds. The roots of the vegetation are to be seen penetrating the upper portion of the lode-system in all directions. In the case of the more vertical bodies of ore and those dipping into the hills the area exposed to such action at the surface is relatively much smaller than in the case of horizontal bodies or those dipping with the hillslopes, and the iron content of the lode-formation is preserved in the form of gossan. For instance, the vertical "feeder" from which so much tin ore has been recovered in the southern portion of the Montana section retains much of its iron content as gossan.

* A. Geikie, "Text-book of Geology," 1903, Vol. I., pp. 598-599.

The relation of the quartzose ore lying above the "floors" and the gossans to the unoxidised pyritic ore is shown diagrammatically elsewhere.*

The gossans which result from the oxidation of the simple or branching lodes are of normal character, and from their general appearance led early prospectors to examine them for lead and silver contents only.

The prospecting of these gossans more recently has not been, in many cases, thoroughly carried out. Too much reliance has been placed upon samples very roughly taken.

The tin contents of the gossans cannot be leached out by atmospheric waters, but the iron contents of all gossans are redistributed in a very irregular manner. Thus, if care is not taken to expose the ore-body proper before sampling, fragments containing the reprecipitated iron oxide only may be selected, and with them tin ore may or may not occur.

It is known that some of the gossanous ores are extremely rich in cassiterite, notably rich specimen-ore being obtainable from the "big blow" and from above the river tunnel on the Renison Bell lease, from the old Cornwall workings, and from the main outcrop on the Dreadnought lease.

Before passing on from the question of the gossans, one more point may be noticed. At the "big blow" workings on the Renison Bell Mine the inclined ore-body called the "big blow" is more or less completely oxidised, while the more vertical ore-body encountered in the underground workings is, on the same level, unoxidized. This may perhaps be due to the geological structure. It seems possible that the inclined lode should catch the surface water, and let it sink downwards, running all the way over the ore and finding an outlet along the direction of the junction of the "branch" lode with the "stem."

It may therefore, in my opinion, be expected that oxidized ore will be found for some distance into the face of the hill above the junction of the "branch" and "stem" in both portions of the branching system. The progress of such oxidation is indicated in the diagram referred to.*

Some other oxidized ores were met with that are due only to the action of surface waters. The most notable occurrence is that of native copper, azurite, malachite, and covellite at one point in the bed of the Argent River where a small stream issues from the gossan on the northern bank. This is certainly due to the deposition of the copper-

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* See Plate V., Fig. IV.

bearing minerals, which are the result of the weathering of chalcopyrite in the pyritic-cassiterite ore. The actual copper pyrites has not been seen at this period, but it is known to be a constant constituent of the ore-bodies of this type.

Chalcanthite and vivianite were observed on some of the joints and weathered surfaces of the ore.

(7)—The Secondary Ore-deposits of North Dundas.

By the term "secondary," as applied to ore-deposits, it is implied that the ore-deposits thus described have resulted from the operation of chemical and mechanical forces upon primary ores.

A.—TIN ORES.

1. *The Residual Tin Ores.*—Consequent upon the chemical alteration of the floors of pyritic-cassiterite ore and the mechanical action of water there have been formed a number of deposits which are commonly referred to as "alluvial" deposits.

But the constituents of these deposits have not moved any appreciable distance, and they retain, on the whole, their original character. Thus, well-formed crystals of quartz are common, and the fragments of vein-matter and country rock are alike angular.

A large proportion of the tin ore in these deposits is excessively fine in grain; and it would indeed be remarkable if quite a considerable proportion of this cassiterite-slime has not been removed and distributed far and wide by the surface waters. It is possible to find this slime tin ore in the surface soil of the district, as, for instance, on the north-eastern slopes of the Dreadnought Hill.

But a great portion of the tin ore has remained, and these deposits have constituted for some time the principal sources whence the output of the field has been maintained.

The vegetable cover has, no doubt, largely assisted in keeping the residual matter from sharing in the general degradation of the district.

The residual deposits are for the most part restricted to the Renison Bell-Montana-Boulder lode-system, but ore of essentially similar character has been worked on the boundary between the two sections of the Boulder Company's lease and at several points round Pine Hill. In almost all cases the residual deposits are from the disintegration of lode-matter enclosed within the slate. However, some of the shallow deposits lying on the quartz-porphyry containing reticulating veins of tin ore have been really residual deposits, since the tin ore has remained practically where it was deposited by the vein-forming solutions.

2. *The Alluvial Tin Deposits.*—The early workings on the tinfield were all on the alluvial ore, which filled the gorges carved out by the Dalcoath and Gormanston Creeks. A portion of Dead Man's Creek has also been worked, and the greater part of Penzance Creek. Little now remains of the true alluvial ore, save near the junction of Dalcoath Creek with the Ring River, where only the central gutter has been worked out.

The tin ore in this area has almost wholly been derived from the Pine Hill lodes, and the rounded pebbles which predominate in the alluvial deposits are formed of the tourmalinized quartz porphyry of that district.

No doubt some contribution of tin ore has been made to the lower portion of this alluvial deposit by that branch of the Dalcoath Creek which traverses the south-eastern portion of the Renison Bell-Montana-Boulder lode-system. Nevertheless, the greater part of the tin ore comes, in my opinion, from Pine Hill.

The most notable feature about these alluvial deposits is the occurrence in the Gormanston Creek of some very large nuggets of tin ore. These are all similar in character, and consist of a crystalline aggregate of quartz tourmaline and cassiterite in variable proportions. Microscopically they show no further details, and are, in my opinion, formed of semi-waterworn fragments of a lode situated in the slate country.

The largest boulders were obtained at a point 2 chains north of the southern boundary of Section 317-M, in the bed of the creek.

Altogether, several tons in weight of these "Gormanston boulders" were obtained at this place, and smaller ones were recovered at various points for several chains down the creek. The largest boulder weighed some 19 cwts., and has been preserved in the Tasmanian Museum, Hobart.

Precisely similar ore occurs right down to the junction of Dalcoath Creek and the Ring River, but the specimens at this end of the creek are all small.

The small creek running into the Argent River in Section 1945-M contains a little tin ore at the north-western corner of Section 4550-93M, but not in sufficient quantities to justify any work being done at that point. This ore is undoubtedly derived from the gossan body in the immediate vicinity.

There is a little alluvial ore in the creeks which run into the Ring River from the eastern slopes of the Dreadnought and Stebbins' Hills. The ore is derived from the lode-system traversing the slopes of those hills.

In the immediate vicinity of the sawmill on Melba Flat there is a small amount of tin ore in the recent alluvial of the flat. Since it does not occur in the upper part of the alluvial deposit the tin ore must be considered to have been shed by the gossanous formation which crosses the hills to the south of the flat.

The Dundas Rivulet near the town site of Dundas has a shallow fringe of alluvial material, in which some tin ore occurs. The deposit is not of any great extent, although on Section 3765-M the grade of the ore is good. The ore here, too, is of local derivation.

In the centre of the deserted town site of Ringville an alluvial deposit of recent date has been worked. The source of this ore is very probably the tin-bearing formation on Section 453-M; and the old workings in Great Northern Creek were probably on ore which had a similar source.

None of these alluvial deposits extend beyond the immediate vicinity of the lodes, which are known to carry the tin ore. Moreover, there is seldom any admixture of other material with the tin ore than fragments of the wall-rocks of the lodes.

But in the case of the broad alluvial deposit of the old Pieman River we find constituents of all the rock-formations in the whole district represented. The more permanent minerals from these rocks occur with a small proportion of tin ore throughout the whole breadth of the formation.

Thus, chromite and colours of osmiridium and gold are all recovered with the tin ore when prospects are being tried with a tin dish.

The reason for the variety of the metallic minerals present is given by the mode of origin of the alluvial formation as a whole. It has been shown that the deposit formed the floor of the matured valley of the Pieman River, and that it contains the fragments of the rock-formations traversed by the tributaries of that river.

The tin ore varies considerably in the matter of grain, the fragments sometimes attaining a diameter of three-quarters of an inch. This tin ore is not often absolutely pure, but contains a small content of quartz and tourmaline. The majority of it appears to me to have been won from the central area of the tinfield and from Pine Hill. There are many rich patches in the pyritic-cassiterite deposits, for example, in the Renison Bell, Dreadnought. and other leases, which would on disintegration produce nuggets like those recovered from the alluvial.

The widespread character of this alluvial has suggested to many the idea of treating the formation as a whole for the tin content.

This does not seem to the writer to be practicable, since the water-supply in the district is insufficient for sluicing on a large scale; and the deposit does not appear sufficiently rich to admit of being treated as a whole on any but an enormous scale.

Where there has been a secondary concentration of ore in the beds of the small creeks traversing this formation deposits of better grade have been formed, but these are small in extent, and have only produced a limited amount of ore.

The deposit of alluvial which carries tin ore may be expected to extend for some distance beyond the limits of the area here mapped.

The principal creeks which have been worked for tin ore within this formation are Isaacson's Creek and the small creeks which take their rise in the button-grass plain to the north of that creek.

B.—OSMIRIDIUM AND GOLD ORES.

1. *Gold.*—Brief mention has been made above of the presence of both gold and osmiridium in the alluvial tin deposits of the old Pieman Valley.

With regard to the origin of the gold it is difficult to pronounce an opinion. Very little can have been afforded by the pyritic-cassiterite lodes of the tinfield, and these alone can be the local sources of gold. It seems to the writer more probable that the majority of the gold has been derived from the lodes situated a few miles to the eastward of the centre of the tinfield. An objection to this view has been offered on account of the difference in assay value between the gold of the alluvial and that of the lodes of North-East Dundas. The lode gold is of lower grade than the alluvial gold.

This is not exceptional; it is, in fact, usual to find alluvial gold of a higher degree of fineness than vein gold, even in cases where the presumption is very strong that the latter has been the source of the former. The difference in fineness must have been caused by the intervention of chemical action.

Taken as a whole, the alluvial deposit of the Pieman River cannot be considered likely to prove of value, but a few ounces of gold have been won by prospectors while working for tin ore in Isaacson's Creek.

In the alluvial deposit on the Melba Flat there is gold, and a large number of prospectors have been at work there at different times. The writer did not attempt on this occasion to solve the problem of the origin of the gold.

2. *Osmiridium.*—The presence of osmiridium with tin ore seems at first sight curiously anomalous; for it is usual to think of osmiridium as being associated with basic or ultra-basic igneous rocks, and of tin ore with those of acidic character. The anomaly is dispelled by the explanation which has here been given of the association of these two groups of igneous rocks. The acidic and basic rocks of the district are in very close proximity, and the ores which are genetically associated with each group have intermingled in the alluvial deposits.

Chromite is in all cases the common associate of the osmiridium, and gold is usually present.

Very little osmiridium has been won from the tinfield proper, but a number of ounces have been recovered from the creeks situated a short distance to the northward of the area represented on the geological map.

Mr. J. Riley, who has done a large part of the prospecting of this area, kindly offered to show me over the country, and I was thus enabled to make a flying visit to the district. The following brief notes on the occurrence are the result of that visit.

The creeks which carry the largest proportion of the osmiridium are those which traverse a broad belt of serpentine lying to the north of the area included in the geological map, at a distance of about a mile from the junction of the Pieman and Huskisson Rivers. This serpentine, at its southern boundary, has a bearing about W.N.W.-E.S.E., and appears to be continuous for some considerable distance.

The Pieman alluvial comes right up to the edge of the serpentine, which forms a series of low hills.

In mineralogical character the serpentine does not appear to differ essentially from the other occurrences of the rock in the district. It varies in colour from dark green to a dull greenish-yellow, and from the weathered surfaces crystals of chromite sometimes stand out in relief.

The surface of much of the serpentine is entirely covered by a dense crust of residual limonite; a fact which led to the pegging of the whole outcrop in the boom days by inexperienced prospectors who thought the iron oxide to be the gossan of a large lode-formation.

Those creeks which have been worked have proved payable only within the boundaries of the serpentine itself or in the slate which is but a few chains distant from the serpentine.

The extraordinary feature of these "alluvial" deposits is the almost complete absence of "wash." The creeks have for the most part clean smooth beds, with occasional deposits of sedimentary material an inch or two in depth. The osmiridium is recovered by scraping up the bottoms of the creeks, which consist, as a rule, of soft decomposing serpentine. There are numerous limonite-stained crevices in the bottoms of the creeks, and these act as natural riffles and hold the osmiridium. Especial care is therefore taken to clean out these crevices.

In one place I was shown a couple of bags of tin ore which had been won while sluicing for osmiridium, but not removed on account of the difficulties of transport. This tin ore is doubtless the result of secondary concentration from the Pieman alluvial, which is near at hand, and which may even have extended over this locality before the drainage system acquired its present development.

The origin of the osmiridium is undoubtedly the serpentine rock, although no specimens attached to fragments of the rock have been seen. The mineral is probably disseminated throughout the body of the rock, and not restricted to veins, as most other metals are. The workable deposits, therefore, will only be alluvial deposits.

The other streams taking their rise in this serpentine are all worth examination for osmiridium.

In other parts of the field there are small quantities of the same mineral, but, with the exception of some said to be present in the Melba Flat, all the colours are derived from the old Pieman alluvial formation.

As regards any other contributing source than that body of serpentine mentioned above, the writer regards the broad dyke of serpentine which traverses the western flank of the Colebrook Ridge as the most likely. The streams which flow towards the Ring River are worth prospecting for osmiridium.

C.—IRON ORES.

There are some occurrences of the ores of iron which have been regarded by some as possible economic sources of iron.

The principal occurrences are classified here, since they are formed of residual limonite due to the weathering of ferriferous serpentine. The limonite forms only a superficial crust, and is not likely to prove of any commercial value.

It is best developed on the serpentine area near the junction of the Pieman and Huskisson Rivers which has just been mentioned, and on the southern slopes of Serpentine Hill, near the Argent tunnel.

At this latter place there are a number of fragments of columnar magnetite from the disintegration of veins in the serpentine. The veins are as much as a foot thick in places, if we may judge by these fragments, and in some cases the columns are curiously contorted. The specimens are of interest for the marked polarity which they display, but are not likely to prove of value.

The origin of this magnetite is to be explained by the transformation of a rock rich in ferrous compounds into serpentine.

The chromite in the Pieman alluvial and in all the creeks which flow away from the basic rocks is too small in amount to be of commercial importance.

One occurrence of iron ore on the eastern slope of the ridge running down from Pine Hill to the junction of the Ring River and Dalcoath Creek is probably to be classed as a gossan rather than a residual iron ore. A small gold content having been found in some of this ore, it has been proposed to work it for fluxing purposes.

(8).—Summary of the Genesis of the Ore-deposits.

At the close of the period here provisionally termed Cambro-Ordovician the site of the field was occupied by a great sedimentary series, of which the lower members were intruded by intrusive types, and the upper members interstratified with the effusive types of a rock which is usually a quartz porphyry or a felspar porphyry. The ore-deposits of the whole field were quite unknown.

Following upon the prolonged period of sedimentation, some great earth movement took place, and the sediments acquired a certain schistosity or slaty cleavage, while the igneous rocks were also rendered schistose and suffered an alteration and reconstruction of their constituent minerals

Into this complex, after some considerable interval of time which is not recorded in the formations of the field, there intruded a great igneous magma.

Whether the earth movements of prior date had caused any directions of crustal weakness by which the distribution of the igneous material was governed is not now certain. As far as the geological map can explain the structure, no such general directions of weakness can be detected for the earlier phases of the intrusion. There was an intrusion of molten material into the deeper portions of the earth's crust, and this material began to solidify in amorphous form. From the processes of consolidation resulted the basic rocks of the district in all their variety, and at this period the osmiridium first appeared in the district.

The mechanical stresses of intrusion, possibly aided by other stresses, seem to have caused a more or less regular fissuring of the central portion of the field, and a more irregular fracturing of the surrounding district. This fissuring was not utilized by the early magma itself save in one instance, where a long narrow dyke of gabbro was formed. But the fissures became of prime importance at a later date when they became filled first by the quartz porphyry and later by the ore-bodies of the field.

As solidification proceeded the magma appears to have altered very materially in composition, and finally a highly acidic type was evolved. This penetrated the deeper portions of the crust in the form of dykes of quartz porphyry and granite porphyry. And still the magmatic reservoir continued to differentiate until quartz, tourmaline, and sometimes tin ore were forced upwards. At about this time also the vein-forming solutions were given off, and they rose through the fissures mentioned above into regions of lower pressure and temperature, where their mineral contents were precipitated. The pressure must have been exceedingly great, even where ore-deposition took place, and the solutions probably forced apart the fissure-walls until free crystallization was possible. The internal evidence of the ore-bodies affords proof of this free crystallization, and the pressure conditions may be deduced.

For it is now known that certain lode-forming minerals are characteristic of certain zones of depth or types of veins.* Taking the vein-types of this field, it will be seen

* *Vide* W. Lindgren, "The Relation of Ore-deposition to Physical Conditions"—Economic Geology, Vol. II., 1907, pp 105 *et seq.* Also, W. H. Emmons, "A Genetic Classification of Minerals"—Economic Geology, Vol. III., 1908, pp. 611 *et seq.*

that the mineral groupings are characteristic of "contact metamorphic deposits," or the "deposits of the deep-vein zone."

With this period of ore-deposition, which eventuated in Devonian time, the genesis of the primary ore-bodies ceased.

No feature of importance to the economic side of the geology of the field was impressed upon the district until the agents of denudation had removed so much of the cover as to expose the deeply seated ore-deposits to surface weathering and degradation. Then the period of disintegration and redistribution of material began, and proceeded steadily until a matured river system—that of the old Pieman—was evolved; and deposition of the load of material gathered from the hills began. This proceeded for some considerable period, and the conditions were altered by an uplift of the western portion of Tasmania, whereby the river systems were revived. This latter period has lasted up to the present time, and during it the secondary ores have been formed and reconcentrations made of the contents of the older alluvial.

VI.—THE HISTORY OF MINING ON THE FIELD.

The mining history of the field dates back to about 1890, when many prospectors were traversing the district. During this earliest period of prospecting little, if any, thought was entertained of the possible presence of tin ore; and attention was given first of all to any gossanous outcrops which might, in the opinion of the prospectors, prove to be the cappings of silver-lead ores.

It is probable that some of the early workings, of which no history can now be obtained, belong to this period. Tunnels were driven for short distances, and then the sections were abandoned, for the silver contents of the gossans proved always low.

The tunnel driven into the Dreadnought Hill is an example of these workings which is notable, in that the rich tin-bearing lode-stuff was actually penetrated without its character being recognized.

The first actual discovery of tin ore on the field was made in June, 1890, when Mr. Ringrose Nicholson found tin ore in the Ring River, in the neighbourhood of its junction with Dalcoath Creek. This discovery was not followed by any active mining operations at the time, and little notice was taken of it until a temporary set-back in the Zeehan field caused a number of men to look for work which would tide over the bad times. Payable alluvial tin ore was then found, and the prospectors followed the course of Dalcoath Creek and Gormanston Creek up to Pine Hill. In the course of this prospecting the lode-formations on the Boulder Company's ground were found, and some work had been done on these at the time of publication of Mr. Montgomery's report in 1893.

The Gormanston boulders were discovered by Mr. T. Strong in November, 1893, but no rush resulted, as tin was at that time at a low price.

Between this period and that of Mr. Montgomery's later visit in 1895, the work of prospecting the lodes was restricted mainly to the ground now held by the Boulder Company and by Mr. A. D. Sligo.

The prospecting of the Renison Bell lease had been begun, but it does not seem to have been fully appreciated at that time that the gossan outcrops were the cappings of tin ore-bodies. In fact, the report of Mr. Montgomery includes a strong recommendation to the company to test the lode for tin and gold.

The next important step in the development of the field was the construction of the Emu Bay Railway, which was carried through in 1900, and a connection was thus made with both Zeehan and the remainder of the island.

The railway-line necessitated a large cutting on the Renison Bell lease, which actually penetrated the main lode-system on that property.

There was still little progress made in any part of the field, and little activity was displayed until, in October, 1905, the detrital tin deposits were first revealed by Mr. H. E. Evenden's discovery of payable ore on the Renison Bell lease.

This was the beginning of the present period of mining the surface of the pyritic floors.

The other end of the Renison Bell-Montana-Boulder lode-system (which at that time was only known in the Renison Bell ground) was found by Mr. A. Duncombe in the north-western portion of the Boulder Company's lease in May, 1906.

In view of these discoveries it seems remarkable that no attention had been paid to the gossan outcrop on the Dreadnought Hill. It remained for Mr. H. E. Evenden to recognize the possibilities of the gossan in February, 1908, and since that discovery the Dreadnought-Federal lode-system has been prospected at several points.

Still later, in 1908, tin ore was found near the Dundas town site by Messrs. P. Quinn and P. Hodge, who are now prospecting their discovery.

VII.—THE MINING PROPERTIES.

(1)—The Renison Bell Prospecting and Mining Company, No Liability.

The company's property consists of a number of smaller sections now united to form the consolidated lease, No. 3187-m, consisting of 181 acres in all; and a water-right, No. 408-w, for eleven heads of water in the Argent River.

This large lease lies mostly on the southern side of the Argent River, and comprises the summit and slopes of the Renison Bell Hill, which are steep, and are traversed by no streams of any importance.

The creek known as Porphyry Creek affords the small amount of water now used in the sluicing operations; but this small supply will prove quite inadequate when operations are being conducted on a larger scale, and the company must look elsewhere for a source of power and water. The Argent River, which runs through the northern portion of the property, will doubtless be drawn upon to supply the necessary water, but it is doubtful whether the remaining available water-rights on this river can supply the necessary power for a milling plant.

The rock-formations represented within the lease are members of the slate series, porphyroid, and sericitized and tourmalinized quartz porphyry.

The members of the slate series are broken up and folded by earth movements subsequent to their formation, and it is not possible to state an average value for their dip and strike. Adjacent blocks are found to dip in entirely different directions, and the railway-cuttings show that, in addition to the fracturing and dislocation of the sediments, there has been a gentle folding. Nevertheless there cannot be said to be any regular general folding into anticlinal and synclinal folds. One railway-cutting immediately to the west of the lease shows this structure, which is, in my opinion, a local, not a general, feature.

A well-defined fault is shown in the railway-cutting which has traversed the main lode-system, and the result of the faulting has been to lower the western portion of the country relatively to that on the eastern side of the fault. The amount of the movement is not to be ascertained, but it has sufficed to bring the conglomerate down on to the same level as the slate.

This fault-plane is itself important, in that the fault-breccia which marks its position has been impregnated by pyrites. It is this fault-breccia which has been called by the company the "cross lode." The capping and weathered portion are stanniferous, but whether tin ore is present in the railway-cutting seems to be unknown.

In my opinion this plane of dislocation is one of the "feeders" referred to above, and further work on the property may prove that the main lode which has been cut in the underground workings is one and the same with this "cross lode."

The property contains within its boundaries a number of lodes which at first sight appear to be separate bodies of ore. They are, however, to be more properly regarded as belonging to a smaller number of lode-systems which present a variety of structural detail.

These are here referred to as—(1) the low-level lode-system; (2) the "big blow" lode system; (3) the western lode; (4) the gossan outcrops north of the Argent River.

(1) The "low-level lode-system" is the title here applied to the lode-matter now being worked on the north-eastern slope of the Renison Bell Hill, the lodes which are exposed in the Emu Bay Railway cutting, and the lode-matter partly worked between the railway-line and the Argent River.

The underground workings at the river level are fully described in Mr. Twelvetrees' report on the property in the year 1906.

Briefly, they are as follow:—A drive has been carried southwards on the footwall of a gossan lode visible at the river bank, and crosscuts have been put out east and west.

The western crosscut met with nothing but country rock (soft slate), although there is a mass of dense gossan vertically above it. This gossan, called the "No. 1 lode," dips at a very flat angle to the east, and the western crosscut has been driven below the level of this flat lode.

The first eastern crosscut passed through two zones of lode-matter, the more westerly being an admixture of gossan and clay, the second a silicified slate carrying pyrrhotite.

The second eastern crosscut passed through both these formations. The gossanous one is contracted, but the hard siliceous lode is associated with a very broad belt of dolomite or ankerite, with which is associated a little pyrrhotite. This carbonate lode, is, as has been indicated above, apparently due to merely a local variation in the character of the mineral-bearing solutions at the time of the formation of the lodes. The normal pyritic body was cut through in the last few feet of this crosscut, and another small vein of dolomite found on the hanging-wall.

Driving was resumed in a south-easterly direction on the hanging-wall side of the lode. After driving for 60 feet in the hanging-wall a short crosscut has been put in to cut the lode, which carries both quartz and carbonates as gangue minerals at this point. The drive was carried another 60 feet and crosscuts driven towards the north-east and south-west. The latter cuts the continuation of the pyritic body already mentioned, and on passing through it a few odd splashes of galena associated with ankerite were met with.

The north-eastern crosscut was abandoned in very hard pyritiferous slate at a point 70 feet from the hanging-wall drive, when it had not been carried far enough to cut the massive pyritic lode exposed in the railway-cutting above this point.

These underground workings have not served to prove anything conclusive with regard to the main lode. It is to be regretted that the drive was not pushed forward in the lode itself, rather than in the country. The cost of working would have been greater, but the information to be obtained from a drive on the course of the lode would have more than compensated for the increase of expenditure. As it is, too little has been done to show the mode of distribution of the tin ore in the pyritic lode.

