REPORT ON THE ZEEHAN SILVER-LEAD MINING FIELD.

[With Map and Two Plates.]

Zeehan, 10th April, 1904.

SIR.

I HAVE the honour to forward you the following report on the Zeehan Silver-lead Mining Field. In accordance with your instructions, I have made a geological sketch-plan of the principal portion of the field, and have marked thereon the approximate position of most of the lodes which have been worked, as well as the general geological and topographical features of the country. The area included in this plan is not, however, sufficiently large to enable much to be learned from it as to the structural geology of the district. Since finishing the plan I have learned more about this subject by examining the surrounding country, and have been able to arrive at certain conclusions which are of scientific interest, and may also, I hope, eventually prove to be of considerable economic importance. I have also made a careful study of the lodes, and have ventured to make certain deductions from the observed facts, concerning the origin of the ores and the formation of the rich shoots which have from time to time been discovered on the field.

GENERAL GEOLOGY.

An account of the general geology of the Zeehan mining field must begin with a description of the geological structure of Mount Zeehan itself. The mountain lies directly south of the town of Zeehan, and is distant a little more than three miles in a direct line from the post-office. Plate I., Fig. 1, gives an ideal section through the mountain on an approximate bearing 45° west of north. The section commences at the Little Henty River to the south-west of Mount Zeehan. Here we have white sandstones containing innumerable casts of some organic substance, probably fucus or kelp, striking north-westerly, and dipping to the south-west at an angle of about 60°. For want of another name, I have been calling the rocks in which these casts occur "fucoid sandstones." This name must, however, be regarded as provisional only. It is quite possible that subsequent research may show that the casts have a different origin. They are known in several other

localities on the West Coast, notably at Bell Mount, in Middlesex, where the rock is known as "pipestem," owing to the resemblance of the fucoid casts to the stem of a clay pipe. The section exposed here is a remarkably good one, and the fucoid sandstone is seen lying perfectly conformably on the conglomerates, as shown in Plate I. Going north-east from the Little Henty towards Mount Zeehan, we pass over a fine section of the Mount Zeehan conglomerate formation. The strata are regularly bedded, and dip consistently to the south-west. The formation consists of coarse to fine-grained conglomerates of a characteristic red colour, which graduate into grits and sandstones. The material is almost wholly silicious, the pebbles being composed of quartzite and the cement being silica, stained red with iron oxide. The rock is often excessively hard, and when broken the planes of fracture pass indifferently through both pebbles and cement. This is a true pudding-stone. Other layers are not so hard, and the pebbles may easily be separated from the enclosing cement. There is often a distinct cleavage and a certain amount of schistosity in other directions than those of the planes of sedimentation, showing that the rock has undergone enormous pressure. The western slope of Mount Zeehan is heavily timbered, and could not be properly examined. A good view of the mountain, however, may be had from the north-west, and the general direction of the planes of stratification are seen to be approximately as shown in the section. From Mount Zeehan the plane of sections passes along the crest of a curious spur running out to the north-east from the mountain. The north-eastern end lies to the north of the Oceana Mine, and is known as the North Oceana hill. This is almost all conglomerate, but is dipping in the opposite direction to the conglomerates on Mount Zeehan. It is evident, therefore, that we have to deal with a great anticlinal fold, the axis of which appears to pass a little to the north-east of Mount Zeehan. The strike of this anticlinal axis must be approximately 45° west of north at this point. The presence of the anticline is confirmed by the re-appearance of the fucoid sandstones on the eastern slopes of the North Oceana Hill. The rock is of precisely the same nature, and contains the same fossils, as the rock on the other side of Mount Zeehan. The latter dips to the south-west and the former to the north-east, while both are lying conformably on the red conglomerates. There can, therefore, be no reasonable doubt that these two outcrops once formed a continuous bed overlying the conglomerate, and that they owe

their present positions to a great disturbance which has crumpled the whole series, and formed the magnificent corrugation represented in the section.

The country to the east of the fucoid sandstone consists of the fossiliferous limestones, slates, and sandstones which form the general country-rock of the eastern portion of the Zeehan mineral field. They lie conformably upon, and are therefore younger, than the fucoid sandstones. In 1895 Mr. A. Montgomery, late Government Geologist, sent to Mr. R. Etheridge, jun., Curator of the Australian Museum, Sydney, a collection of fossils from the Zeehan and Heazlewood mineral fields. Mr. Etheridge's paper describing these fossils was published in the Secretary for Mines' Report in 1896, and also in the Proceedings of the Royal Society of Tasmania in 1896. Referring to the age of the formation, Mr. Etheridge states: "The species detailed in the foregoing paper present both a Lower and an Upper Silurian facies, but with a preponderating tendency towards the latter. I think it not impossible that they represent a series of beds, homotaxially equivalent to the lower portion of the Upper Silurian." It is usual to find beds of conglomerate at the base of all the larger stratigraphical divisions. It would appear likely, therefore, that the Mount Zeehan conglomerates represent the base of the Upper Silurian formation.

Fig. 2 represents a section about half a mile to the south-east of Mount Zeehan, the plane of section being—as in Fig. 1—at right angles to the anticlinal axis. The section through Mount Zeehan is shown in outline in the background, so that the relative positions of the strata can be readily compared. It will be seen that in both sections we have the same series of strata; *i.e.*, counting from the north-east we have (1) limestone, (2) slates and sandstone, (3) limestone, (4) fucoid sandstone, (5) conglomerate. These strata do not, however, run continuously between the two planes of section. This is best seen at the Oceana Mine, where the limestone of the Oceana flat butts up against the conglomerates of the North Oceana Hill. It is evident that we have here to deal with a great fault, which has heaved the country south of the North Oceana Hill to the westward, and has brought the fucoid sandstones and limestones into juxtaposition with the conglomerates. This fault probably strikes about 60° east of north, and follows approximately the course of the Oceana Creek at the head of the flat. An examination of the country farther south reveals the presence of other parallel faults of

smaller magnitude. The heave of these is sometimes to the east and sometimes to the west, but on the whole the easterly heave seems to preponderate, so that at Argenton the fucoid sandstones are about in the same position as they would have occupied had there been no faults between this point and the North Oceana Hill.

About a mile to the south of Argenton, as may be seen by consulting the sketch-map of the West Coast published by the Mines Department, the Little Henty River crosses the railway line, and takes a course of nearly due west to the south of Mount Zeehan. The conglomerate ridge, of which Fig. 2, Plate I., gives a section, continues in a south-easterly direction as far as the Little Henty, and the river flows around the end of the spur. The conglomerate formation also ends abruptly at this point, and butts on to slate. There appears to have been another great fault here, which has thrown the conglomerate country to the east, for it outcrops again on the high hills to the east of the railway. The conglomerate country outcrops again at Mount Professor, eight miles further south, and from a distance this mountain appears to have exactly the same structure as Mount Zeehan. It would be a most interesting and valuable piece of work to run out all of this country between Mount Zeehan and Mount Professor, but the time at my disposal did not permit of my attempting it. It seems certain that one of the main anticlinal axes of the West Coast passes through this country.

We have so far followed the conglomerates from Mount Zeehan in a southerly direction to Mount Professor; but we have still to deal with their extension in the opposite direction. We have seen that Mount Zeehan lies approximately on the axis of a great anticline, the strata dipping away in opposite directions on either side of the mountain. Examination of the country to the north-west of Mount Zeehan brings another interesting fact to light. It becomes apparent that Mount Zeehan lies in or close to the axial plane of another disturbance. If we follow the conglomerates which occur to the south of Mount Zeehan, and which we have already seen from the south-western arm of the great anticline, we find that when we get opposite (south-west of) Mount Zeehan the strike gradually alters from 45° west of north to a few degrees north of west. It would appear, therefore, that the great anticline itself has been bent round through an angle of about 40°. This is confirmed by observations made to the north of Mount Zeehan; but here disturbances have taken place which

have made matters very complicated. If we follow the north-eastern arm of the great anticline to a point a little to the west of the North Oceana Hill, we not only find that the strike changes, but we also find that the rock itself changes. Instead of conglomerates we have slates and sandstones, and these are not evenly bedded, but are much contorted and disturbed. Further investigation shows that this country belongs to a disturbed zone about a mile and a half wide, which runs northward through the Zeehan mining field. Most of the well-known Zeehan mines are situated within this highly disturbed zone. Thus, the Western, Montana, Oonah, Zeehan-Queen, New Mount Zeehan, Argent, Spray, Colonel North, Nubeena, Maxim, Watt and McAuliffe's, and Montagu Mines are all situated within this zone. On the other hand, part of the Despatch, Silver King Extended, Silver King, and Silver Bell Mines are situated in the regularly stratified country to the east of the disturbed area. The western limits of the disturbed zone are not well defined. At the Sylvester Mine the strata are very evenly bedded, and strike a little north of west. In general, it may be said that throughout the disturbed area the strata tend to bend round to the west as we go westward, and finally assume a more or less constant strike of a little north of west.

I have already alluded to the fact that besides a change in strike there is also a change in the nature of the sediments in this disturbed zone. The conglomerates on the North Oceana Hill come into juxtaposition with slates and sandstones. Going farther north, we find other differences between the regularly-bedded sediments to the east and the disturbed sediments to the west. In the disturbed area we find melaphyre tuffs interbedded with slates, and farther north still numerous sheets, masses, and dykes of melaphyre. None of these rocks have so far been discovered in the regularly-bedded strata to the east of the disturbed zone, though they occur to the west of it. There is, however, no reason to believe that these rocks belong to a different geological period. Fossils are present in the disturbed zone, and these are of the same species as those found in the rocks which overlie the fucoid sandstones; so that there is no doubt that we are still dealing with Upper Silurian sediments. They must, however, belong to a different geological horizon, and, if we accept the conglomerates of Mount Zeehan as forming the base of the Upper Silurian system, it follows that they must be younger than the beds which lie conformably on the con-

glomerates. The change of country, therefore, can only be explained by faulting, and it follows that the rocks of the disturbed area, and those farther west which belong to the same formation, have undergone a great subsidence, and have been brought into juxtaposition with rocks belonging to a much lower horizon.

It is worth noting that this disturbed area occurs just at the curve of the strata. We all know that when a beam is subjected to a bending moment, the fibres in the external half are in tension, and tend to fracture. Possibly this may afford some explanation of the great disturbance to which the rocks of the Zeehan field have been subjected.

Coming now to a more detailed description of the rocks of the disturbed area (which, it should be remembered, form the wallrock of most of the productive Zeehan mines), we may first notice the belt of slate and sandstone country adjoining the conglomerates of Mount Zeehan, and forming the southern portion of the mining field. This belt includes all those high button-grass spurs to the north of Mount Zeehan, extending from the conglomerates on the North Oceana Hill westward for some distance beyond the old Grubb's Mine. Farther west than this the country is flat, and heavily timbered, and was not examined. The mines situated within this area include the following:— The southern section of the Mount Zeehan (Tasmania) Silver-lead Mines, Limited, including the Spray Mine and the Britannia Mine; the whole of the ground held by the Colonel North M. and R. Company; the Nubeena Mine; the South Nubeena Mine; and the south-western portion of the Maxim Mine. White sandstones or quartzites appear, from a superficial examination of the country, to be the prevailing rock in this area, as it outcrops largely on most of the spurs; but work underground has shown that this is not the case. The white sandstones and quartzites which are found so abundantly on the surface do not occur underground. They alter in depth to a silicious slate, or a dark argillacious sandstone or quartzite. Bands of this silicious rock are interbedded with the softer slates, sometimes one predominating, sometimes the other. Speaking generally, the rocks are more silicious in the eastern portion of the belt than in the western, where slates appear to predominate. These slates and sandstones appear to be devoid of fossils. The general strike is a little to the west of north, but the whole area is much disturbed. I think it is probable that the area includes a number of minor

anticlinal and synclinal folds. This is certainly the case at the Spray Mine, where, in the main crosscut, the strata are seen to dip alternately to the north-east and south-west at comparatively low angles.

Until comparatively lately the southern portion of the Zeehan field has received very little attention. It has been roughly prospected, and the existence of a great number of lode-formations have been discovered. Most of them contain small quantities of galena, but there has been little or nothing done to prove their value at any depth from the surface. The discovery of splendid shoots of ore at the Spray Mine, at some distance from the surface, has lately given some encouragement to prospectors to test this country farther, and so far the results have been very promising.

North of this slate-sandstone belt we find a belt composed of melaphyre tuffs interbedded with slates. The tuffs are usually seen as a grey or reddish fine-grained, or slightly granular soft decomposed rock, interbedded with fine-grained black or dark chocolate-coloured slates, into which they appear to pass over by intermediate types. The only place I know of where the rock can be obtained in anything approaching to a fresh state is in a cutting on the Comstock tramway at the Comstock Mine. Here kernels of fairly fresh rock occur, surrounded by and passing over into the decomposed sediments. This rock when examined under the microscope shows signs of much alteration, and the scoriaceous structure of the tuff has been obliterated. It is a fine-grained fragmentary rock, and contains numerous angular particles of the mineral augite. This rock occurs all along the Comstock tramway from the Central Balstrup's Mine to the Comstock. Wherever it occurs, the hillsides are covered with a red clay, as, for example, at Manganese Hill; but often, when this clay is bottomed, black slate appears underneath. I take it that this clay is formed by the decomposition of the tuffs, which often occur as quite narrow seams interbedded with the slates. There appears also to be every intermediate stage between the slates and the tuffs. It is quite conceivable that in the case of submarine eruptions, the volcanic ashes, or "tuffs," would become mingled with the normal marine sediments, and so form these intermediate types.

Where the tuffs occur on the flats—as in the case of the Argent Flat, or the Sylvester Flat—the colour is grey instead of reddish, but there is no doubt that the rock is the same. The change in colour is probably due to the

fact that the iron oxide has been leached away by the organic acids which form in swampy ground.

The geological distribution of these tuffs is very curious. The formation has the shape of a kind of tripod, with Manganese Hill in the centre. One limb of the tripod goes away in a westerly direction towards the Comstock. A second goes off north-east, along the Argent Flat, into the town of Zeehan (Queen end), while a third stretches away down towards Watt and McAuliffe's Mine, in a south-easterly direction. This is a remarkable shape for a sedimentary formation to assume, and it leaves plenty of scope for speculation as to how it originated. I should state that the limits of the formation are only approximately charted on the geological plan; in many cases the colour of the soil was all I had to go on in determining the extent of the formation. Still, I have no doubt at all that the plan does fairly well represent the general shape and position of the tuffs and interbedded slates. In the case of the north-eastern limb of the tripod, the tuffs are very much distorted, and it can hardly be said that one direction of strike prevails over any other. The slates and sandstones to the south are very evenly bedded, striking about 40° west of north up to within a couple of hundred feet of the tuffs. There they appear to bend round sharply to the north-east. This is, I think, one place where the break between the regularly stratified country and the disturbed area is well defined. The line appears to run along the southern edge of the Argent and Florence Flat. The Queen Hill is situated to the north of the tuffs. This is mostly slate, and is very much crushed and distorted. The general strike here is probably east and west. The south-east limb of the tripod is also a good deal disturbed; it is mostly covered with heavy timber, and could not be closely examined. The strike of the tuffs conforms with the general direction of the formation, and probably also with the slates and sandstones to the south. To the east and north-east the slates and sandstones are evenly bedded, and the break in the country must occur between these two formations. Perhaps if we take a line from the north end of Watt and McAuliffe's Mine to the centre of the western boundary of the Central Balstrup Mine, this will approximately represent the position of the dividing-line between the regularly stratified and the disturbed areas in this part of the field.

The western limb of the tripod is quite conformable with the strata to the north and south. This part of the

district is all covered with heavy timber, and there are not many good sections available for examination. Perhaps the best are in the Sylvester Flat, where a number of long prospecting ditches have been cut. The tuffs are here seen to be striking a little to the north of west, and dipping vertically.

The eastern portion of this "tuff" formation has proved very highly productive. From the head of the Argent Flat to the northern portion of the town of Zeehan there are innumerable lodes, which have been worked with more or less success, and include some of the very rich shoots which have made Zeehan famous. Farther south a number of lodes have been worked in Watt and McAuliffe's Mine, the Montagu Mine, the Maxim Mine, and the Central Balstrup Mine. The western limb has not proved so productive; but perhaps this is due to the fact that it has not so far been much prospected. Large quantities of timber and firewood are now being brought from this locality, along the North-East Dundas tramway, and it is possible that when the bush is cleared lodes will be discovered which will bring this part of the district into greater prominence.

To the north of the tuffs there is a belt of slate and sandstone country containing flows, masses, and dykes of vesicular melaphyre. The latter is an ancient basalt which has been very much decomposed. It has been examined microscopically by Messrs. Twelvetrees and Petterd; their paper describing this rock appears among the proceedings of the Royal Society of Tasmania for 1896. There are also beds of tuffs associated with the melaphyres, but these are not abundant, or so conspicuous as in the country to the south. The Western, Montana, Oonah, and Zeehan-Queen Mines are all situated within this melaphyre zone. The whole formation here has been very greatly distorted and faulted. As will be seen by the geological plan, there are a number of apparently isolated masses or blocks of melaphyre throughout this portion of the district. These are only the larger and more conspicuous masses. It would be impossible to chart all the minor occurrences of melaphyre separately. They are extremely irregular, and their shapes and positions can only be accounted for on the assumption that the whole area has been faulted and distorted to an extraordinary extent. This is also apparent by observation of the strata. The slates and sandstones are often so mashed that all signs of stratification have been lost. The area appears to stretch away

to the westward almost as far as the Comstock. The eastern portion of this belt also has been most highly productive, and the larger part of Zeehan's output has so far been derived from this area.

To the north again we come into slate and sandstone country, not dissimilar to that occurring in the southern portion of the field. The general strike is a little to the north of west. Numerous lodes are known in this area, but up to the present none of them have proved payable.

The Eruptive Rocks.

With the exception of the melaphyres and associated tuffs, the eruptive rocks are by no means conspicuous in the Zeehan mineral field. The melaphyres form sheets and flows interbedded with the Upper Silurian strata, and are therefore of the same age as those rocks. They were probably the products of submarine volcanoes, as they occur interbedded with slates; and the tuffaceous sediments have, in parts, evidently mingled with the ordinary marine sediments, forming tuffaceous slate.

Gabbro and Serpentine.

It appears likely that this comparatively small volcanic eruption of melaphyres and melaphyre tuffs in the Upper Silurian period was the forerunner of the much greater eruption which is responsible for the great masses of basic and ultra-basic plutonic rocks throughout the West Coast. These consist of the gabbros and pyroxenites, with their alteration product, serpentine. It is possible that these rocks taken together are more abundant than any other eruptive rock on the West Coast. This eruption must have been accompanied by huge disturbances of previously existing strata. We know that the gabbros are younger than the Upper Silurian, because they form intrusive masses and dykes in the rocks of that period. It is, therefore, certain that the Upper Silurian rocks must have been greatly disturbed during the eruption of the gabbros, and it is quite possible that the main upheaval may have taken place at that time.

A large mass of gabbro or serpentinised gabbro occurs to the west of the Zeehan field, and the eastern corner of this protrudes into the area included in the geological plan attached to this report. It is probable that there is more of this rock present in the south-western portion of this area, but as it is very flat and heavily timbered, it could not be

properly examined. In the vicinity of the old Tasmanian Mine and Grubb's Mine there are some curious decomposed rocks, which will probably be found to be dykes connected with the gabbro series. These are not marked on the geological plan. At what is known as the Summit Cutting on the Comstock tramway on Section 195-87M, a small dyke of serpentine was discovered by Mr. F. J. Ernst. The rock is very much crushed and altered, and unless carefully examined, is not easily distinguished from the crushed slates and tuffs which occur in the vicinity. That it is a true dyke, and connected with the gabbro series, is proved by the occurrence of a small deposit of nickeliferous pyrites on one of the walls. Several of the mines working in the vicinity have cut similar serpentine, which possibly is connected with the same dyke. The rock also contains small quantities of chromic iron. It is probable that these dykes of serpentine are much more common than might be supposed. Small quantities of chromic iron can often be obtained by testing the wash in many of the creeks with the prospecting dish. This mineral is believed to be always associated with serpentine. If the dykes are as much altered as the one which has been found in the Summit Cutting, it is not much wonder that they have, so far, escaped notice.

The Granite.

The next great eruption after the consolidation of the gabbros is that which was responsible for the tourmaline and tin-bearing granites. That these rocks are younger than the gabbros and serpentines is proved by the fact that they occur as dykes in the latter, as well as in the Upper Silurian strata. A good example of this may be seen on the beach at Trial Harbour, where the serpentine and granite come in contact with one another. The serpentine is very highly altered at the contact, and contains small dykes of porphyry, which are seen to come from the granite. Similar evidence is also available at North Dundas. We therefore know that both the granite and the gabbro are younger than the Upper Silurian, and that the granite is younger than the gabbro. There is further evidence to show that the granite is older than the Permo-Carboniferous strata. The up-ended Silurian rocks on the West Coast are overlain in parts by horizontal and undisturbed layers of Permo-Carboniferous strata, in which granite is never found, except in the form of waterworn boulders in conglomerates. This shows that the granite

must have been in existence before the Permo-Carboniferous strata were formed. At Ben Lomond also we have Permo-Carboniferous strata, lying on the denuded surface of the granite. We therefore have the age of the granite and of the gabbro determined between these two limits. They are both younger than the Upper Silurian strata, and older than the Permo-Carboniferous. Between these two comes the great Devonian period. The eruption of the gabbro probably occurred at the close of the Upper Silurian period, and was probably accompanied by a great upheaval of the Upper Silurian strata. The granite eruption followed probably in Devonian times, and this, apparently, completed the work of upheaval, as we know the rocks have undergone very little disturbance since Permo-Carboniferous times.

The great mass of the Heemskirk granite is situated at the north-west of the Zeehan field, and the contact is a little more than a mile to the west of the area included in the geological plan.

In the Zeehan field the granite rocks are not strongly in evidence. Dykes of a curious quartz felspar porphyry have been found, which are, in all probability, connected with the granite. They are, however, curiously deficient in quartz, and are certainly more basic than the normal granite. They are usually a good deal decomposed, and have not yet been subjected to an exhaustive microscopical examination. Six occurrences are marked on the geological plan. The best exposures are at the Sylvester Mine in the northern portion of Section 1287-87M. Another good exposure is situated about a mile to the west of the Western Mine, in the southern portion of Section 3307-93M.

Tertiary Basalt.

Tertiary basalt has been found in one locality only, in the Zeehan district. It is quite a small patch, close to the Smelters' Road, to the west of Watt and McAuliffe's Mine.

The Zeehan Lodes.

The lodes of the Zeehan field are true fissure veins. They have been formed along fissures in the rocks, and their mineral contents have been deposited, either in open cavities in the fissures, or as a replacement of the wallrock on either side. Many of the lodes were originally fault fissures, as evidenced by the numerous slickensides on the walls and throughout the formations, and also by the

seams of pug and rubble with which the lode-channels are often filled. The formations are not usually characterised by two well-defined walls. These are sometimes present, but more often there is only one well-defined wall, and sometimes there is none at all. When this happens the "lode formation" consists of a zone of sheared and crushed rock, containing, perhaps, several seams of rubble, all more or less mineralised. As a rule, however, there is one main seam of pug or rubble, which may be regarded as the main lode-channel, and along which the principal faulting movement has taken place. The best shoots of metal are always found in the main channel. Many of the smaller lodes do not appear to have been formed in fault fissures. They are merely cracks which have served as a channel for metal-bearing solutions, and the metal has been deposited in the cracks or as a replacement of the wallrock. These lodes are usually very limited in extent.

The lodes differ very greatly in their mineral contents. and especially in the relative proportion of the different minerals present. Still, the different types are all intimately connected, and pass over into one another by gradual transitions. Viewing all the lodes as belonging to one great family, we recognise three types which admit of somewhat precise definition. All the lodes of the Zeehan field either belong to one of these types, or occupy some intermediate position between them.