The railway-cutting, almost vertically above the most southerly portion of these underground workings, affords an excellent section of the lode-system. There exists to the eastward of the zone, partially exposed underground, a very dense pyritic body of the pyritic-cassiterite vein-type. This pyritic lode is 24 feet in width at the level of the rails, and on either side of it is a belt of altered and fissured slate impregnated with pyrites. The eastern zone of pyritic slate is some 11 feet wide, and the western 46 feet in width. It is this impregnated slate which shows the elaborate system of "floors" and "feeders" on a small scale with the same structure as the lode-system when viewed as a whole. The officers of the company have taken a sample over a width of 40 feet at this point (including the dense pyritic lode and the impregnated slate on either side of it), and I am informed that the sampling gave most encouraging results. Nevertheless, it would be unquestionably better to take a number of samples over shorter sections of the ore-body than to take a single bulk sample in the way that has been done.

The massive pyritic lode appears to be continuing downwards at the level of the rails, yet it does not reach the surface only a few feet above. It is capped with indurated pyritic slate similar to that occurring on either side of the pyritic body. No anxiety need be felt by the management at this failure on the part of the pyritic lode to reach the surface, for the lode is a "feeder" in the lode-system; and although the continuity of one member of the lode system may fail abruptly at a given point the continuity of the system as a whole must exist, even if the other portions of the system are not, in the present state of development of the mine, apparent.

The fault-fissure, which is filled with brecciated fragments of slate and impregnated with pyrites (the "cross-lode" referred to above), lies 128 feet to the west of the pyritic lode in the railway-cutting. It is 10 feet in width, and shows a notable development of quartz and pyrites on the footwall (western) side. The fault can be traced northwards from the railway-line for a distance of 100 feet on the surface, where its course is marked by an outcrop of quartz.

Southwards it cannot be followed with certainty, but may possibly be connected with the quartz veins to be seen on the crown of the ridge in the uppermost portion of the area stripped by sluicing operations. The strike of the fault-plane at the cutting is N. 45° W.

Tin ore can be seen in the weathered portion of the sandstone and conglomerate, which form a nearly horizontal series resting conformably on the slate on the western side of the fault-plane.

The ore is largely confined to "heads" or joint-planes, and on the whole is not abundant. Where unweathered, in the railway-cutting, the conglomerate is seen to be impregnated with pyrites and indurated by the introduction of silica; both the pyrites and silica having apparently been simultaneously introduced.

The rock weathers to a white friable sandstone or conglomerate, and this character has given to the formation as a whole the name of the "white lode." Below these layers of conglomerate and sandstone, and apparently conformable with them, the railway-cutting exposes the surface of a dense pyritic floor. Whether this pyrites carries tin or not is not known.

A little higher up the hill, above the railway-line, there have been put down a few shallow shafts, which met with a soft tin-bearing formation. This may be the result of weathering upon yet another member of the lode-system lying to the west of the "cross lode." The shafts were full of water during my visit, and could not be examined.

No pyrites is visible above the railway-line, but the cubical cavities in the weathered conglomerate prove beyond doubt its former presence there.

The pyritic "floor" of the railway-cutting is very probably connected with the "cross-lode" a few feet below the level of the rails, the fault-plane having been the channel by which the mineral-bearing solutions rose and spread out laterally to form the "floor."

These details yet remain to be proved, but there can be little doubt about the suggested relationship of the several members of the system referred to.

From the portion of the lode-system which lies between the railway-line and the river the detrital ore has been removed by sluicing.

There is yet another portion of the lode-system exposed at the surface on the western side of the "cross-lode." This is a dense gossan, which appears to constitute another flat floor, differing from the flat seam of pyrites in the railway-cutting in that it is completely oxidised. Its tin content, if any, is not known. The gossan junctions with the main lode near the mouth of the main river tunnel, and a little above that level.

The only other workings below the railway-line on the lode-system above described are situated near the mouth of the main adit.

A second short tunnel has been driven in a south-westerly direction. In the approach a vein of rich ore is said to have been passed through, and a winze put down here on the lode. This, however, has since been filled in. Although the tunnel is apparently on the line of the lode intersected in the main adit to the westward, no ore-body was encountered after that mentioned as being in the approach. The main lode-fissure may have bent abruptly, or it may have ceased abruptly in the manner described in another part of this report. It is also possible that a fault may have caused a dislocation, and that the northern portion of the lode has been moved a few feet to the westward.

A small open-cut has been started on the outcrop of the pyritic body at the river level, and from the gossan some 5 tons of tin ore have been obtained. This is the recovery from the friable portion of the lode only. Work at this point was not being carried on during my visit. So far only the oxidised portion has been worked, and a little pyrites is beginning to make its appearance in the face. The forkings from these workings show some rich specimen ore, but the heaps are of very uneven grade when examined as a whole.

During sluicing operations upon the ground lying between the railway-line and the Argent River a certain amount of waterworn alluvial material has been treated. This is a portion of the Argent River gravel, formed when that river was flowing at a higher level, and now left as a terrace upon the banks. The tin ore won at this place was darker in colour than that which has not been river-borne, and it was associated with chromite. Some boulders of lodestuff (black cassiterite and quartz of splendid grade) were recovered, and have been stacked apart for later crushing.

With these boulders there were associated some boulders of tourmalinized quartz porphyry derived from the Penzance district, and both sets of boulders have undoubtedly a common origin. The chromite has been derived from the serpentine traversed by the Argent River in its upper portion, and under such circumstances its association with the tin ore is inevitable. Not being of local derivation, and the alluvial wash in which it occurs not being of any serious importance, the chromite cannot be regarded as an impurity of any material moment. As referred to elsewhere it is a very common associate of the tin ore in some of the secondary deposits in this district.

Above the railway-line, on the northern fall of the long spur of the Renison Bell Hill, the present workings of the company are situated. The lode-matter here cannot yet be connected with certainty with any of the occurrences already described, nor with the "big blow" to be mentioned later on. Yet it undoubtedly forms portion of the one belt of mineralization, in which the workings on the Boulder lease, those of Messrs. Duncombe and Maddox, and of the Montana Company are situated.

The present mining operations are restricted to the sluicing of the detrital material resulting from the superficial oxidation and partial disintegration of a lode which is essentially pyritic in character. The slate associated with the lode and lying above it also conforms to the general type found along the line of the lode-system. It carries veins of tin-bearing quartz, and cubical cavities formed by the oxidation and removal of pyrites crystals are always visible along the bedding-planes.

A tunnel has been driven into the side of the hill in a south-westerly direction for a distance of 67 feet, and passes obliquely through the pyrrhotite body, which dips at an angle of from 40° to 45° in a direction E. 30° N. The adit starts on the hanging-wall side of this lode, and at 31 feet from the mouth of the adit the pyritic ore passes out of the back of the drive. From this point onwards there appears on the walls of the drive only slate dipping E. 30° N. at 45°. In the face a few small seams of pyrites occur, crossing the bedding-planes or sometimes coinciding with them. These veins seem to me likely to belong to the casing of a more vertical body, which may have been the feeding-fissure whereby the stanniferous ore has been introduced to the lode which is being worked.

The material now being sluiced is merely the surface portion of this lode lying between the thin cover of vegetable soil and the non-disintegrated lode-stuff below. The depth of the detritus may be estimated at an average of about 6 feet over the area already worked. It becomes as much as 9 feet in some places, and only 3 feet in others.

The depth of the ground sluiced away varies in a very irregular manner, except at one place where a very hard ridge occurs, running in a north-west—south-easterly direction. This may possibly be the outcrop of a more vertical lode, and possibly identical with the one beginning to show in the face of the tunnel below.

The detrital ore varies considerably in appearance, and must necessarily do so, since the composition of the lode, in its unaltered condition, is variable. The original proportion of the pyrrhotite to the quartz very largely determines the physical character of the oxidised lode-stuff. There is no doubt whatever but that this detrital ore has been pyritic in character. There are a few patches of a dense aggregate of quartz and cassiterite, which cannot have contained much pyrites in the unweathered condition, but the bulk of this class of ore is here, as elsewhere on the field, small in proportion to that of the pyritic ore.

In addition to the sluicing of the surface, a trench has been carried up the face of the hill for 150 feet. It is located above the tunnel, and has been cut down to the pyritic floor.

In all, about half an acre has already been sluiced, and from the results of the prospecting holes which have been put down on the slope of the hill it is estimated that about two acres of payable ground remain to be sluiced. Very little work, indeed, has been done to prove the south-eastern extension of the lode-system. What little prospecting has been done is sufficient to prove conclusively that there is a continuation of the pyritic lode-matter towards the Montana ground. Whether this lode-matter contains tin ore in payable quantities remains to be proved.

Near the south-western corner of Section 1215-M a shaft has been sunk some 20 feet, and a short drive carried for 16 feet in a south-westerly direction. The shaft was full of water at the time of my visit. It is stated that some flat seams of gossan were met with in the slate penetrated by the shaft, and the drive went in under the gossan.

Some trenching has been done, and a shaft has been sunk 16 feet near the north-western corner of the Montana section, and this work serves to prove the continuity of the lode-system to the boundary of the lease. The lode-matter is known to carry a certain amount of tin ore.

Some prospecting holes have been put in on the hillside below this formation, and are stated to have afforded encouraging returns. It is estimated by the management that there exists here half an acre of detrital lode-matter which will pay for sluicing.

2. The " big blow " lode-system.—Next to the lode-system already described, the most important ore-body is that known as the " big blow." This name has been given to a dense gossan consisting mainly of limonite, but with a certain amount of quartz in addition. The lode dips at a flat angle towards the south-east, and the strike of the main portions of the ore-body is north-east and south-west. The outcrop curves with the spur of the Renison Bell Hill. The total distance over which the lode outcrop may be traced is 358 feet, measured in a direction approximately north-east and south-west; but the lode is not continuous over this distance. The most southerly portion extends for 85 feet towards the north-east and then terminates abruptly, having been cut off by a fault. Between this point and the spot where the outcrop again continues in a north-easterly direction there is a break of 130 feet. Within the limits of this break there is an isolated patch of gossan outcropping.

The strike-lines of the fault which have dislocated the main lode are not yet to be determined. The strike of the main lode cannot be exactly stated. The lode seems to be dipping towards the south-east at the southern end of the outcrop, while the dip approaches more nearly to the eastward at the northern end of the outcrop. Yet the isolated patch of gossan, occupying a position at the south end of the gap in the main outcrop, is dipping towards the south. The explanation of this change of dip cannot be given until there is more work done upon the property and the course of the faults becomes known.

Beyond the break mentioned the main outcrop continues without interruption for 143 feet, and then terminates abruptly as if cut off by yet another cross-fault.

No accurate idea of the width of the lode can be obtained from the outcrop, for it apparently dips at a flat angle, and the irregularities of the ground surface consequently have a considerable effect in determining the width of the outcrop.

Some surface work has been done upon this gossan with a view to the determination of its tin contents, and a number of sample holes have been put in along the whole length of the lode. These holes have been bored as " half-uppers " in the footwall side of the lode, and the returns from the assay of these borings indicate that the lode is one of great possibilities.

Some underground work has been done to try and obtain some further information concerning this lode, but so far the workings are too insufficiently advanced to afford any definite figures as to the strike, width, dip, or value of the lode.

The main adit starts in country, and bifurcates at a point a few feet in. From the more westerly drive a rise was put up to the surface, and a crosscut carried eastwards to meet the other arm of the main drive. At the point where this crosscut meets the drive the northern limit of the lode is clearly seen.

The drive is continued for some distance on the lode, which is still completely oxidised, and gradually passes out into the footwall of the lode. A rise has been carried right through to the surface and penetrates this lode, emerging at the surface at a point 86 feet above the level of the drive. It is difficult to determine satisfactorily the real thickness of the lode passed through by this rise. There were no ladders in the rise, and from the examination which was possible from a bucket it appeared that the footwall of the lode was passed at 43 feet from the surface, and that the gossan continued from that point to within 18 feet of the surface. Thus the rise was for 25 feet in gossan, but this is not the true width, inasmuch as the rise and the lode are both inclined in the same direction, and the lode has therefore been intersected at an angle.

Some short crosscuts have been put in from the main drive towards the east, and indicate the presence of a sulphide lode of the normal pyritic-cassiterite type. The slate in the end of the drive is mineralized, and the ore-body appears to be making in the last few feet of the drive.

This pyritic body appears to be distinct from that lode which is called the "big blow." It seems to be much more nearly vertical, and may possibly be connected with an outcrop of gossan which extends southwards up the hill for some distance. If this proves to be the case, the "big blow" lode will probably unite with the pyritic body along a line not yet exposed underground, but not far from the position of the main drive. Mention has been made above of these branching lode-systems, and this system appears to be likely to offer a clue to the structure of others, since in this case the tin content offers every inducement to the company to develop the lode. Moreover, should the "big blow" lode prove to be the offshoot or branch of a more nearly vertical body there will be every reason to look to the vertical pyritic lode as a productive source of tin ore. It is reported that excellent values have been obtained from samples taken from the pyritic lode-stuff.

On what is probably this same lode a short tunnel was started at a point slightly to the east of the main adit, but the workings have collapsed.

Higher up the hill a little work has been done on the gossan outcrop referred to above as being the possible outcrop of the pyritic lode in the tunnel. The outcrop has been bored and samples taken, but nothing beyond this has been done.

The gossan has become more and more siliceous as the summit of the hill is approached, and the lode merges finally into a belt of indurated slate. This lode, if it does prove to carry tin ore in payable quantities, and supposing it to be identical with the pyritic formation in the underground workings at the "big blow," will be an extremely valuable asset to the company, for some 300 feet of the backs could be obtained at the southern end by working it from the level of the tunnel at the "big blow."

No time should be lost by the company in pushing on the development of this portion of the property. Until this is done no definite statement can be made as to the quantities of ore, nor any accurate knowledge be gained of the structure of the lode-system. It must be remembered that the above account is no more than a description of the probable relationship of certain bodies of ore which are not yet positively known to be connected.

There are some other outcrops on the upper portion of the hill which may be connected with the same lode-system.

To the east of the long gossan outcrop mentioned above some trenching has been done for a distance of 5 chains in an east and west direction. Some further gossan has been disclosed by this work, and outcrops here and there all along the trench. A little tin ore is known to exist in the surface-soil immediately below this formation, but not in payable quantities. The strike and dip of the lode cannot yet be determined.

Still further south, and near the top of the hill, there is a small open cut, which has exposed a pyritic lode carrying galena, zinc-blende, and siderite. A little tin ore is said to have been obtained from a soft "dig" running down alongside the formation.

3. The "western lode" is a massive outcrop of gossan outcropping on the western bank of Porphyry Creek, and coursing in a direction bearing north-west and south-east. It is distinct from any ore-body referred to above. Practically nothing, beyond the driving of a short tunnel at the northern extremity of the outcrop, has been done on this lode. It is said to be tin-bearing. As in other cases, there has not been sufficient work done for the structure or true thickness to be ascertained. The lode appears to be dipping in a south-westerly direction at a flat angle. The outcrop is of such a size that it merits more attention than it has received up to the present.

Still further to the west of this point a trench has been excavated many years ago, but no record has been kept of the results obtained. There is some gossan exposed, and this is said to give a little tin on being crushed and vanned.

4. The gossan outcrops on the northern bank of the Argent River form, in all probability, part of the continuation of the lode-system described above as the "low-level system."

Two short drives have been put into the face of the hill, and show a lode-matter consisting of gossan and irregular masses of ankerite and dolomite. From the more westerly of these workings tin ore has been obtained.

Opposite the main river adit the river gravel has been cemented by native copper, and stains of secondary copper ores appear on the face of the slate underlying the wash. The origin of this material has been indicated elsewhere in this report.

Near this place pyrites can be seen in the bed of the river.

Ascending the hill towards the north-western corner of the property there are some further outcrops of gossanous material upon which some trenching has been done; and right on the corner of the section a dense outcrop is visible. This can be traced for some distance to the north-west, and is dealt with elsewhere.

The structure of the lode-system in this corner of the property will be better understood when further work has been done on the southern lodes, and the work of prospecting will thus be rendered less arduous and costly.

The present mining operations are confined to the sluicing of the detrital lode-stuff which forms the capping of the main lode-system, and the area being worked is situated on the north-eastern slope of the Renison Bell Hill.

The methods of sluicing do not differ materially from those followed in other portions of the field.

The detrital material is broken down with a pick and sluiced downhill. About one head of water is being used, being obtained from Porphyry Creek. The heaviest of the non-disintegrated lode-matter is removed in the face. The rest passes over a hopper plate, which removes all stone of a diameter more than three-quarters of an inch. Below this hopper plate is a box-race, some 3 chains in length. The first two chains are 1 foot in width, and the lower chain 2 feet. The material, after passing through the race, runs over a screen, in which the holes measure 4 millimetres in diameter. The oversize passes to waste. The fines go to a wide box, 16 feet by 8 feet, with a fall of 4 inches in the 16 feet, and the fine tin is recovered here. The tails from this box pass to the tailings dam, where they are being stacked for mechanical treatment at some future period.

The work done with this crude plant is excellent, and all the more creditable in view of the extremely fine state of division of a large proportion of the tin ore.

There is nevertheless no doubt but that by mechanical concentration it would be possible to effect a greater saving of tin ore, and an economy of labour.

The company are at the present time making arrangements to instal crushing and concentrating machinery on the mine, and are wise in pushing on with this work at once.

A milling plant, working continuously and dealing finally with the ore as it is mined, will effect a great saving in handling alone, whereas the present practice of stacking forkings and tailings is steadily increasing future costs.

As regards the ore which the mill will treat, there already exists a certain amount of material already wholly or almost wholly exposed.

The tin-bearing gossan won from the open-cut near the mouth of the main river-tunnel, the forkings and screenings can be dealt with at once. Then there is a quantity of thoroughly oxidised lode-stuff remaining *in sitû* at the surface on the slopes which have been sluiced.

Better values are reported to be obtained from the coarser forkings than from the finer screenings. The reason of this appears to the writer to be that the tin ore is very largely restricted to the veins which pass out of the pyritic ore-body into the slates overlying it, rather than scattered through the altered slate itself. For the forkings show a greater proportion of vein-matter to altered country than do the screenings.

Besides the ore mentioned above there is every reason to expect that free milling ore will be derived from the "big blow." In fact, the sampling of a portion of this lode has given such encouraging returns that it may confidently be regarded as a most valuable asset. Moreover, it is so situated that the ore can be easily won and transported to the mill.

In view of the early erection of milling machinery this lode should be fully opened up at once and thoroughly sampled.

In addition to this oxidised lode there will probably be some more gossanous lode-matter to be won from the upper portion of the pyritic lode between the railway-line and the Argent River. This could easily be mined by means of an open cut.

Also, when a mill has been erected it may possibly prove profitable to mill the whole of the oxidised lode-matter which overlies the main lode-system. At the present time, since sluicing alone is possible, there has been no attempt made to estimate the tin contents of the lode-matter as a whole. Prospecting holes have been sunk at more or less regular intervals, and the grade of the ground has been judged solely from the dish assays made for tin recoverable by sluicing. These have not taken into account the tin content of the non-disintegrated lode-stuff. There may be as much tin ore contained in the lode-matter in some holes which have given poor results for mechanically-free cassiterite as in other holes which have yielded high returns. This question should be gone into without delay, as it will have a very practical bearing upon the future working of the mine. That is to say, careful assays should be made of the whole of the lode-material, whether compact or in a state of partial or complete disintegration. The area to be tested in this way is that belt or zone already referred to as the main or low-level lode-system passing through the north-eastern portion of the lease in a direction approximately north-west and south-east. Its full limits cannot be said to have been yet defined. The present working face is within this zone, and the work of testing the whole surface lode-stuff might well proceed outwards from the present workings.

Beyond these more obvious assets the company should look to other possible sources of ore.

Reference has already been made to the necessity for investigating the pyritic lode encountered underground in the "big blow" workings. For it must be remembered that the oxidised ore cannot be expected to last for an indefinite period; the sulphidic ore must be worked in the future and the development of the lodes which are not in the oxidised condition should proceed steadily, while the free milling ore is being mined.

Again, from the structural features presented by the portions of the main lode-system exposed at the surface, and the general conclusions arrived at by the writer after studying the lodes on this mine and those on adjacent properties, it is considered possible that there may perhaps exist other bodies of ore not yet exposed to view. This question of the lateral and vertical extension of the lode-system is treated of in another part of this report.

Whether or not these ore-bodies will turn out to be sufficiently rich in tin ore to be payable cannot, of course, be told. Practically nothing has been done on the exposed pyritic lodes in the way of systematic sampling.

The irregular distribution of the tin ore in the pyritic-cassiterite lode-matter renders it more necessary to carry on more extensive prospecting operations than would otherwise be required; but the large extent of ground covered by the lode-system, and the encouraging results already obtained from the surface workings, should offer sufficient incentive to the company to push on energetically with the work of prospecting. For the present this work should be restricted to the opening-up of the "big blow" and the prospecting of the "low-level" lode-system in the vicinity of the area already sluiced.

Arguments are given elsewhere to indicate the probable future value of the pyritic floor, at present practically untouched. This should be carefully sampled, and full records retained for future use.

The sampling of the gossans should be very carefully carried out in the way indicated above.

In conclusion, the property of the company is one of great potentialities, for there are at least two lode-systems within its boundaries, each of which has great possibilities. Beyond this statement little can be said, on account of the backward state of development of the mine.

However, there appears to be a period of much greater activity now at hand, and much more information should shortly be available, if the work is carried on with the fixed intention of accumulating such data with regard to the lodes as will be of permanent value. In particular, it will be necessary to open up the lodes themselves, since drives in the country rock are at present of very little, if any, value. Information is not yet to be acquired from neighbouring mines, and the pioneer work in lode-mining must be done by this company.

The output of tin ore from the mine up to June 30, 1908, has been 57 tons 9 cwts. 2 qrs. 14 lbs., of which the assay value averaged 72.7 per cent. metallic tin.

The gross value of this ore is about £6725.

I am indebted to the management of the company for the figures regarding the quantity of ore produced and the assay value thereof.

(2)—Montana Tin Prospecting Syndicate, No Liability.

The company holds one section, No. 1342-m, 78 acres, together with the water-rights for 7 heads of water.

The section is situated to the eastward of the Renison Bell Hill, and includes portion of the lower slopes of that hill. The water-supply is brought on to the section by a long race running round the Renison Bell Hill, and extending southwards along the western slopes of the Commonwealth Hill.

The water-race intersects the quartz porphyry, porphyroid, and gabbro dykes, but is for the most part in slate country.

The members of the slate series are the principal rock-types present in the mineral section, but a quartz-porphyry dyke is visible in the south-eastern corner of the section. The long dyke of diabase traverses the section diagonally, but is not visible near the northern boundary. In the place where the outcrop might be expected to be visible the members of the slate series are coloured a deep red. This may be due to the development of haematite by the intrusion, but it is a very local phenomenon, and was not observed elsewhere.

The occurrences of ore which are being worked by the company are situated within the lode-system, which has been here called the Renison Bell-Montana-Boulder lode-system.

This lode-system traverses the section diagonally, and has been worked in the northern and southern portions of the section.

The northern workings are situated on the northern fall of the saddle which connects the Dreadnought Hill with Renison Bell Hill.

The hillside is very steep, and there is very little accumulated detrital matter on the lower slopes, but on the ridge and upper slopes the tin-bearing detritus is 6 feet or more in depth. This surface material has been sluiced off the upper slopes, and laid bare two very distinct "floors" of almost completely oxidised ore, on the spur between the two branches of Renison Bell Creek.

These two floors are about 12 feet apart, and exhibit the structure of the system more fully than any other point throughout its length.

The "floors" conform closely to the dip and strike of the bedding-planes of the slate, which is here considerably disturbed, but of which the prevailing dip appears to be to the north at a very flat angle. They are connected by smaller bands of siliceous gossan, more or less vertical in position, and carrying tin ore.

The slate country also carries veinlets of tin-bearing quartz, and has been impregnated with pyrites, which has since weathered out and left cubical cavities.

The ore in the "floors" is said to have been the richest in cassiterite. It consists largely of a friable aggregate of acicular quartz crystals, but in parts is more compact. These denser patches of stanniferous quartz have been forked out of the races, and are stacked apart for future treatment.

The more compact portions come from exactly the same type of lode-stuff, and have remained massive on account of the higher proportion of quartz in those particular portions of the vein-filling from which they are derived.

There is a little pyrite showing in the deeper portions of the open cut, but the greater part has been removed by surface waters.

The portion of the lode-system which has been worked at this point is bounded on the south-west by a fault-plane which itself has been mineralized. The fault strikes in a direction bearing N. 43° W., and dips to the north-east at a steep angle.

This fault-fissure has very probably been the main feeding fissure of this portion of the lode-system, and in this respect appears to play the same part as the "cross lode" on the Renison Bell lease referred to above.

The two "floors" referred to above may be found to extend no further to the south-west at this particular point, but the lode-system, when viewed as a whole, does not cease with the fault-plane.

The section in the railway-cutting on the Renison Bell lease shows similar features in many respects, and both occurrences show the similarity between the structure of the complex lode-system and that of the branching lodes.