These three types may be described as follows:—

1. *The Pyritic Formation.*—Lodes in which the gangue is principally iron pyrites associated with argentiferous galena, and often large quantities of zinc-blende. Carbonate of iron is absent, or present only in small quantities.

2. *The Sideritic Formation.*—Lodes in which the gangue is siderite (carbonate of iron) associated with argentiferous galena, and little or no zinc-blende. Iron pyrites may be present in small quantities.

3. *The Stannite Formation.*—Lodes in which the gangue is principally iron pyrites associated with argentiferous stannite (sulphide of tin, copper, and iron), chalcopyrite (copper pyrites), small quantities of wolframite (tungstate of iron and manganese), bismuthinite (sulphide of bismuth), and occasionally small quantities of galena and carbonate of iron.

As examples of the pyritic formation, the numerous lodes of the Comstock district may be mentioned. These have been more particularly dealt with in my report on the

iron and zinc-lead ore deposits of the Comstock district. Other examples may be found to the north and east of the Comstock, that is, in the western portion of the Zeehan field; indeed, all the lodes in this locality appear to be of this type. In the Zeehan field proper many of the lodes belong to the pyritic formation.—Several lodes, for instance, in the Queen Hill, including Clarke's and Taylor's lodes; also on the Oonah Hill, including Bradshaw's and Pustkuchen's lodes. Many of these are very massive pyritic formations, carrying but a small proportion of galena. Zinc-blende is not nearly so abundant as in the Comstock district.

Of the sideritic formation, most of the lodes of the Western and Montana Mines may serve as examples. There are probably no lodes in which pyrites is quite absent, but in many it is present in quite insignificant quantities.

The stannite lodes are not common. The only perfect examples are the two stannite lodes at the Oonah Mine, which have been extensively worked for some years. These lodes supply a most important clue to the origin of the Zeehan lodes in general.

Intermediate Types.

Between the lodes of the pyritic and the sideritic types there are innumerable intermediate formations, in which both pyrites and carbonate of iron occur as gangue. Perhaps most of the most productive lodes of the Zeehan field belong to these formations. The main lode of the Oonah Mine, No. 4 Queen, and many others in the Queen Valley, most of the lodes in the Argent Valley, the Spray and Grubb's lodes, and many others, are examples of these intermediate formations. They contain carbonate of iron and pyrites in about equal proportions, sometimes one preponderating, sometimes the other. Zinc-blende is often fairly abundant in these "pyrito-sideritic" lodes. It certainly appears to be more abundant in lodes which contain considerable quantities of pyrites, than in those in which the gangue is all carbonate of iron. The antimony minerals, especially jamesonite, appear to be more abundant in the intermediate formations than in either of the extremes.

As the stannite lodes themselves are rare, it is not to be expected that we should know of many examples of intermediate formations connecting them with other types. There is, however, sufficient evidence to show that these lodes are undoubtedly connected with the other types of

lode-formation. In the stannite lodes themselves small quantities of galena and carbonate of iron are often found. This alone would lead one to suspect a connection, and this suspicion is confirmed when we find that Clarke's lode on the Zeehan-Queen contains considerable quantities of stannite. This is, for the most part, a pyritic lead lode, containing some good shoots of galena. But in parts it contains a considerable quantity of stannite, and must therefore be regarded as an intermediate formation betwen the pyritic and the stannite types.

Besides the minerals which I have mentioned as being characteristic of the main types of lode-formation, several others should be mentioned as occurring in the Zeehan lodes, but which do not appear to have any particular preference for any one formation. Chalcopyrite is one of these. All the pyritic lodes carry small quantities of copper, and in one or two cases the copper contents may prove to be sufficient to warrant mining operations being undertaken. Small quantities of copper pyrites are also often found associated with rich galena in other lodes. The antimonial ores, viz., jamesonite, tetrahedrite, &c., are found associated with galena in the sideritic formation; but they seem to be even more characteristic of intermediate types, in which both pyrites and siderite are present. Quartz is a mineral that is seldom absent from the Zeehan lodes, though it is usually present only in small quantities. In one or two instances, however, notably at the Argent Mine, lodes are known consisting largely of white quartz, with galena and carbonate of iron. Calcite is often present in the lodes, but never very abundantly, and only when the lodes traverse limestones and calcareous slates. Dolomite is present in several instances, and sometimes it is very abundant. In one instance at least there is very good evidence to show that this mineral has been produced by the action of the lode-forming solutions on the rock serpentine. In a lode marked on the geological map, near the north-east corner of Section 195-87M belonging to the Mount Zeehan (Tasmania) Silver-lead Mines line, there is a large dolomite formation, which has been sunk on by Mr. W. Moyle, carrying galena and carbonate of iron. Serpentine is known close by, in the Summit tunnel, and has also been met with in the shaft. Both the serpentine and the dolomite contain small grains of chromite distributed through them. Now, chromite is a mineral which is never found in lodes as a deposition from solution. Its home is in the serpentine as a primary constituent of this rock. The presence of

these grains of chromite in the dolomite is therefore very strong evidence that the latter has been derived from the serpentine. I think it quite likely that dykes of serpentine will be found in the vicinity of all such dolomite formations.

The Grade of the Galena.

The amount of silver contained in the galena varies very greatly in different lodes, and in different parts of the same lode. The factors which have produced these differences are evidently very complex, and it is hardly possible to make any general statement on this question to which there are not numerous exceptions and qualifications. Viewing the whole evidence broadly, it appears to me that the grade of the ore depends principally on three factors, namely:—

1. The type of lode-formation.
2. The nature of the country-rock.
3. The presence or absence of secondary enrichment.

All of these factors can, I think, be fully demonstrated to affect the grade of the galena in certain specific cases; but it often happens that two, or even all three, factors work together, and when this is the case it is very difficult to say which has had the greatest influence.

In lodes of pyritic formation the galena is usually low grade. This is specially the case where there is no question of enrichment having taken place. In the case of most pyritic lodes, where the lode matter is hard and undecomposed, and where the galena is disseminated through the gangue, the grade of the galena is very low—usually under $\frac{1}{2}$ ounce of silver to the unit of lead, and going down to $\frac{1}{4}$ ounce per unit. On the other hand, in the case of lodes which are more or less decomposed, and in which the galena occurs in a more massive form, the grade is higher. Most of the galena exported from the Comstock Mine, for example, has averaged about 1 ounce of silver to the unit of lead. Occasionally patches of very rich galena are found, assaying up to 3 and $3\frac{1}{2}$ ounces per unit; but these are exceptional, and may safely be put down to secondary enrichment.

In lodes of the sideritic type, on the other hand, the grade of the galena is high. The ore from the Western and Montana Mines has averaged from 1·75 to 2 ounces of silver to the unit of lead, and on the whole is very uniform. In these lodes there is little difference between the grade of the galena from the upper decomposed parts of the lodes

and that from the more disseminated ore lower down. Indeed, the galena from the lower levels is of somewhat better grade than that near the surface. The grade of the ore has certainly not been appreciably affected by surface enrichment in those cases.

The grade of the galena of the intermediate pyrito-sideritic formations is intermediate between that of the pyritic and that of the sideritic formations. I think we may even say that the grade of the galena improves in proportion as the formation approaches towards the sideritic type. That is, a lode containing an excess of pyrites will, as a rule, contain galena of lower grade than one containing an excess of carbonate of iron. To give a few examples: Grubb's main lode is not far removed from the pyritic type; the galena in the upper levels yielded a little over 1 ounce to the unit of lead; in the lower levels it sank to about $\frac{1}{2}$ ounce per unit. The several lodes mined from No. 4 shaft Zeehan-Queen (Clarke's lode excepted) show the properties of the pyritic and sideritic formations in about equal proportions. The grade of the galena averages 1 ounce of silver to the unit of lead. In the Argent Valley most of the lodes approach the sideritic type, and the grade of the galena averages $1\frac{1}{4}$ to $1\frac{1}{2}$ ounce per unit of lead. Many exceptions will, of course, be found to this rule; but I think if we exclude all occurrences in which secondary action may have altered the grade of the galena, it will, on the whole, be found to be true.

The nature of the country-rock has in some instances a very marked influence on the grade of the galena in the lodes. The most conspicuous case is that of limestone. Where lodes occur in limestone or calcareous slate, the grade of the galena is usually low, varying from $\frac{1}{4}$ to $\frac{1}{2}$ ounce, or at most 1 ounce of silver to the unit of lead. The Oceana, Silver King, and Despatch lodes are cases in point. In these lodes, both pyrites and carbonate of iron are present, the latter being in excess. They approach, therefore, to the sideritic type, and were they not in limestone country, we should expect them to contain metal of good grade. It is not, I think, certain if any of the other rocks affect the grade of the ore. Mr. T. Vincent, Manager of the Mount Zeehan (Tasmania) S.L. Mines, and Mr. Craze, Manager of the Montana and Western Mines, consider that the harder silicious slates are more favourable than the soft argillaceous varieties. But this rule appears to apply with greater force to the quantity rather than the quality of the metal. I have often noticed that where the

galena occurs in splashes through slate, and intimately grown on to and united with this rock, it is of low grade; whereas, even in the same lode, the galena which occurs in well-defined seams is of high grade. Numerous instances of this may be found in the southern portion of the Zeehan field.

Secondary enrichment appears to be the only possible explanation for many of the differences in grade which are observed in the galenas of the pyritic and pyrito-sideritic formations. The causes of secondary enrichment must be dealt with later; the general facts are as follows. In numerous lodes in which pyrites forms an important portion of the lode matter, the grade of the galena is subject to considerable variation. The richer galena is usually dense and solid, and not mixed with much veinstone. The large shoots of galena are nearly always of high grade. These are mostly found in the upper portion of the lodes, and are usually accompanied by signs of decomposition by surface waters. The carbonate of iron, for instance, is soft and friable instead of hard and vitreous, as it occurs lower down. As depth is gained, the grade of the metal often declines, and sometimes, as in the case of Grubb's lode, this decrease is very considerable. Low-grade metal is not, however, confined to the lower levels. It often occurs in the form of splashes through the lode-formation close to the surface. As a general rule, where the lode-formation is hard and undecomposed, then will the grade of the galena be lower than elsewhere. These statements only apply to lodes in which pyrites forms an appreciable portion of the gangue. I have noticed no such variations in lodes of the sideritic type.

Strike and Dip of the Zeehan Lodes.

Many of the Zehan lodes are very irregular as to strike and dip. In the geological plan almost all the lodes are shown as straight lines, but this is merely because it was impossible to show, on such a small scale, the numerous bends which many of the lodes make. Wherever possible, the average strike, as given by the positions of the workings on the lode, is given. As will be seen by the geological plan, there is no fixed direction of strike. Lodes may be found striking in almost all directions. Still, there appear to be certain directions which are more favourable than others; thus a great number of lodes strike from 25° to 35° west

of north. This is specially noticeable in the southern portion of the field. From the Silver King lode in the east to the Tasmania lode in the west there are a great number of lodes striking within these limits. In the central portion of the field we have also a great number of lodes striking about 30° west of north, and another series striking about 30° east of north. Several of the most productive lodes strike nearly north and south. The prevailing dip is to the east, but here again there are some notable exceptions. The lodes in the southern portion of the Zeehan field appear to be straighter and more continuous than those of the central and northern portions. There is reason to believe that the Spray lode, for example, runs almost in a straight line for a distance of considerably over a mile.

Age of the Zeehan Lodes.

There is not much direct evidence as to the age of the Zeehan lodes, and there is no evidence as to the relative ages of the several formations. One instance is known of a quartz porphyry dyke being faulted by a small lode containing pyrites and zinc-blende, and evidently belonging to the pyritic formation. This lode is charted on the geological map; it is situated in the southern portion of Section 3307-93M, about a mile to the west of the Western Mine. This fixes the age as younger than the granite. We further know that the lodes must be older than the Permo-Carboniferous. These rocks are quite unmineralised wherever they occur on the West Coast, and have evidently been laid down after the mineralising processes had ceased to operate. The age of the lodes is probably, therefore, Devonian.

Origin of the Zeehan Lodes.

The theories concerning the source of the metals contained in fissure lodes may be divided into two main groups, namely, (1) meteoric theories, (2) Plutonic theories.

(1) *The Meteoric Theories.*—In the meteoric theories it is supposed that ores are concentrated into veins by the action of circulating meteoric waters; that is, by waters which originally came from the surface, and which, penetrating into the rocks through small cracks and other openings, eventually flowed after a longer or shorter journey into the larger fissures. There they deposit any metals, &c., which they have taken into solution from the rocks with which they have come into contact during their passage

from the surface. Of the meteoric theories, that known as the *lateral secretion theory* was extremely popular in Australia some years ago. According to this theory, the metals are supposed to have been derived from the rocks immediately adjoining the lodes, and the variations in the metallic contents of the lodes are supposed to depend on variation in the metallic contents of the adjoining rocks. This would be a simple explanation of a most complicated problem, but in the Zeehan district at least it is negatived by the fact that the distribution of the different lode-formations is *independent of the country-rock.* Lodes, for example, of the pyritic formation occur in limestones, in slates, in sandstones, in melaphyre tuffs, in melaphyres, and even in conglomerates. It is impossible to suppose that lodes formed by the leaching of all of these rocks should be so uniform in character. The other types of lode-formation occurring in the Zeehan district appear to be equally independent of the country rock in which they occur. This evidence shows that if the meteoric theory has any application at all in the Zeehan district, the source from which the metals have been derived must lie outside the rocks in the immediate vicinity of the lodes. If, therefore, we would adopt the meteoric theory we must postulate a deep underground circulation of the meteoric waters. We must suppose that they have obtained their metallic ingredients from some source or sources far removed from the present surface, and that from here the waters have ascended and deposited their burden of mineral matter in our lode-channels. We can never hope to obtain positive or direct evidence of the truth of such a theory. If all evidence in favour of other theories is absent, we may be justified in adopting some such meteoric theory as a working hypothesis, but further than this it is, from the nature of the case, impossible to go.

(2) *The Plutonic Theory.*—According to the Plutonic theory the metals of certain mineral veins have been derived directly from the eruptive rocks. It has been shown that many eruptive rocks in process of consolidation give off highly heated aqueous vapours and waters carrying metals in solution. These waters were originally present in the molten rock, and were expelled at the time of eruption, and also later, during the consolidation of the magma. Such waters would naturally travel along the great fault fissures, and would deposit their burden of mineral matter as they reached cooler regions. Such in outline is the Plutonic theory of the origin of certain metalliferous lodes.

There is, I believe, no doubt that both the meteoric and the Plutonic theories have definite application in the general theory of ore deposits. No modern geologists dispute the fact that tin lodes, for example, have had a Plutonic origin, nor that the veins of hydrosilicate nickel formations have had in the main a meteoric origin. Both theories are possible, and it is merely a question of evidence as to which is applicable in any given instance.

In the Zeehan field proper there is, as far as I know, only one piece of evidence which helps us to choose between these two theories. This evidence is contained in the stannite lodes at the Oonah Mine. These lodes contain three metals which are invariably connected with granite, and which are characteristic of normal tin veins, the Plutonic origin of which is not disputed. These metals are tin, tungsten, and bismuth, occurring in the minerals stannite, wolframite, and bismuthinite. The stannite lodes, it is true, differ very greatly from the normal tin lodes such as we find in the Heemskirk district, but still, taking into consideration the presence of no less than three metals which are, throughout the world, characteristic of granite and tin veins, it is inconceivable that they could have had other than a granitic origin. Now, the stannite lodes have been shown to be merely a modification of the pyritic lodes of the Zeehan field, connected with the latter by intermediate formations. They are merely one of a family of formations, and their connection with the granite being admitted, the connection of the other members of the family follows as a matter of course.

Now, the granitic rocks are very sparsely distributed in the Zeehan district proper. With the exception of a few dykes of quartz felspar poryhyry, no granitic rocks are known. It is therefore clear that if we want more evidence we must go outside the Zeehan district and study the main mass of granite itself. This occurs at Mount Heemskirk, some five miles distant from the centre of the Zeehan mining field. I have dealt at some length with the geology of this interesting district in my reports on the "Tin-ore Deposits of Mount Heemskirk," and "On the Iron and Zinc-lead Ore Deposits of the Comstock District," and for fuller information these reports must be referred to. In this report it will suffice if I give in outline the main points of evidence as presented in this district, which appear to have a direct bearing on the origin of the Zeehan lodes.

In the country immediately surrounding the Heemskirk granite numerous large iron blows have been found. These deposits consist principally of magnetic oxide of iron (magnetite), associated with certain minerals which are characteristic of granite contacts, and which are believed to be formed by the action of heated waters or gases which have been expelled from the granite while it was still in an intensely hot and molten condition. These deposits belong to a well-known type which have been studied in all parts of the world, and the main facts of their origin have been clearly demonstrated and are universally recognised. The deposits are known as "contact deposits," the term "contact" being used in the sense that they occur within the contact zone surrounding the granite. The iron is believed to have been expelled from the granite as a solution in highly heated aqueous vapours, which are mainly responsible for the metamorphism of the rocks in the contact zone. In addition to iron ore, the deposits also often contain small quanities of copper pyrites, zinc-blende, and galena, the former usually preponderating. In the Comstock district the contact deposits appear to contain zinc-blende in larger quanities than either copper pyrites or galena, though both of the latter are present.

The most interesting point which is brought out by an examination of the Comstock district is the fact that the pyritic zinc-lead lodes are undoubtedly connected with the contact deposits. One lode is known (the Tenth Legion lode) which alters its character as it passes away from the granite contact. Near the contact it is composed almost exclusively of magnetite. Further away pyrites begins to come in with zinc-blende, copper pyrites, and galena, and the amount of magnetite decreases. Other lodes are known (for example, the main lode on the Kynance) in the outer portion of the contact zone containing large quantities of pyrites, galena, and zinc-blende associated with small quantities of magnetite. Further away still, numerous large pyritic lodes are known, containing galena and zinc-blende, but here there is no magnetite. This mineral is confined to the contact zone, and when we leave this we leave the magnetite.

All of these facts strongly suggest that the pyritic and magnetitic deposits have a common origin; that, in fact, the solutions originally emanating from the granite in a gaseous condition deposited the iron first in the form of oxide and later as sulphide. The cause of the alteration in the nature of the deposit may be ascribed to decreasing

temperature. As a matter of fact, we know that oxides are deposited at high temperature in preference to other compounds. Thus, in the furmaroles of modern lavas specular iron is often deposited from emanations of aqueous vapour charged with iron chloride. The same fact also probably accounts for the presence of numerous oxides in normal tin veins, such as tin ore, magnetite, and rutile. Oxides as primary minerals are very rare in mineral veins which have been formed at lower temperatures. In these deposits sulphides and carbonates are the commonest compounds.

The pyritic lodes of the Comstock district are, of course, connected with the pyritic lodes of the Zeehan district. Indeed, the Comstock district may be regarded as the western extremity of the Zeehan mining field. The pyritic lodes extend eastwards, and are found plentifully in the country between the Comstock and Zeehan. As we approach Zeehan, however, we notice that many of the lodes begin to assume another character. Carbonate of iron begins to come in, and to replace the pyrites, thus we get the intermediate formation between the pyritic and the sideritic types, till at the Western and Montana Mines the sideritic type reaches its greatest development.

It would appear therefore that the metalliferous solutions, emanating in the first instance from the granite in the form of highly heated vapour, deposit the iron first as oxide. Later, as they penetrate further into the cooler strata beyond the contact zone, the gaseous solutions condense to watery solutions, and the deposition of the iron continues no longer as oxide, but as sulphide. Later still, when the solutions penetrate far beyond the contact zone, and when the sulphur begins to be exhausted, the iron is deposited in the form of carbonate. Other metals (lead, zinc, &c.), having a greater affinity for sulphur than iron, still continue to be deposited as sulphide.

According to this theory all of the metals found in the Zeehan lodes must have been originally present in the granite magma, and must have been contained in the vapours ejected from the granite in the earlier stages of its consolidation, or perhaps prior to consolidation. The sulphur also must have been present in the original solutions. Much of the carbonic acid, on the other hand, was probably derived from limestones within the contact zone. In the Comstock district there are great masses of lime-silicate hornstone associated with the magnetite deposits. These were originally beds of limestone in which the carbonic acid has been replaced by silica. The effect of

the limestone beds, therefore, would be to deplete the solutions of their silica contents and to enrich them in carbonic acid. These masses of lime-silicate hornstone may therefore account, not only for the presence of so much carbonate of iron being deposited in the Zeehan lodes, but also for the comparative scarcity of quartz which otherwise would be difficult to account for on the theory that the lodes were connected with an acid rock like granite.

The distribution of the several characteristic minerals in the Zeehan lodes is illustrated graphically in Plate II. In this diagram the vertical columns are intended to represent three zones of country at varying distances from the main granite mass. Opposite the name of each mineral a black area is marked, crossing these columns laterally. The thickness of these areas is intended to represent the relative abundance of the several minerals in the different zones. Thus, magnetite is at its maximum right at the granite contact, and does not extend beyond the contact zone. Pyrites reaches its maximum outside the contact zone, and siderite is not deposited for a considerable distance beyond this point. All the minerals are deposited in the same way, some sooner and some later, according to their relative solubilities in the gradually cooling and gradually changing solutions. An interesting point brought out by this diagram is the analogy between the relative positions of oxide and sulphide of iron and oxide and sulphide of tin, the difference in the composition of the two precipitates being in both instances attributable to the differences in temperature at which precipitation has taken place.

The diagram is not, of course, to be taken as accurately representing the distribution of the lodes of different types. It is obvious that distance from the granite is not the only factor on which the alteration in the character of the veins depends. The rapidity with which the solutions travel away from the granite must also have a great influence on the distribution of the lodes of different types. It would therefore be quite possible to have at some distance from the granite pyritic and sideritic lodes side by side. This is, indeed, what we actually have in the Zeehan district. The contact zone around the granite is about one mile in width. Beyond this is a zone some two miles in width in which only pyritic lodes are known. Beyond this again there is a zone of undefined width, in which pyritic, pyritosideritic, and sideritic lodes occur.

The Freiberg Lodes.

It will be of interest at this point to compare the silver-lead lodes of the Zeehan district with those of one of the oldest silver-lead mining districts in the world. The lodes of the Freiberg mining district in Saxony have been in operation since the year 1162 A.D., and since the Freiberg Mining Academy was established in 1766 the lodes have been continuously under the observation of trained scientific observers. It is not therefore to be wondered at that the lodes of this district have been more carefully studied than those of any other single district.

The lodes of the Freiberg district are divided into two main groups—an older and a younger. To the younger group our Zeehan formations do not appear to have any resemblance. We may therefore confine ourselves to a consideration of the lodes of the older group. Among these, four main types or formations have been recognised—

1. The noble quartz formation.
2. The pyritic lead and copper formation.
3. The tin formation.
4. The brown spar or noble lead formation.

Of these, Nos. 2 and 4 correspond fairly well with our Zeehan pyritic and sideritic formations, though we have not the variety of minerals which are contained in the Freiberg lodes. No. 3 does not correspond to our stannite formation, as the tin is present in the form of oxide, not as sulphide. The Freiberg tin veins are probably more closely allied to the normal tin veins of granite such as appear at Mount Heemskirk. We do not appear either to have any parallel to the noble quartz formation.

The analogy which the Zeehan pyritic and sideritic formations present when compared with the Freiberg formations 2 and 4 are, however, sufficiently striking to deserve some notice. The analogy extends over the following five points:—

1. Just as the Zeehan pyritic formation passes over by gradual changes into the sideritic formation, so does the Freiberg pyritic lead formation pass over into the Freiberg brown spar formation.

2. One of the essential changes which marks the passage from the pyritic lead to the brown spar formation in Freiberg, is the decrease in the amount of sulphide of iron and the increase in the amount of carbonate of iron. The same change marks the passage from the pyritic to the sideritic formation in Zeehan.

3. Zinc-blende is abundant in the pyritic lead formation, and scarce in the brown spar formation of Freiberg. The same may be said of the pyritic and sideritic formations of Zeehan.

4. The grade of the galena in the Freiberg pyritic lead formation is lower than that of the brown spar formation. The figures given are:—For the former, 1-3rd ounce to 1 ounce per unit of lead (with 75 to 80 per cent. lead, 0·09 to 0·20 per cent. silver)*, and for the latter 1·6 ounce to 2·5 ounces of silver per unit of lead (with 76·5 to 85·5 per cent. lead, 0·38 to 0·66 per cent. silver*). Our Zeehan figures are for the pyritic formation $\frac{1}{4}$ to 1 ounce of silver to the unit of lead, and for the sideritic formation 1·75 ounce to 2·0 ounces of silver per unit of lead.

5. In the Freiberg district the number of lodes belonging to the pyritic lead formation is greatly in excess of those belonging to the brown spar formation. If in the pyritic formation we include all those intermediate lodes in which pyrites forms a considerable proportion of the vein matter, the same statement might be made with regard to the Zeehan lodes.

There are, of course, many minor points of difference which I need not go into here. Perhaps the most striking is the relatively greater amount of quartz in the Freiberg lodes. Chlorite also is a highly characteristic mineral of the Freiberg pyritic lead formation, but appears to be absent from the corresponding formation at Zeehan. The mineral occurs, however, abundantly in the contact deposits of the Comstock district.

Secondary Alterations and Enrichments.

Many of the Zeehan lodes have undergone a large amount of alteration in the vicinity of the surface. Sometimes this takes the form of a gossan capping, or "iron hat." This capping is composed principally of iron oxide (limonite), with usually some secondary silver and lead minerals. Oxide of manganese is also often present. The value of gossans, which lies principally in their silver contents, is very capricious. Some of them are exceedingly rich, assaying up to several hundreds, or even thousands, of ounces to the ton. As a rule no silver mineral can be detected with the naked eye, but in the case of some of the richer gossans small crystals and grains of chloride of silver or strings and flukes of native silver can be seen. Lead

* Die Erzgänge der Freiberger Bergrevieres. H. Müller, 1901.

is usually present as carbonate, sometimes as sulphate. Where the lode crosses dykes of serpentine, chromate of lead is present, and in the case of some lodes occurring in melaphyre or melaphyre tuffs, lead phosphate (pyromorphite) is often abundant. When silver minerals are invisible it is usually impossible to judge of the grade of the gossan by eye. Miners working in the ore learn by experience what to save and what to throw away. It is, however, never safe to work without assaying the ore frequently.

Argentiferous kaolin is sometimes found in the upper portions of lodes, especially those which occur in the "white" country, or melaphyre. Some of the richest secondary ores mined in Zeehan have been of this nature. The silver is present in the form of chloride.

In a great number of cases, especially lodes of the of the pyritic and pyrito-sideritic formation, the whole of the mineral matter has been leached out of the upper portions of the lodes, and the lode channel is practically barren for some distance from the surface. This is most frequently the case in hilly country, especially where the wallrock is a more or less porous slate or sandstone. This may, I think, account for the fact that up to the present so few productive lodes have been found in the sandstone hills.

The chemical reactions involved in the formation of gossans, kaolin, &c., in the upper portions of lodes are of a complicated nature, and need not be gone into at length in this report. It will here suffice to state that the changes are brought about by surface waters which penetrate into the lode channels. These waters bring with them small quantities of oxygen, carbonic acid, and sodium chloride. The sulphides first take up oxygen and become altered to sulphates, in which state they are more or less soluble. When iron pyrites is present sulphurous and sulphuric acids are formed, as well as several soluble sulphates of iron. All of these, but more especially the sulphates of iron, attack the other sulphides as well as the carbonate of iron the latter setting free much carbonic acid, which may preciptate the lead as carbonate. Silver is precipitated as chloride or native silver if conditions are favourable, otherwise it may continue in solution as sulphate or carbonate. Iron oxide may be precipitated from the sulphate by numerous reactions. Phosphate of lead probably is formed through sulphuric acid attacking phosphates in the melaphyre and setting free phosphoric acid. Chromate of lead is formed by the action of sulphuric acid on chromic iron

forming soluble chromates, which precipitate the lead from solution.

During the last few years it has been shown that the influence of secondary alteration extends below the oxidised zone, and has produced enrichments in the upper portions of the sulphide zone. Our knowledge of these processes has been greatly advanced by the researches of several prominent American geologists, who have shown that the large shoots or bonanzas of rich sulphide ores are in part at least the result of these processes. In the Zeehan field it is a notorious fact that the proportion of first-class ore decreases as depth is gained. I have discussed the causes and limitations of this impoverishment at some length in my report on the Western Mine, Zeehan, from which I may quote the following:—

"How, then, is the fact to be accounted for that, in so many instances in the Western and other Zeehan mines, the lodes show such a marked impoverishment in depth? I believe this impoverishment is in part real and in part apparent, and is to be accounted for in two ways. Firstly, the ore is not distributed evenly along the lodes; it occurs in shoots and patches. It is probable that the principal factors which have determined the formation of these shoots are the presence of open spaces and channels along the fissures, and the presence of rocks which, either on account of their porosity or solubility, or both, are specially favourable for replacement. Up to the present time no general law has been discovered which assists us in finding new shoots of ore, and, as far as we know, their distribution is quite irregular. This being the case, we may regard the lodes as fissures in the crust of the earth, containing irregular shoots and patches of payable ore. The present surface is an arbitrary plane, passing through these fissures in a more or less horizontal direction. Where this plane intersects a shoot of ore, the lode is discovered, the shoot is worked, and eventually is found to cut out in depth. This follows naturally from the irregular nature of the deposits, and does not by itself prove that the lodes are on the average more productive near the surface than in depth. Secondly, the shoots in the upper levels have been enriched by concentration of the ore near the surface through the action of the surface water. I believe this concentration is due to two causes, namely, (*a*) the leaching away of the iron carbonate, and (*b*) the redeposition of galena. The first of these causes I believe to be the most important. In the upper portion of all Zeehan lodes the proportion of

first-class ore is much greater than the same lodes contain below water-level. When water-level is reached, the galena is always mixed with more or less carbonate of iron, and the proportion of second-class ore increases. That the change in many instances is due to the leaching away of the carbonate of iron in the upper portions of the lode is proved by the fact that the galena often retains the impressions of the crystals of carbonate of iron. It will be readily seen how this process might convert a large body of second-class ore into a smaller body of firsts. The re-deposition of galena by the action of surface waters depends upon the presence of the sulphides of other metals which have less affinity for sulphur than lead has. The only mineral present in any considerable quantity which fulfils this condition is iron pyrites, which occurs in small quantities with the galena in the lower levels, but in the upper levels of the Western Mine is stated to have been absent. It is probable that the absence of pyrites in the upper levels is due to the fact that it has been replaced by galena. The oxidising waters attack the galena near the surface, converting the lead and silver into sulphates, or carbonates; and in this form carry them downwards till they come in contact with the iron pyrites. Then a chemical reaction takes place, lead and silver sulphide are deposited, and iron sulphate or carbonate goes on in solution. I believe that this reaction is, in part, the cause of the concentration of the galena in the upper portions of the lodes. The theory, however, must not be carried too far. There is nowhere a great deal of pyrites in these lodes, and unless it or some other precipitant is present, it is impossible for secondary deposition of galena to take place."

The last remark in the above extract applies only to the lodes of the sideritic formation. In the case of the pyritic or pyrito-sideritic formations, it must be admitted that there is more than enough pyrites present to account for the reprecipitation of large quantities of galena. The theory also explains the presence of galena of higher grade in the upper portions of the pyritic lodes. It has been shown that the metals may be arranged in a series in such order that any metal of the series is capable of replacing all succeeding metals and of being replaced by all preceding ones. For the commoner metals this series is as follows:— Mercury, silver, copper, bismuth, cadmium, antimony, tin, lead, zinc, nickel, cobalt, iron, arsenic, thallium, and manganese. Thus, iron sulphide is capable of precipitating the sulphides of all the metals of the series from mercury

to cobalt, and iron salts may be precipitated as sulphides by the sulphides of arsenic, thallium, and manganese. From the fact that silver is capable of being precipitated by all but one of the metals of the series, we might well expect that it would not travel far in a downward direction along the fissure before it was precipitated. We should expect the ores near the surface, therefore, to be rich in silver. Similarly for the other metals, those which have precedence in the above series may be expected, as a general rule, to be found concentrated at higher levels than those which succeed them. This is, I think, on the whole borne out in the Zeehan lodes. Besides silver, antimonial ores (jamesonite, &c.) are more abundant in the upper portions of the lodes of the pyrito-sideritic formation, than at lower levels; while zinc-blende appears to increase in quantity up to a certain point as depth is gained. For further discussion of this question my reports on the "Iron and Zinc-lead Ore Deposits of the Comstock District (pages 12 and 13)," and on "The Ore Deposits of North Dundas (pages 27 and 28)," may be referred to.

This theory of reprecipitation of sulphides is, of course, not favourable to the continuance of good shoots of ore to great depths in the lodes of the pyritic and pyrito-sideritic formations. It teaches us that the galena will not only be found to be less abundant as depth is gained, but will also be of lower grade. This applies, however, only to lodes in which pyrites is present in considerable quantities. W. H. Weed* makes the following statement on this point: "From the chemical reactions given it is evident that enrichment is largely dependent upon the presence of markasite, pyrite, or some other form of iron sulphide in the primary ore, since lixiviation depends upon the presence of the iron sulphates, and precipitation is mainly effected by the unaltered sulphides. As a consequence of this it follows that ore-bodies lacking in iron pyrites will not show enrichment, thus explaining the absence of any such phenomena in the pure silver-lead bodies of the Cœur d'Alene district and elsewhere." There is, however, in the case of the sideritic lodes of Zeehan, as I have already shown, another cause for the production of shoots of first-class ore near the surface, namely, the leaching away of the soluble carbonate of iron. But this does not appear to affect the grade of the ore, nor should it greatly increase the amount of galena present in the lodes per unit of lode area.

* Trans. Aus. Inst. Mining Engineers, Vol. XXX., page 439.

This decrease in the value of our lodes as depth is gained is the dark side of the theory of enrichment, and I think that we must look matters straight in the face and act accordingly. Like every other advance in human knowledge, the theory must have a bright as well as a dark side. If, on the one hand, it teaches us that we must not look for rich shoots of ore by sinking shafts to great depths, may it not, on the other hand, show us the most likely places to seek these rich shoots at shallower levels. I think it will do this. What are the conditions necessary for the formation of rich shoots. Evidently we must first have a good lode-formation. We must have a large fault fissure, which would serve as a channel, not only for the original solutions which deposited the primary minerals, but also for the surface waters which leach out the metals from the upper portions and deposit them lower down as an enrichment. We must look, therefore, for a formation in which there has been considerable movement. Slickensides are the best indication of movement; the presence of good seams of "dig" or rubble in the lode-channel is also a good sign of faulting action. The presence of a black pug or slime in the "dig" is a good sign that mineral has been leached out of the lode-channel. This derives its colour from the presence of puverulent sulphides of lead and iron, and often contains specks of galena and pyrites. There are many such lodes in the hilly country in the southern portion of the Zeehan field. The fact that some of the galena found attached to fragments of slate is of low grade should not, in my opinion, discourage prospectors. These represent portions of the primary galena which have escaped the leaching action of the iron sulphate solutions. Prospecting operations should be directed towards the discovery of the big shoots of enriched ore such as have been mined at Grubb's Mine and in the main lode of the Spray Mine. The presence of small quantities of low-grade galena in the slate in the vicinity of the lodes, is no argument that enrichments do not exist lower down. I have had my attention drawn more particularly to the southern portion of the field, where the large amount of backs obtainable by driving on the lodes, and also the large area of the lodes exposed to leaching action in the hills, appear to me to offer good opportunities for prospecting without machinery, and splendid chances of prospecting operations being rewarded by the discovery of rich shoots. Prospecting drives should be driven at as low a level as possible in order to get below the leached zone. I have not been able to examine the

country to the north of the Western Mine, but I can see no reason why this country should not be equally favourable. The Oonah Hill specially appeals to one as likely to contain enrichments, and this country so far has been almost entirely neglected by prospectors. I would deprecate any large expenditure on small lode-formations, and especially those which do not afford an adequate channel for the circulation of surface waters. These lodes may be very payable near the surface, but the enrichment is not likely to extend to a great depth, and with increased cost of mining the chances of their proving payable in depth are not great.

Is there a "Mother Lode" in the Zeehan Field?

I have often been asked this question by mining men in Zeehan, and until quite lately I have always replied that so far as I knew there was no geological evidence which would lead one to suspect the presence of anything of the kind, unless such continuous lodes as those of the Silver King or the Spray Mines could be regarded as "mother lodes." These lodes do not, however, answer to the usual conception of a "mother lode." If this expression is used at all it should, I think, be confined to the great fault fissures which have acted as the main channels along which the metalliferous solutions ascended from the depths below, and from which the smaller lodes have received the metal-bearing solutions which have deposited the valuable minerals. From the nature of the case it is, of course, very difficult to decide which have been the main channels of circulation. In the Zeehan district the whole region is one mass of fissures and fractures, and it is possible that the whole of the metal-bearing region has acted as a kind of huge channel along which the solutions ascended, passing freely from one fissure to another along the line of least resistance. Still, my examination of the Zeehan district has pointed to the presence of certain lines of faulting which appear to have been of vastly greater importance than that of any of the lode fissures which have been extensively worked up to the present. I have pointed out that most of the Zeehan lodes are situated within an area of highly disturbed strata—that this area is probably a zone of subsidence bounded on the south and east by great faults. Is it not possible that these great faults may be the "mother lodes" of the Zeehan district? It is probable that had I not been about to sever my connection with the

Geological Department I should not have alluded to this question in this report. I would have waited till I had more opportunities for studying the question, and until I was more certain that my interpretation of the structural geology of the district, as given in this report, was correct. As, however, I am shortly leaving Tasmania, I think it is only right that I should place on record the speculations which I have made on this question, and the evidence on which these speculations are based.

I have already given my reasons for suspecting that the disturbed area of the Zeehan field is bounded on the south and east by great fault fissures, but I have not alluded to the fact that in several places, where I should expect these fissures to be, there is evidence of the presence of large lode-formations.

Beginning with the southern boundary of the disturbed area, we have a very large lode-formation on the old Silver Duke Mine striking nearly east and west, and very close to, if not actually at, the contact of the slates and the conglomerate, which at this place also strikes east and west. This formation is of unknown width, carries dolomite, carbonate of iron, pyrites, and galena, the latter only in small quantities and of low grade. Where the lode has been worked there is evidence of the presence of serpentine, and it is just possible that the great fault fissure may be a dyke of serpentine. Still, there is undoubtedly a lode here, and a very large one, although there does not appear to me to be much encouragement to develop it at the present time. Still, the lode should not be forgotten. It is possible that when more is known about the Zeehan lodes it may become advisable to test the formation in depth. There is always a chance, in the case of a large fissure formation of this kind, of shoots of enriched ore occurring below water-level. I think also that it might be worth while trenching across the contact of the slates and conglomerates along this line. It is now known that the large pyritic deposits at Mount Lyell occur along a great fault fissure dividing the schists from the conglomerate formation. In that district at least it is practically certain that this great fissure has served as the channel for ore-bearing solutions.

To the east of the Silver Duke section in the southern portion of Section 174M, charted in the name of A. D. Sligo, and marked in the geological plan under its old number, 1876-91M, there are several lode-formations carrying pyrites, carbonate of iron, and galena in small quantities, striking east and west. These formations are in slate

country, and the great contact fissure must lie to the south. Still, their direction of strike being contrary to that of all lodes in the central and northern portions of the Zeehan field, proves that there is a line of fissuring running east and west in the southern portion of the field, and gives a certain amount of circumstantial evidence that the plane of contact between the conglomerate and the slate is actually a plane of fissuring of the same age as the lode fissures.

This east and west contact appears only to extend in an easterly direction as far as to the south-eastern portion of Section 674M. From here the contact of the disturbed slates and sandstones with the conglomerate takes a course a little east of north through Sections 5353-93M, 5342-93M, and 3687-93M. Of this line of country I can only say that there are a number of large lode outcrops, the exact position of which I have not accurately located. They occur approximately along the plane of contact, and may very possibly represent the line of contact in this part of the district.

To the north of Section 3687-93M (the Austral Mine) the conglomerate formation is seen no more. Beyond this we have to follow the contact between the regularly stratified strata of the eastern portion of the field which are conformable with and overlying the conglomerate, and the disturbed area of the central and western portions. From the North Austral Mine the contact appears to take a course of north 65° west, passing through the northern portion of the Montagu No. 1 Mine into the Central Balstrup, and thence in a more northerly direction to the north-eastern portion of Section 1209M (Balstrup's Manganese Hill). I have not examined this line of country, but would suggest that it might easily be tested by a crosscut north from the Montagu Mine workings.

From the north-eastern portion of Section 1209 the contact takes a course of 30° east of north through Sections 192-87M and 193-87M (The Argent Mine), Section 943M (The Florence), and Section 559M (The New Mount Zeehan). This contact is, I think, clearly a fault fissure. To the south-west of this line the strata are evenly bedded, striking from 35° to 40° west of north. As the contact is approached the strata bend round to the north, and at the contact a complete change of country takes place. To the east we have slates and sandstones, to the west melaphyre tuffs and interbedded slates. The faulting movement has had a lateral as well as a vertical component. From the way in which the strata bend round on approaching the contact it is evident that the western country has been heaved to

the north or the eastern country to the south. This is confirmed by observations on one lode at least on the west side of the contact. Currie's lode as it approaches the plane of contact bends round to the west. We have then the strongest circumstantial evidence of the presence of a great fault fissure running along the eastern margin of the Argent Flat. There are also good reasons for believing that this is also a lode-formation. In Flaherty's Shaft on Smith's section a very large lode-formation was cut in the east crosscut. It was a loose open formation, and when first struck there was a burst of water, carrying with it quantities of slurry, broken slate, carbonate of iron, and slugs of galena. This formation was striking 30° east of north, and is marked on the geological plan as Flaherty's lode. I believe that Currie's lode junctions with this lode, bending round to the west as it does so. The old plans of Currie's workings show this bend very distinctly, and it looks as if the shoot of ore in Currie's lode extended for some distance along Flaherty's lode in a south-westerly direction. This lode of Flaherty's appears to me to be very much like what we are looking for. It is in the right position, its strike is right, and it is just the kind of formation which we should expect to find. I think also that the great vugh which was struck in the Florence workings, and which resulted in the loss of one man's life, was connected with this same fissure. The Florence Company were driving along the course of Currie's lode in an extremely hard quartz breccia, evidently connected with the lode, when, without the slightest warning, the shots fired in the face broke into a large vugh, described as being 30 feet wide, 40 feet high, and of unknown length. The rush of water carried with it an enormous quantity of slurry, angular blocks and fragments of slate, carbonate of iron, and galena, which were supposed to have come from Currie's old stopes. These, however, are still intact, and I think the fragments must have come from the vugh itself, which was probably once filled with carbonate of iron. This has been leached away by surface waters circulating in the fissure, and the roof and walls have fallen in, forming the angular fragments of slate and lode-matter which were carried into the Forence workings. This is the only explanation I can offer for this most regrettable occurrence.

I think it is also possible that this same formation has lately been cut in the east crosscut from the No. 6 shaft of the Argent Mine. I have not been able to inspect this lode, but Mr. Vincent describes it to me as a large loose

formation containing a large quantity of water, and, what is of more interest from a commercial point of view, payable quantities of high-grade galena. Carbonate of iron is also present. This lode strikes 30° east of north, and is almost directly in line with Flaherty's lode. It is just about where the contact is to be expected, and I have great hopes that it will turn out to be the main or "mother" lode of this portion of the field. This line of lode will probably in the near future prove whether there is anything in these speculations. Should they turn out to be correct in this instance, then the whole line of country which I have described above will be worth prospecting.

I am a little undecided as to the position of the continuation of this line of contact further north. It must cross the Town of Zeehan somewhere, and then probably passes along the eastern slope of the Montana Hill. This is a portion of the district that I have not been able to examine very carefully.

In concluding this theoretical portion of my report, I wish to say that I feel that my examination of the Zeehan field has been of a very superficial character. It is true that I have been able to spend much more time on it than any previous geologist, and have had opportunities for making observations which were impossible during the flying visits of my predecessors. Still, the district is so extremely complicated, and the whole structure of the country is on such a huge scale, that the examination of a limited area such as that included on my geological plan gives one very few clues as to the real structure of the country. Before this can be correctly unravelled we must go further afield, and not confine our observations to the known metalliferous areas. Until this work over larger areas is sufficiently advanced to enable us to correctly interpret the general geological structure of the country, it is not possible to solve, with any approach to certainty, the great problems of economic importance which are continually being presented to the mining geologist. I trust that the remarks which I have made on the geological structure of the Zeehan district will not be taken as final. The observations require confirmation and extension. In this direction there is a vast field open for useful geological work by active young men, such as many of the students of the Zeehan School of Mines. If the speculations which I have made in this report have no other result than that of awaking interest in some of the geological problems of the

district and of giving direction to future research, I do not think that the expense incurred by the Government in my examination will be altogether thrown away.

The Zeehan-Montana Mine, Limited.

Sections 199-87M, 736-87M, 201-87M, 1666M, 2154-87M, 691M, 1636M, and 243-87M; total area, 422 acres. The parent Montana Mine, now known as Montana No. 1, is situated on Section 2154, originally a 39-acre section, but subsequently enlarged to 62 acres by purchase of a strip of ground from the Silver Queen Prospecting Association. Subsequently the Montana Company acquired the sections held by the Silver Crown Company, including the Dispatch Mine, and still more recently, when the Silver Queen Mine was refloated as the Zeehan-Queen, the company acquired the mine formerly known as No. 1 Queen, situated on Section 691M, and now known as Montana No. 2.

The Montana No. 1.