Work has been carried on in two benches, and at the time of my visit work was proceeding in the lower bench. This lower floor has a thickness of about 4 feet, and is 12 feet below the upper one. The bottom of the cut, therefore, has reached a point nearly 20 feet below the surface, and the sulphidic ore is beginning to make its appearance. As work is carried into the hill more pyrites will probably be encountered, since the unoxidised lode-matter will be found to belong to the pyritic-cassiterite type.

From these workings some 29 tons of tin ore have been recovered.

The eastward continuation of the portion of the lode-system, which has been worked at this point, lies just across the northern boundary-line of the Montana Company's lease, and has been worked in Section 1215-M.

There has been a little work done to the south-west of the principal northern workings at a point across the western branch of the Renison Bell Creek. This place is known as "Campbell's face," and has produced nearly 3 tons of tin ore. The ore at this point has the appearance of being very much more siliceous than usual, but it is difficult to pronounce a definite judgment until further work has been carried out.

Higher up the hill, and to the southward of this place, a pyritic lode has been exposed in a north-and-south trench. The slate above it is silicified. It carries some very good ore, which is high in silica. Some pyrite has been present even in that ore which is now free from it, but the proportion cannot ever have been high in some of the ore. The locality is worthy of much more attention being paid to it, especially as the ore promises to be more easily treated than the average pyritic vein-stuff. A few bags of tin ore were recovered during the excavation of the trench at this spot.

On the southern slope of the saddle between the Dreadnought and Renison Bell Hills a start was being made by the company to open up that portion of the lode-system at the time of my visit. Prospecting holes had been sunk, and had proved the depth of the detrital matter to be between 16 feet at the top of the hill and 3 feet as the lower slopes are reached. The grade of this deposit had not been determined, except by these prospecting holes, when my examination was made, but it was estimated by the management that at least an acre would pay for sluicing.

Still further south in this section the most important and productive workings are situated. A long spur from the Renison Bell Hill runs down to the creek, and the workings are situated on the eastern slopes of this spur. The ground was first opened up by a party of tributors, who, after sluicing away the surface detrital ore, came upon a gossan body. This was followed down, since the lode-matter was of a friable character, and a cutting was made in the hill slope to carry the tail-race. The open cut on the lode was 100 feet long, 5 feet wide, and 16 feet in depth when I last visited the property, and the lode seemed to be strong in the bottom. It is of a very thoroughly oxidised character, and was originally rather poorer in quartz than the average lodes of the pyritic-cassiterite type. Very little trace of pyrites remains, except on the western wall of the lode. The walls are of slate, which has been silicified, and carries numerous veinlets of tin-bearing quartz.

This gossan belongs, in my opinion, to the lode-system, and constitutes one of the "feeders" or more vertical components. It is remarkable both for its size and for the tin content, for the tin ore throughout the lode-system appears to be most abundant in the "floors," and the "feeders" are seldom of such size as this one. There appeared to me to be a flat pyritic vein running into the hillside on the top or south-western side of the open cut. Above this pyrites the slate and grit are impregnated with pyrites right up to the dam near the southern boundary-line of the section. At this latter spot a massive gossan formation exists. It is reported to carry good tin values, but has not yet been opened up.

The lode-matter continues to the northward and eastward of the main open cut on the gossan "feeder," and during my visit a commencement was being made to open up this area on the surface. Some gossan was encountered at two places, but insufficient work had been done to enable its structure to be determined.

A tail-race which was cut in the vicinity of the Government track revealed some highly payable ground, which can easily be opened up and worked. There is an outcrop of gossan which must belong to the general system, but so far it is only partially exposed. Some coarse-grained galena was found at this point, but did not appear to me to be of local derivation. It has very probably come from some portion of the stanniferous lode-system, for there are numerous occurrences of galena and blende within the limits of the lode-system which are regarded by me as local variations from the normal stanniferous type rather than as separate lodes.

The surface of the hill slope is known to be tin-bearing right up to the southern boundary of the section.

Thus far work has been almost wholly restricted to the higher ground; yet in the creek, not far from the south-eastern corner of the section, a pyritic mass has been exposed. The lode-system certainly extends across the creek in this part of the section, and has been worked on a small scale in the adjoining Section 1273-M.

The property has not yet been shown to contain any deposits of ore other than those which belong to the Renison Bell-Montana-Boulder system; yet this latter complex formation extends over about half of the section.

The future of the area will depend on the results of the deeper development work. Two points appear to be most favourable for the testing of the lode-system in depth—one where the gossan feeder is being worked, and one near the northern boundary of the section. Of these, the former appears to me the preferable site, for there seems to be a greater proportion of tin ore present in the lode-matter which is still *in situ*. It is difficult to pick the exact spot from which the deeper development should proceed for reasons which have been given in the general portion of this report. If the large gossanous "feeder" be followed downwards by a shaft on the lode valuable information should be obtained.

During the deep-level prospecting it must be borne in mind that the lode-system comprises both vertical and horizontal members, so that workings in two directions at least are necessary for the location of bodies of ore. The "floors" can be located by means of shafts or rises, but the "feeders" can only be found by crosscutting.

In the event of the deeper workings proving the presence of payable lode-matter, the prospects of the section will be excellent. At present only surface detrital material and the oxidised portions of the lode-system are visible, yet, as has been indicated above, it is improbable that there has been any material concentration of tin ore in this oxidised lode-matter. It is therefore well worthy of attention by the company. Unless this prospecting of the lodes is pushed forward rapidly the life of the section cannot be a long one.

There have been stacked some heaps of the forkings from the sluiced faces which will provide a certain amount of ore for future crushing, but these forkings by themselves are far from sufficient to justify the erection of crushing machinery.

The general methods of mining and concentration on this section are very similar to those already described with regard to the Renison Bell workings. Greater care has, however, been taken over the concentration of the slimes which are allowed to settle in pits. The settled product is run through the boxes with a small supply of clean water. By these means there have been effected both a saving in the amount of tin ore treated and an improvement in the grade of the ore.

The ore sent out has been dressed by these simple appliances till the percentage of metallic tin is 74·7. As a rule, the coarser-grained tin ore is of slightly better grade than the slimes.

The first ore produced from the section was sent to market in April, 1907. Between that date and February 9, 1909, a total weight of 88 tons 8 cwts. of tin ore have been sent out.

The gross value of this ore is about £9500.

(3)—A. B. Duncombe and A. Maddox's Section.

The section held by Messrs. Duncombe and Maddox is that numbered 1963-M, and comprises 80 acres.

With the section is held a water-right, number 674-w, for 2 heads of water.

The section is situated at the base of the Renison Bell Hill, and comprises the south-eastern spur of that hill. The water-race follows the eastern flanks of the Renison Bell and adjoining hills, and picks up the water from the head of the Dalcoath Creek, which takes its rise on the Commonwealth Hill.

The greater part of the section is occupied by slate, which is traversed by two dykes of quartz porphyry. These latter are to be seen in the north-east and south-western corners of the section, and in the very north-eastern angle the dyke of diabase crosses the creek.

There are three occurrences of lode-matter within the limits of the section, and of these the most important is that which belongs to the great lode-system which has been dealt with above in the reports on the Renison Bell and Montana properties.

The workings are restricted to the disintegrated portions of this latter lode-matter which occupies the north-eastern corner of the section, 2 to 3 chains distant from the south-eastern corner of the Montana section.

In the lower ground which has been worked the tin ore is said to have been in part rounded, but in my opinion it has not travelled any considerable distance. Some of the nuggets of tin ore from this place are clearly derived from the formation higher up the hill. They are aggregates of exceedingly fine-grained tin ore, and are very pale in colour. A few specimens from this place exhibit a yellowish tinge, but most are pale grey. With them were found fragments of lode-stuff containing black tin ore in a crystalline quartz matrix, derived from the veins which are mentioned below.

On following this detrital ore up the spur towards the westward the surface of a much-altered dyke of quartz porphyry was found. This dyke is from 2 to 3 feet in width, and traverses the whole width of the working face in a direction bearing 152°, and it dips to the east. In one place the dyke has split, and the two branches have rejoined, enclosing a "horse" of slate. It is hard to recognize this porphyry at first, since the most completely weathered portion appears to have a cleavage. This apparent cleavage is, I think, due to the influence of weathering upon the contraction-joints formed during the cooling of the rock.

In the dyke itself there is not known to be tin ore, but it is charged with pyrites, and, since the pyrite was introduced by the stanniferous solutions, it is worth while to try the dyke itself. This is more especially necessary at this point because the dyke is actually within the limits of the lode-system, and the mineral-bearing solutions have the power of altering rocks of this character very considerably and of replacing non-metallic minerals by metallic ones.

It has been said that this dyke formed the limit of the ore-body on the east, but the statement does not hold true for the whole length of the portion of the lode-system exposed by the sluicing operations, for the lode-matter extends across the Government track in the direction of the Boulder workings. The lode-system may extend a little further to the south on the western side of the dyke, but the latter does not appear to me likely to have exercised any great control over the distribution of the lode-forming solutions.

The sluicing away of the detrital matter lying upon part of the lode-system is all that had been done at the time of my visit. About half an acre had then been stripped to an average depth of 2 feet 6 inches.

The lode-stuff still left *in sitû* when the disintegrated portion has been removed by sluicing presents a rather different appearance from that shown by most of the other outcrops situated within the limits of the lode-system.

At the time of my visit no main "floor" nor any "feeder" was visible. The area is traversed by a very large number of smaller veins, which possess no constant direction of strike or dip.

These veins are thoroughly oxidised, and consist of the aggregate of crystalline quartz and granular grey tin ore which is commonly seen in the completely weathered veins of the pyritic-cassiterite type in this district. These veinlets are on this section much richer in tin ore than any others which I saw elsewhere on the field.

Between the several veinlets the slate blocks are displaced relatively to each other. There appeared to me to be a tendency for these slate masses to dip in a direction bearing a few degrees east of north; but the whole area has been much disturbed by earth-fracturing.

The slate has suffered impregnation along the bedding-planes between the veins, and this impregnation has taken place along the coarser, and therefore more porous, bands. Along these bands the outward and visible sign of the impregnation is the presence of cubical cavities after pyrite. When examined microscopically needles of tourmaline can be seen to have been introduced into the pyritiferous zones. From some portions of this impregnated slate, after crushing and vanning a sample, fine tin ore can be obtained.

Very few signs of the presence of other lode-matter than that mentioned were visible at the time of my examination. At one point in the upper portion of the workings a little dense limonite was visible. This represents undoubtedly the result of oxidation upon pyritic lode-stuff; and at this place there has obviously been some material removed in solution, for the ground is cavernous, and the water used in sluicing was found to escape by some underground channel.

The chief difficulty with regard to the lode system at this place is to determine satisfactorily the structural details. It seems to me that the zone of slate traversed by the tin-bearing veinlets may be either—(1) A shattered zone wherein the fracturing has been much more complicated than usual, so that the numerous small fractures represent collectively the same displacement as one or two "floors" and "feeders"; or (2) the fringe of a system of "floors" and "feeders" of the usual type, the impregnated zone being simply that portion of the system which lies upon a "floor" of ore not yet exposed.

Since leaving the field I have been informed that a flat formation has been partly opened up, but no speculation as to the structure can be framed in the absence of personal examination.

The general direction of elongation of the lode-formation is towards the southern workings on the Montana section, but the limits of the lode-system have not yet been fully marked out.

On the spur above the main working-face some vein-matter consisting of crystalline quartz and black tin ore is exposed in a head-race. This is similar in character to that which has been exposed in a trench on the Montana Company's ground and referred to above.

It is also similar in character to some of the quartzose ore of the Pine Hill area; but until further work has been done it is impossible to say definitely whether this vein-matter belongs to a later period of vein-filling than that of the formation of the main lode-system, or to the same, or even an earlier, period.

As regards the prospecting of this portion of the section the owners must be guided by the structure of the lode-system indicated by the most recent developments. If there are present the "floors" which are so characteristic of the whole length of the formation it is clear that a low-level tunnel may prove insufficient to reveal the presence of any appreciable amount of ore, for the tunnel may start below a floor and continue for a considerable distance in country. Such a tunnel, of course, should be reasonably expected to intersect any more vertical "feeders" that may be present, but it only occasionally happens that these "feeders" assume any considerable dimensions. On the other hand, a shaft sunk would be the best way of prospecting for concealed "floors," but would be useless for the detection of the "feeders."

When prospecting at a depth is undertaken at this place another matter must be borne in mind. The ore occurs here in the shattered slate, and may not be restricted to the main "floors" or "feeders" at a depth any more than it is on the surface. Hence the zones of impregnated slate, which will certainly be pyritic in depth, must be prospected as well as the more compact bodies of ore.

The detrital ore is worked in the usual way. The timber is first cleared and the surface vegetable soil burnt and stripped. The friable portion of the lode-matter is sluiced to boxes. The larger fragments of the lode-matter are forked out and stacked on the worked ground. There are 30 feet of boxes, 16 inches wide. Thence the ore passes over a screen with slots measuring $\frac{1}{32} \times \frac{1}{2}$ inch. The oversize passes to waste. The fines go to the second set of boxes, 24 feet long and 18 inches wide. The overflow passes to a dam, where the fine tin ore has time to settle.

Near the north-western boundary, and close beside the water-race, there are two outcrops of gossan, 80 feet apart. One has had a few shots put in it. No tin ore is visible, and no assay has been made of the gossan.

It is possible that there may be some connection between this outcrop and that which lies to the northward of it, on the northern spur of the Renison Bell Hill.

The only other lode-matter known on this lease is situated on the southern boundary-line where the Dalcoath Creek crosses that line. The lode-matter is a mixture of quartz, siderite, pyrite, and blende. It does not appear to me likely that this lode will prove of commercial value, for it is entirely similar to a number of small veins of galena—blende sporadically distributed through the field, and seldom showing any continuity.

The prospects of the section will therefore depend upon the manner in which the lode-system in the north-eastern corner opens up. At present there is still some detrital material in sight which can be sluiced. Much, also, of the lode-matter which remained *in sitû* will make excellent battery stone. Still, it cannot be claimed that enough ore of an oxidized character (and therefore free-milling) has been proved to justify the erection of a milling-plant for this property alone.

The oxidized ore still *in sitû* and the forkings already stacked would not last long. The depth of the zone of oxidation has not yet been determined. When once it is passed all the ore will be of a pyritic character.

The proportion of tin ore in the veinlets which traverse the slate is such that every inducement is given to prospect the lode-system at a depth.

The output from the section up to December, 1908, has been 21 tons 16 cwts. of tin ore.

This ore has been all won from the north-eastern corner, and represents a gross value of about £2300.

The average assay value of the dressed tin ore is stated to be 70 per cent.

(4)—The Boulder Tin Mining Company, No Liability.

There are two mineral sections held by the company—No. 271-M (77 acres) and No. 5101-93M (80 acres).

The northern section (271-M) is situated at the meeting-place of the principal streams of the district, and contains only the lower slopes of Stebbins, Renison Bell, and Commonwealth Hills, and of the high spur which runs down from Pine Hill between the Ring River and Gormanston Creek.

The topography of a large portion of the section is shown in the photograph reproduced in this report, and it will be seen that the section occupies the principal depression between the hills mentioned.

The southern section (5101-93M) occupies the northern slopes of the Commonwealth Hill.

The geological structure of the northern section is simple. It consists of slate, which is traversed by a single dyke of diabase in a direction about north-west and south-east. The dyke does not cause any notable modification, either of structure or composition, in the slate, and is of the same character throughout. It follows a somewhat curved path across the section, and splits at one place near the battery site.

Above the confluence of the Dalcoath and Gormanston Creeks there is a small area covered with alluvial material, below which a slate bottom is visible along the creek bed.

The southern section is for the most part slate, which is traversed by a broad dyke of gabbro-amphibolite. The long narrow dyke of quartz porphyry which crosses the Renison Bell Hill traverses the south-western corner of the section, and another dyke of similar material intersects the gabbro in Dead Man's Creek. The south-eastern corner is on a belt of clastoporphyroid.

The principal occurrences of lode-matter on the sections are situated in the north-western portion of the northern section, on the boundary between the two sections and on the course of the Dalcoath Creek.

From the accompanying geological map it will be seen that the lode-system which extends from the Renison Bell lease through the Montana section is continuous as far as the north-western portion of Section 271-M, and at this place the present workings of the company are situated.

The detrital ore occurring at this place was found and worked on tribute by Messrs. Duncombe and Maddox before the present company started operations for themselves. Thirty-three tons of tin ore were thus recovered before the company took over the ground.

The deposit is similar in almost every respect to that which has been opened up on the Renison Bell ground and described above. There is exposed at the surface a quantity of pyritic ore, in which the pyrrhotite has for the most part given place to marcasite. The upper portion of this deposit consisted of the friable quartz and tin ore aggregate and impregnated slate. Both of these varieties of ore have been described above.

The chief point of difference which I noticed was that the impregnated slate, even where free from quartz-cassiterite veinlets, was in places fairly rich in tin ore. This ore is very fine in grain, and to the unaided eye invisible, although it can easily be recovered by crushing and vanning the slate. Pyrite has been present in the slate, and the tin ore was probably introduced at the same time.

Taken as a whole, the lode-matter forms a very flat "floor," dipping at a small angle towards the south-west. The pyritic portion was left by the tributors, and only the detrital ore above the pyritic floor removed. Mention has been made in another part of this report of the dense granular quartz-cassiterite aggregate lying upon the pyritic body, and its characteristics. Very little of this massive ore remained at the time of my visit.

A small creek finds its way down to the main creek immediately to the north-west of the pyritic floor, and has deposited along its course some bog iron ore. In this limonite are cemented angular fragments of the lode detritus, hence it is not surprising that the ironstone blocks afford good prospects for tin ore.

Another small creek situated to the south of the lode-matter, and running southwards, has been worked on tribute for a few chains for a width of from 16 to 20 feet. The bottom of the sluiced ground is in slate carrying veinlets of quartz and cubical cavities after pyrite. The slate is much contorted and crumpled here, and adjacent blocks dip in different directions. The diabase dyke crosses this stripped ground, and can be seen to be unaffected by the crumpling and to be free from the veinlets of quartz and to be non-pyritic.

The area lying between this creek and the sluiced "floor" referred to above is part of the one great lode-system.

Such was the nature of the ground when the company undertook to work it.

It was decided to erect a battery and concentrating plant, and the site chosen was the hillside immediately below the sluiced "floor."

A tunnel was put in to test the lode at a depth, and has establiished the fact that here at least the ore forms a "floor." The adit started in detrital matter, which is about 4 feet thick at that point, and traverses soft slate for the first hundred feet. The drive was carried in a north-easterly direction for 129 feet on a bearing of 55°, and thereafter for another 49 feet on a bearing of 60°. At 120 feet from the entrance a rise was put through to the surface, which is 36 feet from the back of the drive.

The slate shows slight variations in the dip of the bedding-planes, but all approach very closely to the horizontal.

After the first 100 feet the slate gradually hardens until from 122 feet to 130 feet a hard vein-stuff was encountered, carrying pyrite, sphalerite, galena, and fluorspar. The pyrite is much the most abundant of these. The slate alongside this vein, which is approximately vertical, is silicified, and carries pyrite in thin veinlets which both intersect and are conformable with the bedding-planes. Beyond the pyritic lode, which is, in my opinion, one of the "feeders" of the system, the slate is again soft nearly as far as the face of the drive. The last few feet are more siliceous, and carry veins of quartz ankerite and pyrite as if another feeder was not far distant.

The rise was put up in slate until within 10 feet of the surface, where it entered friable pyritic ore, and continued in this as far as the surface.

Good pyritic ore is to be seen at the surface near the mouth of the rise, and the section of the ore-body exposed in the rise should be carefully sampled and assayed for the tin ore in both the pyrites and the pyritic slate.

The tin-bearing oxidized lode-matter extends at the surface for some distance beyond the actual pyrites floor; and in erecting the crushing machinery the company estimated that there were available some 10,000 cubic yards of tin-bearing material which would produce over 100 tons of tin ore. The battery material includes the non-disintegrated lode-matter, the detrital ore not yet worked, and the forkings left stacked by the tributors. Up to the time of my departure from the district no crushing had been done by the battery.

The milling-plant consists of a five-head stamper battery of 1000-pound stamps, spitzlutten, spitzcasten, one Card table, and one rotary table. The two tables were, I understand, to be duplicated when crushing started. The driving power is a 12 h.p. simplex oil engine.

During the progress of the stripping and crushing of the oxidized ore every effort should be made to discover the value of the pyritic ore. Arguments have been given elsewhere to show that the tin contents of the pyritic ore may well be as high as those of the oxidized ore, and the matter should be enquired into forthwith.

Moreover, if promising results are afforded by the sampling of the pyritic ore, an effort should be made to discover whether another floor exists below that which is exposed at the surface. None is now visible, but this may be only because the configuration of the country has not laid bare other bodies. The prospecting for such other possible bodies should not be undertaken until an accurate idea is obtained of the value of that pyritic lode now visible, and if undertaken the prospecting must be done by sinking or boring.

The long lode-system apparently terminates near the top of the ridge of the spur of Stebbins Hill, which runs down to the junction of Gormanston and Dalcoath Creeks; but beyond this point other lode-matter is apparent along the boundary-line between this section and Section 1273-M. Whether the three outcrops of gossan which are shown on the map are mutually related cannot yet be told. The two lower ones follow the contours of the spur, and may therefore be regarded as successive "floors" or "branch lodes," more or less parallel to each other and dipping at a very low angle to the south-west. The reason why they appear as gossans rather than as pyritic floors with superincumbent zones of non-pyritic detritus is that they dip into the hill instead of with the hill. This matter has been fully discussed elsewhere in this report.

Some effort has been made in the past to prospect the lode-matter at this point. A tunnel has been driven westwards into the hill on a bearing of 272° for a distance (including an approach of 15 feet) of 227 feet.

The first 39 feet after the approach are in gossan, which then gives place to slate, dipping E.N.E. at a low angle. At 135 feet from the mouth of the tunnel a second gossan body was met dipping on its eastern border to the west at 30°. The drive continues in gossan for 75 feet, and the western border dips to the eastward. The last couple of feet are in horizontal slate. The noteworthy feature is the difference in dip between the two borders of gossan. It may possibly be that the main or feeding lode dips to the east, while the branch lode dips to the west, but this cannot be decided until more work has been done. The gossan should certainly be examined for the presence of tin ore.

At a time when Section 1273-M, to the northward, was a portion of one property with this section, a low-level tunnel was driven from the Dalcoath Creek to cut these gossans in depth. The dip of the lode-matter was probably very seriously underestimated.

The tunnel has a total length of 756 feet, and practically follows the boundary-line between the two sections mentioned.

For the first 525 feet the bearing is 272°; the next 64 feet have a bearing of 261°; the next 100 feet bear 248°; then, after 37 feet on a bearing of 268°, the tunnel bends abruptly, and was carried 30 feet on a bearing of 304°, and there abandoned.

Several inconsiderable bodies of ore were passed through in this drive. The more important of these were met at the following points:—At 85 feet a pyritic formation, said to carry tin ore, was cut. At 210 feet some soft iron pyrites was found, but is not known to carry tin values. Another pyritic body similar to the latter was cut at 267 feet, and yet another at 464 feet. There was a fair stream of water issuing from this latter place.

The last seam met was a 4-feet pyrrhotite lode, cut through at a distance of 695 feet from the approach.

Whether these veins have any essential connection with the massive bodies on the surface is not certain. We do know that some of the feeding-veins are small in comparison with the flatter bodies at the surface, but the main channel whereby the solutions rose to the upper fissures may not have been exposed in this tunnel. Moreover, it appears to me unwise to assume a connection between the veins cut in this tunnel and those of the Dalcoath Creek, which are mentioned below. Only a short exposure is given of a vein in a tunnel, and the strike cannot be accurately calculated on so short a length.

The veins intersected by the tunnel should, of course, be sampled and assayed, and any which may offer inducement should be followed. It would be wise to investigate the gossanous bodies, and the expense of so doing would be less than that of working from the lower level.

On the southern boundary of the Section 271-M there are several fractures filled with lode-matter. Of these, the most important is a pyritic body of ore which belongs to the pyritic-cassiterite type.

The main portion of the lode crosses the boundary-line from the southern section, in which the underground workings are situated. Near the Government track it is faulted. As far as could be determined the strike of this fault is N. 25° W., and it dips to the north-east at 60°. The faulted portion of the main lode has been located further to the westward, on the other side of the track, and has been trenched upon to a depth of 12 feet. The course of the lode here is N. 5° E., and it dips to the east at an angle of 18°. Further reference is made to this lode-matter below.

On following the course of the lode northwards the outcrop becomes lost under some partly worked alluvial ground, and reappears near the junction of the two main branches of Dalcoath Creek. From this point the lode, which is apparently the same ore-body as that mentioned above, follows the course of the creek for some chains on a bearing of N. 70° E. Here it is a vertical lode. Just above the junction of the Dalcoath and Gormanston Creeks it terminates abruptly, having been cut off by a fault. No work has been done on this lode for many years; in fact, the workings are practically in the same condition as at the time of Mr. A. Montgomery's visit in 1895. The report of that gentleman should therefore be consulted with regard to these workings.

A large quantity of ore has been shot out of the creek bed and stacked on the banks. It varies a good deal in composition; quartz, arsenopyrite, and pyrite or pyrrhotite are predominant at different points.