A great number of lodes have been worked on this property. The country is all very much disturbed, and consists of slates, quartzites, or hard sandstones and melaphyre. The latter rock occurs both in the form of dykes (an excellent example of which may be observed in the cutting just opposite the Montana concentrating mill), and also in the form of sheets and lava flows interbedded with the country. Some of these sheets probably represent beds of tuffs. I found it impossible to work out the structural features of the country in this part of the field. The masses of melaphyre occur in the most irregular manner, and have evidently been much faulted prior to the formation of the lode fissures. The latter usually traverse the slates and melaphyres without being materially influenced by the change of country. Sometimes the metal appears to cut out when a change takes place, as in the case of a lode passing out of melaphyre into slate. But in other instances this is not the case. There appears to be no rule to guide one as to where ore may be expected. A curious feature of the Montana and surrounding mines is the presence of what I believe is a series of parallel cross-lodes, striking about 50° to 60° west of north, and dipping to the north-east at an angle of 40° to 55°. These cross-lodes, or as they are called locally, "slides," are more permanent than most of the productive lodes. The latter appear to occur in the

country between two such cross-lodes, and the same productive lode has never with certainty been known to cross them. The cross-lodes are large fissure formations, with slickensided walls, the slickensides being usually nearly horizontal, showing that the movement has been horizontal, not vertical. From the way in which the lodes bend round as they approach the cross-lodes it would appear that the northern walls of the cross-lodes have heaved to the north-east or the southern walls to the south-west. This feature is observable in all the members of the series. The cross-lodes usually contain a little galena and carbonate of iron, and in several instances they have carried very fine shoots of ore. In the Western Mine No. 1 and No. 2 "slides" belong to this series of cross-lodes, and I believe that No. 4 lode of the same mine must be also included. This lode is almost directly in line with the north main slide of the Montana Mine, and as the strike and dip agree, I think we are justified in assuming that they are the same. In the Montana Mine we have the main north slide, and further south again the main south slide. There is a similar formation at the Oonah Mine, known as the main slide, and at No. 4 Queen I think that No. 4 lode north must be included in the series. It appears to me now, after considering the whole of the evidence bearing on these cross-lodes or slides, that the productive lodes have not been faulted by the cross-lodes. I am inclined to think that the age of the cross-lodes and that of the productive lodes is identical; that the direction of strike of these cross-lodes represents the main direction of faulting in this portion of the Zeehan field; and that the productive lodes are merely minor faults and fractures connecting the main cross-lodes. The presence of characteristic lode-matter, and in some cases of rich shoots of ore in the cross-lodes, is strong evidence on this point. Another piece of evidence is afforded by the behaviour of the productive lodes as they approach the cross-lodes. In a great number of instances, as Mr. J. Craze has pointed out to me, the productive lodes seem to throw off branches as they approach the cross-lodes. This is noticeable where the main lode north and No. 2 lodes approach No. 1 slide, and where the main lode south approaches No. 4 lode in the Western Mine. It is very noticeable where No. 6 lode approaches the main slide in the Montana, and to a lesser degree in the case of No. 3 and No. 4 lodes; also where No. 6 lode south approaches the main south slide at the Montana, and similar phenomena occur in the Oonah and Queen Mines. I can see no

explanation of this curious fact in the theory that the "slides" are faults of later age than the lodes, but I think it is capable of a mechanical explanation on the assumption that the main original faulting movement has taken place along the strike of the cross-lodes, and that the country between the main lines of faulting has been fractured and faulted in the process. According to this theory we would expect the cross-lodes to be the main channels through which the ore-bearing solutions originally ascended, and that being the case, it may reasonably be asked: how is it that the cross-lodes have not proved more productive. Possibly this may be because they have so far been more or less neglected, as they have usually been taken for faults of later age than the lodes. Three good shoots of ore have been found in these cross-lodes, namely, (1) the shoot of ore in the No. 4 lode, Western Mine; (2) the shoot of ore in the main slide, Montana Mine, near the junction of the No. 6 lode; and (3) the shoot of ore in No. 4 lode north in the Silver Queen Mine. I am of opinion that these cross-lodes or "slides" should receive more attention than they have in the past. Even supposing they are not cross-lodes, but only faults, it has been shown in a number of cases that the productive lodes contain rich shoots close to the slide, and on this account alone the slides might be worth driving on, just as at Ballarat it is found advisable to drive on the "indicator veins." Also, if these formations are faults of later age than the lodes it would be worth driving on them with the object of picking up the continuation of the lodes on the other side of the faults. I am by no means satisfied that the view I have expressed above is the true one, but this does not affect the practical bearings of the question. Whichever view is taken, a good case may be made out for driving on the slides.

The mine has been worked from a main shaft situated in the eastern portion of the section. The shaft is 641 feet deep, and levels have been opened out at the following depths:—No. 1 level, 112 feet; No. 2 level, 193 feet; No. 3 level, 295 feet; No. 4 level, 401 feet; No. 5 level, 503 feet; No. 6 level, 604 feet.

No. 1 Lode.—Average strike north 30° east, dip 75° to the east. This is the most easterly of the lodes worked by the Montana Company, and was the first lode operated upon. At No. 1 level it has been driven on for a distance of about 550 feet, of which about 350 is stated to have been in good ore, though the lode has been stoped out for

nearly the whole distance driven on. The northern portion of the stoped ground is in white country and the southern portion mostly in slate. At No. 2 level the lode was driven on for a distance of about 260 feet. The good shoot of ore mined above No. 1 level proved to be getting shorter, being only about 200 feet in length at this level. Both north and south the lode is still showing in the ends of the drives, but is quite barren. At No. 3 level the lode was driven on for 160 feet, and at this level the good shoot of ore had narrowed down to about 20 feet. All the ground above this drive has been stoped out, and has proved the shoot to be V-shaped, widening out all the way up to the tunnel level. This is all the work done so far on this lode. A crosscut has, however, been started at No. 5 level to cut this lode, and is now 60 feet east of No. 4 lode. If No. 3 lode preserves its strike and dip this crosscut should cut it in another 90 feet. It is proposed to drive for this lode also at No. 4 and No. 6 levels. It is the same character of lode as No. 4, which has been profitably worked down to No. 6 level, and is in the same country, so there is no reason to believe it will not turn out equally as good.

No. 2 Lode.—Average strike north 6° east, dip north of main shaft slightly to the west; south the dip is about vertical. This lode has been driven along at adit level for about 300 feet south of the main shaft; 60 feet below this an intermediate level was driven for nearly 200 feet, and the whole lode stoped out between this and the surface. At No. 1 level the lode was cut in the plat, and was driven on north of the shaft for a distance of 200 feet, when the main north slide was cut. At this point the slide is in slate country, and the course of the lode bends round to north-west in the vicinity of the slide. This is a feature which appears to be common to all of the lodes which intersect these main slides. At No. 3 level the lode was driven on north of the shaft for 130 feet. Here the lode is poor, consisting of a vein of carbonate of iron, with only splashes of metal. An intermediate level was driven 40 feet above No. 3, and from this the lode was stoped up to the slide. This lode has also been cut 350 feet south of the shaft by a crosscut from the drive on No. 1 lode at No. 1 level, and driven on for a little over 100 feet. A little stoping was done above this drive, but the lode proved to be very poor. This lode is described as having been bunchy, and never at all rich. It is irregular in its course, and has not been cut, or, at any rate, has not been recognised in the lower levels.

No. 3 Lode.—This is a small lode, having an average strike of north 8° east, and dips to the east at an angle of 68°. The workings on the lode are situated to the south-west of shaft. At the adit level the lode has been driven on for 120 feet, and below this at No. 1 level for 240 feet, the whole of the lode being stoped out above this level. The lode was also cut in the main west crosscut at No. 1 level, and was driven on for a short distance both north and south, but it proved to be barren. At No. 3 level the lode was again cut in the main crosscut, and driven on south for 200 feet. A little stoping was done above this level, but it proved to be unpayable. This lode has also been cut in No. 4 and No. 5 levels, but in both cases it was barren where cut, and has not been further developed. There was only one good bunch of ore in the lode, and that was just below adit level. It lived nearly down to No. 2 level, but was only really payable above No. 1 level.

No. 4 Lode.—This lode is situated to the east of the main shaft. It strikes about north 30° east, dipping to the east at an angle of 65°. In No. 1 level it was driven on for a distance of 200 feet. In the south end the lode appears to pinch out when passing out of the white country into slate. In the north end it was cut off by a slide striking north 65° west, and dipping 28° to the north-east. This slide is evidently connected with the main slide north. It is nearly parallel to it in strike, but much flatter, and is situated to the south of where the main slide is to be expected. It evidently junctions with the main slide just above No. 2 level. The lode at No. 1 level and in the stopes between No. 2 and No. 1 levels behaves precisely similarly on approaching this flat slide as it does in the levels below on approaching the main slide. In the vicinity of the slide the course of the lode gradually bends round from north 30° east to north 15° east, and then, when within 6 feet of the slide, suddenly changes to north 15° west. This may be observed in all the levels on this lode. It is the strongest evidence of the fact that the northern or hanging-wall of the slide has been thrown to the north-west or the footwall to the south-east.

At No. 2 level the lode has been driven on for a distance of 450 feet, the ore pinching out south, as in No. 1 level, when the lode passed out of the white country. At this level the lode was driven on south of the white country in slate for a distance of 130 feet. For the first 50 feet south of the contact the lode-channel was unmineralised. After this there is a vein of carbonate of iron, with occasional

splashes of galena, up to the end of the drive, but the lode is unpayable. North of the contact the lode was productive up to the north main slide, a distance of 300 feet. Above this level the lode is completely stoped out up to the surface.

At No. 3 level the lode has been driven on for a distance of 360 feet, and was productive almost the whole distance. In the south end of the drive the lode was not productive quite up to the slate contact as in the upper levels, but became poor halfway between No. 3 and No. 2 levels. The lode is now stoped out between these levels for a distance of over 300 feet, the northern end of the stopes extending up to the main north slide.

At No. 4 level the lode has been driven on for a distance of over 800 feet, and between No. 4 and No. 3 stoping is proceeding along a distance of 600 feet, of which 200 feet are in slate. There is about 40 feet of lode still standing between No. 4 and No. 3 levels.

At No. 5 level the lode has been driven on for about 570 feet, and the whole of this is being stoped. In the north end a slide which was not met with in the upper levels cut off the lode. This slide as seen in the drive strikes north 50° west, dipping to the south-west at an angle of 63°. It faulted the lode 43 feet to the north-west at this level. The lode has been picked up on the other side, and contains a fine shoot of ore between this and the main north slide. The lode has lately been cut at No. 6 level, and has been driven on for 30 feet. It contains about 2 feet of second-class ore.

No. 4 lode has not been specially remarkable for its richness, but it has been a good constant ore-producer for many years. The ground stoped has by no means been all payable, but it has been found that to get at the good ore it is necessary to stope out the bad with the good. Three stopes can be taken out for the cost of driving one intermediate level, and as even the apparently barren portions of the lode contain occasional bunches of ore, it is generally found more profitable to stope the whole lode than to take out the rich patches alone. The distribution of the good shoots of ore in No. 4 lode are instructive. They are not continuous in any one direction, but form detached irregularly-shaped patches in the lode-channel. The intervening spaces are, however, not absolutely barren, but they are so poor that in the absence of the good shoots they would not pay to take out. Four of these shoots were found above No. 4 level and one more above No. 5 level, the

remainder of the ground at this level being not much more than payable.

No. 6 Lode North.—Average strike north and south, dip to the east 62 degrees. This lode runs between the main south slide and the main north slide, a distance of 850 feet. At the south end, where it meets the main south slide, the lode has been bent round to the east, showing that the throw of this slide is in the same direction as that of the main north slide to which it is parallel. In one place I noticed that the striæ on the walls of this slide are horizontal, proving that the motion also was horizontal. For the first 160 feet north of the main south slide, the course of the lode is north and south. Then it takes a bend to the east, striking north 47° east for a distance of about 90 feet, after which it resumes its former strike of north and south, until it reaches the main north slide, a distance of 630 feet. As it approaches the main slide the lode splits up into a number of branches, and when the main lode-channel reaches the slide it turns round to the north-west, and in the upper levels at least the slide itself becomes ore-bearing for some distance north of the junction. The best part of the lode has so far always been found to be at the north end in the vicinity of the main north slide, the last 200 feet being exceptionally good. At adit level No. 6 lode was poor. It was driven on for 250 feet, and very little stoping has been done. There is a little second-class ore still to be taken out, and a good deal of low-grade gossan, which is believed to be just about payable, or would be so if prices were a little better than at present. The good ore is said to have lived up to the floor of the tunnel; between this and an intermediate level 40 feet below the ground is unstoped for a distance of 200 feet. This is said to be good ore, but at present is being held as a reserve. Between No. 1 level and the intermediate the lode has been stoped out continuously for a distance of 450 feet south of the main north slide, and for 120 feet along the slide north-west of the junction. At this point there were a number of branches running parallel with the slide, and these were taken out in one stope 40 feet in width. The lode is said to have been very highly productive at this point, and very rich for 200 feet south of the junction. South of this point the lode was patchy, but taken all through paid well. Some distance north of the main south slide a little stoping has been done on a make of ore at the bend of the lode already referred to. This shoot is unpayable at the present prices of the metals.

Between No. 2 and No. 1 levels the lode has been completely stoped out for the same distances as above No. 1 level. Here, however, it did not pay to take out the veins running parallel with the main north slide as in the upper level, and the main channel of the slide alone was stoped.

At No. 3 level the southern extremity of the stoped ground is a little further south than in the two upper levels. From this point the lode has been stoped almost up to the slide, the latter at this level proving barren. Only the picking-up stope now remains below No. 2 level.

At No. 4 level stoping has been commenced from a rise 340 feet south of the main north slide, and from three to four stopes have already been taken out above this level. At the south end of these stopes the lode is poor, but good ore is said to have been cut in the winze above the present stopes. Three parties of men were at work stoping at the time of my visit. In the first stope the lode is very wide, with from 3 to 4 feet of iron carbonate containing fair seconds, and 15 feet of slate with seams of iron carbonate and occasional bunches of metal. In the next stope going north (the fifth above No. 4 level) the lode was 4 feet wide, beautifully banded with about one-third metal by volume. A little north of this again the lode was 6 feet 6 inches in width and about half metal by volume. The next stope is close to the main north slide. It is 3 feet wide, with seams of galena and iron carbonate. Just below this the lode is cut off by a slide striking a little west of north, and dipping to the east. This slide has not been observed before in this mine. It was cut in the No. 4 level drive and driven along for about 35 feet until it junctioned with the main north slide. This slide does not seriously affect the amount of ore available above No. 4 level. There is still about 50 feet of lode standing between No. 4 and No. 3 levels, 200 feet in length.

At No. 5 level the lode was cut at a point estimated to be 330 feet south of the main north slide, and was driven on north for a distance of 180 feet. The first 130 feet were poor; good ore then came in for 50 feet; and then the slide which cut off the ore in No. 4 level was struck. A good deal of work has been done beyond the slide, but the lode cannot be found. The country also seems to have altered, soft graphite slate coming in with strings of carbonate of iron and quartz. On the whole this looks unfavourable to the continuation of this shoot. There is, of course, a good deal of ore to be won between No. 5 and No. 4 levels, but the slide has cut off that portion of the

lode which, from the surface downwards, has always been the richest part of the lode.

At No. 6 level the lode has been driven on for 230 feet north of the slide. The lode-channel is filled with flucan and bunches of carbonate of iron, but no ore has been found.

No. 6 Lode South.—This lode is situated to the south of the main south slide, and is generally considered to be the faulted portion of No. 6 lode north. If the theory as to the nature of these main slides, which I have already considered, proves to be correct, then the lodes on the two sides of the slides are not to be regarded as one and the same. This must, however, be regarded at present as an open question.

Whatever the nature of the main south slide may be, it is certain that it cuts off No. 6 lode north, the end of the latter bending round to the east as it approached the slide. From the point of junction the slide was driven along at No. 1 level for a distance of 130 feet in a south-easterly direction when No. 6 lode south was cut. This lode is also bent close to the slide in a north-westerly direction, like all the other lodes which junction with either of the main slides from the south. The lode was driven on up to the southern boundary of the Montana No. 1 section, and this drive has subsequently been connected with a drive along the same lode in the old Queen section (No. 691M), now the property of the Montana Company. The lode is very irregular in strike; for the first 100 feet it strikes south 10° west, for the next 120 feet south 17° east; it then bends round to the west again, striking south 36° west up to the end of the drive in the Queen section; a total distance of 400 feet. It appears to me that this last is the true strike of No. 6 lode south, and it is probable that the first lode driven on from the slide is a branch lode to the west of the main lode-channel.

What I believe to be the main No. 6 lode south has been driven on at No. 2 level up to the slide on a fairly constant strike. It is remarkable that just as No. 6 lode north breaks up into several branches in approaching the main north slide, so does No. 6 lode south break up into several branches when approaching the main south slide.

Above No. 1 level the stoping has been confined to within 100 feet of the boundary. For this distance the ore has been stoped up to the surface, the last surface stope being taken out at the time of my visit. The lode is described as

having been very payable; not much firsts, but very good milling ore.

At No. 2 level the stoped ground is of greater extent, but the shoot appeared to shorten going up. The stopes here extend to within 40 feet of the boundary. A winze was sunk on the boundary between No. 1 and No. 2, and for the first 30 feet was in fair ore. This ground still remains to be stoped.

No. 7 Lode.—This is a branch between No. 6 and No. 8 lodes, and was first driven on at No. 3 level. At this level there are 200 feet of payable lode, ten stopes of which have already been taken out above No. 3 level. The strike of this lode is north 18° east, and the dip is to the east. The lode was not observed in the drives above No. 3 level. It is a small lode, and, taken all through, is not highly payable. It appears to cross No. 8 lode, which has faulted it for a short distance. North of No. 8 lode the stopes extend for about 48 feet along No. 7, and at the time of my visit were looking particularly well, there being 3 feet of good milling ore in the face, with a large proportion of firsts. I understand, however, that the lode is patchy.

At No. 4 level the lode has been driven on between No. 6 lode and No. 8 lode, but it is poor, and it is doubtful if it is payable. The lode has also been cut in the west crosscut at No. 5 level. It is said to have contained a little metal, but it has not yet been driven on. The lode has also been cut at No. 6 level, but contains no ore.

No. 8 Lode.—This lode has an average strike of north 32° east, and dips to the north-east at an angle of 60°. It appears to be a branch-lode connecting No. 3 lode with the north end of No. 6 lode north. The lode is believed to be faulted between No. 2 and No. 4 levels by an upthrow slide (known as No. 2 slide), which for a considerable distance strikes almost parallel to the strike of the lode, but dips a little flatter, the result being that the lode is above the slide above No. 2 level, and below the slide below No. 4 level. The throw of the slide is about 200 feet, measured in the plane of dip. In the north end in the vicinity of No. 6 lode the lode does not appear to have been faulted above No. 4 level. At this point, however, the lode takes a bend to the north, so that its junction with the fault will be at a deeper level. I think there is still a possibility of this fault being merely a parallel fissure or branch from No. 8 lode, but there is not much evidence in favour of this view at present, and the former theory must be regarded as the most probable.

At No. 1 level it was intended to drive on the lode simultaneously from the main west crosscut in a north-easterly direction, and from the workings on No. 6 lode north in a south-westerly direction, but the two drives did not meet, and it was then ascertained that the drive from the crosscut had been taken along the slide, which at this level is a short distance to the south-west of the lode proper. The north end of the lode proved to be productive, and has been stoped up to the surface.

At No. 2 level the lode was driven on right through both slide and lode, being in the drive in parts of this level. Only the north end was productive, and this has been stoped up to No. 2 level.

At No. 3 level only the slide was cut in the west crosscut, and this was not driven on. The north end of the lode was driven on from the northern workings on No. 6 lode, and this ground is now being stoped for a distance of 280 feet, ten stopes being already taken out. The lode is wide and mullocky, good ore showing in parts, while in other parts it is practically barren. The lode has always been patchy, but taken all in all it pays fairly well.

At No. 4 level the lode has been driven on from the main west crosscut for a short distance. The slide is seen here in the top of the drive, and distinctly cuts off the lode overhead. The lode is productive, carrying from 3 inches to 8 inches of good ore. On account of the slide cutting off the lode overhead, however, there is very little ore to be taken out above this drive. Lately, however, a vein of ore carrying a foot of first-class metal was cut behind the slide, and has been driven on for 50 feet. It is impossible to say what this may develop into. At the north end the lode has been driven on a short distance from No. 6 lode. It is intersected by another branch-lode parallel to No. 7 at this point, and its continuation beyond the branch was not picked up in the level. Two or three stopes above, however, the lode was found, and has been driven on a short distance from the stope. It appears to have been faulted a few feet by this branch-lode, and has since been picked up in the level and driven on 80 feet. This ground is now being stoped, and is producing payable ore.

At No. 5 level the lode was cut in taking out the plat, and was driven along for nearly 200 feet, being more or less productive all the way; then a fault was met with, which threw the lode to the west. It was picked up again and driven on for a further distance of 50 feet, when a second fault was encountered. Beyond this point the

country appears to be much disturbed. The general course of the lode was followed, and several other faults intersected, but no more ore was seen, and it is probable that the drive is not on the lode. Eventually the drive was continued as a crosscut to No. 6 lode north. The lode is now stoped out between No. 5 and No. 4 levels for a distance of 200 feet.

No. 6A Lode.—This is a small lode which occurs to the north of the north main slide to the north of No. 6 lode. It strikes about north and south, and contained a nice shoot of ore for a distance of 90 feet north of the slide. It is stoped out above No. 2 level, and stoping is now proceeding between No. 2 and No. 3. When I saw it the lode carried from 3 inches to 1 foot of first-class ore.

The above includes all the principal lodes of the Montana Mine. Besides these there are several other small lodes or branches which have been worked, but these need not be described in detail. The reserves of first-class ore in the mine have been decreasing somewhat seriously during the last year, principally owing to the failure of the shoot in No. 6 lode at No. 5 level. This will, of course, in the absence of further discoveries, greatly affect the output and profits of the mine. There are still large reserves of second-class ore, and I think there is reasonable hope that further discoveries will be made, provided prospecting and developmental work is kept going. No. 1 lode appears to me to be well worth testing at No. 4, No. 5, and No. 6 levels. This lode produced a splendid shoot of ore in the upper levels, and, considering the results obtained from No. 4 lode, which is in the same country and a very similar formation, is surely worth further testing. I think it would be also worth while driving on the main north slide, say at No. 2 or No. 3 levels, north-west from the drive in the north end of No. 4 lode. It is quite possible that this formation is productive between this point and No. 6 lode, and there is the additional chance, which appears to me to be a good one, of striking other lodes coming into the slide from the north. Two lodes at least have been worked by the Crown Company in this country with some success, and the chances of finding good ore in this locality seem to me to be particularly good.

Mr. John Craze has kindly supplied me with the following particulars as to the history of the mine. The company was floated in London in 80,000 shares of £1 each, of which 68,000 were paid up to £1, leaving 12,000 contributing shares. The company received £3000 in the allotment of

these shares, and in the first year one call was made which produced £2000. This was all the subscribed capital that has been expended on the mine. The company started operations in January, 1893, and paid its first dividend at the first annual meeting, when £5000 were distributed. Since then the remainder of the capital was called up in order to make all shares rank alike. Approximately £80,000 have been paid in dividends. The mine has been equipped with a fine concentrator, pumping and winding plant, compressed-air plant, electric-light plant, &c; £9500 has been expended in the purchase of adjoining properties; £5489 has been spent in equipping and developing Montana No. 2 Mine; and a reserve fund of £15,000 has been created—all out of the proceeds of the mine, the result of the initial expenditure of £5000.

The following tables give some interesting figures as to the details of work done up to the end of 1903:—

Main shaft sunk	641½	feet
Winzes	1744	feet
Risen	4290	feet
Crosscut	6307½	feet
Driven	20,098½	feet
Stoped	116,976½	feet
Trenched	1312	feet
First-class ore produced	16,669	tons
Milling ores mined and treated	126,043	tons
Concentrates recovered	13,043	tons
Proceeds from sale of ore (approximate)	£405,656	
Total expenditure at mine	£264,075	

Montana No. 2.

The Montana No. 2 shaft is situated close to the southern boundary of Section 1636M. It was formerly known as the No. 1 shaft of the Silver Queen Mine. In the early days of the Silver Queen Prospecting Association a fine shoot of ore was mined from a lode situated 270 feet to the west of the shaft, and striking east of north. It was cut at two levels at depths of 100 feet and 200 feet respectively. The shoot was about 160 feet in length at No. 1 level, and shortened to 70 feet at No. 2 level. The whole of the shoot was stoped out about No. 2 level, and a winze was sunk on the ore below No. 2 level for a depth of 75 feet. At the bottom of the winze the ore is said to be only 13 feet long, and from 2 to 4 inches wide.

A little to the west of this lode there is a large pyritic lode, also striking east of north, which has been driven on for a considerable distance. It contains a good deal of galena in places, but it is low grade, and finely disseminated through pyrites. A parcel of this ore was tested by the Montana Company, but proved unpayable. The western crosscuts have been extended 140 feet west of this lode at both No. 1 and No. 2 levels by the Montana Company, and have cut Donnelly's lode, now known as No. 2 lode. This lode was worked successfully by Donnelly and party on tribute in the upper levels for some years, and yielded a large amount of ore. It has now been driven on 190 feet at both No. 1 and No. 2 levels. A rise has been put through from No. 2 to No. 1, and communication made to an old air shaft from No. 1, securing good ventilation. At No. 1 level the drive north on lode was driven for 32 feet, in barren lode matter, then pyrites began to make up to 12 inches wide for 30 feet; after this the lode has been an average of 2½ feet wide, carrying galena and pyrites, and is still showing well in the end of the drive. The galena is medium grade, assaying 50 ounces of silver per ton, with 60 per cent. lead. The last 41 feet produced 15 tons of first-class ore, worth £8 per ton, and 120 tons of seconds worth 23s. per ton.

At No. 2 level the ore was struck in the crosscut, and continued in the drive for 140 feet, averaging 1½ foot wide of galena and pyrites, the last 50 feet being poor. This lode is a payable one, and when stoping is started will place the mine in a self-supporting condition.

To the east of the shaft the old Queen Company drove a crosscut 72 feet east. This has been extended 720 feet. One vein was crossed at 620 feet, 4 inches wide, carrying ore. It is intended to continue the crosscut for 300 feet to cut what is known as Trotter's lode close to the boundary of the Dispatch. This lode was worked by tributors some years ago, and is known to be 3 feet wide, carrying galena assaying up to 130 ounces of silver per ton. To the east of Trotter's lode there are two others which will be also developed in due course; these are Bullock's lode and Clarke's lode. Both of these lodes have been worked by tributors. I have no information about the former, but the latter is said to have yielded some very rich ore, which still lives below the tributors' workings. In the Dispatch section we meet with a change of country. Here the slate and limestone country comes in, and as is usual on the Zeehan field, the galena is mostly low grade. There are

three large parallel lodes running through the Dispatch Flat striking 30° west of north, and dipping west. They are evidently the continuation of the series of lodes which run through the Silver King Mine to the south. The eastern lode usually known as Whelan's lode I take to be the main lode of the Silver King. This lode is said to carry metal of fair grade where it has been cut in an old tunnel close to the creek on the western slope of the King Extended Hill. To the north of this a tunnel has been driven with the object of cutting this lode, but if the lode is parallel to the other lodes on the Dispatch section and maintains the course which it has further south, it should pass to the west of this tunnel. All three lodes are large, well-defined formations, carrying carbonate of iron and galena. The proportion of galena is such as would render the lodes highly payable were the grade of the galena equal to the average of that mined in Zeehan. As it is, there is some doubt as to whether this low-grade galena will pay to mine. Certainly the profits will not be large. If the lodes were worked on a large scale it is almost certain that masses of first-class ore would be met with, at least in the shallower levels, which would yield handsome profits. It does not follow that the larger masses of ore will be of low grade. They are the result of re-deposition of galena by surface waters, and, as has been proved in the Zeehan field in many instances, the secondary galena is often of high grade, notwithstanding the fact that the primary galena in the same lode is of low grade. If these large low-grade lodes could be made to pay expenses on the second-class ore, it would, in my opinion, be safe to trust to the rich shoots to supply the profits. It is the intention of the Montana Company to test these lodes on the Dispatch Flat as soon as the Montana No. 2 workings are self-supporting. The results will be of the very highest importance to the Zeehan field. These low-grade lodes appear to be larger, more continuous, and more persistent in their metallic contents than any of the high-grade lodes, and their successful exploitation would mean a very large increase of the output of the Zeehan field.

The Zeehan-Western, Limited.

This mine has been fully dealt with by me in a report, dated 27th September, 1902, "On the Western Silver Mine, Zeehan," published by the Mines Department. Since then the mine has been floated in London as the "Zeehan-Western," Mr. John Craze acting as Mine Manager. I

have not been able to visit the workings since the mine has been reopened, and am indebted to Mr. Craze for the following information as to the work done since.

No. 1 lode has been cut at No. 9 level and driven on for 100 feet. It contains 18 inches of second-class ore—hardly payable. At No. 8 level it was found that the drive south from the shaft had been taken along the western wall of the lode for 180 feet. This has been broken down, but has proved to be disappointing. In the end of the drive north, when the old Western Company left it, the face was showing about 5 feet of good seconds. This proved to be only a patch. It cut out going north to fahl ore and copper pyrites. The former is rich in silver, assaying 270 ounces to the ton, but it is present in such small quantities that the ore will only bulk 20 ounces. It has been found impossible to concentrate the ore in the ordinary way.

At No. 5 level a crosscut was driven west from the end of the drive on No. 9 lode. At 20 feet No. 4 lode was cut, and contains a shoot of ore 80 feet long. The ore is 18 inches wide, and carries 15 per cent. of galena.

No. 10 lode south (tributors' lode) has been driven on from No. 3 level for 170 feet, and exposed a payable shoot of ore 100 feet in length. The lode averages 14 inches wide, and contains 40 per cent. galena.

A lode exposed in the eastern workings at No. 4 level has been driven on north to get under Simson's workings; the lode was 18 inches wide, but not payable. The work, however, enables Simson's to be worked economically. In Simson's there is 120 feet of stoping 100 feet high, which is expected to pay well. The drive from No. 4 level is 24 feet below Simson's workings.

At No. 2 level No. 10 lode has been cut and driven on, but was no good. There is still, however, a good deal of ore to be won from this lode, above No. 4 level.

In the crosscut at No. 2 level it was discovered that Simson's lode had been cut, but no notice has been taken of it. This has been driven on for 70 feet south and 20 feet north. It is 14 inches wide, and carries fair milling ore throughout.

The alteration in the character of the Western lode in depth is a very curious thing, and one on which it is impossible to venture an opinion at the present time. I would suggest that some of the ore might be sent to London to be tested by the Elmore oil process. This is the class of ore

which should be eminently suited to this method of treatment. Twenty ounces of silver to the ton with a little copper would be a payable proposition if a process could be found for treating it, and if there were sufficient ore to make it worth while putting up a plant.

Western Consolidated Mine.

The Western Consolidated Company, or, as it was formerly called, the Western Extended, held a large number of sections to the north of the Western Mine some years ago, but now the whole ground is vacant. The only section on which any work was done is No. 1062-87M—40 acres. A main shaft was sunk on the eastern boundary of this section to a depth of 160 feet, and from this level a crosscut was driven west which cut two lodes previously known on the surface. No. 1, or Coleman's lode, was cut 50 or 60 feet west of the shaft. The lode strikes 22½° west of north, and dips east at an angle of about 50°. This lode was driven on for 200 feet at the 160-feet level, but proved unpayable. It was risen on 80 feet, and an intermediate level driven about 100 feet. Of this about 70 feet was stoped out to the surface, but I understand it was hardly payable. No. 2, or Morris' lode, was cut in a crosscut from the intermediate level, and driven on for 80 feet. This has all been stoped to the surface. It was better than No. 1 lode, but did not pay well enough to keep the pumps going. Since the pumps were stopped the lode was let on tribute, and a winze sunk about 60 feet south of the company's stopes. This got down 35 feet on a nice seam of ore, when a burst of water occurred which the hand-pump which was being used could not cope with. The lode was stoped out for 15 feet from the surface for a short distance, and yielded 20 tons of metal, of an average value of £10 per ton. The clean galena from this winze assayed 120 ounces silver and 78 per cent. lead per ton. Both these lodes are said to be about 3 feet wide, carrying up to 6 inches of clean metal, the remainder being concentrating ore. The Western Consolidated Company owned a concentrating mill, which has lately been acquired by the Florence Company.

I regret that I have not been able to include this country in the geological sketch-plan, and have not been able to examine it as carefully as I would have liked. The country consists of slates and sandstones, with interbedded tuffs. Further north on the Western Company's timber sections

we have the vesicular melaphyre again. In fact, the country seems to be a repetition of the Zeehan field. As I have explained, however, I do not attach very much importance to either the tuffs or the melaphyre, and do not regard them as reliable indications of payable lodes. From what I have seen these lodes to the north of the field are more silicious than most of the Zeehan lodes, though they evidently belong to the same family. The grade of the metal is satisfactory, and I should certainly say the country is worth prospecting. It is a part of the field which up to the present has had very little attention paid to it. This is the more surprising considering the splendid shoots of metal which have been mined in the Western Mine.

THE OONAH SILVER-MINING COMPANY, NO LIABILITY.

Sections 819-87M, 1110-87M, and 1111-87M; total area, 235 acres. The principal workings in this mine are those on the main lode (the company's workings), situated in the eastern portion of Section 1110-87M, and on the stannite lodes (mostly tributors' workings), situated in the southern portion of Section 819-87M.

The Main Lode.—For the last three and a half years the work on the main lode has been discontinued, and the workings are now full of water. The shaft is down 450 feet, and there are six levels—at 50 feet (adit level), 137 feet, 163 feet, 250 feet, 325 feet, and 425 feet respectively. The strike of the lode is a few degrees west of north, and the dip is to the east. In the north end the lode terminates at a slide or cross-lode, striking 63° west of north, and dipping to the north-east. This appears to me to belong to the same series of slides or cross-lodes which I have already referred to as occurring in the Western and Montana Mines. The main lode of the Oonah bends round to the west when approaching the slide just in the same way as lode No. 6 in the Montana bends as it approaches the main north slide.

In composition the main lode of the Oonah differs from those of the Western and Montana, in that it is more pyritic in character, and contains more zinc-blende. It may therefore be classed among the pyrito-sideritic formations. Ore was first cut in the south end by a party of tributors, who mined a very rich shoot above No. 1 level. The company then sank the main shaft and mined a fine shoot of ore between No. 1 and No. 4 levels. The ore lengthened as it went down, the payable ground at No. 4 level being

about 600 feet in length. At No. 5 level the lode was poor in the north end, but in the south end a block of ore 230 feet in length was taken out. At No. 6 level the drive is 250 feet in length, but it seems very doubtful whether it was actually on the lode; at any rate, no ore was cut.

To the west of the main lode there is another known as the west lode, which has been cut at No. 1 and No. 3 levels, and is said to carry payable ore. When the mine closed down a party of tributors were doing well on this lode until the water, rising, compelled them to cease operations.

The Stannite Lode.—I have already referred to the remarkable composition of this lode. The mineral carrying the principal value is stannite, a sulphide of tin, copper, and iron. In addition to these metals, the Oonah stannite contains from 90 to 130 ounces of silver to the ton. Up till quite recently the only metals paid for were silver and copper, nothing being allowed for the tin. Lately, however, a contract has been entered into, by the terms of which the company guarantees the ore to contain at least 8 per cent. of tin, and in return receive £1 per ton in addition to the ordinary tariff for silver and copper. Up to the present it has been found impossible to dress the ore except by rough hand-sorting. The stannite is accompanied by a large quantity of iron pyrites, some copper pyrites, occasionally a little galena, fahl ore, and bismuthinite. Small quantities of wolframite are also occasionally found. Of non-metallic minerals, quartz is the most abundant. There is also a little carbonate of iron. It is impossible to obtain anything like a clean stannite product for the market. The ore sold always contains a considerable quantity of iron and copper pyrites. The average tin contents of sale samples is 9 per cent. The ore is said to carry from 1 to 3 dwts. of gold, but this is not paid for.

The lode has been successfully worked for the last three years by Mr. J. Hanrahan under tribute from the Oonah Company. It has also been worked by other tribute parties before Mr. Hanrahan and by the company. The workings are extensive and very complex, and need not here be described in detail. The lowest level of Hanrahan's workings is the No. 1 or adit level of the main workings. The drive on the main lode after it struck the main slide was driven along this for 50 or 60 feet. It was then continued as a crosscut west in the footwall country of the main slide. At 300 feet this crosscut intersected the eastern stannite lode, striking north and south, and this was driven on north till it junctioned with the main slide, a distance

of about 120 feet. Most of this is said to be good payable ground. The stannite lode bends round to the west on approaching the slide, and this was followed by the drive in a north-westerly direction for 80 feet, the slide carrying ore for the whole of this distance. This ground is poor, but it is thought that it will pay to stope. The east lode was then cut to the north of the slide, and a little further west the west lode was cut, which does not appear to have been faulted by the slide. Both of these lodes have been driven on north. The strike is not the same as that to the south of the slide, being about 35° west of north. The two lodes run about parallel, but they probably belong to one large compound fissure, and, from a geological point of view, may be regarded as one formation. They are by no means straight or well defined. They bend about, now in one direction, now in another, and are often made up of numerous branches. These lodes have been worked from three other adit levels to the north, the vertical distance between each pair of levels being 40 feet. The total length of these workings on the stannite lodes is about 400 feet, but the lodes have not been worked to the south of the slide except in the bottom level.

The stannite lode was cut in a crosscut in the No. 3 level of the main workings to the south of the slide, and was worked by a tributor, who is said to have paid 40 per cent. royalty. After a few parcels had been got out the pumps stopped, and the tributors had to stop work.

The following table gives particulars of a few of the parcels sold by Mr. Hanrahan during the last three years, and will be of interest as showing the average contents and value of the ore:—

Parcel No.	Weight.	Silver.	Copper.	Tin.	Net Value of Parcel.
	tons cwts.	ozs. per ton.	per cent.	per cent.	£
6	11 19	84	11·5	—	133
9	23 12	50	10·3	16·0	98
10	24 17	63	13·8	—	184
16	45 10	59·6	12·0	9·73	271
17	23 14	75·5	13·5	—	210
29	81 0	60·5	12·25	8·7	688
30	37 16	68·0	11·5	9·0	325

The total quantity of stannite ore mined by Mr. Hanrahan since July, 1901, amounts to 1227 tons, of a net

value of £9601. This does not, however, represent the total amount of stannite obtained from the stannite lode, as it had been extensively worked before Hanrahan obtained his tribute. The following is the result of a complete analysis made by Mr. M. Sinclair of a bulk sample of 70 tons of stannite ore sold in October, 1903:—

Silver	63·0	ozs. per ton.
Copper	10·7	per cent.
Tin	9·2	,,
Arsenic	4·4	,,
Sulphur	29·75	,,
Alumina	2·20	,,
Silica	23·00	,,
Antimony	Trace.	
Bismuth	Trace.	

As to the advisability of reopening the Oonah main workings. I think that the prospects warrant this being undertaken. Mr. Hanrahan has shown that the stannite lodes can be made to pay. In three years he has produced £9601 worth of ore, and has paid the company a royalty of from 20 per cent. to 33 per cent. on all the ore won. The lode is, however, now approaching exhaustion above the No. 1 level, and unless it is to be closed down the main shaft will have to be pumped out. I understand that the pumping machinery is in order with the exception of the boilers. These will have to be renewed. This work should be undertaken by the company. They have two lodes to go to straight away, namely, the stannite lode and the west lode. The stannite lode has only been tested to the south of the slide at No. 3 level, and where cut it was payable. Most of the ore in the upper levels has, however, been got from the north side of the slide, and it is only reasonable to suppose that this part of the lode will also be productive when cut a little over 100 feet below.

As to the prospects of further working the main lode, I cannot express an opinion on this point, as I have never examined the bottom levels. There is one piece of prospecting work, however, which I think might be done; that is to drive along the main slide on the hanging-wall side. This is a part of the property which has been too much neglected. I have already expressed my opinion that these main slides are really lode-formations, and, like the Western No. 4 lode, which I believe belongs to the same series, are likely to contain good shoots of ore. If this view is not correct, then the main slide must be a fault of later age than the main lode, and by driving north-west on the slide

the continuation of the main lode to the north of the slide must be picked up. On either supposition the slide is worth driving on.

The Junction Lode.—This is situated in the north-eastern portion of Section 891-87M, and is a continuation of the main lode of the Western Mine. The old Junction Company worked the lode from four levels close to the western boundary, but I understand that the main shoot of ore which yielded such large profits to the Western Company only extended a short distance into the Junction workings. The old stopes are now being reworked by a party of tributors for the rich kaolin which was not known to contain silver when the lode was worked. It is not possible to save much of it now, as it is, of course, all mixed up with mullock.

Mr. J. Hanrahan has lately been prospecting the Junction lode further south with some success. He has cut the lode in an adit 332 feet long. The lode was poor when first cut, but after driving 80 feet north on the lode he struck rich ore. This is not the usual silver-lead ore of Zeehan, but a pyritic ore carrying sulphide of silver (argentite) and ruby silver (pyrargerite). The ore naturally is some what variable in its silver contents, but taken all through, is highly payable. This shoot was 40 feet long at the adit level, and has been sunk on in a winze for 40 feet, and is still good. To the north of the rich ore the lode carries some galena, but is poor. This shoot does not live far above the tunnel level, but in sinking a winze from the surface the lode carries 18 inches of gossan, assaying 60 ounces of silver to the ton. The stopes have not, however, reached this yet. From this shoot the following parcels of ore have been obtained to date:—

No. of Parcel.	Weight.		Silver Contents.	Net Value of Parcel.
	tons.	cwts.	ozs. per ton.	£
1	5	7	513·5	273
2	4	14	134·3	52
3	9	15	49·25	23
4	11	10	136·0	135
5	28	0	30·0	364

The reopening of the Western Mine has drained the old Junction workings, and Mr. Hanrahan proposes working

the lode below his tunnel level from the Junction shaft. The workings are now within 40 or 50 feet of his rich shoot. There is also a lot of low-grade fluxing ore in No. 3 level of the Junction, which he thinks he can mine at a small profit. It is principally carbonate of iron. A parcel of 200 tons which has been got out assays 15 ounces of silver, 40 per cent. iron and manganese, 2 per cent. silica, and 2 per cent. sulphur. Besides the silver, the iron and manganese in excess of silica is allowed for. There is a lode of this class of ore 4 or 5 feet wide, with 100 feet proved at No. 3 level. This should be mined so long as it can pay expenses, as there is no telling when rich patches will be discovered.

Bradshaw's Copper Lode.—This is situated in the north-western portion of Section 1110-87M. It is a pyrites lode about 6 feet wide, striking 28° east of north, and dipping to the south-east at an angle of 60°. The lode carries a good deal of copper, bulk samples taken from the face of the drive having given as high as 6 per cent., with small quantities of gold and silver. I am, however, inclined to be sceptical about these assays. The copper is leaching out of the lode, and is being deposited as an encrustation of sulphate of copper on all exposed surfaces. Unless great care were taken by breaking well into the solid ore, the result from the samples would be unreliable. Still, there is evidently a good deal of copper in the ore. It is too poor to export, and the lode is not big enough to warrant the erection of smelters. Is there, then, any other method by which such ore could be profitably treated? There are, I think, two possible processes, one or other of which might be applicable. They are the processes of natural and artificial cementation, as employed at Rio Tinto in Spain and elsewhere. The success of natural cementation depends principally upon the rapidity with which the pyrites oxidises in the air, different samples of pyrites differing very greatly in this respect. The ore is crushed in an ordinary jaw-crusher and spread out on floors in the open air in heaps varying from 15 to 40 feet in thickness. In Spain the rainfall is small, and the heaps have to be sprinkled artificially with water at intervals. In Zeehan this could probably be dispensed with during a large part of the year, the natural rainfall being sufficient. The drainage from the heaps is led into precipitating-launders, in which is placed a quantity of scrap iron, which precipitates the copper in the metallic state. The precipitate usually contains about 66 per cent. of metallic copper, and is readily saleable. The

process occupies from six months to three years to complete according as the pyrites weathers quickly or slowly. It would not cost much to make an experiment with a few hundred tons of the ore from Bradshaw's lode. The precipitating-launders are very simply constructed, and may be seen in operation at the Mount Lyell Mine, where the copper contained in the mine water is saved by this process.

I think it is probable, however, that artificial cementation would be more likely to succeed in the case of the Oonah ore. In this process the ore is roasted in heaps before leaching, either with or without the addition of salt. The leaching and precipitation is carried on in the same way as described above. This heap-roasting is a very simple and cheap process. No fuel need be used except in starting, as the burning sulphur of the pyrites is sufficient to supply all the heat required.

Besides the low-grade pyrites in Bradshaw's lode, there is on the footwall a seam of an earthy-looking substance 2 or 3 inches wide, which Mr. J. Burden examined under the blowpipe. He found it to be rich in copper, and subsequent assays proved that it contains 25 per cent. of that metal. This is probably mostly black oxide of copper, and is certainly worth testing. It is not an ore which will be found to live in depth, but there might be very considerable concentrations in the upper levels; 25 per cent. copper is worth as much as good galena at present prices, and 3 inches would pay to mine.

This lode has been driven on at two levels for some distance in the hope of discovering shoots of galena, but so far without success, though one or two bunches of rich ore are said to have been found. There are excellent facilities for mining this lode cheaply to a depth of 200 or 300 feet by adits. Should a cheap process for extracting the copper be discovered there is no reason why the lode could not be profitably worked.

Pastkuchen's Lode.—This is situated in Section 1111-87M, and has been worked to a small extent in a shallow shaft and trench on the eastern slope of the Oonah Hill. It is a very large pyritic lode, striking about 45° west of north. In the old shaft I noticed a seam of galena about 2 inches wide. I understand that a few tons of ore were obtained from these workings. Further west in the gully what I take to be a continuation of this lode occurs as a large gossan outcrop. This is 150 feet below the outcrop on the hill, and this amount of backs would be gained by driving north on the lode.

There are several other lodes on the Oonah sections which have been worked to some extent by tributors. Most of them will be found marked on the geological plan attached to this report.

Zeehan-Queen, Limited.

T. Vincent, jun., Mine Manager. Sections 1640M, 1639M, 1638M, 690M, 1641M, 1642M; total area, 258 acres. This company was formed about a year ago to take over the property of the old Silver Queen Prospecting Association, No Liability. The mining plant of the old company has been renovated and added to, and operations have been started from the old Queen No. 4 shaft in the south-eastern portion of Section 1638M. This shaft is 230 feet deep. At 28 feet there is a connection with what is known as the 44-feet level—an old level driven from another shaft (Mace's Shaft). No. 1 level is at 110 feet and No. 2 level at 210 feet. The lodes being operated on at present consist of No. 4 lode north and Clarke's lode.

No. 4 lode north has an average strike of 42° west of north, and dips to the north-east at an angle of 45°. It is a well-defined fissure formation, and I take it to belong to a series of parallel lodes, or, as I have termed them above, cross-lodes, which traverse the northern portion of the Zeehan field, and which appear to mark the main direction of faulting in this part of the field.

When the present company took over the mine No. 1 level had been driven 160 feet north on this lode. This drive has been extended 180 feet. At 270 feet from the shaft ore was cut in the floor of the drive, and a winze was sunk for 30 feet. The lode is rather bunchy, but on the whole is deemed payable. At best it is said to contain 18 inches of first-class ore, with 3 feet of seconds. The lode is reported to be good in the bottom of the winze. To get under this shoot of ore the lode was driven on north for 160 feet. From this point on, a western branch in the footwall was followed which brought the drive below the winze, and a crosscut is now being put out east to cut the main lode. The branch which was driven on is a good-looking formation 3 feet wide, carrying strings of carbonate of iron, and the drive will be continued in order to cut several other lodes showing on the surface to the west of No. 4 lode.

Clarke's lode strikes 30° east of north, and dips to the south-east at an angle of 60°. It is a large pyritic lode, and

has been traced for a long distance. In the No. 1 level the drive on Clarke's lode has been extended 210 feet, and cut two small shoots of ore 35 feet and 27 feet in length respectively, with 30 feet of blank between. The ore is not massive, and is of low grade, and mixed with pyrites. It would only pay to stope if a good mill were available for treating the ore. On the level above (the 44-feet level) the lode has been driven on for 600 feet, and a good deal of stoping has been done above this level. To the north of this drive the lode has been worked by tributors for a distance of 200 feet, at about the same level as the 44-feet. They are said to have mined a good shoot of ore, which still stands underfoot. The drive from No. 1 level, which is now being advanced, will shortly come underneath these workings. A good deal of ore mined from Clarke's lode contained stannite as well as galena. The ore contained much pyrites, and a good deal of the silver values were contained in the stannite.