Throughout the length the lode seems to be about 8 feet in width. The tin ore is not often visible, but it is always hard to detect it in the pyritic ore. According to Mr. Montgomery's report the lode carries both silver and gold. The sample taken by him in the way described cannot be of any more than qualitative value, but it serves to point out the necessity of testing these pyritic-cassiterite lodes for the precious metals.

At the junction of the Dalcoath and Gormanston Creeks, and from the western bank of the former, a tunnel has been driven to test the lode at a depth, but the results of the driving were unsatisfactory. The tunnel was driven for 76 feet from the entrance on a bearing of 274°. Here a lode from 1 to 3 feet in thickness was met with and followed for 42 feet on a bearing of 241°. The lode-matter resembles that of the ordinary semi-oxidized lodes, consisting of a crumbling aggregate of quartz, marcasite, and pyrite. Whether it carries tin ore is not known. It dips to the south-east at 55°.

This lode was cut off by a cross-fault, which was followed northwards, on a bearing of 321°, for 32 feet. The fault-plane is filled with silica, pyrite, galena, and blende for a width of 2 to 3 inches, and does not seem important.

The main drive was continued for 44 feet on a bearing of 227°, and then for 17 feet on a bearing of 261°. The next 37 feet of driving were on a bearing of 305°, and after 20 feet more on a bearing of 284° work was abandoned. A small veinlet a few inches in width and similar to the other one was met with. It was dipping E.N.E. at 15°, and appears unimportant.

The relation of these two small veins to the main lode in the creek is not quite apparent from the work which has been done up to the present. It is quite possible that they may be branches of the main lode, which probably lies further to the south-east.

On following the Dalcoath Creek down towards the mouth of the very long tunnel referred to above there are two small veins to be seen crossing the creek. A 30-feet tunnel has been driven on one of these in a direction S. 10° W., but the formation was passed through near the mouth of the adit. The ore consists of quartz and pyrites, but no information as to the tin ore contents is available.

In the south-eastern corner of the section, where Dead Man's Creek runs into Gormanston Creek, a quartzose vein is visible. It carries zinc blende, and tin ore is reported to have been obtained from it. The strike follows the course of the Gormanston Creek.

Reverting now to the ore-bodies on the south boundary of Section 271:—The main lode is one of great importance on account of the proportion of tin ore present. The dip of the lode is eastward at an angle of about 40°, and the lode-matter is strongly banded. Unfortunately only extremely weathered surfaces were available for examination at the time of my visit. However, the lode has been partly exposed by an open cut, and the structure of the lode is clear. The slate has been replaced in zones parallel to the bedding-planes, and the lode-matter, therefore, contains a certain amount of undigested slate. The lode minerals are those usually present in the pyritic-cassiterite type; but the distribution of the tin ore can be studied on account of its relative abundance. It is certainly irregularly distributed on the whole, and where more abundant can be seen to occur in seams parallel to the bedding-planes of the slate and in veinlets which traverse these bedding-planes at all angles. These latter cross-fractures are, in my opinion, not of later date than the others. Both appear to have been simultaneous, and the tin ore was introduced at the same time as the less valuable minerals.

At one place in the open cut axinite is visible along the central portion of the lode and conformable with the bedding-planes. It has been introduced at a later date, in my opinion, and has been derived from the axinite vein which fills a fault-plane in the formation.

The disintegrated portion of this formation at the surface has been sluiced for detrital ore, and some of the semi-oxidized ore which caught fire spontaneously on the dump has also been profitably sluiced.

The open-cut exposure is about a chain in length, and at its northern end a shaft has been sunk. The greater part of this shaft has been filled in, but some excellent ore is lying on the surface, nearly—probably derived from thence. This ore is crustified, and consists of quartz and an intermixture of arsenopyrite and fibrous-radial cassiterite. The depth of the shaft is said to be 40 feet.

There is some further work done underground upon the more southerly portion of this lode. A tunnel was driven for 78 feet on a bearing S. 34° E. This crosscut intersects the axinite vein at a small angle. At 78 feet from the entrance a short crosscut of 12 feet was carried eastwards. It encountered a dense pyrrhotite body dipping to the eastward, and was abandoned.

Driving was resumed in the country, and at 22 feet past the turn-off from opening drive the axinite was again met.

A crosscut was here carried along on the axinite vein. Pyrrhotite came in first on the eastern wall of the drive, dipping at about 30° to the eastward, and strongly banded in structure.

On the western side of the crosscut the structure appeared more massive. The bounding-wall of the lode on this side of the crosscut appeared to me to be dipping to the west, but the ore had weathered to such an extent that accurate observations were impossible. At a distance of 28 feet from the main drive a winze was put down 6 feet. This is said to be on good ore, but it was full of water. Good ore is also said to occur above the winze on the eastern side of the axinite vein. Crosscutting was continued past the winze till a total distance of 76 feet from the main drive was reached.

A narrow veinlet of ½-inch to 1 inch in width was found rising in the back of the crosscut as the latter advanced (dipping westwards). This is said to assay well for gold. A few feet ahead of this place, in the face of the crosscut, there are quartz seams carrying tin ore and dipping in all directions.

The main drive was carried forward on the footwall side of the lode. The country is strongly banded, and carries pyritic veins said to carry tin ore. At 88 feet from the crosscut mentioned above another was started and carried eastwards for 21 feet. It was abandoned in hard slate carrying pyrrhotite.

Some 40 feet further on a rise was put through to the surface, and emerged at a point 90 feet above the back of the drive. Good ore is said to have been passed through for 30 feet on the eastern side of this rise, and the ore is said to have passed out on that side. This seems remarkable, as it would indicate a dip to the westward. The rise was inaccessible, and I could make no investigation of it myself.

The main drive was continued beyond the rise, and after driving 30 feet no more ore was seen. At 68 feet past the rise a small crosscut was driven some 12 feet eastwards on a small vein said to be tin-bearing. Beyond this, at a distance of 16 feet, the underground work ceases. A little axinite is visible in the face.

All of these exposures are very much discoloured by the weathering which has proceeded during a long period of inactivity, and it is hard to decipher the details of occurrence; but from the appearance of the ore upon the tip there can be little doubt but that the lode is an extremely valuable one.

The more friable portion of it is partially decomposed, and would be amenable to cheap treatment, but the undecomposed ore is dense and hard, and carries pyrrhotite rather than marcasite and pyrite as the principal gangue mineral.

In Section 271-M there is yet another lode of the pyritic-cassiterite type, which appears to have a close genetic connection with the lode just described. It is striking towards the tunnel mentioned above, on a bearing S. 24° E. It is a narrow lode, 1 to 2 feet in width, and has been trenched upon for a length of 3 chains to a depth of 2 feet. I am informed that the work done here was highly profitable.

This lode, when considered in conjunction with the larger mass worked underground and on the surface, as described above, shows a marked resemblance to the structure of the quartz-porphyry dykes. Mention has been made of this in another part of this report.

It is therefore proper to investigate the question of the southward continuation of this small lode. Up to the present very little has been done in the southern section, but enough, in my opinion, to show that part of this lode-system does continue up the hill to the southward.

On the southern bank of Dead Man's Creek some trenches have been put in to try and locate the origin of some tin ore which was found on the slope towards the creek. These trenches have proved the presence of a broad band of slate traversed by numerous stringers of stanniferous pyrites and quartz. The veinlets have no constant direction where visible.

A short tunnel driven for 21 feet in a direction S. 18° E. had intersected several of these bands in a semi-oxidised condition when abandoned.

Nearer to the main workings, and in the creek bed, a pyritic lode carrying tin ore was found alongside an 18-inch dyke of quartz porphyry which intersects the gabbro at this place. The workings were covered up at the time of my visit.

The quartz porphyry is very probably connected with the dyke which is showing in the face worked by Messrs. Duncombe and Maddox. The lode has some connection with that on the boundary between the sections, for the water met with in the rise mentioned above suddenly ceased when a dam on the site of this lode was removed.

The axinite vein which intersects the underground workings has been trenched on for a distance of 2 chains. The lode is of the "limuritic" type, and has been described above. It is itself distinct from the tin-bearing lode-stuff, and occupies a fissure which has intersected the pyritic-cassiterite lode after its formation.

The property owned by the Boulder Company shows much promise, and the development of the other lode-matter should be pushed forward while the battery is treating the detrital ore and oxidized lode-matter in the north-western corner of the lease.

In particular, the old Cornwall workings should be reopened, since without a considerable amount of further work actual mining cannot be carried out. It will be decidedly unwise if the opening up of the lodes is left until the battery has no ore of an oxidized character left to treat. In the event of the Cornwall workings opening up well it will probably be found necessary to move the site of the battery.

The total output of tin ore from the section cannot now be arrived at.

Alluvial ore has been won from both Dead Man's Creek and Gormanston Creek, and a certain amount also from Dalcoath Creek.

The amount of detrital ore obtained from the outcrops near the boundary of the two sections is not known.

Some 33 tons of cassiterite were won from the sluicing of the pyritic "floor" near the present battery site.

Since crushing started I am informed that the mill has recovered altogether 10 tons of tin ore from 700 tons of stone crushed. The average assay value of this ore is 70 per cent. metallic tin.

These figures afford the details of the output up to the beginning of February, 1909, and have been courteously furnished by the mine manager.

(5)—The Dreadnought Sections.

The two sections constituting the Dreadnought lease are No. 2650-M (78 acres), standing in the name of Chas. Brumby, and No. 2763-M (77 acres), registered in the name of A. G. S. Morton.

These two sections comprise the northern and eastern slopes of the Dreadnought Hill, and beyond these the southern fringe of the old flood-plain of the Pieman River. The greater part of the section is occupied by the slate of the Dundas series. A dyke of diabase crosses the south-western corner of the lease, but is not of economic importance in any way, since it is of later age than the ore-deposits, and does not intersect them within the boundaries of the lease.

The economically important portions of the lease are—(1) The lode-system which has been styled above the Dreadnought-Federal lode-system; and (2) the secondary concentration of alluvial material in Isaacson's Creek, which runs along the northern boundary of Section 2763-M.

(1) The Dreadnought-Federal Lode-system.—This term has been here applied to the complex system of veins which extends through the greater part of Section 2650 in a north-west—south-easterly direction. The northern limit of the system, as far as has yet been proved, is near the crest of the Dreadnought Hill, and it extends beyond the southern boundary into Section 1273-M.

The width of the formation cannot yet be definitely stated, but it is considerable.

The principal work done on the formation has been carried out at a point near the summit of the Dreadnought Hill, where the most prominent outcrop is located.

The north-eastern slope of the hill is extremely steep at this place, and the outcrop, which came right up to the surface, was masked by a dense cover of scrub. On this account, no doubt, the lode remained so long unprospected. However, in the early days of the mining field, it must have been found, as a tunnel was started at a point about 180 feet below the crest of the hill, and driven into the hillside for 99 feet before being abandoned.

Mr. H. E. Evenden's discovery of tin-bearing stone in the outcrop, and afterwards in the gossanous body intersected by the tunnel, led to the present resumption of work, both on the surface and underground.

The scrub has been cleared, and a few trenches cut in the hillside to the north-west of the tunnel entrance for a length of 2 chains, and at heights varying from 30 to 90 feet above the level of the tunnel. This trenching has been done on the line of the lode-system, and without so far exposing the north-western limit of the formation.

The main trench is some 2 chains in length, and has been carried up the hill face in steps. The direction of the trench is W. 25° S.

From the exposure that has been made of the ore it can be seen that there are a series of more or less parallel zones of tin-bearing gossan in the slate, and that these zones at this point usually conform to the bedding-planes of the silicified slate. The prevalent dip at this place is to the E.S.E., at an angle of about 50°.

Samples taken from a width of 40 feet in the lower portion of this trench have given exceedingly promising results.

A shaft was started at the head of the first bench, but abandoned when 4 feet 6 inches of sinking had been done. The object of this sinking does not seem clear, since the successive zones of tin ore are much more nearly vertical than horizontal, and with a steep hill face to assist prospecting short tunnels would afford much more information regarding the structure and contents of the lode than isolated shafts can give.

The other trenches which have been cut are more shallow and give less information. They show in places bands of extremely rich stanniferous gossan of a character which is common to the richer portions of the pyritic-cassiterite lodes of the district. How much of this ore is present cannot be determined from the amount of work done on the surface up to the present.

The directions and angles of dip of the bedding-planes of the slate are at first a little confusing when the surface evidence is examined.

As a whole, the lode-system appears to me to be dipping at a fairly steep angle towards the north-east; and in most cases the slate which lies within the limits of the formation has a similar dip. These remarks apply, of course, only to the present exposed portions of the formation, which constitute only a fraction of the total length of the system.

The tunnel was driven on a bearing S. 22° W. for the first 99 feet. At 54 feet from the entrance a small excavation has been made in the western wall of the drive on gossan carrying tin ore. At 86 feet from the entrance short drives have been carried on lode-matter in both north-westerly and south-easterly directions; for it was at this point that the stanniferous gossan was first recognized underground.

The north-western drive was only carried 10 feet. It shows that the lode-matter partly follows the bedding-planes of the slate and partly cuts across them.

The bedding-planes at this point dip E.N.E. at an angle of 10°. In the face of the drive semi-oxidized pyritic ore is visible.

The south-eastern drive runs for 37 feet on a bearing of 140°. It runs along a zone of slate impregnated with a number of veins of pyritic-cassiterite ore. No pyrites was showing in the old tunnel, but the new drive came into the pyritic ore at once. The principal veins of ore dip E.N.E. at 58° in this drive, and conform to the bedding-planes of the slate.

The main adit, at 99 feet from the mouth, has been turned, and continues for 69 feet on a bearing of W. 27° S. This drive has intersected a number of zones of iron-stained slate with bands of clean slate between. The gossanous slate zones dip N.N.E. at an angle of 40° to 50°. Numerous small cross-fractures occur, which are filled with ironstained clay, and carry tin ore.

In the face of the drive there is less limonite, and a few veins carrying quartz, pyrite, pyrrhotite, and cassiterite are visible.

The underground workings, as far as they have gone, show that the lode-system is still continuous at that level, and that there is rich ore present in the lode-stuff. The quantity of ore cannot, of course, be even guessed at until much more extensive workings are available for examination.

The level of the tunnel appears to have intersected the lode-system near the base of the zone of weathering, for oxidized, semi-oxidized, and unoxidized ore are to be found on the same level. The base of the weathered zone is not a plane surface.

Some 7 chains to the south-east of the tunnel a trench has been cut in a formation very similar to that which has been described above. The slate is indurated by impregnation with silica, and is stained with iron oxide resulting from the weathering of pyrite. Cubical cavities whence the latter has been removed are to be seen. The impregnation of the slate has as usual followed well-defined bands, and the tin ore is distributed in the same way. Some of the bands of tin ore at this place have been sampled, and have afforded high values on assay. Between this occurrence and those which are situated to the north-west (described above) and the south-east, there has not yet been proved a definite connection. There is, however, no doubt in the mind of the writer but that the several outcrops belong to a single-fracture system, and that they will be proved to be more or less continuous throughout. This opinion is considerably strengthened by the ascertained facts of the distribution of the outcrops, for they are situated on a line which runs about north-west and south-east; that is, in the main direction of fracturing in the district.

Very little more work has been done, except in the south-eastern portion of the section on the line of this lode-system.

A small cut has been made in the bed of the creek and the lode-matter has been exposed. It is very much more siliceous at this end of the section, but both pyrrhotite and pyrite are present.

Some of the quartz is crystalline, but for the most part it is massive. Tin ore is present, especially in the more gossanous portions of the lode.

A similar outcrop has been cut into at a point still further to the south-east, and has proved tin-bearing.

Taken as a whole, the lode-system which has been tapped at the several points described above may be regarded as one of considerable possibilities. Until more work has been done in exposing the length and breadth of the formation little more can be said. The formation extends in a south-easterly direction to the boundary of the section. So far its north-easterly limit can hardly be said to have been proved. The most northerly trenches have not penetrated the surface cover of decomposed slate, which may well conceal the continuation of the outcrop. In this connection it may prove of interest to state that the outcrop of a diabase dyke on the opposite fall of the hill has been concealed in exactly the same way; yet we can have no doubt about the connection between the outcrop of the diabase on the Dreadnought Hill and that which is visible in the creek bed to the north-west of Section 3621-M.

The question of the northern extension of the ore-body can, in the opinion of the writer, be left unsettled until more is known of those portions already partly exposed. The configuration of the country is favourable to the prospecting of the lode-system by adit levels; and in locating the site of a future tunnel, it would seem wise to secure as many feet of backs as possible. By such a procedure a double purpose would be served, for, apart from the question of the height of possible stopes, there is thus to be gained some information regarding the width of the lode-system.

This lode-system is to be regarded as a shattered zone of rock impregnated with pyritic-cassiterite ore of normal type. While the dip and strike of the several veins which constitute the whole system are variable from point to point, there is not that marked divergence from normal lode-structure which is shown by the other great lode-system running through the Renison Bell, Montana, and Boulder leases; that is to say, the vertical components of the Dreadnought-Federal system are the more important, and the structure is not essentially different from that of complex lode-formations in other localities, where mineralization has followed the course of a zone of fracture rather than a plane of fracture.

(2) The deposits of Isaacson's Creek have been worked at various times by small parties for the tin ore collected by the creek from the older Pieman alluvial deposit through which it runs.

This appears to be one of the few localities in which there has been found workable ore within the limits of the older alluvial, and, as has been indicated above, another concentration by a present-day stream has been necessary to render working for the tin ore payable.

It was impossible to ascertain how much tin ore has been won from this creek. A few ounces of gold are said to have been obtained while work was in progress.

The chief value of the northern section, as far as is yet known, lies in its position on the line of strike of the lode-system.

(6)—The Federal Tin Mines, No Liability.

The section numbered 1273-m, 79 acres, and standing in the name of A. S. Stebbins, contains the crest and slopes of Stebbins' Hill.

The area is almost wholly covered by members of the Dundas slate series. Near the north-west corner there is a small outcrop of porphyroid, and in the south-west corner the diabase dyke is visible.

The lode-matter of most importance in the section is that which belongs to the "Dreadnought-Federal" system, to which reference has been made. Besides this, the south-western portion of the section lies within the limits of the Renison Bell-Montana-Boulder lode-system, and on the southern boundary dense gossans are outcropping.

The principal work done on the section up to the present has been the renewal of operations upon the lode-system extending into this section from the Dreadnought Company's ground. The outcrop was found many years ago, and a tunnel was started at a point 150 feet below the top of the hill, but after being carried 27 feet the tunnel was abandoned.

The lode-matter was just touched by these workings.

On the resumption of mining the driving of the tunnel was continued, and an open cut started upon the outcrop higher up the steep hill slope.

These open-cast workings have disclosed the presence of some pockets of rich ore enclosed in ore of much lower grade. The rich ore is of a gossanous character, and similar to that from the Dreadnought lease. The main cut at this place shows a wall to the lode-matter, composed of slate, and striking N. 4° E. At first sight this may seem strange, since the lode-formation as a whole has been charted as running on a N.W.-S.E. course. But it must be remembered that the fracture-system is a complex one, and that the several minor fractures may not correspond in strike with that of the system as a whole.

A trench has been carried up the hill in a direction nearly due west, and has not disclosed the presence of any ore.

The tunnel has been driven for 52 feet on a bearing of 243°, and thence onwards on a bearing of 227° for a total distance of 107 feet from the entrance.

For the first 25 feet the tunnel penetrates weathered slate. This is succeeded by a broad zone of quartz and gossan for 29 feet. The lode-formation is very irregular in structure and composition. Parts are dense quartz and other parts contain fragments of altered slate, while here and there are cellular patches of interlacing quartz crystals stained brown with limonite.

At a distance of 50 feet from the approach good ore was met, and at 54 feet some very rich iron-stained tin ore was found. This zone is followed by 19 feet of mixed lode and country. At 62 feet from the approach there are some rich pockets of soft pug and tin ore.

Beyond this, at 73 feet from the approach, a belt of slate 11 feet wide has been cut. The boundary between the lode-matter and the clean slate dips to the north-east at 35°. Beyond the slate another body of ore, consisting of quartz and gossan, 5 feet in thickness, was passed through. This ore-body dips north-east at 70°. Beyond it only slate was met with.

It is not possible to detect the dip of the bedding-planes of the slate underground.

The several ore-filled fractures vary considerably in dip, but in the latter part of the tunnel the ore seems to be crossing the direction of the tunnel at right angles, so that the direction of strike would conform to the general strike of the whole formation.

A little driving has been done on the course of the rich ore in a south-easterly direction for 33 feet and in a north-westerly direction for 9 feet. The longer drive is in gossanous ore carrying some very rich patches.

The outcrop on this lode-system continues to the north-east for some distance. At the surface it appears to turn a little more to the eastward as it is followed south, but this cannot be regarded as certain until the ground is opened up, for the more easterly outcrop may belong to another portion of the system.

A low-level tunnel could easily be put in to test this lode-formation, as the configuration of the country is favourable. The same advantages would be gained by a low-level tunnel as those mentioned in the case of the Dreadnought lode.

On the south boundary of the section, where it adjoins the Boulder lease, some work has been done on the lodes mentioned above in the account of the Boulder lease.

The gossan outcrops which curve with the contours of the hill have been sampled in this section. A number of bore holes are visible, but no records have been preserved of the results. I am informed that a rough sample chipped from the surface showed the presence of tin and silver as well as a trace of copper.

At the top of the ridge and near the southern boundary of the section a shaft has been sunk at some period now unknown on gossan.

The shaft was full of water, and to judge by the size of the dump, must have been 40 or 50 feet in depth. The material composing the dump is a quartzose gossan, and should be examined for tin ore.

The scrub is very dense at this place and should be cleared, and the surface trenched to determine the nature of the gossan and its structure.

In the south-western portion of the section there has been a little sluicing done upon the lode-system which continues southwards into the Boulder lease. This has been sufficient to show that the flat "floor" structure is well developed. The richest detrital ore was found at a spot too high for sluicing, and it was found necessary to pass it down a timber slide to the necessary level. The excavation of a dam for this work at the foot of the slide revealed the presence of a massive pyritic formation.

This is probably continuous with the pyritic "floor" exposed by a trench 2 chains long that has been carried up the hill at a point some little distance to the northward; and there is also very probably some connection between the pyritic mass and that exposed on the Boulder section.

The slate overlying the pyrites is banded and irregularly impregnated with opal and quartz.

The methods for prospecting this lode matter and the need for samping the pyrites have already been discussed above.

The only other place where tin-bearing lode-matter has been found is situated near the foot of the eastern slope of the hill. A trench has been cut in a quartz and limonite formation for a few feet. This work was done some years ago and abandoned. More recently it has been found that the lode carries tin ore. It may possibly be connected with the Dreadnought-Federal line of lode, but this cannot be regarded as established until some work has been done between the known outcrops.

Hitherto the output of tin ore from the section has been small, and has been derived from the sluicing of the detrital ore in the south-western corner near the Boulder lease.

The future of the property depends largely upon the way in which this latter lode-system and the formation in the north-western portion of the section open up. The gossan outcrops on the southern boundary, if they prove to carry a payable percentage of tin ore, will be valuable assets, for the ore-bodies are large and easily accessible.

(7)—C. Brumby's Section.

The Section 1215-M, of 36 acres, charted in the name of C. Brumby, lies between the Dreadnought and the Renison Bell sections, and occupies the western slopes of the Dreadnought Hill, with a small part of the northern spur of the Renison Bell Hill.

The greater part of the section is slate, and the diabase dyke is visible on the eastern boundary and for a few chains into the section.

There are two isolated outcrops of gossan on the section, and the south-western portion of the lease lies within the limits of the Renison Bell-Montana-Boulder lode-system. It is this latter portion which has been profitably worked along the bed of the eastern branch of the Renison Bell Creek.

The workings at that point are not extensive, but, for the area treated, highly productive. They are undoubtedly part of the lode-system, and connected with the closely adjacent workings on the Montana section. There is a pyritic "floor" visible in the bed of the creek, and the detrital ore has been sluiced down to this.

At the time of my visit very little work was being done, for the formation within this section has now been stripped of practically all the disintegrated ore; and to treat the residue of even the oxidized lode-stuff crushing will be necessary. The pyritic "floor" visible in the creek bed may be a portion of the lower of the two floors visible on the Montana section, or possibly it may be yet a third floor not elsewhere exposed.

A few chains down the creek, and on the eastern bank, there is an outcrop of black gossan, which stands up precipitously. No attention has been given to this huge outcrop, probably because it does not continue on the surface for any distance.

There is another outcrop of gossan near the north-western corner of the section on the boundary-line between this section and the Renison Bell lease. It was probably thought at one time that the two isolated outcrops of gossan were portions of one lode, for a very long tunnel has been driven, apparently in the hope of cutting the supposed lode. This tunnel was started in the Renison Bell ground and driven eastwards on a bearing of 75°. It is wholly in slate, dipping to the north at an angle of 15°.

A small plant has been erected in the bed of Renison Bell Creek to deal with the accumulated slimes and sands which have come down from the workings at the head of the creek. The sands and slimes have settled in the creek bed, which has been dammed for the purpose.

The treatment scheme is as follows:—

There are two main dams, the upper of which serves to control the flood-water by diverting it into a bywash. This water is used lower down for scouring the waste material into the creek.

From this upper dam only enough water is allowed through to carry feed to the trommel, which is situated immediately below the second dam. The trommel-screen is perforated by circular holes of $1\frac{1}{2}$ m.m. diameter.