No. 4 Lode South.—This lode contained the best shoot of ore mined on the Queen property. It strikes 15° east of north, and dips from 20° to 45° to the east. The lode junctions with No. 4 lode north, and at the junction the latter contained ore, and was usually regarded as a continuation of the same lode. This lode has been stoped out from an intermediate level, 50 feet below No. 2 level, up to the surface. Below the intermediate level a winze was sunk 50 feet, but bottomed on iron pyrites. The lode appears to have been worked in a most extravagant manner. Some of the old stopes are still accessible, and several patches of good second-class ore are still standing, which would have paid well to take out if the lode had been mined systematically. As it is, they will now probably never pay to mine.

No. 2 Lode.—This lode has been worked from No. 2 shaft, 900 feet to the west of No. 4 shaft. The lode strikes 60° east of north, the dip being about vertical. From No. 2 shaft there are three levels—80 feet, 157 feet, and 224 feet respectively—and on these levels the lode has been driven on 440 feet, 360 feet, and 240 feet respectively. This lode produced a large amount of ore from all three levels, but I have no detailed information as to the character of the lode.

No. 3 Lode.—This lode has been worked from an inclined shaft (No. 3 shaft) at two levels, and has been also driven on from No. 3 level of No. 2 shaft. A lot of ore is said to have been won from the stopes above No. 2 level, and in No. 3 level there is said to be payable seconds.

To the east of No. 3 lode a crosscut was driven 250 feet. At 160 feet a small lode was cut, carrying splashes of galena, and was driven on for 100 feet. This is known as No. 5 lode. It is reported to be unpayable so far as it was tested in the drive, but near the surface a party of tributors obtained a fair parcel of ore from the same lode. Several other lodes are known on the surface to the east of No. 5, and these it is proposed to test from the drive on No. 4 lode north.

Although the Zeehan-Queen Company has not been fortunate up to the present, there is, I think, a reasonable hope that the prospecting operations now being carried out will turn out successfully. There have been a number of good shoots of ore mined in the immediate vicinity, and there is plenty of virgin ground, in which lodes are known to exist, to the north-west of No. 4 shaft. This appears at present to be the most favourable direction in which prospecting operations can be carried on. With regard to Clarke's lode, it is, of course, worth while extending the drive at No. 1 level below the tributors' workings, and the shoot of ore mined by them may be reasonably expected to live down to this level, but for reasons which I have explained at length in the theoretical portion of this report, I am of the opinion that the metal in these pyritic lodes will decrease both in quality and quantity as depth is gained, and that expenditure on them in depth will result in disappointment.

The Silver Queen Extended Prospecting Association, No Liability.

Sections 187-87M and 188-87M; total area, 156 acres. There are a great number of lodes known on these sections, several of which have been worked with success. The mine has been worked by tributors for many years, and there is not much doing at the present time.

In the northern section Fahey's lode was the principal ore-producer. This was worked about eight years ago by Messrs. Fahey Brothers, who obtained large quantities of gossan from the upper levels, much of which was very rich. This turned to galena in depth. I have no information as to the state of the lode in the lower levels. To the west of this there are a number of lodes which have been worked with more or less success, and some of them are still being worked. Many of these lodes are small, but the country is soft, and for 30 or 40 feet from the surface they

can be worked very cheaply. I have not gathered sufficient data to be able to form an opinion as to whether these lodes warrant development at deeper levels.

In the southern portion of Section 187-87M and the northern portion of 188-87M there is a regular network of lodes, some of which were being worked by tributors at the time of my visit. One of these lodes was worked by Messrs. Featherstone Brothers some years ago, and yielded a fine shoot of ore. I was not able to examine this lode, as the workings were inaccessible at the time of my visit. The lode strikes about 30° west of north. The only well-defined lode I saw is what is known as the pug lode. This strikes 60° west of north, dipping vertically. I think, however, that this is probably a branch from Featherstone's lode further west. Had it continued it should have been cut in the main adit further south. The other lodes are all small branches, often containing nice bunches of metal, but too small and irregular to yield large profits. This network of lodes is just in line with the No. 1 lode of the Spray Mine, and it is just possible that Featherstone's lode may be the same. I must confess, however, that I have not much faith in this theory. The whole of this country and that to the south is so disturbed that it is difficult to believe that even such a strong lode as the Spray has proved itself to be could live in a straight line through it. The network of lodes is situated 200 feet above the level of the valley to the south, and I think it would be well worth driving underneath it from the lower workings. The pug lode appears to me to be a most promising formation, and well worth testing in depth.

To the south-east of these workings there is a lode known as No. 1, which has been driven on for about 275 feet. The lode strikes 15° west of north, dipping to the east at a high angle. A good deal of stoping has been done on this lode above the adit-level, and at the time of my visit stoping was proceeding at one place, the lode carrying from 2 to 6 inches of ore. To the south of the adit a shaft has been sunk 20 feet, and from this some stoping has also been done. The lode is a small "tight" formation in very hard country, and I think will never be a very payable one. A crosscut has been driven west from the adit-level on this lode for 150 feet, and cut two other small formations, neither of which is at all promising. The crosscut might with advantage be continued in a north-westerly direction with the object of getting under Featherstone's workings. If Featherstone's lode lives it cannot be far away from the

end of the crosscut, and if this is cut it should be followed north.

There are a number of other lodes on this section to the west of No. 1 lode. None of these have as yet been worked with any degree of success. The country is for the most part a fine-grained dark slate, with interbedded seams of tuff, and up to the present this country has not been shown to be productive. I know of no reason why this should be so. The lodes are mostly filled with low-grade gossan near the surface. In the few instances where they have been cut below the gossan there is a little galena and white glassy carbonate of iron, which locally is looked upon as unfavourable. Certainly there has not yet been enough work done to enable one to come to a definite conclusion on the question. The best-defined and most-promising formation is Perry's Lode, near the centre of the section. This lode is, I think, worth driving on south from the creek, where a large amount of backs are obtainable.

The Sylvester Mine.

Sections 1855-91M, 877-87M, 821-87M, 820-87M, 878-87M, 879-87M, 4052-93M, 1287-87M, 1852-87M, 1288-87M; total area, 363 acres. This mine is now owned by the Tasmanian Smelting Company, Limited. All the western sections of the property are situated on an extensive flat 1000 feet above sea-level. The country is mostly made up of tuffs, with interbedded slates, striking about east and west. To the north of this masses of melaphyre occur, also in slate country. The main lode is situated on Section 878-87M. It is a large pyritic lode striking 25° east of north, and carrying a good deal of galena and zinc-blende. I have not had an opportunity of examining the workings, but I understand that a good deal of ore has been obtained from the lode.

Mr. Cashbolt is at the present time working the lode on tribute, and he tells me that he has good prospects, and has been on fair metal since he started. The lode requires a concentrator to enable the ore to be effectively treated.

The Tasmanian Smelting Company has done a large amount of surface prospecting on these western sections by digging deep ditches through the country in several directions. Unfortunately, nothing of value has been found. In two or three places small seams of pyrites carrying a little metal were cut, but none of these look at all encouraging.

A long adit was started from near the south-west corner of Section 821-87M with the object of draining the workings on the main lode, and at the same time prospecting the intervening country. This was driven 100 feet, and then stopped. The total length would have been about 2700 feet, and the amount of backs obtained under 200 feet. A deep trench has been brought along the surface on the course of the proposed adit, and as nothing very promising has been cut, there does not seem to me to be much encouragement to continue the adit.

In the eastern portion of Section 820-87M there is a pyromorphite lode striking 26° east of north, and dipping east. This is a well-defined lode, and has been worked at several adit-levels. The lode consists of gossan, with a large quantity of pyromorphite. I understand that it only carries a few ounces of silver to the ton, so it is practically a lead ore. Pyromorphite is a chloro-phosphate of lead —a secondary mineral—and it is not easy to see where the phosphoric acid came from to precipitate the lead in such quantities. The country-rock is a decomposed melaphyre, and it seems probable that the phosphoric acid has been derived from apatite contained originally in this rock. The lode is now practically worked out above water-level. I cannot venture on an opinion as to how it will turn out in depth.

There is another lode in the western portion of Section 1852-87M, formerly belonging to the Sacramento Company, from which a good shoot of ore is said to have been got a good many years ago. Mr. Clabburn spent a lot of money trying to find the continuation of this lode further south, but without success. The country is very much disturbed about here, and there is a good deal of graphitic slate, which is always looked upon as unfavourable in the Zeehan field.

On the whole, I fear that I have not formed a favourable opinion of the Sylvester property. The main lode appears to be a fine strong formation, and it may yield good returns in the upper levels. But, for reasons which I have given in the theoretical portion of this report, I do not think these pyritic lodes will be payable in depth. This is the general experience in the Zeehan field, and is in accordance with theory.

The New Mount Zeehan Silver-lead Company, No Liability.

Sections 909M and 559M; total area, 120 acres. This mine is under the great disadvantage of being situated right

in the heart of the Town of Zeehan. The greater part of Section 559M has been cut up into residence and business blocks, and cannot be touched by the company except at a depth of 50 feet below the surface. This is, of course, a very great disadvantage. A great number of small lodes pay very well for the first 50 feet, but below this they become unpayable. Until the upper portions of the lodes have been worked to some extent it is impossible to form an opinion as to whether any given lode is of sufficient importance to warrant sinking operations being undertaken, with the necessarily large expenditure on pumping machinery; and so it has happened that, though there are as many promising lodes on the New Mount Zeehan sections as on most of the mines which have been successfully worked in the Zeehan field, this mine has not flourished. The company has sunk a main shaft in the western portion of Section 559, and has done a good deal of work at two levels on five lodes which occur in this part of the section. A good deal of ore was raised, but the mine does not seem to have paid. At any rate, after having been several times reopened, the main workings have now been closed down for about four years.

Most of the known lodes will be found marked on the geological plan. Many of them are said to be good payable lodes, carrying up to a foot or more of metal, but I have been able to get very little detailed information. The only lode which has been worked persistently during the last year is Williams' lode on Section 909M. This is a strong lode, carrying a good deal of pyrites, especially in the north end, from which a good deal of ore has been obtained. Williams and party have got a small drawlift at work, actuated by a waterwheel, and have sunk a shaft to a depth of 80 feet. They have had nothing very rich, the seam of ore varying from 2 to 4 inches in thickness. It seems however to be persistent, and they have been producing small parcels of ore for a long time.

There is one portion of Section 559M which I think might contain a good lode if it were developed in depth. This is at the contact of the regularly stratified country, in the south-eastern portion of the section, with the tuffs and interbedded slates in the western portion. I have already explained my views as regards this line of country in the theoretical portion of this report. Should Flaherty's lode in the Florence Mine turn out well in the lower levels, it will greatly enhance the value of the New Mount Zeehan Mine.

THE FLORENCE SILVER-MINING COMPANY, NO LIABILITY.

Sections 943M, 40 acres, and 546M, 80 acres. The latter of these sections has only lately been taken up, and is marked on the geological plan by the old number of 5444-93M. F. Astle, Esq., is Mine Manager. Section 943M is one of the earliest sections pegged in the Zeehan field, and, until the formation of the Florence Company about two years ago, has been known as Smith's section. The mine was worked largely by tributors prior to the formation of the company, the principal lodes operated upon being McKay's lode, Dunkley's lode, Horton's lode, and Currie's lode.

McKay's lode is situated in the north-western corner of the section, and was worked for a considerable distance at shallow levels by McKay and party many years ago. The lode strikes 30° east of north, and passes through the south-west corner of Section 909M of the New Mount Zeehan Company. It is said to have been very productive so far as it was worked.

Dunkley's lode is in all probability a continuation of Currie's lode. The strike is about north and south. It is a large carbonate of iron formation, carrying a lot of milling ore and seams of firsts, and should prove a highly payable lode when the Florence concentrator is available for treating the ore.

Currie's lode to the south strikes a little west of north. From this lode a splendid shoot of metal was worked some years ago by Mr. N. Currie and party. Currie's workings are about 400 feet in length and about 150 feet in depth, the whole of the lode being stoped out above Currie's bottom level. Currie's lode bends round to the south-west in the south end, and at this point was specially rich, carrying up to 8 feet in thickness of solid galena, worth about £20 per ton. As I have already explained in the theoretical part of this report, the bend in Currie's in all probability occurs at the junction of Currie's with another large lode (Flaherty's lode), striking 30° east of north. This lode was cut in the east crosscut from Flaherty's shaft, and is described as a very wide loose formation. When struck first a burst of water occurred, filling up the crosscut with slurry, angular fragments of slate, carbonate of iron, and slugs of galena. When crosscutting was continued other bursts occurred, and the lode was not considered sufficiently encouraging to develop further. From geological considerations, however, I am inclined to think, as I have already

explained, that this lode may turn out to be a very important one. It is evidently a very large formation, and its loose open character would cause its metallic contents to be leached out for some distance below the surface. There is, therefore, a reasonable chance that when the unleached portion of the lode is reached it may turn out to be a payable lode, while there is the additional chance that the metals which have been leached out of the upper portions of the lode-channel may be redeposited in the form of rich shoots below. This theory is, in my opinion, well worth testing.

Horton's workings were situated a little to the west of Currie's, and were probably partly in Flaherty's lode and partly in Astle's lode, which is now being mined from the Florence main shaft. The workings were very irregular, but produced a large quantity of ore. I visited the mine shortly after Horton had struck metal, and besides several seams of clean ore which were then exposed in the workings, I can recollect a crosscut 30 or 40 feet in length through a soft black decayed rock, carrying metal all through it. A large amount of ore was won from this formation by treating the dirt in sluice-boxes. This formation was close to the junction of the three lodes, namely, Currie's, Flaherty's, and Astle's.

The Florence shaft is situated about 250 feet to the west of Currie's lode, and was sunk 216 feet, levels being opened out at 130 feet and 200 feet respectively. The No. 2 level crosscut was advanced first, and cut Astle's lode 50 feet from the shaft. This lode strikes 55° west of north, and dips to the north-east. When first cut it was only 3 inches wide of carbonate of iron, but soon widened out to a nice lode 1 to 2 feet in thickness, carrying good metal; this lode has now been stoped above No. 2 level for a distance of 200 feet in length by 35 feet in height, and has produced the greater part of the output of the Florence Mine up to the present.

The drive at No. 1 level is also on the lode, but has not yet got into the best of the ore. The shoot is dipping north, and the drive has still a short distance to go before the good ore may be expected. The end of the drive is now in payable seconds. The crosscut from the shaft was continued as a drive along this lode for some distance, and then as a crosscut again to cut Currie's lode. This was cut across, but proved to be poor, containing only second-class ore, and that of doubtful value. A drive was started south

along a seam of hard silicious breccia, supposed to be connected with the lode. This unfortunately tapped a hugh vugh, which drowned the mine for the time being, and which was responsible for the loss of a man's life. I have already discussed this occurrence in an earlier portion of this report, and have given my reasons for thinking that the vugh is connected with Flaherty's lode. If this turns out to be the case it shows that the leaching action has extended down to below this level. This lode has now been drained by the Florence workings, and might be easily tested at this level. The Argent Company is, I think, driving on the same formation further south, and is getting good ore. This should be an encouragement to the Florence Company to test the formation. It may be that this level is not deep enough at the Florence to get the best of the ore, but still a drive along the lode would not be a costly undertaking, and if it did not actually strike payable ore, would at least give valuable information about the nature of the lode, and might give encouragement to test it at a deeper level. I think that the chances of this lode turning out a valuable one are particularly good.

Since the accident Currie's lode has been driven on north of the crosscut for a distance of 140 feet. The first 50 feet was on a small carbonate of iron seam in the foot (west) wall. A short crosscut from this cut Currie's main lode, which was driven on for 90 feet, and a rise put up in the end connecting with Currie's workings. In the level there is an average of 18 inches payable seconds, and in the rise 50 feet above the level a seam of first-class ore came in, the lode widening out to 4 feet. Another lode has been lately cut south of the main shaft, and driven on for 60 feet. All of this ground is payable. The lode is 8 inches wide of good seconds, with a fair proportion of firsts for 18 or 20 feet.

Still another lode about 400 feet north-east of the shaft has been cut in a trench on the hill to the south of the flat, carrying rich kaolin, assaying up to 2000 ounces of silver to the ton. This has been driven on 80 or 90 feet from the north, and has passed through a shoot of ore 40 feet long, carrying 4 or 5 inches of galena. A shaft is now being sunk on the formation.

The output of the Florence Mine to date is approximately as follows:—

Output of mine from tribute parties prior to the formation of the Florence Company—ore of the net value of £56,000.

Output of mine since the formation of Florence Company to the end of March, 1904—387 tons, of the net value of £4000.

The total output is approximately £60,000. The Florence is a good mine, and if my speculations as to the nature of Flaherty's lode turn out to be correct, it will soon become a very valuable property.

The Mount Zeehan (Tasmania) Silver-lead Mines, Limited.

Sections 193-87M, 192-87M, 1643M, 1665M, 189-87M, 1209M, 4805M, 196-87M, 195M, 5085-93M, 1512-93M; total area, 661 acres; T. Vincent, Esq., Mine Manager. This extensive property is the result of the purchase by a British company of a number of smaller mines and sections, and includes two sections (Nos. 192-87M and 193M) formerly belonging to the Argent Silver-mining Company, two sections (Nos. 1665M and 1643M) formerly belonging to the Silver Queen P.A., one section (No. 189-87M) formerly belonging to the Silver Queen Extended, one section (No. 1209M) formerly belonging to the Balstrup's Manganese Hill Company, two sections (Nos. 195-87M and 196-87M) formerly belonging to the Silver Spray Company, and two sections (Nos. 1512-93M and 5085-93M) formerly belonging to the Britannia Company. Lodes are known and have been worked on all of these sections, but at present work is principally confined to the Argent sections, the Queen Extended section, and the Spray section.

The Argent Sections.—On Section 192-87M there are a great number of known lodes, most of which have been worked with more or less success by small parties of tributors in the upper levels. A glance at the geological plan will show that there are two main directions of strike—one about 30° west of north and the other about 30° east of north. The greater number of the lodes belong to the first of these series, but on the other hand the lodes striking east of north appear to be more permanent, and are traceable for further distances. As a rule the lodes striking west of north do not cross the lodes striking east of north, but there appear to be some exceptions to this rule. Beginning with the lodes striking west of north, we have, going from east to west, Brampton's lode, Lambert's lode, Astle's lode, Ingle's lode, Cockran's lode, Quinlevan lode, and Kestle's lode, all forming a parallel group in the southern and eastern portion of the section. All of these lodes have been

worked by tributors, and between them have produced a large quantity of ore. The first four in this list were all very payable lodes in the upper levels. In Astle's and Ingle's lodes the principal ore mined was kaolin and gossan, much of which was exceedingly rich. No. 6 shaft has lately been sunk to test these lodes in depth. This shaft was sunk 122 feet, and a crosscut put out east to cut Astle's and Ingle's lodes. These were cut, but proved unproductive, and the crosscut was continued. At 292 feet a large lode was cut, striking north 30° east, and dipping 80° to the east. This has been driven on 128 feet north and 105 feet south, and has turned out a fine payable lode. Where cut first the lode was a good deal broken up, and was poor; but good ore has been cut both north and south. The ore is of good grade, the results of a bulk sample giving 86·7 ounces of silver and 64·7 per cent. of lead. From the position and strike of this lode I think there is a great possibility of it proving a most important one. It is just where a remarkable break in the country takes place, a break which separates the evenly-bedded slates and sandstones on the south-east from the crushed and disturbed tuffs to the north-west. I can only account for this break on the supposition of extensive faulting, and this lode is just in the position where I should expect the fault to be. It is almost exactly in line with another large lode-formation (Flaherty's lode) on the Florence Mine, which also occurs just at the change of country. If my theory is correct it will be found that these lodes are one and the same; and if so, there is, I think, a reasonable hope that this lode may turn out to be the "mother lode" of this portion of the district, the other smaller lodes being merely branches from this one. The lode is a loose open formation, which may perhaps account for the fact that it carries no metal at the outcrop, and was in consequence only discovered in the drive 120 feet below the surface. Another drive from No. 6 shaft is being extended along Mainwaring's lode to the north. From this lode Mainwaring obtained about £160 worth of ore a short while ago; this drive will test the formation thoroughly. It is also proposed to crosscut west from No. 6 lode to test four other lodes which have been worked with more or less success by tributors in the upper levels.

No. 3 lode lies to the west of the group already described. This lode also strikes west of north, and has been sunk on by the company to a depth of 60 feet, and was driven on north and south about 100 feet each way. It consists

of second-class ore, carbonate of iron, with 4 per cent. of high-grade galena. This should pay to put through the mill, provided it did not have to bear pumping charges. It will probably be worked from No. 6 shaft.

No. 16 Lode.—This was cut in a tunnel from the east at a depth of 50 feet from the surface. The country was quite oxidised, and although the lode was driven on 30 feet north and 50 feet south, nothing of value was discovered. A winze was then sunk 20 feet, and ore began to make underfoot. The galena is high grade, assaying 190 ounces of silver to 78 per cent. lead. It was proposed some time ago to continue No. 5 shaft, which is now down 45 feet, to work this lode and others in the vicinity, but at the time the lodes in the vicinity of No. 6 shaft appeared more promising, and the sinking of No. 5 has been postponed for the time being.

Of the lodes which strike east of north, in addition to the new lode at No. 6 shaft, McKay's lode, Lee's lode (No. 1), No. 6 lode, and No. 4 lode are the principal ones. The two former were worked by tributors with some success many years ago, while No. 6 and No. 4 were worked by the company from their No. 1 shaft. There are here three levels—at 72 feet, 132 feet, and 190 feet respectively. No. 4 lode contained one rich shoot of ore 75 feet long, which was good down to No. 2 level, but did not live down to No. 3. The lode was driven on for a considerable distance without cutting anything further. No. 6 lode is described as having been a really good lode, and still contains ore which will pay to take out. It is thought that when the workings from No. 6 shaft are extended westward these old workings from No. 1 will be drained, and it is possible that this lode will then receive further attention.

On the Queen section to the west the most productive lode was No. 18, or Flaherty's lode. On the geological plan No. 4 lode is marked in error as Flaherty's. The two lodes junction towards the south, and Flaherty's is the western, not the eastern, branch, as shown. From the south end of this lode Messrs. Flaherty Brothers won a large amount of rich gossan some years ago, and this turned to galena going north. This lode will be tested in depth from No. 5 shaft. Lodes Nos. 19 and 20 are branches from Flaherty's lode, and have been worked to a small extent close to the surface. Kelly's lode is further west, and has produced a few small parcels of ore.

No. 20 lode strikes east of north, but bends round as it approaches another lode at the south end. In the vicinity

of the junction a good deal of ore has been won by tributors. Lodes Nos. 8 and 9 were worked by the company from No. 4 shaft. No. 8 lode was very rich in places, but it was very patchy. No. 9 contained a good deal of disseminated ore, assaying 2½ ounces silver to the unit of lead, but there was not enough galena to pay. Neither of these lodes were payable taken right through.

On the Queen Extended section there are a number of lodes which have been successfully worked by tributors, and some of these and several others are now being worked by the company from No. 2 shaft. This is situated in the northern portion of the section, equidistant from three groups of lodes situated north-east, south-west, and south-east of the shaft respectively. These three groups of lodes have all been worked from adits, approximately on the level of the collar of the shaft. No. 1 level is at a depth of 65 feet, and No. 2 level at 170 feet below the collar of the shaft. The workings are complex and irregular. The lodes are by no means well defined, and are bunchy in character.

In the north-east group there are two principal lodes, known as No. 10 and No. 15. The drive from the shaft follows the track of No. 10 lode, but for the first 100 feet it passes through a softish dark-coloured slate, which appears to be unfavourable to mineral deposition. The country then changes to a hard black quartzite, and a good shoot of ore was found, which remained in the drive for 120 feet. This ground has all been stoped out up to the surface. The metal terminated at a crosscourse, which strikes 50° west of north, and dips to the south-west at an angle of 66°. Beyond this the track of a lode—presumably No. 10—was followed, but carrying no metal. This track is running parallel with the strata for a distance of 140 feet north of the crosscourse. It then begins to break across the planes of stratification, bending round to the north, and at the same time becomes metal-bearing. The lode continues to bend round till it meets a second crosscourse striking parallel to the other already mentioned. The metal continued in the crosscourse for some distance past the junction, and the crosscourse was driven on to the north-west. This is known as No. 4 crosscut. This led to the discovery of what is supposed to be the continuation of No. 10 lode north of the crosscourse. This lode was driven on for 50 feet on a course of north 45° east, when the lode began to bend round to the north again. It is not a well-defined formation, and is crossed by three or four slides or crosscourses striking 80° west of north, and dipping north.

It contained some fair ore for 30 or 40 feet north of the crosscourse, after which it is barren. This ground has been all stoped out to the surface.

No. 15 lode is situated about 100 feet to the north-west of No. 10 lode, and is connected with the drive along No. 10 lode at No. 1 level by two crosscuts (No. 3 and No. 4), which have been driven along the two main crosscourses already mentioned. The lode has been driven on for a distance of 360 feet, of which about 70 feet contained payable ore. This shoot is situated just south of No. 4 crosscut, *i.e.*, south of the second main crosscourse. The latter faulted the lode just the width of the drive, but the lode was too poor to stope to the north of the crosscourse. It was driven on north some distance, but is disturbed similarly to No. 10, and eventually junctions with a third crosscourse after bending round to the north to meet it. Like No. 10 lode, No. 15 is also in hard black quartzite, and for the greater part of the distance runs parallel with the strata. Occasionally, however, it breaks across the planes of stratification, and these are the places where metal may be expected. An excellent example of this occurred near the south crosscourse; the lode, or perhaps, more strictly speaking, a branch from the lode, breaks across the strata at a considerable angle, and then resumes its normal strike parallel with the bedding planes. Just at the break a very rich shoot of metal occurred. This branch from No. 15 contained metal up to the first crosscourse (No. 3 crosscut), and was specially rich right at the crosscourse. A small vein of ore continues to the south of the crosscourse, but it is doubtful whether it can be regarded as the continuation of the lode.

At the adit-level this No. 15 lode was highly productive, and has been stoped from 50 to 75 feet above this level. The lode continued productive past the second crosscourse at this level, and contained fair ore until the third was reached, which appeared to cut it out. The northern shoot of metal at this level was 150 feet in length.

There is a flat lode, striking north 30° west, and dipping to the north-east at an angle of 31°, which was cut in the drive on No. 15 lode at adit-level. This was driven on a short distance north, and then risen on for 20 feet, and an intermediate level driven from the rise. Above this a good deal of stoping has been been done. The composition of this lode is interesting, as it presents a contrast to the majority of Zeehan lodes. The gangue is almost all white

quartz, with a little carbonate of iron. The ground stoped is said to have contained a good deal of galena and considerable quantities of capillary and felty jamesonite. This lode cuts through No. 15 lode without faulting or being faulted by the latter, but it was barren to the east of No. 15. At No. 2 level the shoot of ore in the south end has been cut, and stoping is now proceeding between No. 2 and No. 1 levels.

In the south-west group the principal lodes are No. 30, No. 13, No. 29, and No. 11. No. 30 lode is parallel, and almost in line with No. 10 lode, and strikes 45° west of north, dipping south-east. The drive south from the shaft at No. 1 level followed No. 10 for 170 feet, when a slide was struck, which cut off No. 10. On the south side of the slide No. 30 was picked up and followed for 420 feet. Three other crosslodes striking a little east of north were also cut in this drive running into No. 30 from the south-east. These lodes in the order in which they were cut are No. 13, No. 29, and No. 11. No. 30 lode is productive for 180 feet south of its junction with No. 29, and the lode has been stoped out for 50 feet above the level. The lode is good underfoot, and an intermediate level was driven from a winze, but had to be abandoned on account of bad air. This ground has now been reached by the drive at No. 2 level. The lode is showing fair ore, but the ground is very hard. There should be a nice block of stoping to be done between this level and No. 1. No. 13 lode was driven on from the drive on No. 30 for about 230 feet, when a crosscourse was struck, which faulted the lode about 100 feet to the east. The lode was productive to the south of the crosscourse, and has been stoped above the level. The shoot was 120 feet long in the level, but shortens as it goes up. There is another small lode 100 feet to the east of No. 13 which has been driven on for 80 feet, and carries payable metal. The stopes were 50 feet above the drive at the time of my visit, and showed a seam of metal from 3 to 6 inches in width. No. 29 lode was productive to the south of its junction with No. 30. At No. 1 level there are two blocks of stoped ground, each about 60 feet long, extending up to tunnel level. This lode dips to the west, while No. 11, which is nearly parallel in strike, dips to the east; the two lodes junction a short distance below No. 1 level. No. 11 lode has been worked by tributors from the tunnel level, but has not been driven on at No. 1 level. It is a very small lode, and where it is unproductive is marked simply by a small joint in the rock.

The south-western group of lodes consists of No. 12 and No. 14 lodes, and up to the present these have only been productive in the upper levels. Margetts and party had a tribute on these two lodes, and obtained good metal above an adit-drive, which they put into a small conical hill at the south end of the Argent Flat. There is also a little underhand stoping done below Margett's tunnel. They were tested at No. 1 level, but proved valueless. There are several other lodes in this vicinity which have been worked with more or less success by tributors. They are small lodes, and the shoots of galena are usually short.

Wall's lode is one which so far has not been worked by the company. It appears to be about the most persistent lode on this section. It may, I think, be traced right through the section, and has been worked in several places in the north-eastern portion. The strike of this lode is 25° east of north, and dips to the south-east at a flat angle 30° to 45°. Wall and party have been winning considerable quantities of medium to low-grade gossan from their tribute on the flat, while there are other older workings on the same lode further north. In the southern portion of the section the lode is traceable up the hill by a large gossan outcrop, which can be seen crossing the Comstock tramway, and appears to be making for a very large gossan blow just where this lode should cut the line of the Spray lode. This is a part of the ground which would be well worth prospecting in depth, and no doubt will be tested eventually from the Spray workings.

*Section 1209*M (*Manganese Hill*).—This section was in the early days looked upon as the most promising mine in the Zeehan district. The hill rises 400 feet above the level of the Argent Valley, and is composed of weathered tuffs with interbedded slates. The summit of the hill is covered by a massive capping of oxide of iron and manganese (limonite and pyrolusite), and this outcrops all down the hill to the south-east, evidently marking the outcrop of a lode-formation. Several other similar outcrops, but of smaller dimensions, occur to the west of the main outcrops, and two of these are marked on the geological plan accompanying this report. The presence of manganese in these outcrops, coupled with their great size, led to the belief that the lodes were of the same type as the great deposit at Broken Hill, and the highest expectations were indulged in as to the future of the mine. These expectations have unfortunately not been realised. It has been proved, for one thing, that the size of the gossan outcrops bears little

relation to the size of the lodes a short distance below the surface. The former appear for the most part to be surface deposits of the nature of bog iron, and sometimes cut out on a flat floor 30 or 40 feet below the surface. In other parts the fissure appears to have been enlarged near the surface and filled in with gossanous material. This is the more conceivable when it is remembered that the whole country is in a highly decomposed condition. The gossan is very poor, and of no value except as a flux. Considerable quantities have been used for this purpose, especially from the section south and adjoining the one under consideration. The main outcrop of ironstone is believed to be the capping of what is known as Balstrup's lode. The strike of this lode is 45° west of north, dipping to the north-east at a high angle, and was driven on at two levels from the north-western corner of the section. The upper level was started on the lode, but soon lost it, and was continued in the footwall country. A cross cut was put out east and cut the lode, carrying 6 feet of carbonate of iron and galena. This was driven on, and a winze sunk on the lode. Nothing very rich was found, but the lode was worked for some distance by a party of tributors. The lode was cut at No. 2 level and driven on for a considerable distance without much result. Another long adit was driven from the north-eastern portion of the section, and for over a thousand feet, and though a number of gossan formations were cut, none of these has been definitely recognised as Balstrup's lode. There is a formation at about the spot where the lode should pass, but it was of no value where cut, and was not driven on. All the formations cut in this adit are completely oxidised and leached of any metallic contents which they may have contained. It is above this adit that the huge mass of ironstone outcrops on the top of the hill, and it was naturally most disappointing when, after putting in such a long and costly crosscut, so very little was found. Still, the lode can hardly be said to have had a fair trial below water-level. It is still possible that rich shoots of ore may exist below the gossan. If secondary deposition of galena has taken place, the enrichments are likely to be large, since the area of the oxidised lode now standing above water-level is very great. The proposition is, of course, a purely speculative one, but considering the profits which would ensue if the lode turned out well, I believe it is worth risking. It is possible that when No. 16 lode, which is in similar country, is worked, it may throw some light upon the value of the lodes in Manganese Hill.

The other lodes on this section are worth testing provided Balstrup's lode turns out well. This is the biggest, and, as far as can be judged at present, the most promising lode on the section. The development of the other lodes should depend upon the successful exploitation of this one.

The Spray Mine (Section 196-87M).—This is at present undoubtedly the most valuable section owned by the Mount Zeehan (Tasmania) Company. The contact of the slates and sandstones with the melaphyre tuffs runs approximately east and west through the northern portion of the section. The lodes have so far only been proved to be productive to the south of the tuff belt. They are not, however, confined to the slates, the main lode, for example, passing distinctly through the plane of contact, and continuing in the tuffs. Sufficient work has not been done to prove whether one rock is more favourable than the other, as the only workings in the tuffs are at shallow levels, and the lode where driven on is completely oxidised.

The lodes of the Spray Mine present a remarkable contrast to those on the adjoining sections to the north. In the latter the lodes are very numerous, but they are for the most part small, irregular, ill-defined, and patchy. The good lodes on the Spray section are, on the other hand, fine, well-defined fissure-formations, running parallel with one another, and maintaining a true course throughout. The strike of the lodes is about 28° west of north, and the dip almost vertical. The latter changes somewhat in different parts, being sometimes slightly to the east and sometimes to the west. The two principal lodes are No. 1, or the main Spray lode, and No. 3 (Gurnie's lode), 584 feet to the south-west of the main lode. Between these there are three other formations, which so far have not been developed. These lodes belong to the pyrito-sideritic formation, the gangue being partly pyrites and partly carbonate of iron. On the whole, they appear to approach the sideritic rather than the pyritic type, though pyrites appear to be more abundant as depth is gained. As I have already stated, the lodes are large fissure-formations, with usually a main seam of "dig" or flucan on one of the walls. Often there is only one well-defined wall, and even this is sometimes absent. The walls are usually grooved or striated in a nearly horizontal direction, but inclined slightly to the north, showing that the movement has been in this direction. The ore is of high grade, assaying about 100 ounces of silver per ton, with 70 per cent. of lead. There is a good deal of antimony in the ore, especially in the upper

levels. This occurs principally in the mineral jamesonite, which is sometimes poor and sometimes very rich in silver. I think that there can be little doubt that the main shoot in the Spray lode owes its existence in some measure at least to enrichment by surface waters. The antimony ores are, I think, mostly secondary, and occur as a replacement of pyrites. Some of the galena also probably has this origin. The main lode was discovered by a party of tributors (Messrs. Page and McDermott), who have worked the lode to the north of the present company's main workings. They worked from two adits, known as C tunnel and E tunnel respectively, the latter being about 75 feet below the former. At C tunnel there is about 50 feet of backs, but this increased at the rate of 1 in 4 in the drive south. This was driven for a distance of 340 feet. For the first 150 feet the lode was barren, but after this good ore was met, and continued for a distance of 240 feet. This ground has now all been stoped out. It appears, however, that the lode first cut in the upper tunnel was only a branch, for recently prospecting operations to the north of the adit have resulted in the discovery of three good veins of ore to the west of the lode first driven on. These contain from 6 inches up to 2 feet of solid metal, and above the galena there is a little rich gossan, assaying 500 ounces of silver to the ton. This metal has not yet been found at the lower level. At D tunnel the lode was driven on south for 400 feet, and a good shoot of ore was mined between this and the level above. The lode has also been driven on north into the soft melaphyre tuffs. It is here a good deal broken up, and so far no good ore has been met.

In order to develop the lode to the south, "A" tunnel was driven by the company. This is at a slightly higher level than Page and McDermott's lower adit, and about 500 feet further south. This cut the top of one of the richest shoots of ore which has been mined in the Zeehan field. The ore for most of the distance hardly lived up to the roof of the drive. It was sunk on and widened out very rapidly to from 4 to 8 feet of solid metal. This shoot of ore is now known to be nearly 400 feet in length, of which about 200 feet is exceptionally rich. At its best the lode carried 16 feet of ore, about two-thirds of which was galena, while for long distances from 3 to 5 feet of solid ore was present in the lode. All the ore is now stoped out above No. 2 level, which is 130 feet below "A" tunnel, and rather more than half the ore between No. 3 level and No. 2. No. 3 level is 213 feet below "A" tunnel, and

has been driven 130 feet south and 115 feet north of No. 4 winze. The south end is barren, but the north end is still in payable ore. No. 4 level is 269 feet below "A" tunnel. There was at this level 20 feet of blank near the winze, but the ore is coming in in the drive both north and south. In the north end there is 40 feet of good ore. A bulk sample from the face in the north end yielded 13·1 per cent. lead and 35·6 ounces silver per ton.

To the west of the main Spray lode "A" tunnel has been extended for a distance of 585 feet. At 200 feet No. 2 lode was cut, and was driven on for a short distance both north and south. This is only a small formation, carrying metal here and there, but nothing payable. A winze has been sunk a short distance in the north end. Further west another lode, known as No. 2½, was cut; this is a better-defined formation, and carries a little jamesonite, but up to the present it has not been driven on. At 443 feet west of No. 1 lode No. 4 lode was cut. This is a well-defined formation, consisting of mullocky lode-matter, with strings of iron carbonate and antimonial galena. It has been driven on a short distance north and south of the crosscut, but so far as it has proved it is unpayable. This lode is well worth driving on.

At 584 feet No. 3 lode was cut. This lode was first discovered by Mr. Gurnie on the summit of the Spray Hill, where he found a seam of very rich gossan. He obtained a tribute on the lode from the company, and mined a very rich patch of ore to a depth of 60 feet. Several other parties obtained tributes on the same line of lode, and worked them with more or less success. The rich ore was contained in lumps of very dense limonite distributed through a soft gossan formation. Some of the ore contained the silver in the form of chloride, and some as native metal. The soft gossan in which the harder lumps were found only carried about 25 ounces of silver to the ton. The hard lumps would assay anything from hundreds to thousands of ounces per ton.

Where cut in "A" tunnel No. 3 lode was composed of galena, carbonate of iron, and a little pyrites. It was driven on both north and south, and payable ore was met with in both drives. The south drive bends away to the west in the end, and has, I think, followed a branch which junctions with the main lode from the west. What I take to be the main lode has been cut in a short crosscut east from this branch. There is, however, in my opinion no reason to

believe that the lode does not continue to the south of this point.

The north drive has been extended for about 400 feet, and of this 330 feet are payable. At best the lode is 4 feet wide, with 2 feet of first-class ore, and from this it dwindles down to 6 inches of seconds. It is a splendid continuous lode, and has been cut 700 feet north of "A" tunnel in another adit known as "G" tunnel, about 100 feet higher than "A" tunnel. The drive south on the lode from "G" tunnel passed through two shoots of ore—one 50 feet long and the other 100 feet long. Stoping is now being carried on above both these levels, and is turning out a large quantity of ore. The grade of the galena in this lode is not quite so good as in No. 1 lode, a bulk sample of the ore yielding 82 ounces of silver per ton, with 68 per cent. of lead. Still, it is good metal, and there appears to be splendid prospects of this lode maintaining a big output for years to come.

A crosscut is now being driven from No. 2 level on No. 1 lode to cut No. 3 lode 130 feet below the drive from "A" tunnel; this crosscut is now in 292 feet, and still has 192 feet to go to cut the lode. Till this lode has been cut, further development north on No. 1 lode has been postponed, as it is thought that the present pumping-plant may not be able to cope with a greatly increased flow of water. The sinking of a main shaft in this part of the property should, I think, be taken into consideration by the management. The present system of mining is far from economical, and the splendid returns which have been obtained from these lodes surely warrant the expenditure necessary for their thorough and systematic development. I am only able to give the returns from the Spray Mine for the three years ending December, 1903. These amount to 14,208 tons, of a net value of £158,815. The lode has now been worked for about six years.

Section 195-87 M.—In the north-eastern portion of this section Mr. W. Moyle has been working on a curious formation on the line of the No. 3 Spray lode. It is a big formation, and the workings are not yet sufficiently extensive to enable one to form an opinion as to the strike of the lode. The iron outcrop at the surface strikes a little north of east, but this seems to have been cut by another lode-formation striking west of north. From the shaft which he has sunk a good deal of dolomite and serpentine has been obtained, carrying splashes of galena. Chromate of lead also occurs

in the gossan. The dolomite appears to be an altered serpentine; the one rock passes over into the other, and both now contain small particles of chromite, which was one of the original constituents of the serpentine, and has remained unaltered when this rock was converted into dolomite. I think the formation may be best accounted for on the hypothesis that we have here a dyke of serpentine which has been cut by a lode-fissure. The mineral-bearing solutions from the lode have attacked the serpentine, altering it to dolomite, and depositing at the same time small quantities of galena. The formation is a most interesting one, and I think throws a lot of light upon the dolomitic lodes of the Dundas district, which probably have a similar origin. Unfortunately, the indications of galena were not sufficiently promising to warrant the formation being more fully developed.

To the west of Moyle's lode there is a small deposit of nickeliferous and cupriferous pyrites close to a dyke of serpentine. This is situated on the southern bank of the Summit tunnel. The ore assayed high, both in copper and nickel, but when sunk on turned out to be only a small patch. I have treated of the origin of these nickeliferous deposits in my report on the North Dundas district, and this should be referred to for information on this point.

Further west again there is a galena lode striking a few degrees west of north, which has been worked by tributors, and some few parcels of ore obtained.

The Britannia Sections.—In the western portion of Section 1512-93M there is a large pyritic lode striking 20° east of north, on which a good deal of work was done some years ago. The lode is principally composed of pyrites, but contains a good deal of galena disseminated through it. Unfortunately, like most of these pyritic lodes, the ore is of low grade, though patches of high-grade galena are said to have been found. A little to the west there is a large iron blow striking apparently west of north, which so far has not been tested. This could easily be driven under from the east, and is, I think, worth a trial. At the Susannite Mine to the west one of these pyritic lodes, oxidised and barren at the surface, has produced a good deal of rich secondary silver ore when cut at some distance below the surface. I do not think it likely that any of these lodes will be payable below the zone of surface enrichment.

In the eastern portion of Section 5085-93M there is a big lode striking west of north, from which a good deal of medium-grade gossan has been obtained. There are a great

many gossan blows in this vicinity, anv of which are liable to contain local enrichments. For the most part, however, they contain very little silver.

Taken as a whole, the ground held by the Mount Zeehan (Tasmania) Silver-lead Mines, Limited. must be regarded as a most valuable property, and one which should be able to maintain its present output for many years to come.

The Colonel North Mining and Railway Company, No Liability.

Sections 1585-91M, 861-93M, 1674-87M, 1562-87M; total area, 300 acres. Of these sections, No. 1585-91M, the original Colonel North section, is situated south and adjoining the Spray Mine. The two principal lodes which have been worked in the Spray should, if they continue, pass through this section. No. 1562-87M was the old Grubb's Mine, and has been acquired by the Colonel North Company.

Section 1585-91M.—The main shaft of the Colonel North Mine is situated a little to the north of the centre of this section. It was sunk to test several large iron blows which occur in the vicinity. The shaft is 200 feet deep, and from the bottom level a crosscut was driven north-east. I have not been able to get much information about these workings. I understand that a lode was cut, but proved unpayable, and the crosscut was continued. This crosscut is said to be within a short distance of where No. 3 lode of the Spray Mine (Gurnie's lode) is to be expected. It is said that in the last shot fired in this crosscut galena was cut, and it is thought that this may possibly be Gurnie's lode. It is proposed now to form a tributing party to bail out the main shaft and continue the crosscut with the object of cutting this lode. The prospects appear to be good, as Gurnie's lode has been traced right up to the southern boundary of the Spray on the surface, and carries rich gossan. A lode has also been worked on the Colonel North section which is nearly in line with Gurnie's lode, carrying chloride of silver. This is, however, a little west of the line of lode, and I think that probably Gurnie's lode is to be sought further east. Gurnie's lode is a fine big formation, and there is no reason to believe that it does not continue past the boundary of the Spray. Of course, it may not contain ore where first cut, but this is a risk which mining speculators always have to face. Sufficient capital

should be provided to enable the lode to be driven on for 200 or 300 feet at least after it has been cut.

The main Spray lode should pass through the north-eastern corner of this section, and to test this a local company, known as the Silver Foam Tributing Company, was formed which obtained an extended tribute from the Colonel North Company. The Foam Company put in a long tunnel and cut a lode-formation 300 feet from the approach. This lode was barren where cut first, and as it was met with rather sooner than was expected, it was thought that it was probably not the main lode. The adit was continued for over 200 feet without cutting anything but a small stringer of galena, which could not possibly be mistaken for the Spray lode. The first lode cut was then driven on north for 80 feet, but with the exception of some pyrites nothing was found. A winze was then sunk 60 feet, and a little galena and jamesonite began to make in the lode-channel. After some delay it was decided to continue this winze, and after sinking a few feet the hanging (east) wall was broken into, and was found to contain fair bunches of galena for a width of 3 feet. It was then decided to sink a vertical shaft from the adit and cut the lode again at 100 feet. This was done, but unfortunately the results were disappointing. The hanging-wall of the formation was again found to contain splashes of galena, but nothing payable was met with. A crosscut was put out into the hanging-wall country for 75 feet, and the lode driven on for a similar distance without any encouraging development. Work is now suspended for the present. I am strongly of opinion that this is the main Spray lode. It is a fine big formation, but its metallic contents have been leached out to a greater depth than has been attained by the present mine workings. I do not think that much attention should be placed on the splashes of galena in the hanging-wall country. This is not at all likely to develop into anything payable. The good shoot in the Spray Mine is situated along the main fissure, as represented by a seam of dig or rubble from 6 to 12 inches thick. This seam is also present at the Foam, but it was passed through without notice in the crosscut from the shaft. To the west of this seam the country is completely oxidised. Similar country was met with in the Spray Mine at a higher level, but it gets deeper going south. I think that it will be necessary to get below this oxidised country before any enrichments can be expected. Down to this level the lode-channel seems to have been leached of any metals which it may have contained.

The bottom of the shaft is now about on the same level as the "A" tunnel of the Spray, and it should be remembered that the main shoot of the Spray only lived up to this level. Above this in the oxidised country the lode-channel was barren.

I am of opinion that the lode the Foam Company has been working on is the Spray main lode. The work done has not been a fair test of the lode, as sufficient depth has not been attained. The presence of galena in the hanging-wall country is a favourable sign, for it points to the likelihood of there having been at one time metal in the main lode-channel. This has, however, been completely leached away, and may have been redeposited as an enriched shoot below the oxidised zone. I am still of opinion that the lode is worth further trial at a deeper level; nor should I be satisfied until a drive had been made for several hundred feet along the course of the lode below the level of oxidation. If no ore is struck when this has been done, then it might be fairly said that the lode had had a fair trial; but to abandon it now before the permanent water-level is reached is to leave the work of testing the lode unfinished. The Foam Company has stuck to its mine like men. It has, however, been severely handicapped by want of adequate capital and by incapable management. I trust it will succeed in reforming its company, and that it will yet reap the reward to which its perseverance undoubtedly entitles it.