The oversize from the trommel is carried away by the bywash, as mentioned above. The undersize passes over the waterwheel which drives the trommel, and thence is carried to two settling pits. These are filled alternately, and the overflow from them drives an overshot waterwheel which drives the rotary table.

The table is geared to rotate three times in four minutes.

The slimes from the settling-pits are hand-fed into a launder and pass through a trommel with a woven wire screen of 30 mesh. The oversize passes to waste, and the undersize is fed on to the table.

Two settling-boxes are placed in series to catch any slime tin ore which may not be caught in the concentrate compartment.

The tin ore is streamed by passing it over the table.

The first product assays between 25 and 30 per cent. of metallic tin, and the reconcentrate assays 70 per cent. or thereabouts.

The value of this section will depend upon the future of the lode-system in its south-western portion. The prospecting of the lode-system is dealt with elsewhere in this report. It will be particularly interesting to the owner of this section to find what is the dip of the lode-system as a whole. At present it is undetermined, but some of the principal feeding-fissures dip towards the north-east, and it is possible that the lode-system as a whole may have a similar dip. If so, it will underlie into this section.

The gossans which have been mentioned should certainly have a cut put into them, and should then be sampled and assayed for tin ore.

The output from the section from all sources has been nearly 25 tons of tin ore, the assay value of which is about 70 per cent. metallic tin.

The gross value of this ore is about £2350.

(8)—H. E. Evenden's Section (3370-m), and H. E. Evenden and S. Reardon's Section (3660-m).

These two sections lie between the Dreadnought and Stebbins Hills and the Ring River.

The greater part of both is covered by slate, but there is an outcrop of gabbro in one portion of Section 3370-m.

In this section, which comprises 70 acres, very little work has been done, save in the creeks which run towards the north-east. From these creeks some tin ore, as well as a little gold and osmiridium, have been recovered. These occur with chromite in the creeks round the foot of the hill, and are clearly derived from the older river alluvial, of which traces still remain.

On following the creeks up towards their sources the chromite, gold, and osmiridium cease, and the tin ore is more angular in character. This tin ore is doubtless from the Dreadnought-Federal lode or from some other similar ore-body.

At a point only a few chains distant from the south-eastern corner of the Dreadnought lease some gossanous ore rich in tin oxide has recently been found, but not enough work had been done, when my examination of the spot was made, to determine whether the gossan was *in sitû* or not. Possibly it is fragmental, and derived from the lode-formation higher up. Other masses have been located in the scrub at this place, which may have had a similar origin. The question can be quickly settled by cutting a trench down to the bed-rock.

It is stated that about 3 tons of tin ore, 5 ounces of gold, and 3 ounces of osmiridium have been taken from the creeks in this section.

The section 3660-m, lying to the northward of the latter, comprises 62 acres. It has been, up to the present, hardly prospected at all. On the southern boundary-line, near the south-western corner, a quartzose lode has been partly uncovered in the creek bed. This lode-stuff has not been tried for tin ore, but a prospect of tin ore can be obtained by washing in the bed of the creek just below the lode.

Near the south-eastern corner of the section a creek running towards the Ring River carries in its bed some water-worn quartzose pebbles, which clearly formed part of the older river alluvial. In this creek-wash there is a little tin ore.

The attention of prospectors on these sections should be devoted to any traces of lode-matter which may be found. It is quite possible that another line of fracturing may occur to the eastward of the Dreadnought-Federal system, and if such does exist the probability is that the strike will be within a few degrees of a north-west—south-east line.

Such being the case trenching should be carried out in a direction south-west and north-east.

(9)—A. Kemp's Sections, and M. Keys' Section.

There are four sections standing in the name of A. Kemp—2101-M, of 13 acres; 496-M, of 5 acres; 103-M, of 40 acres; and 1059-M, of 5 acres.

These are all situated near the junction of the Ring River with Dalcoath Creek; and the three former have been located in such a way as to comprise the bed of Dalcoath Creek for the whole distance from the north-eastern corner of the Boulder lease to within a few chains of where it enters the Ring River. The other section is on the Ring River.

The 13-acre section is wholly in slate, through which the creek has cut a steep-sided gorge. In the adjacent 5-acre section this gorge terminates with a fall, and the creek flows onwards through a small alluvial plain of recent date. The deposit of alluvial material only extends to the Ring River, and is at all points shallow.

That portion of the alluvial wash which is nearest to the gorge of the Dalcoath Creek is composed almost wholly of pebbles from the Pine Hill area, while near the junction of the creek with the Ring River there is a preponderance of pebbles of quartz and quartzite-schist. These latter doubtless come from the upper part of the area drained by the Ring River, and also from the older river alluvial which has been cut through by the Ring River and its tributaries.

The principal workings are situated on the site of the channel of the Dalcoath Creek, which has been turned aside so that it flows along the western border of the alluvial flat.

About 10 chains in all of the old creek channel have been worked, and at the time of my visit the face was very close to the falls. The central gutter only has been worked, although tin ore is known to exist in other portions of the alluvial flat.

The depth of the gutter below the surface of the flat is usually about 10 feet, and in some places as much as 15 feet.

This has been worked by hydraulic power. The water is taken from the Dalcoath Creek just above the falls, and carried down to the face. A hydraulic jet elevator is used to convey the gravel from the face into the race.

The tin ore is, on the whole, coarse in grain, and some of the nuggets recovered are several pounds in weight. These larger nuggets are exactly similar to those recovered in the upper part of the Gormanston Creek, and are certainly derived from the same source.

Towards the centre of the 40-acre section the alluvial material becomes intermingled with that derived from the Ring River, and the tin content is poorer. Some rich pockets have been found on the bottom, but these have not proved to be of any extent.

Mr. Kemp informs me that from these low-level workings £3000 has been taken for the tin ore recovered.

Above the creek channel, on the slopes of the hill, there has been a shallow terrace of alluvial wash similar to that in the bed of the creek. It has been sluiced for several chains, and 12 tons of tin ore are said to have been won from it.

Near the northern boundary of the section some 3 tons of tin ore have been recovered from a similar deposit.

When the main channel through the alluvial flat has been worked it will be necessary to examine the flat carefully for any other former channels which may exist. It is improbable that the Dalcoath Creek has always found its way to the Ring River by the same course, and any other channels which it may have occupied should contain payable wash.

There has been a large amount of non-productive work carried out on these sections which was necessary for the successful working of the main gutter. Such work has now been done, and should any other gutter be located there will not be the necessity for preliminary expenditure and delay.

The flat should be systematically prospected by a series of holes across the unworked area, spaced at short intervals.

The 5-acre section 1901-M, charted in the name of M. Keys, adjoins the north-western corner of A. Kemp's northern section, and lies on the eastern bank of the Ring River.

On it a galena lode has been located, and a tunnel has been started on the lode which strikes N. 11° W., and dips at a steep angle towards the east. In front of the mouth of the tunnel a hole has been sunk, and has exposed some fair ore.

The lode-matter consists of quartz, siderite, and galena, together with iron pyrites.

A few yards to the eastward there is a gossanous outcrop, which probably marks the site of a parallel or branch fissure.

The lode has been lined out with stakes up the hillside, but the underlie has not been taken into account. Before trenching is carried out, this line should be turned a little to the westward, for the dip of the lode would carry it in that direction, as the outcrop rises from the low ground.

The galena has proved to be of good grade, and the lode is well worth further attention.

From this section a small amount of tin ore has been won. It was recovered from a small creek running into the Ring River.

(10)—The Button-grass Plain North of the Dreadnought Hill, and T. C. Goodall's Section.

The nature of the alluvial deposit which covers the flat country to the northward of the Dreadnought lease has been described, and the conditions under which it formed have been indicated. Some dredging areas were formerly pegged out on the site of the creeks which drain the button-grass plain, and flow northwards to the Pieman River; but the deposit is too shallow, and the only section now taken up in this area is that charted in the name of T. C. Goodall, 3621-M, 80 acres.

Some fair prospects can be obtained in most of the creeks running through this area, but there is only a foot or two of wash, and there is some difficulty in bringing in sufficient water to treat the alluvial.

In no case did there appear to be any tin ore present which was of local derivation.

The chromite, gold, and osmiridium found with the tin ore point to different sources in the case of the various constituents.

A few bags of tin ore have been won from the creeks in this area, but the total amount cannot be great.

(11)—E. Hawson's Section.

The Section 1945-M, 79 acres, is situated to the north of the Renison Bell lease, and is traversed by the Argent River. The eastern portion of the section is almost wholly covered by the older river alluvial deposit. Where this shallow formation has been removel by denudation, as in the western part of the section, the slate outcrops.

That portion of the section which is economically the most important is the south-western corner. The great lode-system which stretches southwards through the Renison Bell, Montana, and Boulder leases extends into this section at the place named. A cut has been made in the western bank of the Argent River, which runs north and south at this place, and a pyritic body has been exposed. The exposure is a small one, and is terminated by a cross-head striking W. 15° N., and dipping northwards at 50°. I am informed that this pyritic ore when roasted and vanned will show a prospect of tin ore. This being so, the lode should be opened up.

The western bank of the river rises abruptly from this point in the direction of the north-western corner of the Renison Bell lease, and gossan outcrops here and there on the slopes.

A short tunnel has been started into the hill just above the outcrop in the river, and is driven 20 feet on a bearing of 243°.

It passes through 10 feet of slate, and the next 10 feet are in semi-oxidized pyrites, with branches of ankerite and dolomite. Far too little has been done yet for any idea of the structure of the ore-body to be obtained. The gossan carries a certain amount of quartz, and does not appear to me to vary in any particulars from the normal gossans of the pyritic-cassiterite ore.

A little galena is visible in the carbonates mentioned above, and a solid body of galena, blende, and pyrite is said to occur in the bed of the river. The specimens taken from this vein and now lying on the bank show a little cerussite. The river has been turned during the dry weather in order to work this vein, but during my visit it was concealed. In all, half a ton of lead ore was removed.

The lead ore is not, in my opinion, likely to prove of much value. There are numerous other instances throughout the district of such veins; but they have failed to fulfil the promises shown by the outcrops.

More attention should therefore be given, in my opinion, to the tin-bearing lode-system which extends up the hill.

(12)—R. D. Lewers' Section (now Renison Bell Prospecting and Mining Company, No Liability).

The Section 4550-93M, of 37 acres, charted in the name of R. D. Lewers, adjoins the Renison Bell lease on the north-west. It occupies the crest and slopes of a hill which faces the low-level workings of the Renison Bell Mine.

The boundaries of the section enclose only members of the Dundas slate series, with the exception of a narrow strip of the older alluvial deposit of the Pieman River, which is left as a terrace along part of the northern boundary.

The conglomerate which forms the capping of the pyrites in the railway-cutting on the Renison Bell lease continues across the south-western slopes of the hill. It is impossible to say whether the fault-plane (the "cross lode" of the Renison Bell Mine) forms a boundary of the conglomerate here. There were, at the time of my examination, very few outcrops of the rock visible through the scrub. It is more than probable that the fault-plane referred to does continue through the section, and that the main gossanous ore-body which is charted on the section marks its outcrop. The strike and position correspond, but the dip could not be compared for want of the necessary exposures.

The main body of ore occurring on the section is this gossan, which runs from the north-western corner of the Renison Bell ground right across the section to a point 3 chains eastward of the north-western corner of the lease.

The largest development of the gossan at the surface is in the centre of the section, where the outcrop seems to be one of a nearly vertical ore-body.

There are at this place two other smaller gossan outcrops lying to the northward of the main lode, which belong, in my opinion, to two branches of the main lode. They are in each case bounded by a sharp bluff about 12 feet in height on the north-eastern side.

Shallow trenches have been cut between the main outcrop and these, and only slate country met with. Hence we may regard the three as belonging to a branching system of the variety described elsewhere in this report.

Whether the gossan carries tin ore did not appear to be known when I examined it. It is certainly well worth sampling.

On the northern boundary of the section the gossan becomes very much more siliceous, and is strongly banded. The silica is mostly of the chalcedonic variety.

This lode-matter is said to be tin-bearing, but the tin ore is not visible in the gossan to the unassisted eye. The pyritic ore is not far from the surface here, as pyrite is visible on the freshly broken surfaces of the gossan.

There is a western gossan outcropping on the western boundary-line at a point 2½ chains south of the north-western corner. The surface of this has been stripped off for a few feet, but nothing more has been done. The strike appears to be parallel to that of the other larger lode.

As will be seen later, tin ore has been obtained in the creek bed just outside of this section, and it is logical to conclude that some of it at least has been derived from these lodes.

The creek in the south-western corner of the section probably carries a little alluvial tin ore, but no work has been done there.

Since my return from the district the section has been, I am informed, taken over by the Renison Bell Company, and prospecting work has been carried out along the lode, with the result that tin ore has been proved at several points.

If there is a payable proportion of tin ore present along this lode, the occurrence will be one of considerable commercial value, and the Renison Bell Company will be able to work it from a tunnel driven from the south side of the hill.

(13)—W. A. J. Briggs' Sections.

The mineral sections standing in the name of W. A. J. Briggs are four in number—2764-m, 38 acres; 2766-m, 20 acres; 3240-m, 20 acres; and 2765-m, 20 acres.

These are so located as to wrap round R. D. Lewers' section, and lie for the most part between the Argent River and the McKimmie tramway.

The 38-acre section lies on the strike of the lode which crosses R. D. Lewers' section, and the outcrop is continuous into it for some chains.

So far nothing at all has been done in the way of testing the lode-matter.

The main outcrops mentioned above cross the creek near the southern boundary of this section, and from the disintegrated lode-matter in the bed of the creek I saw some tin ore washed.

The best prospects are to be obtained by washing the material caught in the crevices and spaces between the boulders of gossan in the creek.

Abutting against the massive lode which crosses the creek, and extending for 3 chains in a direction N. 70° W., is another gossan lode, which forms a junction between this lode and the second gossan lode to the westward of the former.

The concentration of lode-matter at this place should offer every inducement for active prospecting to be carried out. Until the lode-matter has been properly sampled and assayed, no idea of the value can be obtained, but the size of the ore-bodies is such that this work should certainly be done.

The lode-matter continues for some distance to the northward, where a little trenching has been done. The old alluvial terrace deposit is found at this place, but in addition to the rounded pebbles of quartz-schist, quartzite, and porphyroid, there is subangular lode-matter of local derivation. This is principally dense gossan, chalcedonic silica, and silicified slate similar to that found on the lode outcrops in the vicinity. A small outcrop of gossan has been located, and near it the prospects of tin ore are better. The gossan seems to me to belong to the lode already mentioned.

To the north-west of this outcrop there is a surface cover of the older alluvial deposit.

The only other outcrop of gossan on the section is situated near the eastern boundary-line in the gorge cut by the small creek which runs into the Argent River. The gossan shows only on the northern bank of the creek, and the structural details were not discernible. The country rock alongside the lode has been converted into a red quartzite carrying veins of silica.

On the northern 20-acre section, 2766-M, some tributors were starting to work the bed of the creek which traverses the south-western corner of Lewers' section and takes its rise here. The alluvial deposit is from 1 foot to 2 feet 6 inches in depth. There is some coarse tin present, which has the appearance of not having travelled far. The country rock at this point is slate merging into the same white sandstone and conglomerate which caps the "white lode" of the Renison Bell Mine. Exposures are rare, but I noted at one point that the dip of the slate was N. 30° E., at an angle of 70°.

The wash is full of fragments of the sandstone and conglomerate, and it has been inferred that the tin ore was shed from those rocks. If it has been thence derived, it is certainly not an original constituent of the formations, and therefore search should be made on the hill above this place for any veins traversing the conglomerate.

To the south-west of this point, in Section 3240-M, and at the head of another small creek there is a dyke of quartz porphyry 10 feet in width exposed for a short distance.

The strike of the dyke is N. 38° W., and the small exposure here visible is difficult to connect with the other long dyke, to which it is entirely similar. There must have been a very abrupt turn to the westward or a fault to account for its position at this place. Reference to the geological map will show that some turn or dislocation has occurred. There are very few outcrops, and the vegetation is very dense in the neighbourhood.

On the south-western border of the porphyry dyke there is a vein of quartz and pyrites, which is probably the source of the tin ore that can be obtained by washing at this place.

Fair prospects of tin can be obtained at a point further down the creek, near the south-western corner of R. D. Lewers' section.

There is a certain amount of detrital quartz associated with it, which appears to have come from a vein not far distant.

In the north-eastern corner of the southern section, in the creek bed, the most northerly outcrop of the long dyke of quartz porphyry is visible. It is said to carry traces of tin ore at this place.

(14) The North-western Extremity of the Tinfield. (A. D. Sligo's Section and G. Dunkley's Section.)

There appears to be a break in the continuity of the lodes as we pass north-west from W. A. J. Briggs' Section 2764-M. The adjoining 80-acre section, 3356-M, standing in the name of A. D. Sligo, is covered, in its northern portion, with the older alluvial terrace deposit. A number of holes have been sunk on this, along the track which crosses the section. The deposit is a shallow one, and carries only small quantities of tin ore. It appears to me that the best prospects should be obtainable in the beds of the creeks traversing the section.

In the centre of this lease a tunnel has been driven in a south-westerly direction into the bank of the principal creek. The tunnel intersects only slate and some irregular masses of quartz and limonite. It has been carried 85 feet on a bearing of 237°.

No record has been kept of this work, and it is not now easy to discover the object of driving the tunnel, as the ground above it does not suggest the presence of an ore-body.

Near the north-western corner of the section there is a gossan outcrop, which can be traced, with interruptions, into G. Dunkley's 65-acre section, 3296-M. In this latter lease it becomes massive and continuous, and can be followed almost the whole way across the section. Tin ore is said to have been obtained by crushing some of this gossan, but no details are available. In the creek near the termination of this outcrop there has been a little work done, and some galena and siderite are exposed.

This area should be carefully tested for tin ore, in spite of the fact that it is approaching an area which is predominantly a silver-lead district.

It has been shown that there is very commonly a little galena and blende present with the pyritic tin ores of the district, and it should not be assumed that a gossan is the capping of a silver-lead lode because some galena is visible.

(15)—The Penzance Tin Mines, No Liability.

The Penzance Company holds two mineral sections—5093-93M, 72 acres; and 5094-93M, 59 acres—together with two water-rights—810-W and 811-W.

The western mineral section includes the crest and slopes of Pine Hill, and the eastern one is situated on the slope from Pine Hill towards the Ring River.

The water-rights bring in the water from the eastern fall of the Commonwealth Hill.

The geological structure of this area is a little more complex than that of most of the other leases in the neighbourhood.

The surface of the western Penzance section is, for the most part, covered by the talus of quartz porphyry through which the massive quartz porphyry, still *in sitû*, protrudes. Where the talus has been removed by sluicing it is clear that the quartz porphyry is not continuous below, but forms dykes cutting through the slate. By reference to the generalized section on Plate III., the geological structure will be better understood.

The eastern section is for the most part occupied by the basic igneous rocks, but a narrow dyke of quartz porphyry crosses the south-western corner.

The principal occurrences of lode-matter are situated in the western section, and all appear to belong to the stanniferous quartz-tourmaline vein-type. The ore is found in lodes, which are so far not definitely connected with each other, and in a network of small veins intersecting the quartz porphyry and passing outwards into the slate.

In addition, there is a fair quantity of detrital ore in the talus, especially where this deposit rests upon a quartz porphyry bottom.

Up to the present the attention of the company has been directed chiefly to the larger lodes, and the detrital ore has been worked by tributors on both the northern and southern slopes of Pine Hill.

The fact that the removal of the stanniferous detritus has resulted in the uncovering of lode-matter should be sufficient incentive to the company to work the detritus on a much larger scale than hitherto.

The principal outcrop of lode-matter is situated close to the crest of Pine Hill and on its northern slope. The actual exposure of ore is small, but the grade is extremely high. Measured over the 15 feet of outcrop, which have been laid bare by the removal of the overburden of porphyry talus, the strike of the principal vein is very nearly north-east and south-west—S. 42° W. The dip is to the south-east at a considerable angle, which is not yet discernible. It will probably be about 50°. The formation itself is a complex one, consisting at the surface of a belt of brown or black indurated slate, which carries numerous irregular veinlets of quartz and tourmaline, with which tin ore is associated. This quartz is partly massive and partly crystalline, and some of it occurs in seams the surfaces of which are marked by a number of small indentations resembling cuts. This peculiar variety is due to the deposition of the quartz as a layer upon some other mineral since removed. It is regarded as a good sign when this variety of quartz is found in the detrital deposits, but where it occurs here *in sitû* the tin ore is not very closely associated.

A tunnel has been started on the hanging-wall side of the rich vein, and driven southwards for 60 feet from the opening set of timber. The approach and the tunnel passed through indurated slate carrying veins of quartz-tourmaline rock and stanniferous quartz-tourmaline veins for a width of 40 feet. The drive cuts across the formation at an angle, since the bearing of the drive is S. 8° E.

At 60 feet from the mouth solid quartz porphyry was met with, and the drive was abandoned.

Recently it was decided to drive a low-level tunnel to cut the rich vein mentioned above at a depth. The site chosen for the starting-point of the new tunnel is 156 feet north of the mouth of the old one, and 95 feet below it.

The overburden was sluiced from a narrow strip of ground between the two tunnels. From this work no tin ore has been sent to the market. What was recovered lies in the race. This work has been of great value in that it has given some idea of the country to be traversed by the tunnel. Another bar of indurated slate is exposed, carrying some smaller stanniferous quartz-tourmaline veins, and parallel to that mentioned above. The slate has been shattered, and the fragments impregnated and recemented together by quartz. A little pyrites is present, but most of it has been removed by oxidation. There are, however, a few irregular masses of limonite, which suggest the former presence of larger pyritic bodies, since weathered.

On the eastern border of the sluiced ground there are signs of another zone of indurated slate crossing the other (which runs north-east and south-west) at right angles.

The low-level tunnel is driven on a bearing S. 13° W., and had been carried 88 feet at the time of my examination. A gossanous lode-stuff carrying tin ore and tourmaline was cut in the first few feet of the tunnel. Then followed soft decomposed slate up to 64 feet from the opening set. At this point indurated slate carrying narrow veins of quartz and tourmaline was met. Finely divided pyrites is disseminated through the slate, and a little tin ore has been found in the veins. The drive was still in this rock when I last saw it.

After leaving the field I was shown some slate carrying veins of actinolite from this tunnel. The actinolite must have been introduced at a time other than that of the quartz-tourmaline impregnation, for it belongs to another class of deposit altogether. Large masses of it occur to the north-east in the huge vein which runs down the Gormanston Creek bed.

It is difficult to say what distance will have to be driven in this tunnel before the vein, which is so rich in tin ore at the surface, will be met with. Assuming that its dip is 50° there must be at least 230 feet of driving done.

A few trenches have been cut at a point 4 chains to the north-east of these workings, and the same hard slate carrying quartz veins is visible, but it is impossible to say whether this occurrence is the continuation of the rich vein of ore or the poorer zone in which driving was being done at the time of my examination. It seems to me advisable to push on with the present drive, and at the same time to continue the stripping of the surface deposit of talus so that the rich shoot of ore may be further exposed.

In the north-eastern portion of this western section there has been some work done to try and locate the vein from which the large Gormanston boulders were shed. Some trenches have been cut, and a shaft was started, but abandoned when down a few feet.

From the site of the shaft some good ore was obtained. It is rather different from the majority of the lode-stuff in this area, consisting of clean white crystalline quartz and black tin ore. The vein is distinctly crustified. There are loose blocks of similar vein-stuff found on the south fall of Pine Hill.

At the shaft there are some small veins of quartz-tourmaline rock, which are probably connected with the dyke outcropping to the southward.

Nearer to the north-eastern corner of the section the trenches have exposed a small portion of the actinolite vein, which extends for many chains towards the north. There are visible at one place haematite, garnet, pyrrhotite, and actinolite, all of which minerals belong to this vein, and not to the normal country rock.

The work done at this place is too limited to give an idea of the probable site of the vein from which the large alluvial boulders have been shed. Still, the vein-stuff exposed, and referred to above, differs in character from that of the rich stanniferous boulders*, and hence cannot have been the source of the boulders.

The parent vein whence these boulders were derived, to judge by the evidence of the boulders themselves, must be one of the stanniferous quartz-tourmaline variety, and it is most probably situated in the slate country.

Hence I regard it as most probable that the large rounded masses of the Gormanston Creek come from either the vein which is now being sought underground near the crest of Pine Hill, or from another vein similar in character and not far distant from the known one in position. It will be seen from the geological map that the strike of the known vein is such that its north-eastern extension would bring it very close to the spot where the big boulders were found.

The only workings upon the eastern section, 5094-93M, are very close to the boundary between the two sections.

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* *Vide supra*, p. 73.

A tunnel has been driven westwards for a distance of 245 feet on a bearing of 275°, and at a height 35 feet below the tunnel now being driven.

In cutting the approach for this tunnel a zone of black slate carrying quartz-tourmaline, and tin ore was passed through. It appears to have a north and south strike, and to dip at a flat angle towards the east.

Two trenches have been put in on either side of the tunnel, and show that the tin ore is almost totally confined to the hard zone, although a little is to be seen in the soft yellow slate cut in the northern trench.

The tunnel cuts through a number of bands of indurated slate, some of which carry a high proportion of pyrites, but no tin ore was seen in these in spite of the occasional presence of tourmaline. In one place there is a development of gossan from the oxidation of this pyritic material.

The last few feet of driving are in dense quartz porphyry of average type.

The tin-bearing lode left behind at the approach of the tunnel should be further opened up at the surface to determine the length of the shoot and its value.

The workings on the western portion of the lease have been responsible for the greater part of the output of tin ore, but they are all shallow surface workings. In all cases they are in immediate proximity to, or situated directly upon, the massive porphyry.

The talus varies very much in depth from point to point, being only a few inches deep in some places, and as much as 20 feet in others. On the northern fall of the hill, the area which has been worked by the company and by parties of tributors is very close to the boundary, and on the eastern bank of the Penzance Creek. The tin ore is found for the most part on the bottom, but can also be seen in the non-disintegrated boulders of quartz porphyry.

The quartz porphyry which is exposed on the sluiced faces can be seen to carry a reticulating system of veins, which cut, tend to divide the rock up into more or less rectangular blocks. The rock on each side of the veins has been altered by the vein-forming solutions in the manner described above.* The principal veins of the reticulating system have a N.W.-S.E. strike, or thereabouts, and the porphyry has been therefore subdivided into altered zones, which have a strike corresponding to that of the veins.

* *Vide supra*, p. 60.

Adjacent blocks are differently affected. In some tourmalinization is the prevailing type of alteration; in others silicification; while in others again the change is one of sericitization.

The tin ore is very largely restricted to the principal veins, some of which are very rich. But it is most important to remember that the ore-body includes also the rock adjacent to the veins into which tin ore has been introduced. This question is fully discussed below.

From this reticulating system the greater part of the alluvial and detrital tin recovered from this lease has been shed.

The tin ore can be seen in the massive porphyry which is *in sitû*, in almost every outcrop, but the percentage which is present has not yet been ascertained.

No time should be lost in sampling the various zones of impregnated rock. If the ore should prove payable, the quantity of it available for treatment is very large, and the facilities for working are great.

This sampling can be rapidly effected on the sluiced faces, and on the exposed face of rock which is crossed by the high-level water-race, and on the cliffs which run from the top workings up to the top of Pine Hill.

At the south-western corner of the lease, and on the southern slope of Pine Hill, a party of tributors are working the deposit of talus in the western fork of the creek.

The upper portion of these workings has revealed a slate bottom, which is brown in colour, and contains veinlets and contorted bands of quartz, with which tin ore is present in several places. Tourmaline is not abundant. The strike of this formation appears to be north-east and south-west, but the exposure is short. The dip could not be ascertained.

Below this impregnated zone the slate is soft, and gives way to a greenish, hydrous silicate of alumina, which appears to be pyrophyllite, the mode of formation of which does not seem clear.

The notable feature of the porphyry wash at this place is the occasional presence of large blocks of a vein-stuff which has not yet been found *in sitû* on the southern fall of Pine Hill. It consists of quartz crystals and black cassiterite, showing marked comb-structure. It is similar to the ore obtained in the shaft at the north-eastern corner of this section, but has doubtless been derived from some vein or veins on the southern side of the hill not now visible. Some of this ore carries a very high tin content, and a search for the vein should be made by sluicing away the surface deposit systematically.

As a prospecting proposition these two sections, taken by themselves, should offer every inducement to investors. Several occurrences of ore have been located, and mention has here been made of other possible sources of battery stone.

There has been hitherto too much hesitation in exposing the veins of good ore which have been found, and in two instances tunnels have been driven while ore was left behind in the approach. Even granting the fact that grave difficulties have been experienced through the dense cover of vegetation and porphyry talus, the methods of prospecting which have been adopted need modification in this respect.

Should the developments of the property create the need for a battery, the site will probably need to be fixed on the Ring River, and the question of amalgamation with the leases to the northward must be considered. The milling and concentration of the ore from this area will present no difficulties, as far as can yet be seen, and the configuration of the country is very favourable to mining.

Some of the questions discussed with regard to the alluvial ground on the area to the northward are of application to the similar material which is found on this section.

The output of tin ore from the company's lease is estimated to be in all about 36 tons, of which 30 tons were won on the northern fall of the hill.

(16)—A. D. SLIGO'S SECTIONS.

The sections here grouped together are six in number, viz.:—3495-M, 20 acres; 822-M, 25 acres; 317-M, 53 acres; 774-M, 75 acres; 3657-M, 73 acres; and 3658-M, 60 acres.

A water-right, 893-W, for 40 sluiceheads in the Ring River, is held by A. D. Sligo in connection with these sections.

One of these sections, 3495-M, occupies a part of the saddle between Commonwealth Hill and Pine Hill. The others occupy the northern slopes of Pine Hill and the long spur between Dalcoath Creek and the Ring River. The upper portions of the area embraced are traversed by the Gormanston and Penzance Creeks.

No one of the sections named is occupied by a single rock-formation. The greater portion is covered by slate, which is penetrated by, or associated with, igneous rocks.

The quartz porphyry forms a dyke which crosses the north-eastern corner of Section 3495-M. Another broad dyke extends across Section 822-M, and as far as Gormanston Creek on the boundary-line between Sections 317-M and 774-M.

The basic rocks occur as an isolated patch in Section 3495-M, and a broad belt to the east of Gormanston Creek in Section 317-M.

A zone of clastoporphyroid crosses Section 822-M, and is well exposed on the Penzance track.

The quartz porphyry talus extends northwards from the Penzance Company's sections, and almost wholly covers the spur between the Penzance and Gormanston Creeks.

The diabase dyke can be traced into Section 774-M, where it disappears.

Besides these there is a deposit of the older alluvial material in Section 3658-M.

These sections embrace the area which was first worked for tin ore in the district, and until quite recently they provided the greater part of the tin ore which left the field. Apart from the creek workings very little has been done in the way of prospecting the northern ground, but the more southerly sections have received some attention at different times.

On Section 3495-M, at the head of the Penzance Creek, and in the saddle between Pine Hill and Commonwealth Hill, a gossan "blow," attracted the attention of prospectors in the very early days of the field, and was first worked with the idea of testing it for silver and lead.

This ground was then held by the Renison Bell South Company, and Mr. Montgomery, in his report of 1895, makes a brief mention of it. At a later period the ground was held by the Mt. Lyell Copper Estates Company, and was being worked by this company at the time of Mr. Waller's visit in 1902. The workings, when I saw them, were much the same as at the time of Mr. Waller's visit, but the lode-matter exposed has been seriously altered by weathering in the interval.

It is now difficult to ascertain the structural features of the lode which has been responsible for the gossan outcrop. An open-cut has been excavated at the outcrop, and from what I could see the structure at that point is complex, and resembles in some respects that of the lode-systems in the northern part of the field; for the gossan cuts across the bedding-planes of the slate, and also lies between the bedding-planes.

Whether the vein-type is the same as that in the northern area cannot be determined until some unoxidized ore is exposed.

A tunnel was started at a depth of about 80 feet below the top of the hill to drive under this lode.

The approach of the tunnel is cut through a dyke of quartz porphyry, which strikes in a direction bearing 119° at this place. Immediately to the southward of this dyke a broad belt of gossan was encountered, which carries tin ore through it. The tunnel has been driven in a direction nearly due south. The bearing observed was S. 1° E., but this reading, with others obtained here, must be treated with caution, since the adjacent gabbro is heavily charged with magnetite, and pyrrhotite may be present in the lode-matter.

The tunnel was carried 138 feet on this bearing, and then 23 feet more on a bearing of 226°.

At 53 feet from the entrance a crosscut was driven eastwards for 28 feet, bearing 102°, and at 138 feet from the entrance another parallel crosscut was driven eastwards for 26 feet.

For the first 60 feet the tunnel passes through decomposed slate and gossan. Beyond this, both the tunnel and crosscut traverse indurated slate, carrying tourmaline. The first crosscut, also, is in gossanous material.

Until further work has been done at this place it is practically impossible to form any conception of the value of the lode. The size of the gossan outcrop and the visible tin ore in parts of the lode should suffice to justify the recommencement of work here at once. It will first be necessary to carefully sample the ore-body to gain an idea of the value of the lode-stuff. Then the two eastern crosscuts should be extended. It seems probable that the most southerly eastern crosscut will cut the lode if extended a short distance, and should it encounter good ore a drive on ore could be carried between the two crosscuts.

In the meanwhile much could probably be found out concerning the structure of this body by extending the surface workings.

Veins of quartz and tourmaline carrying tin ore run out into the gabbro near these workings, and with them is some magnetite, which appears to me to have been derived from the gabbro.

To the southward on the crest of the hill some trenching has been done on a very rich tourmaline-bearing vein. The ore exposed shows coarse crystals of tin ore in a band of tourmalinized and silicified slate. It is similar to that near the top of Pine Hill, and now being tested at a depth by the Penzance Company.

Whether it is part of the lode which has been followed in the underground workings above described cannot yet be said, for until further work has been done it is impossible to say whether pyrites is one of the important constituents of this type of vein, or whether the pyrites of the Penzance workings (and the gossan on this section) belong to another period of impregnation.

The rich vein on the top of the hill should be opened up in such a way that its strike, dip, and width can be ascertained. It can then be sought in depth from the underground workings mentioned.

The lode-matter on Section 822-M demands attention. At this point the workings on the steep eastern bank of Penzance Creek have afforded an excellent exposure of the reticulating system of veins in the quartz porphyry. The latter has been exposed at its junction with the slate by the sluicing away of a dense cover of porphyry talus.

The porphyry dips here in a direction E.S.E., and at an angle of about 40° or 50°. It was hoped that an ore-body would be exposed at the contact with the slate, but the results show that the contact between the two rocks is crossed by numerous veinlets of quartz, tourmaline, and cassiterite. The slate is not itself visibly affected by the igneous intrusion. At the time of my visit the soft slate carrying these stanniferous veins was being sluiced away below a cliff of quartz porphyry.

Some 10 tons of tin ore have been recovered from these workings, and it is estimated that 20 tons have been won from the Penzance Creek between this point and its junction with Gormanston Creek.

The careful examination of the cliff of quartz porphyry shows that it may yet be proved to be a deposit of very considerable value. It is, at least, necessary to test the whole exposed surface very carefully.

The features presented are similar to those shown by the smaller exposures already referred to in treating of the Penzance sections. The veins which traverse the igneous rock subdivide it into blocks.

The blocks probably owe their origin in the first place to an elaborate system of jointing consequent upon cooling. The veinlets occupy the joint-planes, and the impregnation of the rock has taken place on either side of the fissures.

At this spot many of the veinlets are obviously rich in tin ore. What is required in addition is the knowledge of what is the tin ore content in the impregnated zones of porphyry.* If it can be found that there are even a few zones of porphyry (consisting of the impregnated rock and the central veinlet) containing sufficient tin ore over a workable width to make them payable, the prospects will be bright indeed.

The writer is convinced that the investigation of this matter is one of the most vital questions concerned with the future of the field, for the exposure of available material is very large, and the facilities for open-cut mining are great. The porphyry is traversed by these veins for a great distance, and the ore, so far as exposed, is an excellent milling proposition.

It is not supposed that the whole of the porphyry can be treated, nor is it definitely known yet that zones of workable width carry sufficient tin ore to render the working of them profitable; but as a problem to be dealt with in future prospecting the importance of the question cannot be exaggerated.

The writer has, with microscopical assistance, seen an appreciable content of tin ore in rock which does not appear, to the unaided eye, to carry any at all.

This impregnation of the rock has not taken place to a similar extent in the slate country, and the veins themselves are less readily noticed in the porphyry. Hence it is that this occurrence has hitherto received no attention.

On the western bank of the Penzance Creek there is a little tin ore in the surface soil. It has probably been derived from the porphyry higher up the hill. The only other occurrence of lode-matter here is that of a little zinc blende in the porhyroid, but it does not appear to me to be very promising.

The deposit of most value in this area, apart from the lode-matter above described, is the alluvial or talus deposit which extends across into Gormanston Creek, in Section 317-M.

At a place 2 chains north of the south boundary of this latter section the large Gormanston boulders were found, and similar material in smaller sizes has been recovered all the way down the creek. The big ones probably came, as has been pointed out, from some such lode as that for which the Penzance Company is now driving a tunnel. Other similar bodies may exist beneath the cover of talus, and are, in fact, now being found where the alluvial

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* See Plate V., Fig. III.

material is sluiced away. In support of this view, that other such lodes occur but are not yet revealed, may be cited the occurrence of angular blocks of tin ore in the Gormanston Creek at a place 3 chains to the northward of the southern boundary of Section 774-M. Some of these were so big as to weigh 50 lbs.

The creek-bed deposits are only that portion of the talus that has reached the creek and has not yet been carried down to lower levels.

Here and there a little work has been done above the level of the creek-bed, and the talus has been worked; but the work has been spasmodic, and the difficulty of handling the larger boulders has proved an obstacle to successful treatment by small parties of tributors. The small areas which have been worked successfully are sufficient evidence that much of the ground would be payable if worked on a large scale; and if this were being contemplated it would be most important to ascertain whether the boulders of porphyry which constitute the talus deposit are not themselves worth treating. They are composed of precisely the same materials as the massive porphyry described above, and, if the massive rock contains a payable percentage of tin ore, the boulders in the talus should do so also. The difficulty which arises here is that the vein can be seen in the solid rock, and attention can be paid only to the most likely portion or to that which is actually known to carry tin ore, whereas the talus contains boulders from all portions of the porphyry intrusion jumbled together.

However, it appears to me possible that discrimination between the various types of altered porphyry can, with a little practice, be made by eye. Sampling of the several types will, of course, be necessary, and the eye must be trained, but the quantity of available rock is large, and it is worth while attempting to turn the disintegrated rock to account.

The sluicing that has been carried out near the bed of Gormanston Creek has revealed a lode of "contact" type, composed chiefly of actinolite and garnet. There is very little axinite associated with this lode in the southern part of its outcrop, but in Section 774-M, above the bed of the creek, axinite is fairly abundant. The lode attains a maximum thickness of 2 chains on the boundary between Sections 774-M and 317-M, where the banded character is very clearly shown. Zinc blende is the most common metallic constituent at this place. The lode is fully described elsewhere in this report.

The lode continues southwards under the spot where the big boulders were obtained, and a quantity of surface gossan which is visible at the head of the creek has very probably resulted from the oxidation of the pyrrhotite, which has been introduced during this period of vein-formation. Part of the gossan may, of course, have been derived from the weathering of the basic rocks which occur here. At the head of the creek the normal gabbro appears, but in Section 317-M the gabbro-amphibolite variety predominates.

In the bed of the Gormanston Creek, a few chains above its junction with the Penzance Creek, there is a lode which has been proved to carry tin ore. It is about 18 inches wide, and dips to the south-west at an angle of 30°. Judging by the composition of the exposed portion, I believe that this lode will prove to be of the pyritic-cassiterite type, and to be more closely related to the lodes to the north-west rather than those to the southward.

In the northern portion of this Section 774-M there are two small creeks which join and flow into the Dalcoath Creek opposite the long low-level tunnel on the northern boundary of the Boulder lease.

There is a shallow deposit of wash similar to that occurring in the bed of the creek on the eastern bank in this place, and it has been worked by tributors. The wash seldom exceeds 3 feet in depth, and is not often over a foot deep.

The exact amount of tin ore recovered from this place is not known, but must be fairly large.

A little gold and osmiridium was obtained here. It has doubtless been derived from the older alluvial deposit, which forms the crown of the hill to the north-east.

In the opinion of the writer, this older alluvial terrace does not constitute in itself a body which is likely to prove payable. Yet the deposit at this place is likely to prove richer in tin ore than at other spots more distant from the tributaries of the older Pieman River, which brought in the tin ore. The present site of the Dalcoath Creek does not appear to be very far from that which it occupied at the time of the formation of the alluvial deposit now forming a terrace. It will be worth while examining this older alluvial formation carefully for the presence of quartz porphyry pebbles, since these would certainly be present in the terrace deposits in greater proportions than usual at the former junction of the Dalcoath Creek and the old Pieman Valley.

Some work has been done on the course of a small creek in Section 3658-M, and the usual characteristics are shown. The tin ore was associated with chromite and a little gold and osmiridium, and, as usual, proved payable where secondary concentration has taken place.

On the eastern fall of the spur, above the Ring River, some sluicing has been done many years ago. The boulders and pebbles in this wash are similar to those of the Ring River of to-day, and to those in the terraces, except that in the lower portion some pebbles of quartz porphyry are to be seen. This wash is in places 3 feet or more in depth, and the bottom is slate. Mr. A. Montgomery, in his report on this area in 1895, suggested the presence of a former gutter running through this hill. It may be present, but I could find no positive evidence of it. The Dalcoath Creek must have existed at a very much higher elevation than it does at present, for the porphyry wash is visible high on the sides of the spur to the westward of the ridge. In fact, it may have joined the old Pieman River in some part of Section 774-M, and if so the porphyry boulders now visible on the Ring River side of the spur are due merely to a redistribution of the material brought down into the older Pieman basin.

A shaft has been sunk near the top of the spur in Section 3658-M, to which Mr. Montgomery refers in his report. It is down some 35 feet, and has been untouched since Mr. Montgomery's visit.

The evidence of the material on the tip, which consists of soft kaolin and fragments of slate, does not, to my mind, show any proofs of a gutter which might be the site of the former course of Dalcoath Creek. There are at least no pebbles of quartz porphyry in the materials heaped round the collar of the shaft.

On the eastern bank of the Ring River there is another terrace of the alluvial deposit of the old Pieman River, and Star Creek, which joins the Ring River in Mr. A. Kemp's section, 1059-M, has been worked in the earlier days of the field for the tin ore which has, doubtless, been derived from the older alluvial.

It is a very similar occurrence to several others mentioned in this report, and the payable ore occurs where the secondary natural concentration has happened.

The only other work done within these sections is that which has been directed towards the proving of a lode situated at the water's edge, on the western bank of the Ring River, and in Section 3658-M.

The lode strikes with the Ring River a few degrees west of north, and appears to dip to the eastward. The lode belongs undoubtedly to the pyritic-cassiterite type, and should be tested for tin ore wherever it is exposed. The lode-stuff is impregnated slate and clean ore as well, and is remarkable for the proportion of zinc blende and galena present. Reference has been made above to the presence of small amounts of zinc blende and galena in the pyritic-cassiterite lodes. At this place the lode shows so much of the two minerals mentioned, together with fluorspar, that it resembles more closely a pyritic lead vein than one of the type to which it has been here referred. It is in reality one of the occurrences of vein-matter which is intermediate in character between two related types.

At one spot there are a few veins of clean galena running in a south-easterly direction into the Ring River. These appear to be only small branches of the main lode.

There is a small outcrop of quartz stained with limonite at the northern end of the spur between the Ring River and Dalcoath Creek, but it is not known to carry tin ore.

The several mineral sections here considered constitute a property the chief value of which is situated in the northern portion. However, if it be found possible to work the porphyry as a whole, or a large portion of it, the ore can be carried to the Ring River on a good grade without leaving the boundaries of these sections; and it will probably be found possible to utilize the power stored in the Ring River for milling purposes. The supply of water is reliable; and from the topographical map published herewith it will be seen that there is a fall of over 200 feet (aneroid reading) between Ringville and the junction of the Ring River with Star Creek. The available water-rights are secured.

Should it be found possible to work the reticulating vein-system in the porphyry, these sections here treated of, together with the small section, 5063-93M, in the name of E. Swenson, should be amalgamated with the Penzance sections, and the whole group worked together, for the occurrence of tin ore is the same in these sections, and the problems of treatment are the same for all. Moreover, a large amalgamated lease should offer more inducement to capitalists. The possibilities, especially of the veins in the porphyry, are, to my mind, at least as great as those of any in the district; but it is certain that operations must be conducted on a large scale, and for that reason an amalgamation of interests is desirable.

Until capital is found to undertake the systematic sampling and prospecting of the area, nothing very definite can result. Yet, as a prospecting proposition, there can be no doubt about the merits of this area.

The output of ore from the leases standing in the name of A. D. Sligo cannot be given. The amount of ore removed from Gormanston Creek is not known, but it must have been considerable. Star Creek, also, is said to have produced a fair quantity.

(17)—The Remaining Sections near Pine Hill.

E. Swenson's Section 5063-93M, 5 *acres.*—This section is situated at the south-western corner of A. D. Sligo's section, 317-M, and occupies the central part of the spur between Gormanston and Penzance Creeks.

A fairly large area of the porphyry talus has here been worked with profit by a small party. Prospects which I saw washed on this section were certainly very good. Below the talus bands of indurated slate can be seen. They run in a N.W.-S.E. direction, and are probably due to the action of the vein-forming solutions which affected the quartz-porphyry.

I am informed that 18 tons, in all, of tin ore have been recovered from this section, of which 8 tons have been recovered by the present owners.

M. Curtin's Sections—3650-M, 76 *acres; and* 3651-M, 40 *acres.*—These sections are situated on the south of Pine Hill, and include the area between the Penzance lease and the Confidence Saddle. The northern of the two sections is situated on the broad belt of gabbro which runs through to the Melba Flat. The southern section is for the most part on slate. A quartz porphyry dyke traverses the two sections.

In the northern section there is a very promising vein in the gabbro, but at no distance from the quartz-porphyry dyke. Crystalline tin ore is visible in a gangue which is composed of quartz and fibrous radial aggregates of tourmaline needles.

The vein strikes S. 31° W., and dips towards the south-east at an angle of 75°. A little work has been done by the former owners of the section, but the intention has not apparently been to prove this lode, since the tunnel was driven away from it.

The bearing of the tunnel is S. 19° E., and it has been driven 40 feet. In the approach the lode is cut, and is of good value. The rest of the tunnel has been driven at an angle with the strike, and is gradually getting further and further from the lode. A short crosscut driven westwards from the end would intersect the lode in a few feet of driving. This should certainly be done.

A little trenching has been done near the mouth of the tunnel, and this work should be continued on the strike of the lode.

On the southern section, 3651-M, a tunnel has been driven for 96 feet on a bearing of 27° through a zone of brecciated slate. In this slate are some veins of quartz and pyrite, but no definite lode-structure could be discerned. A trench which has been cut on the slope above the tunnel is said to have afforded good prospects of tin ore.

From the creek which runs towards the Ring River from the north-eastern portion of the section a little tin ore has been obtained. But there is a great deal of chromite with it, as might be expected from the proximity of the basic rocks.

W. A. Hawkes' Section 1085-M, 27 *acres*.—Some work has been done in the north-western portion of this section, which adjoins the western section of the Penzance lease, and lies to the south of it.

The more recent work has been carried on in the bed of the creek which runs out of the Penzance ground through the quartz-porphyry talus. On the northern boundary this deposit is 20 feet thick. With the boulders of porphyry are a few composed of altered gabbro, the latter occurring *in situ* at this place.

A few small veins of quartz and tourmaline are visible in the bottom where the wash has been sluiced away.

From these workings 8 tons of tin ore are said to have been won, and the assay value of this ore is between 68 per cent. and 72 per cent. metallic tin.

Altogether, about 6 chains of this creek, southwards from the Penzance boundary, have been worked.

To the west of these workings some attempts have been made to pick up the course of a lode which was partly exposed by a trench in the north-western corner of the section. The country rock is slate, and it carries quartzose veins, in which tin ore is said to occur. The lode appears to me to be the continuation of that which is partly exposed in the south-western corner of the Penzance section.

A shaft was sunk to a depth, it is said, of 38 feet, and tin ore is reported to have been found in it. At the time of my visit the shaft was full of water.

At a point further east, a tunnel has been driven for 120 feet towards this lode-formation in a direction bearing 306°. The first 18 feet of the drive are in gabbro, and the remainder in shattered slate. At 90 feet from the entrance a drive of 18 feet was carried northwards on a small make of quartz.

The workings which show tin ore at the surface are still further to the north-west, and the tunnel must be continued in order to prospect the lode in depth.

G. K. Moore's Section 3114-M, 40 *acres*.—On this section there are some quartzose bands in the slate which occupies the northern part of the section. These were very probably introduced during the period of impregnation during which the siliceous lodes above described were formed.

No actual mining has been done on the section, but it is said that tin ore occurs in the surface soil. How much of this tin ore is of local derivation remains to be proved. The chief value of the section lies in its position on the strike of the lode running through the north-western corner of W. A. Hawkes' section.

G. E. Brown's Section 453-M, 80 *acres*.—This section is situated a mile and a half to the south-east of Pine Hill, on the Great Northern Creek, and is traversed by the North-East Dundas Tramway. The topography is extremely rough, and the greater part of the section is covered with dense scrub. Two lodes have been located in the lease, one of which is predominantly copper-bearing and the other is known to carry tin ore.

Both lodes should, in my opinion, be classed in pyritic-cassiterite type.

The copper-bearing lode is situated in the northern part of the section, on the western bank of the Main Creek, and just below the falls in the creek. The lode is 2 feet wide, and strikes N. 38° W., and dips to the north-east at 80°. On the foot-wall side the slate is impregnated for a width of a foot. The predominating mineral in the lode is arsenopyrite, with which occur pyrrhotite, copper pyrites, and quartz. The lode should certainly be tested for tin ore and gold, in addition to the copper known to be present.

A small open-cut has been made, the workings being carried into the steep hillside; and on the opposite bank a strip has been cleared for the purpose of erecting a haulage-system to raise the ore to the North-East Dundas Tramway-line, but at the time of my visit work was not in progress.

The tin-bearing lode has been exposed in the tramway-cutting near the southern boundary of the section. It is there in a semi-oxidized condition. The strike appears to be N. 60° W., and the dip is to the north-east, at about 80°. The lode-stuff is for the most part quartz and pyrites, but some specimens were shown to me which are said to have come from this place, and these are certainly rich in tin oxide.

An attempt has been made to cut the lode underground, and a short tunnel has been driven westwards on a bearing of 260°. This tunnel intersects a shattered belt of slate carrying flat quartz veins and seams of siliceous gossan. Some of these have been followed for a few feet in the underground workings, and some of the ore removed from thence shows a little crystalline tin ore.

(18)—Other Occurrences of Ore in the Central Portion of the Tinfield.

The section, 2816-M, 79 acres, held by Messrs. C. E. Brown and A. E. Hodge, contains a galena lode upon which some work has been done. It lies in position between the Emu Bay Railway line and the Argent River.

There has been a shaft sunk on the lode to a depth of 23 feet, and from this shaft some 3¼ tons of galena were recovered. The shaft was full of water at the time of my visit, and no work was proceeding.

If the lode exposed in the railway-cutting is the same as that upon which the shaft was sunk the ore-channel has pinched very considerably. The strike appears to be N. 30° W.

An assay made of clean galena from the shaft is said to have given a return of 86 per cent. lead and 66 ounces of silver per ton. The grade of the metal is therefore good, but the continuity of the lode remains to be proved.

On vacant ground near the top of the Commonwealth Hill a little work has been done some years ago by the West Coast P.A. upon a lode which is composed of galena, zinc blende, iron pyrites, with a gangue of quartz and siderite. The slate alongside the lode is indurated.

Another lode on vacant ground which has been partly worked is situated on the north-western slopes of the Commonwealth Hill, and is distant a chain and a half from the end of Messrs. Duncombe and Maddox's water-race. The lode-matter consists of zinc-blende, with pyrite, pyrrhotite, and a little galena in a gangue of quartz and chlorite, with minor amounts of calcite, ankerite, and fluorite.

It is a lode which resembles that described above as occurring in the bed of the Ring River, in Section 3658-M, and should be examined for tin ore, since it is clearly only a variant from the normal type of pyritic-cassiterite veins.

The lode runs almost exactly north-west and south-east, and a tunnel has been driven in a south-easterly direction for 129 feet on its course. The thickness of the lode varies from a few inches to a foot, and the dip is to the north-east at an angle of from 70° to 80°.

Both in this case and in that of the old West Coast P.A. workings, mentioned above, the distribution of the metallic minerals is irregular; and the occurrences do not offer very much encouragement.

On the eastern slope of the long spur which lies between Gormanston Creek and the Ring River there are two outcrops of gossan which are situated at points 5 chains east and 5 chains south of the north-eastern corner of Section 317-M. The area enclosing these two outcrops has, I understand, been recently taken up with a view to the proving of these gossan outcrops. Whether the two are connected it is yet impossible to say.

Samples taken from the more easterly outcrop are said to have shown a small content of gold; and, such being the case, the lode has possibilities for smelting purposes.

As in the case of other gossans in the district it should not be forgotten that there may be tin ore present.

(19)—The Occurrence of Tin Ore on the Melba Flat and in H. E. Evenden and W. T. Moyle's Section.

There has been a fair quantity of tin ore won from alluvial workings on the Melba Flat. Very little is being obtained at the present time, but some tons have been sent away in the past from the neighbourhood of the sawmill. The tin ore is not found more than a few chains eastward of the sawmill, and has been traced into Section 3558-M, 80 acres.

Up to the present time very little more than its actual presence on the section is known.

A strong gossanous ore-body crosses the section, and the tin ore has been traced up to this lode.

I saw some of the lode-matter crushed and vanned, with the result that fine tin ore could be seen; but it seems probable that there are veins of better grade than any which I saw *in sitû*, for the tin ore on the Melba Flat is sometimes fairly coarse and clean. More careful prospecting is therefore required on the section here referred to. The gossan is a dense one, and carries a high proportion of haematite, in addition to limonite. This may not be a feature of the lode in depth, and till some work has been done it cannot be decided. There has been a tunnel driven on the lode in a southerly direction, but it had completely collapsed, and was inaccessible at the time of my visit.

The upper portion of the hill is composed of the brecciated conglomerate referred to elsewhere, and there are two well-defined branches of the main lode exposed. Careful search should be made for any other branch veins in the conglomerate, some of which may have shed the cleaner ore found in the alluvial deposit of the Melba Flat.

The main lode follows a course which bears S. 12° E., and can be traced southwards for many chains beyond the boundary of Section 3558-M. It crosses Section 2339-M, and has been broken into on the surface at a number of places south from this section.

Whether a tin-ore content has been proved outside of Section 3558-M, I could not ascertain. Some of the work done was carried out a long time ago, and it is probable that no thought was paid to the possibility of tin being present in the lode.

(20)—The Occurrence of Tin at Dundas.

During my examination of the North Dundas tinfield there was a discovery of tin ore made near the centre of the town site of Dundas. The alluvial tin ore was discovered by Messrs. Quinn and Hodge, and was by them traced to a lode outcropping along a south-easterly spur of the Razorback.

The occurrence is one of extreme interest, in that no acidic igneous rocks have yet been seen in the neighbourhood, and the lode mentioned is very close to the junction of the slate with a broad belt of serpentine. However, the common origin of this serpentine, and the acidic rocks, has here been strongly advocated, and if this view be accepted there is less cause for comment on the association of tin ore with serpentine.

The lode lies in slate which shows a remarkable induration near the contact with the serpentine. The upper part of the Razorback consists of the brecciated conglomerate referred to elsewhere.

Two sections have been pegged out by the discoverers, viz., 3756-M, 20 acres; and 3765-M, 10 acres. Of these, the former is located high up upon the spur of the Razorback, and the latter lies in the flat country traversed by the Dundas Rivulet near the town.

At the time of my visit the upper section was being worked, water having been brought on to the section by means of short races from the small streams. A dam has been built at the top of the spur, but the water-supply is precarious, and rapidly ceases when rain stops falling. The area being sluiced lies on the north-eastern slope of the hill, and when my examination was made, very little had been done beyond the preliminary work of race-cutting, &c. The deposit being sluiced presents many surface features in common with the detrital deposits of North Dundas, but the structure remains to be proved. At only one place was the bottom exposed. It consists of slate in which are numerous cubical cavities after pyrite and veinlets of a siliceous or gossanous character.

In some of these veinlets the tin ore is fairly clean.

Those which I saw are small, but the presence of large slugs of lode-stuff in the detrital ore is proof of the presence of some fair-sized veins, some of which must carry a high percentage of tin ore. The forkings from the race present many features of similarity with those of the central area of the tinfield.

The depth of the detrital ore varies considerably—from a few inches up to over 5 feet in one place.

Only half a chain distant from the face which was being worked when I was on the section is an outcrop of quartz and limonite from which tin ore can be obtained by crushing and vanning. This outcrop appears to be part of the lode-system which is being worked, although its relationship to the detrital ore cannot yet be deciphered.

On the lower slopes of the hill there is a good deal of limonite in the surface detritus, and on account of this cover the junction of the slate with the serpentine is difficult to determine.

In the northern part of the section there is a tunnel which has been driven for 180 feet on a bearing of 248°. It is in serpentine all the way. The apparent reason of this work was probably the testing of the iron outcrop in depth, but the work was abandoned before reaching the slate country.

On the southern section taken up by Messrs. Quinn and Hodge some excellent alluvial ore exists. No work has yet been done on the section beyond the sinking of prospecting holes. The prospects washed here are certainly good, some of them giving as much as 4 ounces of tin ore to the dish.

Along the junction between the serpentine and slate at this point there is a considerable silicification of the slate. It seems to me probable that the tin ore has been derived from some veins in this silicified zone.

The amount of available alluvial ore is not large, and the deposit is restricted to the immediate neighbourhood of the creek and the zone of silicification. The tin ore is hardly rounded at all.

Just outside the section, and close by the western boundary, an attempt has been made to work the alluvial ground. A few square yards of surface wash have been sluiced away, and a few bags of tin ore won, but on the whole the ground was too poor to pay. The wash here is from 6 inches to 2 feet deep, and the bottom is a gritty sandstone belonging to the slate series. The tin ore obtained was partly coarse and partly fine. The latter contained an admixture of crystalline chromite, which could not be sieved out, but the coarse tin ore was effectively cleaned by sieving.

The section, 1897-M, which lies between the two sections taken up by Messrs. Quinn and Hodge, lies on the junction between the slate and serpentine; and along the contact runs an irregular outcrop of limonite, which has been partly prospected for the purpose of testing its value as a flux.

No work was proceeding on this section when I visited the district.

Only after the discovery of tin ore by Messrs. Quinn and Hodge was the section tested for tin ore. This is reported to be present in the lode-matter at one point in the northern portion of the section, but nothing more seemed to be known concerning it.

The lode-matter should be tested right through the length of the section, and the surface soil examined for detrital ore.

The lode which traverses the area here referred to appears to be continuous for some distance to the southward, and in view of the discovery of tin ore here should be tested right along its outcrop.

The type of vein represented at Dundas is the pyritic-cassiterite type, but the unoxidized ore has not yet been exposed.

VIII.—CONCLUSION.

It is as yet a very difficult matter to make any confident prediction with regard to the future of the field, for the era of lode-mining is only just beginning, and in very many cases still no attention is being paid to ores other than those of an alluvial or detrital nature. The future of the district cannot depend upon these classes of ore, which have hitherto provided almost the whole of the output.

A number of the more important occurrences of ore in the central portion of the tinfield have been here grouped together under the title of the Renison Bell-Montana-Boulder "lode-system," and the collective system presents certain difficulties when the future mining and metallurgy of the ore are considered. For the structure of the lode-system is exceptionally complex, and the ore for future treatment is a pyritic one.

It is perfectly certain that the oxidized ore cannot last long; therefore, for the sake of the future of the properties, a proportion of the profits made from the comparatively simple treatment of the oxidized ore must be spent in perfecting a system of treatment for the pyritic ore.

This question—the treatment of the unoxidized lode-stuff—must be always foremost in the minds of those to whom the management and control of the mining properties have been entrusted. It is a question which must not be left over wholly unsolved until all the oxidized ore is exhausted. Such a procedure would be economically unsound.

Since the problem must now be faced by a number of separate companies or interest-holders, its solution would undoubtedly be aided by the amalgamation of interests in the case of those mining properties in which the mode of occurrence of the ore is the same or similar.

It may be that the problems concerning the treatment of this pyritic-cassiterite ore will prove to be less serious than the holders of the several properties anticipate, but they can only be solved by careful and systematic experimental work. Statements have been made regarding the impossibility of having the ore treated locally by Australian metallurgists. Such statements are wholly unjustifiable.

There are several matters which are at present almost wholly undetermined with regard to this pyritic ore, and which demand solution forthwith.

First and foremost, the average value of the ore in the several mines must be ascertained. This cannot be done without development, and it cannot be done without careful and systematic sampling.

Then several other questions must be considered, and the details regarding the crushing, roasting, and concentration of the ore, together with the plant necessary for these operations, must be taken into account. The metallurgical and dressing problems cannot be settled in an off-hand way without experiment, and the best available advice should be sought at an early date.

There is no doubt but that the ore can be successfully treated, and marketable tin ore produced, if the grade of the ore is sufficiently good to enable the several operations of mining, milling, and roasting to be carried on at a profit. It is therefore essential to determine as soon as possible the value of the ore-bodies.

And in this valuation of the lodes there is one matter in particular which requires careful investigation.

The pyritic-cassiterite ore may prove to be itself of sufficiently high grade to allow of treatment, but it may be interlaminated with slate in some places in such a way that the bands of slate and ore must be considered together as the ore-body. In these cases it remains to be determined whether the ore-body as a whole can be profitably mined and treated, or, if not, whether hand-sorting or rough concentration can be effected so that the grade of the ore can be raised to the necessary standard.

The mineralized area in the centre of the field is certainly large, but it has been shown that this is mainly due to the horizontal position of many of the component members of the principal complex lode-system.

It remains for future prospecting to reveal the nature of the downward continuation of that lode-system. It is certain that the system continues downwards, but the details of the structure of the lower portions remain to be laid open by mining operations.

The work which has been done up to the present upon the Dreadnought-Federal lode-system would seem to indicate a greater simplicity of structure. Hence the mining and prospecting of the system will prove less difficult. But the same problems as those indicated above must be solved with regard to the dressing of the ore, which is of the pyritic-cassiterite type, Outside of the two lode-systems mentioned, and the lodes immediately adjoining these, the outcrop of greatest promise is that which is situated in the boundary between the two sections of the Boulder Company's lease. Some of the ore here is undoubtedly of very high grade, but very little work has yet been done on the actual lode.

The ore of the sections situated in the neighbourhood of Pine Hill presents a far greater simplicity of character, and as far as can yet be seen does not show any appreciable percentage of pyrite as an essential constituent of the lode-matter. The dressing costs should therefore be considerably lower than those of mines which have to deal with the pyritic ore.

The future of the properties in this area depends more upon the results of development work now actually in progress or suggested in this report than on the perfection of an effective and inexpensive method of treatment. Some excellent veins of ore have already been located; but there has been far too little done yet (in the way of following up these veins along their outcrop on the surface and of prospecting them in depth) to determine whether the future of the area is assured.

It has here been pointed out that the great mass of quartz porphyry, penetrated by stanniferous quartz-tourmaline veins and impregnated by mineralizing solutions on either side of these veins, is a possible site of future mining operations. The large area of impregnated rock, and the readiness with which it could be mined and treated, are surely sufficient inducements for active sampling and prospecting.

In the absence of any ascertained data bearing on the questions herein briefly indicated, an expression of opinion as to the future of the field cannot be given.

The field has produced a large amount of tin ore, and this fact alone should stimulate prospecting and encourage section-holders to proceed steadily with the work of testing the unoxidized ore.

With regard to the future of sections situated outside of the central portion of the field still less can be said, for very little work of any kind had been done on these at the time when this examination was made. There are numerous occurrences of lode-matter, some of which have shed a fair quantity of alluvial ore. In all such cases the parent lodes should be very carefully prospected.

The boundaries of the tinfield have probably been almost fully delineated by the limits of the area included in the geological map herewith.

It does not appear to the writer very probable that tin ore will be found *in sitû* far beyond these limits; but, as has been shown, alluvial tin ore may be expected to be seen for miles down the Pieman River, both in the older river terraces and in the more recent gravels.

Those portions of the area mapped within which prospecting should be carried on in greater detail, and within which lode-matter not yet located seems most likely to be found, are:—

(1) The long spur lying between the Gormanston-Dalcoath Creek and the Ring River.

(2) The area lying to the east and south-east of Pine Hill, between Ringville and the Confidence Saddle.

Before finally closing this report, it should be stated that there are certain points herein emphasized which should prove of value in the prospecting of areas beyond the limits of the tinfield of North Dundas.

Of these, much the most important is the association of the basic and acidic igneous rocks, and the association of the tin ore with both.

It is known that the igneous rocks of the North Dundas tinfield are not separate units, without connection with any other similar rocks, for the igneous invasion has extended for many miles to the north and north-west (without taking the granite of Granite Tor into account).

The area in the neighbourhood of the Meredith Range therefore calls for careful examination, and the mode of occurrence of the ore at North Dundas should be borne in mind in the prospecting of this still unknown country.

This report embodies the results of field-work which was carried on continuously, save for the interval of one week, from June 22 to October 14, 1908.

In expressing my thanks to the mine managers, prospectors, and others on the field who have at all times afforded me all possible assistance and information, I wish to assure them that their help has been fully appreciated.

To Mr. A. D. Sligo, of Zeehan, I am especially indebted for much information regarding the field, and for field assistance on very many occasions.

The Dreadnought and Penzance Companies kindly placed their respective camps at my disposal during my stay on the field, and for this hospitality also I wish to express my thanks.

L. KEITH WARD, B.A., B.E.,
Assistant Government Geologist.

Launceston, 12th February, 1909

APPENDIX.

Notes with regard to the Plates.

Plate I.—The heights given are in feet above sea-level. The altitudes of points on the Emu Bay Railway and the North-East Dundas Tramway lines have been courteously furnished by Mr. J. Stirling and Mr. G. C. Bernard respectively. The figures given apply to the heights of the rails at the points indicated.

The altitudes of other points are from the aneroid readings made by the writer of this report.

Plate II.—The numbers of only the outlying mineral sections are recorded on this map.

Plate IV.—The numbers of the mineral sections other than those mentioned above are shown on this map. The sections which are shown are those which were held at the time of the writer's visit to the field.

Plate V.—The diagrams to explain lode-structure are not drawn to scale. They are diagrams only, and are not intended to be applied to particular localities.

Figure I. represents the branching type of lode referred to on page 61.

Figure II. represents the complex type of lode-system referred to on page 63.

Figure III. shows the method of distribution of the veins and zones of impregnated rock in the reticulating vein-system in the quartz porphyry of Pine Hill.

Figure IV. is intended to show diagrammatically the passage of pyritic-cassiterite ore into (1) gossan, and (2) siliceous ore free from iron. The controlling causes producing the two varieties of oxidized ore are discussed on page 70 of this report.

Figure V. is an ideal section across the main lode-system in the centre of the field—here called the Renison Bell-Montana-Boulder lode-system.

The diagram shows the relation of the "floors," "feeders," and zones of impregnated slate.

The different varieties of feeding channels are shown.

KEY TO THE NUMBERS OF THE MINERAL SECTIONS SHOWN ON PLATES II. AND IV.

Number of Section.	Acres.	Lessee.
3187-M	181	Renison Bell Prospecting and Mining Co., N.L.
4550-93M	37	R. D. Lewers, now Renison Bell P. & M. Co., N.L.
1342-M	78	Montana Tin Prospecting Syndicate, N.L.
1963-M	80	A. B. Duncombe and A. Maddox
271-M	77	E. Flight } The Boulder Tin Mining Co., N.L.
5101-93M	80	M. P O'Dea } The Boulder Tin Mining Co., N.L.
2650-M	78	Chas. Brumby } The Dreadnought Sections
2763-M	77	A. G. S. Morton } The Dreadnought Sections
1273-M	79	(A. S. Stebbins) The Federal Tin Mines, N.L.
1215-M	36	C. Brumby
3370-M	70	H. E. Evenden
3660-M	62	H. E. Evenden and S. Rearden
103-M	40	A. Kemp
496-M	5	A. Kemp
2101-M	13	A. Kemp
1059-M	5	A. Kemp
1901-M	5	M. Keys
3621-M	80	T. C. Goodall
1945-M	79	E. Hawson
2764-M	38	W. A. J. Briggs
2765-M	20	W. A. J. Briggs
2766-M	20	W. A. J. Briggs
3240-M	20	W. A. J. Briggs
3356-M	80	A. D. Sligo
3296-M	65	G. Dunkley
2212-M	32	E. H. Butler
3166-M	56	H. E. Evenden
3762-M	75	A. Nicholas
5093-93M	72	The Penzance Tin Mines, N.L.
5094-93M	59	The Penzance Tin Mines, N.L.
3495-M	20	A. D. Sligo
822-M	25	A. D. Sligo
317-M	53	A. D. Sligo
774-M	75	A. D. Sligo
3657-M	73	A. D. Sligo
3658-M	60	A. D. Sligo
5063-93M	5	E. Swenson
3650-M	76	M. Curtin
3651-M	40	M. Curtin
1085-M	27	W. A. Hawkes
3114-M	40	G. K. Moore
453-M	80	C. E. Brown

Number of Section.	Acres.	Lessee.
2816-M	79	C. E. Brown and A. E. Hodge
3771-M*	78	J. Hamilton
2196-M*	40	G. D. Cooper
2197-M*	40	
3558-M	80	H. E. Evenden and W. T. Moyle
2339-M	20	W. J. Hodge
3573-M*	20	
1788-M*	40	V. Braggiotti
3756-M	20	P. P. Quinn
3765-M	10	
1897-M	80	J. S. Robertson

NOTE.—Ore-bodies on the sections marked * were not examined.

JOHN VAIL,
GOVERNMENT PRINTER, TASMANIA.

PLATE I

G886

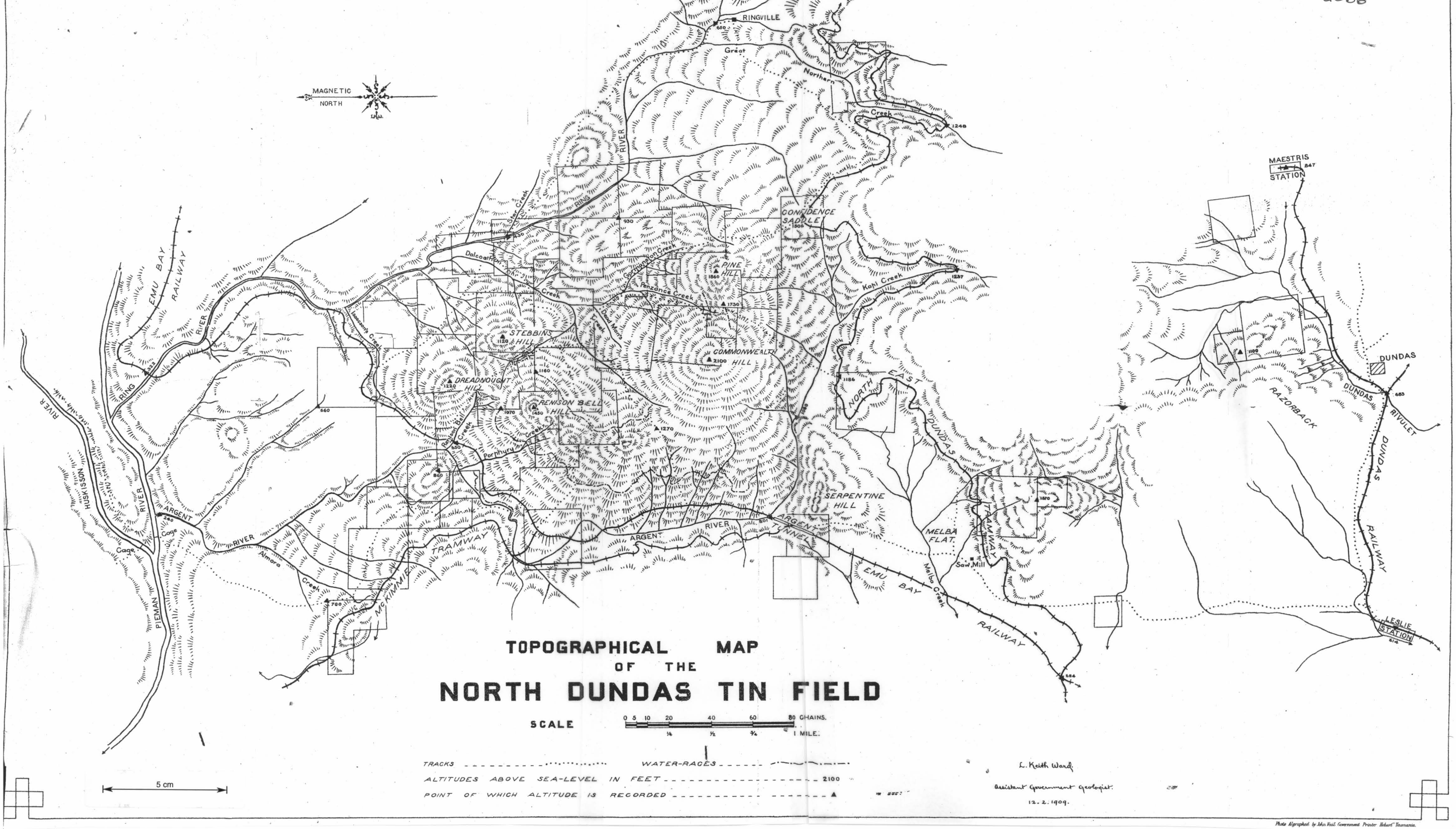

MAGNETIC NORTH
RINGVILLE
Great Northern Creek
1248
MAESTRIS STATION
847
RING RIVER
CONFIDENCE SADDLE
1506
930
Dalcoath Creek
PINE HILL
1860
Penzance Creek
1730
Kohi Creek
1237
EMU BAY RAILWAY
RING RIVER
STEBBINS HILL
1120
COMMONWEALTH HILL
2100
1160
DREADNOUGHT HILL
1220
RENISON BELL HILL
1450
1070
NORTH EAST DUNDAS
1186
DUNDAS
RAZORBACK
DUNDAS RIVULET
683
DUNDAS
1180
1270
Renison Bell Creek
Porthury Creek
550
560
660
HUSKISSON RIVER
RIVER
ARGENT RIVER
240
Cage
Cage
PIEMAN RIVER
Almora Creek
TRAMWAY
McKIMMIE TRAMWAY
700
ARGENT RIVER
ARGENT TUNNEL
SERPENTINE HILL
MELBA FLAT
TRAMWAY
Saw Mill
Melba Creek
1570
EMU BAY RAILWAY
DUNDAS RAILWAY
LESLIE STATION
614
TOPOGRAPHICAL MAP OF THE NORTH DUNDAS TIN FIELD
SCALE
0 5 10 20 40 60 80 CHAINS.
¼ ½ ¾ 1 MILE.
TRACKS
WATER-RACES
ALTITUDES ABOVE SEA-LEVEL IN FEET 2100
POINT OF WHICH ALTITUDE IS RECORDED ▲
L. Keith Ward
Assistant Government Geologist.
12.2.1909.
Photo Algraphed by John Vail, Government Printer Hobart, Tasmania.
5 cm

PLATE II

GSB6

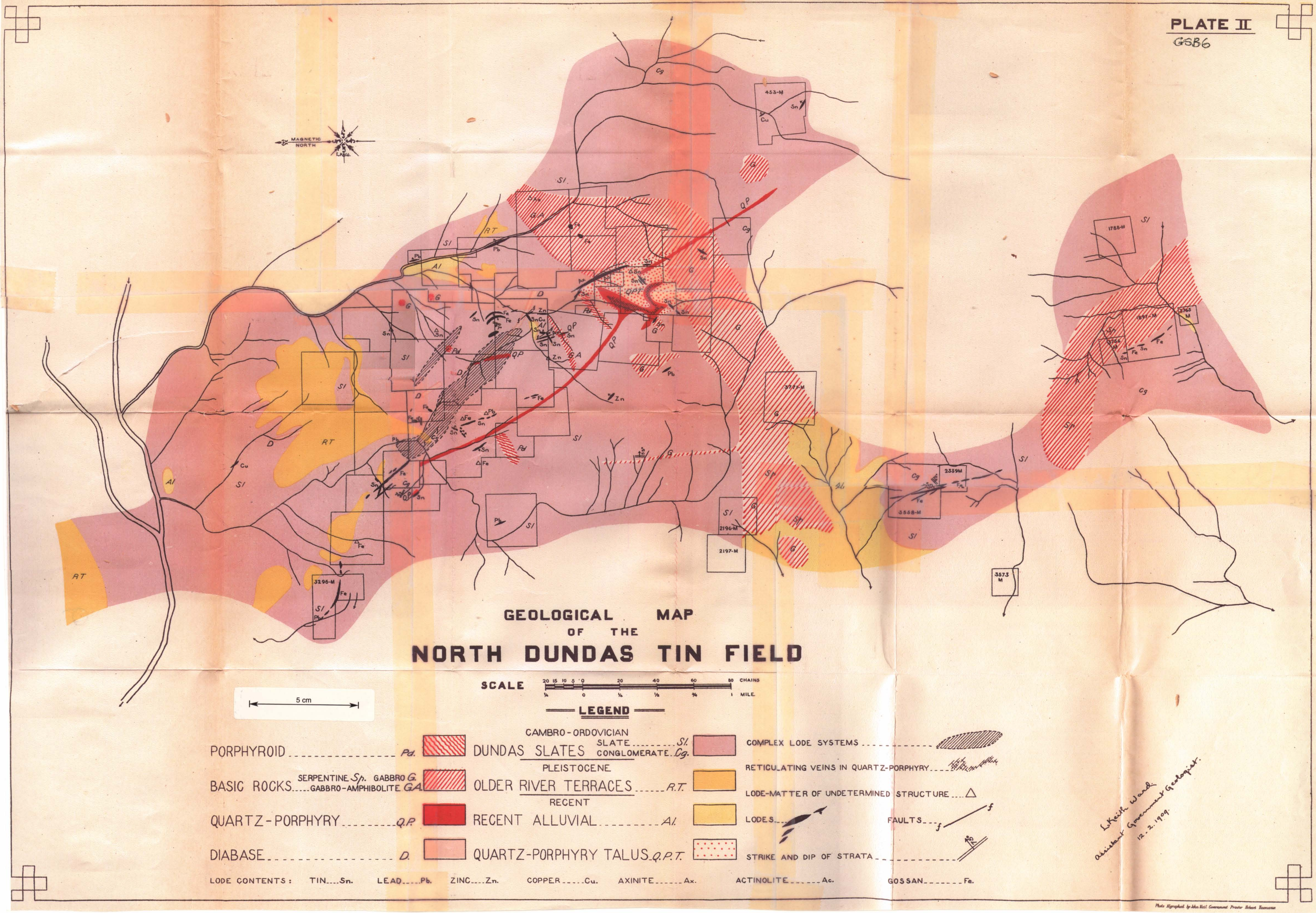
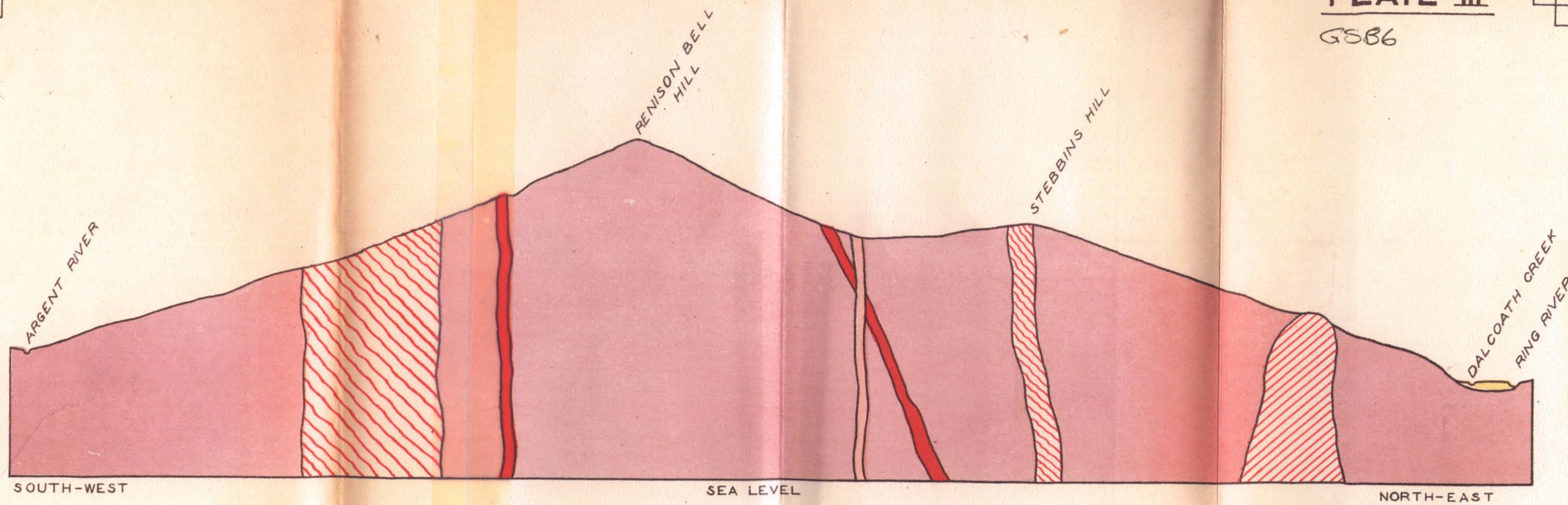
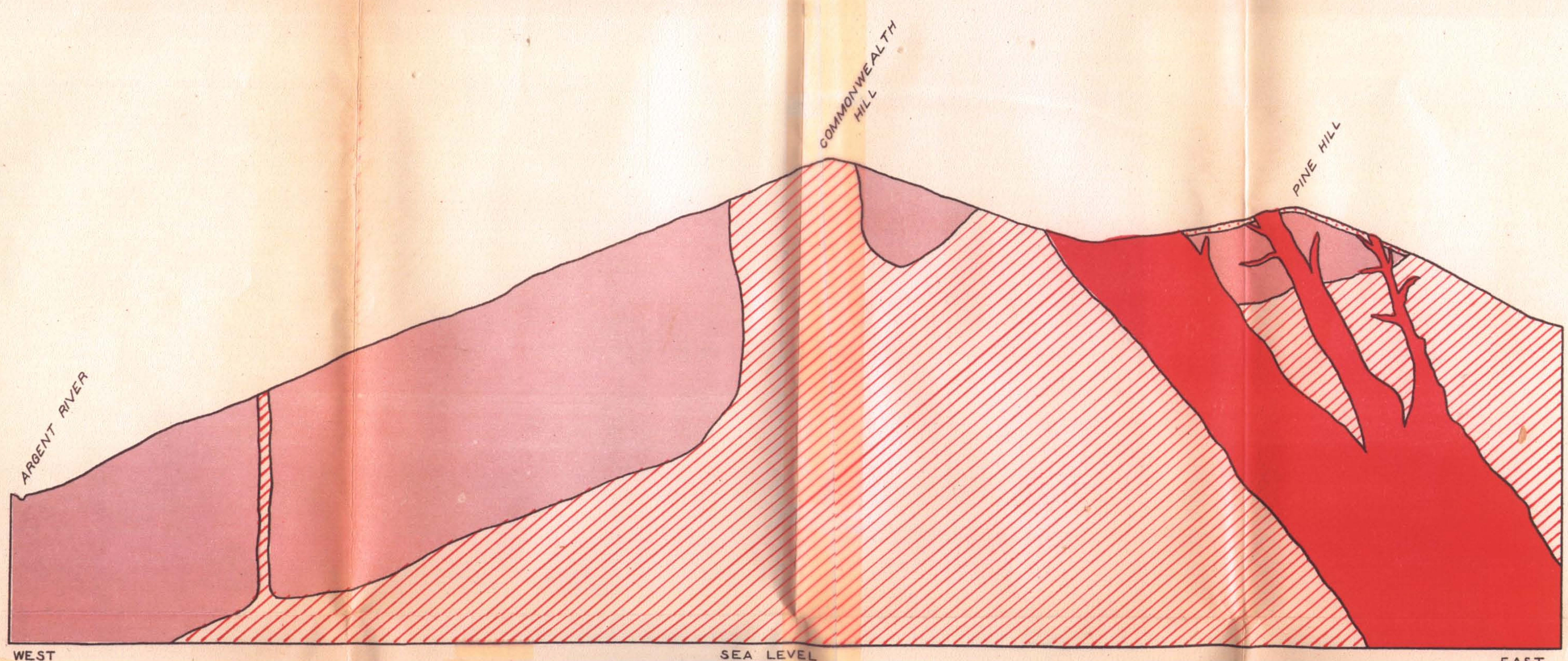


PLATE III

GSB6



ARGENT RIVER TO RING RIVER



ARGENT RIVER TO PINE HILL

GENERALIZED SECTIONS

SCALES

HORIZONTAL: 0 5 10 20 40 CHAINS

VERTICAL: 0 100 200 300 400 500 1000 1500 FEET

— LEGEND —

DUNDAS SLATES
PORPHYROID
DIABASE
RECENT ALLUVIAL
GABBRO
QUARTZ-PORPHYRY
QUARTZ-PORPHYRY TALUS

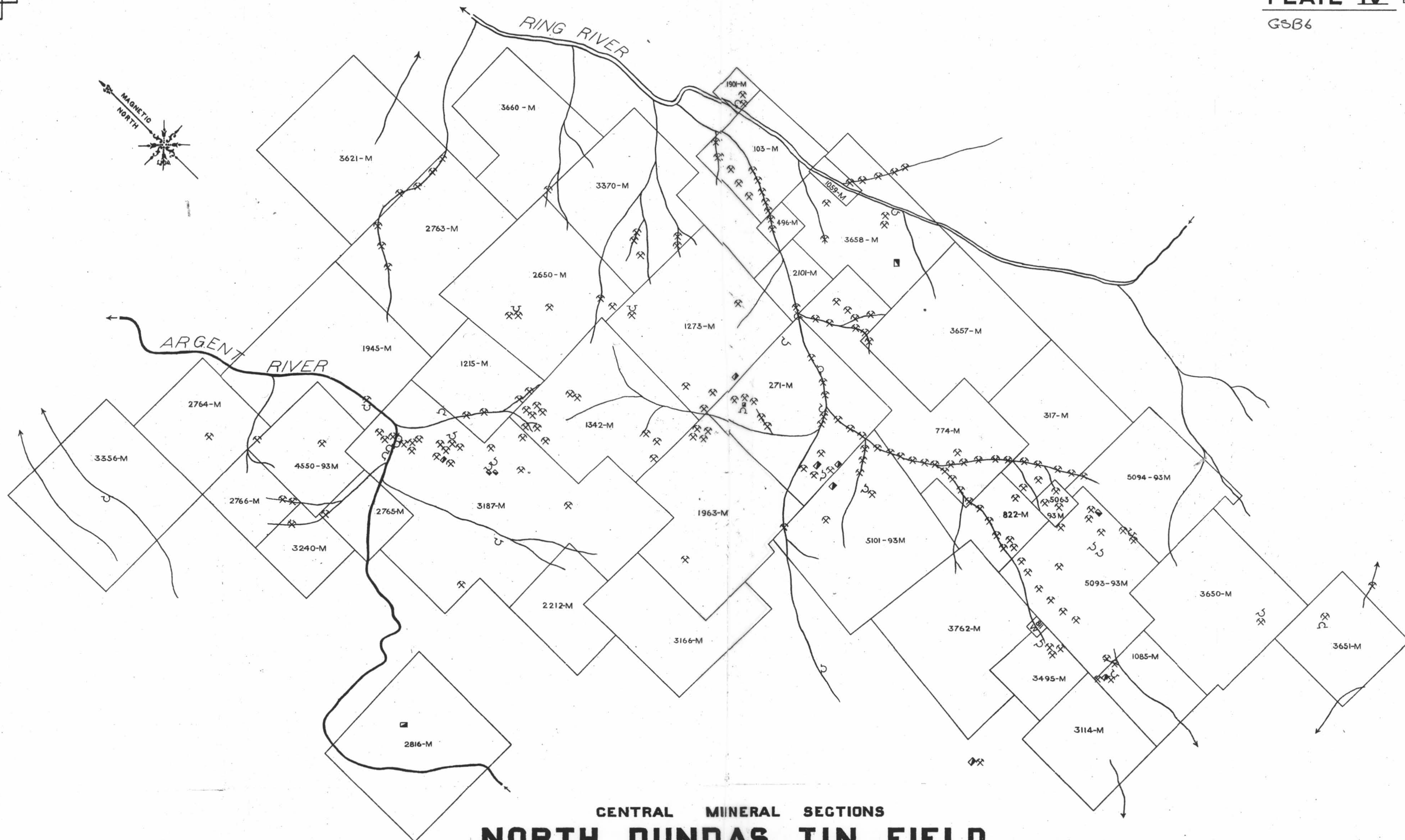
5 cm

L. Keith Ward.
Assistant Government Geologist.
12.2.1909.

Photo Algraphed by John Vail, Government Printer Hobart Tasmania.

PLATE IV

GSB6



CENTRAL MINERAL SECTIONS

NORTH DUNDAS TIN FIELD

SHOWING POSITION OF WORKINGS

SCALE 10 5 0 10 20 30 40 50 60 70 80 CHAINS

1/8 0 1/4 1/2 3/4 1 MILE

SIGNS EMPLOYED

SHAFTS

SURFACE WORKINGS

TUNNELS

5 cm

L. Keith Ward.
Assistant Government Geologist.
12.2.1909.

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

G5B6

PLATE V.

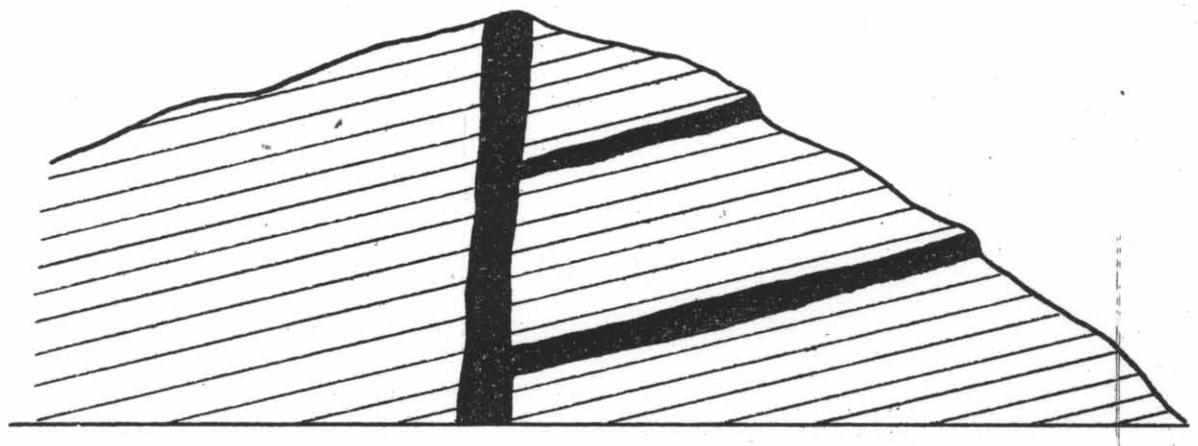


FIG. I.

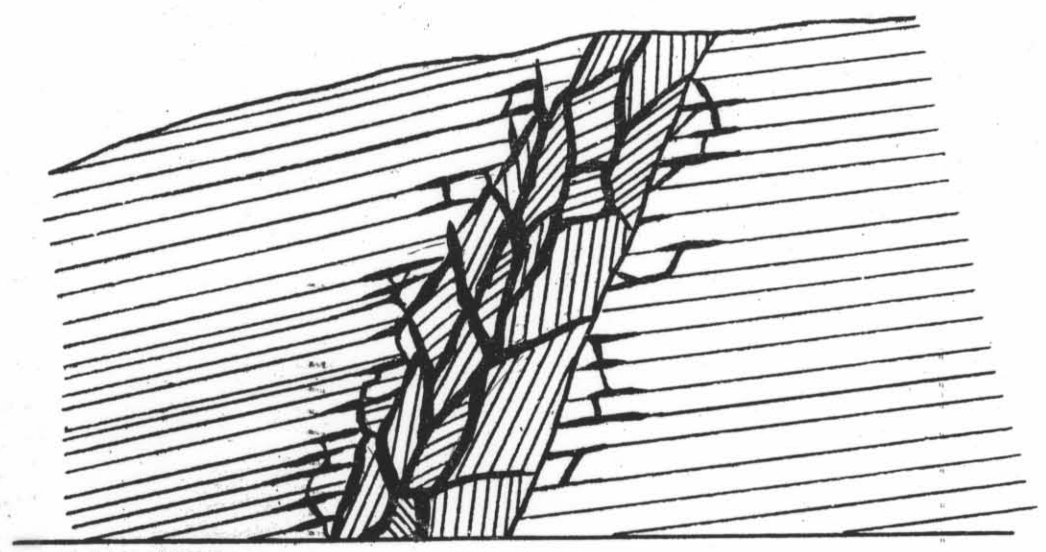


FIG. II.

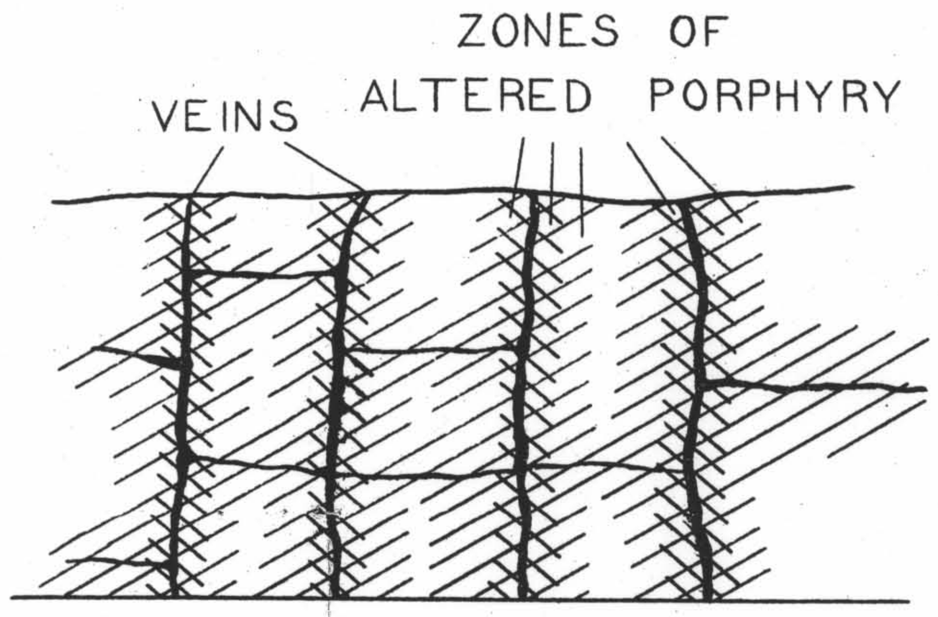


FIG. III.

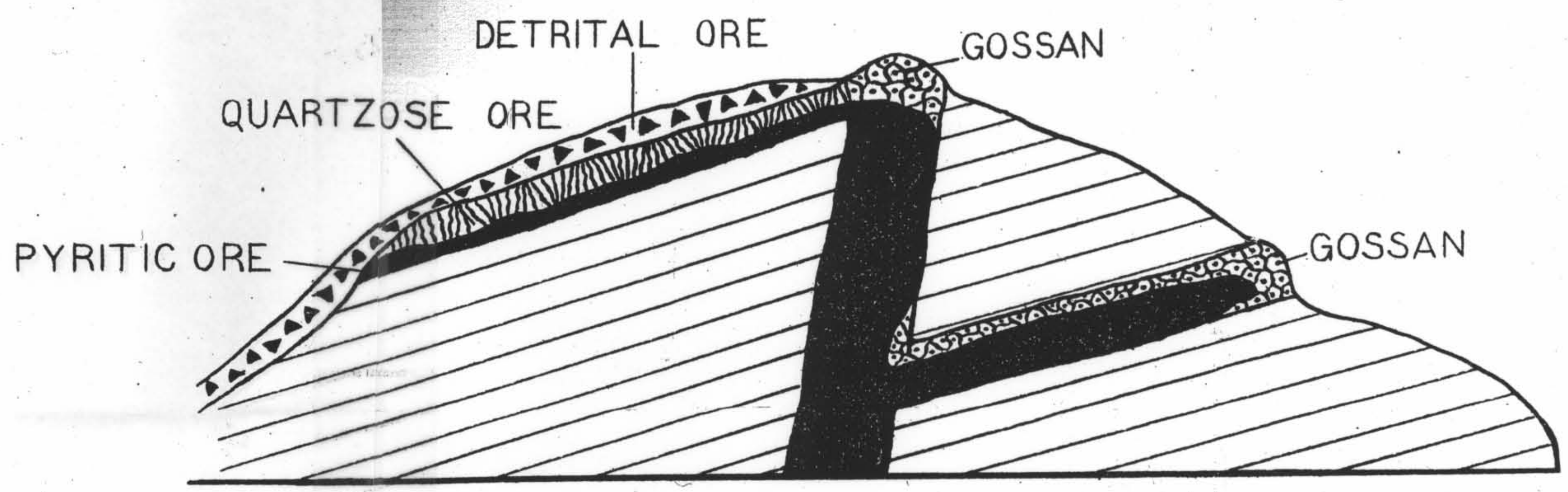


FIG. IV.

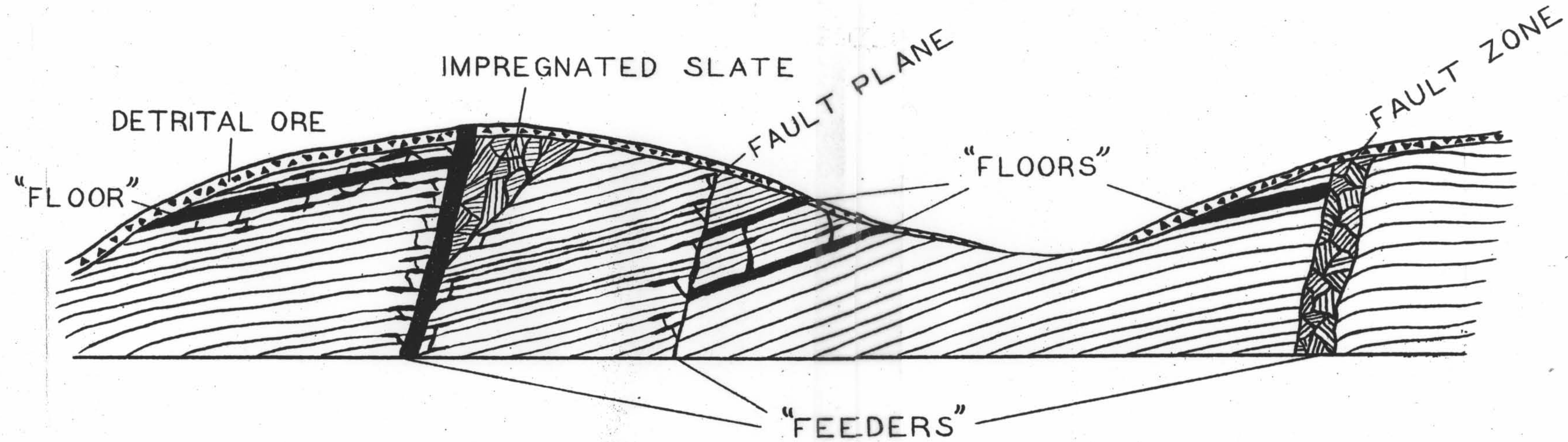


FIG. V.

5 cm

DIAGRAMMATIC SECTIONS OF LODES

L. Keith Ward.
Assistant Government Geologist
12.2.1909.

Photo Algraphed by John Vail Government Printer Hobart Tasmania.