*Section 861-93*M.—This section is east and adjoining Section 1585-91M, just described. There are some old workings on the western boundary just about on the line of the Spray lode, and in one drive a lode has been driven on which may possibly be the Spray. I think, however, that it hardly looks sufficiently well defined for the lode—perhaps it is a parallel formation. The country is quite oxidised in these workings, and I do not think it likely that much will be found without sinking in this part of the property.

Further south are the workings of the old Silver Wave Tributing Company. These are also on the line of the Spray lode, and if I am not mistaken the lode has been cut and driven on for a considerable distance. The lode which I take to be the Spray lode is known as the "pug" lode; the strike is 30° west of north, and the dip 80° to the east. There are several other lodes to the west of this, which at the level of the present workings carry a little galena, and a good deal of work has been done on them. When I first visited the workings Messrs. Fahey and party

were working in the lower adit-level. This level was driven east from the creek, and first cut a small lode striking north and south, and dipping 60° to the east. This lode junctions with the "pug" lode a few feet north of the crosscut, and the pug lode was followed north a few feet, but is apparently barren. The north and south lode was then followed south. Some stoping has been done on this lode, but I understand it is hardly payable. There is from 4 to 8 inches of good seconds, with some firsts, showing in the stopes; but the country is hard, and without a concentrator to treat the ore only a small proportion can be dressed up to a marketable condition.

Forty feet south of the crosscut a short crosscut has been put in to the west from the drive on the north and south lode, and has cut another branch-lode striking west of north. This also carries some galena, and a winze was sunk for about 20 feet on this lode. This lode is still to the west of the pug lode. The latter has been cut again in another crosscut further south, and has been driven on for about 100 feet. There was some metal in the lode here when first cut and some stoping has been done above the drive, but it did not live far. Most of the drive is in barren lode-matter.

In the level above the adit was driven along the course of the same branch-lode as the winze is sunk on in the lower level. At a point a few feet south of the winze Messrs. Featherstone Brothers were working on another branch-lode striking east of north. I did not make an accurate survey of these workings, but I think that this lode must junction with the pug lode a few feet beyond the face which was being worked at the time of my visit. Messrs. Featherstone have obtained 15 tons of ore from this lode worth £8 per ton, and carrying a little over 1 ounce of silver to the unit of lead. The lode is not a big fissure—it is rather a zone of fractured rock which has been impregnated with galena. There were 6 feet wide of seconds showing at the time of my visit. I am told that the lode contained up to 2 feet of clean metal for a short distance. I do not think there will ever be much ore won from these small formations. The country is too hard and the metal too scarce. The pug lode, on the other hand, though it apparently contains less metal, is, in my opinion, the most likely formation if it were tested in depth. I have often noticed that the small "tight" lodes carry the best metal in the upper levels, while the large loose formations are best at a depth. I account for this by the leaching action of the surface

waters. In a large loose formation these waters can circulate freely, and the metal becomes leached away. In the small tight lodes the water does not get the same chance of attacking the ore, and they remain unaltered. The presence of these branch-veins alongside a large fissure-lode such as the pug lode is a good indication that metal was once contained in the latter. This lode will, I think, have to be tested in depth from a shaft. I should mention that the lode charted on the geological plan as the Silver Wave lode is the lode on which Messrs. Flaherty and party were working at the time of my first visit. I did not on that occasion examine the whole of the workings. The pug lode lies slightly to the east of the lode charted in the plan.

About twelve chains east from the Silver Wave workings there is another parallel lode exposed on the side of a steep hill. This has been exposed in a trench on the surface, and has been cut at a depth of 40 or 50 feet by a tunnel from the creek. The lode carries a little galena and blende, but is unpayable. It is, however, a very likely-looking formation, being undoubtedly a large fissure-lode belonging to the same series as the Spray. It is well worth testing in depth. At least 100 feet more backs could be obtained by bringing in an adit from lower down the creek.

*Grubb's Mine, Section 1562-87*M.—This mine has now been closed down for over eighteen months. The workings are under water, and could not be examined. The main shaft is 330 feet in depth, and levels are driven approximately at the following depths—30 feet (adit-level), 90 feet 130 feet, 200 feet, 250 feet, and 320 feet. The strike of the lode as marked on the geological plan is the general strike at No. 1 level. It is different in the lower levels, as in the north end the lode dips east, and the south end dips west. The general course of the lode at No. 4 level is about 30° west of north. This is parallel with most of the other lodes in this part of the field, and is perhaps a more reliable bearing than shown on the geological plan. One good shoot of ore occurs in the lode-channel to the south of the shaft, and above No. 2 level was stoped out for a length of 200 feet. At No. 3 level the stoped ground is about 150 feet long, and at No. 4 level 350 feet long, but all of this was not taken out. At No. 5 level one short block of ore has been taken out. The shoot of ore is said to have been very good above No. 3 level. Lower down, though the galena continued, it was of much lower grade, and eventually ceased to be payable. The lode terminates in the north end at a slide or cross-lode, striking about east and west, and

very little has been done in the way of searching for the lode on the other side of the slide. This, I think, is the work which at the present time looks most likely to result in further discoveries in this part of the property. I do not think there is much chance of striking other rich shoots of ore by developing the mine at lower levels for reasons which I have explained in the theoretical portion of this report.

I believe the Colonel North Company has a valuable property in its two northern sections. There are at least three good fissure-lodes traversing these sections, and two of these are being most profitably worked in the north and adjoining section—the Spray Mine—while one of these is now being profitably worked in the section south and adjoining, namely, the Nubeena Mine. It would be a remarkable thing if between these two points no good ore could be found. The lodes will require capital to develop. It is hardly fair to expect tributors to undertake the heavy expense of testing these large lodes in depth, even though the terms may be favourable. The property needs a fair working capital and intelligent management. If it gets this I have every confidence in the future of the mine.

Section 4805-93M.

This section is held by the Tasmanian Smelting Company. In the north-eastern portion of the section is a large iron and manganese outcrop, believed to be the capping of Balstrup's lode. This has been largely mined as a flux from a quarry on the side of the hill, most of the stone having been sent to the North Lyell smelters. It is not now being worked, as the local smelters are fully supplied with iron flux from Dundas and elsewhere. This lode is not worth testing in this section, as it dips out of the ground to the north-east in depth.

In the southern portion of the section there are several lodes which appear to belong to the Spray series, striking about 30° west of north. One of these was cut by a tributor in the south-western portion of the section and driven on south for some distance. A fall of earth prevented my examining the lode, but I am told it is a good well-defined formation. This is very likely the same lode which has been cut on the hill in the southern portion of the Colonel North section south and adjoining.

Mr. Peter Lloyd has lately cut a small lode parallel with this one and some distance further east. This was showing

some nice ore at the time of my visit. Further east again there are two other lodes, both of which are well-defined fissure-formations, and, in my opinion, worth developing. This section could be most advantageously worked in conjunction with Section 861-93M belonging to the Colonel North Company.

The Nubeena Mine.

Section 5115-93M (79 acres), charted in the name of A. Shillington. This section is south and adjoining No. 861-93M, belonging to the Colonel North Company. As will be seen by the contour lines on the geological plan, there is a ridge running north and south, approximately through the centre of the section. Up till about a year ago all the work was confined to the western portion of this ridge, and several lodes have been worked on this side. Mr. John Llewellin determined to try the other side, where the very dense timber and undergrowth led him to think that this part had probably escaped the attention of previous prospectors. He was rewarded by what promises to be a very fine lode.

The old Nubeena lode is situated in the western portion of the section, and strikes east of north. It is only a small lode, and was worked to a small extent about 10 years ago. The lode contained a seam of galena up to 4 or 5 inches thick, assaying 100 ounces to the ton.

Some 35° east, and about 70 feet higher up the hill, there are two lodes which junction just above the approach of an adit. One of these is a north and south lode carrying a seam of metal about 3 inches wide. This lode has been worked for some distance south of the junction. It is a small lode, and not likely, I think, to prove payable in depth. The other lode is Jaeger's lode, which, though quite barren where cut, looks to me a more promising formation. It is only exposed in one place, in a cutting above the tunnel. It is a fissure-formation, striking about 35° west of north. This lode might be driven on to the south, nearly 150 feet of backs being attainable in this direction.

Barnet's lode is parallel to Jaeger's, and about 150 feet further east. It is one of those small "tight" formations which often carry very nice shoots of metal. Barnet's lode contains a shoot of ore 50 or 60 feet in length, of an average width of 8 or 9 inches, in places going up to 2 feet. The galena is of somewhat low grade, the price realised ranging from £5 to £7 per ton. This is, however, partly due to the fact that the metal is difficult to dress up to a high stand-

ard. The shoot of ore should, however, pay very well to mine. The ore lives right up to the grass roots, and is good in the bottom of the present adit-level, which is from 20 to 30 feet below the surface. Another level might be brought in from the adit below, which would give 75 feet of backs, with 150 feet of driving.

Llewellin's lode is a very large loose fissure-formation, striking about 28° west of north, and dipping almost vertically, or perhaps a little to the east. I take it to be a continuation of the main Spray lode. It is the same character of lode, and the walls are grooved in a nearly horizontal direction, pitching slightly north, just as in the case of the Spray lode. It is therefore evident that faulting movement has been in the same direction, and as the two exposures are very nearly in line with one another, and agree in other respects, I think there is not much doubt that they are the same.

Mr. Llewellin has attacked the lode from two adits about 40 feet apart vertically, the upper level being about 130 feet below the crown of the hill. At the time of my visit to the workings the upper level had been driven along the course of the lode for about 90 feet. There was a little ore in the main lode-channel when first cut, and this continued in and out for about 50 feet, making in bunches, and cutting out again. For the last 40 feet the ore was more continuous, and widened out to about 12 inches in the back of the drive and 18 inches in the sole. The lower adit is further south, and had been driven about 75 feet on the course of the lode at the time of my visit. I understand that since then this level has been extended to bring it below the good ore in the upper level, and cut a large body of cube lode-matter and slurry, carrying splendid jigging ore. A winze was then started on the good ore from the upper level, and this quickly widened out to 4 feet wide of solid galena, but narrowed again to 8 inches as it approached the bottom level. A crosscut was put across the lode in the bottom level, and proved the jigging ore to be 15 feet in width. This shoot of ore promises well at the present time, and must be energetically developed at deeper levels. It exhibits so many signs of leaching that one is tempted to speculate on the presence of much more massive ore lower down. These large loose formations of the pyrito-sideritic formations contain all the elements necessary for the formation of rich bonanzas below the zone of leaching, and I think they will prove of the utmost importance to the Zeehan field.

THE SOUTH NUBEENA.

Section 667M (77 acres), charted in the name of G. E. Butler. This section appears under its old number, 3499-93M, in the geological plan. It is situated south and adjoining the Nubeena Mine. Prospecting has been carried on for some months, with the object of finding the ntinuation of Llewellin's lode, and after several formations had been opened up, a lode was discovered in the creek which flows through the eastern portion of the section, which has all the characteristics of Llewellin's and the Spray lodes. It is, I think, a little to the east of the line, so perhaps the lode has been disturbed between the two points. When I saw the lode it had been driven on for about 20 feet. There was a good vertical wall on the east side, containing horizontal grooves, just like those of Llewellin's and the Spray lodes. On the wall there was a seam of metal from 1 to 2 inches in thickness. To the west of this was a seam of dig and rubble, 12 inches wide, and then sheared and broken country of undetermined width. The galena assays 70 per cent. lead and 100 ozs. of silver per ton. This lode has now been driven on for about 120 feet. The formation is a very large one, and it is difficult to know what to follow. There is metal through the formation, but up to the present no payable ore has been cut. I understand that the lode has been cut at a lower level, and driving is now proceeding. A considerable amount of backs can be gained by driving south on the lode. This lower level is as low as can be got on the lode in this part without sinking. I have been shown specimens from the lode obtained recently. These show unmistakable signs of leaching. There appears to be nothing to be done but drive south on the lode. This may cut ore at any time, but the best shoots will, in my opinion, be found at a still lower level.

SECTION 674M.—A. D. SLIGO.

This is an 80-acre section south-west and adjoining the South Nubeena. If the South Nubeena lode maintains its course, it should cross the northern boundary of the section about 6 chains east of the north-west corner. As will be seen by the plan, there is a high spur running east and west through the northern portion of this section. This spur affords splendid opportunities for testing the lode, by means of adits. An adit might be driven from a deep little gully to the north of the section, and would, with about 300 feet of driving, cut the lode 200 feet below the surface.

If from here a drive were continued south on the course of the lode, 300 feet of driving would gain an additional 200 feet of backs. The ground is so steep to the north that I do not think there would be much chance of picking up the lode on the surface. The country seems to have slipped a good deal. On the south side of the spur a little trenching has been done, but so far without picking up the lode. One or two formations have been cut, striking east and west, and carrying specks of pyrites, carbonate of iron, and galena, but nothing very promising. This work is too far west to cut the South Nubeena lode. The section has an excellent chance of getting the lode, as it has been followed to within 700 feet of the boundary, and, as I have already explained, I believe this lode is continuous right through from the Spray Mine. It has been picked up at four intermediate points, and has the same characteristics right through. The section is well worth prospecting.

The Tasmanian Mine.

Sections 5222-93M, 5314-93M, and 5352-93M. This mine is not held at the present time. There are several lodes known on the sections, the principal of which is McLean's lode. This lode has been traced for considerably over a mile, and contains metal almost everywhere it has been cut. The lode belongs to the pyritic or pyrito-sideritic formations, and contains a good deal of zinc-blende. One fine shoot of ore was mined by the old Tasmania Company, who sank the main shaft, erected a concentrator, and connected the mine with the Trial Harbour road by means of a tramway. The grade of the ore is low, which probably accounts for the fact that the mine did not pay. Another shoot was mined by a party of working miners in Section 5222-93M, on what has been called No. 2 lode, but which is probably the continuation of McLean's lode. The country is mostly low-lying, which prevents the lode being worked by small parties.

Horton's lode is a gossan formation, which Mr. B. Horton tested by an adit at a shallow level. He cut the lode, but it turned out no good. The depth obtained can hardly be regarded as a fair test of the lode.

Central Balstrup Mine.

Section 741-87M. The only work which was going on on this section when I visited the mine was a small tribute

party, which was working on Cashboult's lode, in the southern portion of the section. There are two small lodes here, which come together in the south end. The party had a small waterwheel, and was pumping the water from about 40 feet. Above this level a nice little shoot of ore had been taken out. This lode has been abandoned since my visit. In the south-west corner of the section there is a large carbonate of iron lode, carrying fair seconds, which has been driven on for some distance north from the creek. This lode is a promising formation. Balstrup's lode passes through the south-western portion of this section, and may be seen crossing the Comstock tramway, right on the western boundary, as a large gossan formation. A few chains to the east of this a main shaft was sunk, but I understand the lode was not cut.

This section includes the contact of the slate sandstone country and the tuffaceous rocks of Manganese Hill. As I have already explained, this contact is probably a great fault-fissure, and if so, is likely also to be a large lode-formation. The line of contact is not at all clearly defined on the surface, and the line marked on the geological plan must be taken as only very approximate. This part of the section is, I believe, well worth prospecting.

The Montagu No. 1 Mine.

Section 306M, charted in the name of N. Currie. This mine, at one time known as O'Rourke's, is situated south-east and adjoining the Central Balstrup. A number of lodes are known on the section.

O'Rourke's lode is situated in the eastern portion of the section, on the north bank of the creek which flows eastward from the Spray Mine. A good shoot of ore was mined in the upper levels of this mine by Mr. O'Rourke, and he is said to have left 2 feet of solid metal underfoot at the adit level. The Montagu Company was formed to work this lode at a depth, and with this object in view a main shaft was sunk. At 100 feet a crosscut was driven from the shaft, to cut O'Rourke's lode, with very poor results. It is difficult, now, to get the whole facts of the case. Several of the men who worked for O'Rourke tell me they are convinced that O'Rourke's main lode was never cut in the bottom level, but only a parallel lode some distance to the west. They are very positive as to the presence of the shoot of metal below O'Rourke's workings, and they say this metal was never seen by the Montagu Company. Mr. Currie has

discovered two other lodes to the west of O'Rourke's lode. The first of these he cut in a crosscut from No. 1 level. The shoot is 30 or 40 feet in length, with from 2 inches to a foot of galena. This has now been stoped up from No. 1 level, but is said to be still good underfoot. The country is soft decomposed melaphyre tuff. He has also cut another lode in an adit from the surface at the level of the mouth of the main shaft, and sunk a winze on metal, connecting with his crosscut from No. 1 level. This lode was showing from 6 to 9 inches of metal at the time of my visit, and since then he has been producing fair parcels of ore for several months. Several other lodes are known on the flat to the south, but these will require pumping machinery to work effectively. Sufficient power to sink to 100 feet or so is available from the creek which flows through the section. The contact between the tuffs to the south and the slates and sandstones to the north is, in my opinion, well worth prospecting in this part of the field. I have already given my reasons for thinking there may be a large lode running through the northern portion of the Montagu section. This could readily be tested by a crosscut north from the Montagu workings, at as deep a level as possible.

The Maxim Mine.

Section 412M (40 acres), charted in the name of M. Glock. This section is south and adjoining the Montagu Mine. The country for the most part is composed of melaphyre tuffs, interbedded with slates. There are a series of parallel lodes crossing the flat on this section. The most westerly of these is the main lode of the old Maxim Company. A main shaft was sunk on this lode in the old days, and on the old dump there is a good deal of carbonate of iron and galena, which I should judge to be fair seconds. From the position of this lode, it appears that it might be a continuation of Balstrup's lode in Manganese Hill. It is evidently a very strong formation, and I should suggest that it would be worth looking for in the sandstone spur to the south. These sandstone hills were not looked upon with favour at the time when the Maxim Mine was being worked, and it is probable that the lode has never been looked for in this direction. To the east of the main lode there are several other lodes, the chief of which are known as Glock's west lode, Weber's lode, and Glock's east lode. All of these lodes carry metal of good grade. Cornish and party have got a tribute on Glock's east lode, and have

erected a waterwheel on Watt and McAuliffe's section, and transmit the power to a draw-lift by means of a wire rope. They are, however, badly off for water, and have been under a disadvantage during the exceptionally dry summer this year. In the winter months they should be able to work pretty constantly. The lode consists of a seam of black pug, about 9 to 14 inches wide, containing about 50 per cent. galena, and evidently the capping of a carbonate of iron lode. The galena is worth about £12 per ton. Glock's west lode has produced a small parcel of ore, carrying 108 ozs. of silver to the ton. Weber's lode is said to have yielded a good shoot of metal in the upper levels, but the difficulty of sinking in the flat has so far prevented any depth being attained. This whole flat reminds one strongly of the Argent-Florence flat, and considering the results obtained from the small amount of prospecting which has been done, compared with the latter, it is quite likely to be equally productive.

Watt and McAuliffe's Mine.

Sections 288-93M and 3686-93M (total area, 93 acres). These sections are situated west and adjoining the Montagu No. 1 Mine. The mine has been a fairly steady ore-producer for some years, being worked in part by the owners and in part by tributors. The country is mostly flat, and very little can be done without pumping. A dam has been constructed on the creek which flows through the sections, and from this sufficient water can be obtained to work a water-wheel, which enables the workings to be carried down to a depth of 80 or 100 feet.

There are seven lodes on the sections which have been worked. These will be all found charted on the geological plan. No. 1 and No. 2 are parallel lodes, striking 30° west of north. Both lodes have been tested along their course by a number of prospecting-shafts. No. 2 lode was the best on the section, the workings extending over a distance of about 5 chains. This was a highly payable lode, and was, I understand, the principal ore-producer of the mine. To the east of this, No. 3 lode strikes 23° east of north. This lode has also been worked for a considerable distance. In the south end it junctions with No. 4, which strikes east of north. No. 3 lode was not tested south of the junction, as the metal followed No. 4 lode.

No. 5 lode also strikes 23° west of north. A shaft has been sunk on this lode, and a water wheel was at work

pumping at the time of my visit, but there was not enough power to keep the water under. I understand that a fair amount of ore has been taken out of this lode.

Nos. 6 and 7 lodes lie to the south of No. 5. These lodes strike east of north, and junction towards the south; both of them have been worked from two levels, the lowest level being 80 feet from the surface. Two men were at work underground at the time of my visit, and were getting a little ore.

As I have already stated in the theoretical portion of this report, I have same reason to think that a large lode, striking about 65° west of north, may be found in the North Austral Mine (Section 3686-93M). I have not, however, been able to examine this country very carefully. The lode should lie at the contact of the tuffs, which occur on the flat to the south, and the evenly-bedded slates and sandstones to the north. I believe this contact lies to the north of, and runs approximately with, the creek. I should like to see a good deep trench taken up from the creek northwards, till the regularly-bedded strata are entered. The lode may not contain ore at the surface, but sufficient evidence of a lode-formation to warrant further prospecting in depth may be obtainable by a good trench.

SILVER KING PROSPECTING ASSOCIATION, NO LIABILITY.

Sections 217-87M, 219-87M, 220-87M, 223-87M, 469-87M, 468-87M, 221-87M, 470-87M, 218-87M, 222-87M (total area, 352 acres). This mine is situated in the regularly-stratified country to the east of the disturbed area. The rocks are principally slates, often more or less calcareous, and containing casts of numerous Upper Silurian fossils. The sections are traversed by a series of parallel lodes, striking 35° west of north, and dipping west. They are, for the most part, well-defined fissure-formations, containing abundance of iron carbonate, with a little iron and copper pyrites. The galena is fairly abundant, but for the most part is of low grade, which has, of course, greatly affected the profits obtainable by mining the ore. The concentrator at the mine is an inefficient one, and it has become apparent that the mine cannot be successfully worked unless sufficient capital is provided to enable the ore to be cheaply and effectively handled.

The main lode of the King Mine is one of the most persistent lodes in the Zeehan field. It has been traced right through Sections 223-87M, 221-87M, and 222-87M; thence it passes through the Zeehan Bell sections, and on to the Sunrise Mine; a total distance of over one mile. It seems

also highly probable that the same lode extends northwards to the west of the King Extended hill, in which case its total length would be considerably over two miles. At the Silver King Mine the principal workings are on Section 223-87M, where the main shaft has been sunk, and on Section 222-87M, where Messrs. Burridge and party, and later, Messrs. Fahey and party, mined a very rich and extensive shoot of ore.

The main shaft, on Section 223-87M, is 250 feet deep, and from this three levels have been driven—No. 1 at 106 feet, No. 2 at 176 feet, and No. 3 at 246 feet. At No. 1 level the lode has been driven on to the north of the crosscut for a distance of 240 feet, and south for a distance of 285 feet. Beyond this point the south drive still continues for about 120 feet, but is in blank country. It is now known that the lode lies to the west of the drive in the south end. In an intermediate level above No. 1 the lode has been followed, and takes a bend to the west, carrying pug, with slugs of galena. It has also been found to the west at No. 3 level. The best of the ore was found in the vicinity of the main shaft, but almost the whole of the lode-channel is metal-bearing. At No. 1 level there are two blocks of ground stoped out, one 130 feet in length and the other 175 feet in length, and there is said to be still 75 feet of good ore to the north of the stoped ground.

At No. 2 level the lode has been driven on for 140 feet north and 400 feet south. Of this, about 250 feet have been stoped, and there is still a large quantity of second-class ore standing.

At No. 3 level the lode has been driven on for 130 feet north, and nearly 500 feet south. There is one block of stoping done above this level, but most of the lode is standing. A large proportion of this is said to be good seconds, which would pay well to mine, provided the mine were equipped with an efficient concentrating plant. In the south end the lode turns to the west. It is here 20 feet wide, carrying small quantities of metal right through, with 8 inches of first-class ore on the hanging-wall. The lode is a fine strong formation, and the area which has been exploited has produced a very large amount of ore. The galena is of low grade, assaying 25 ozs. of silver to the ton, with 70 to 75 per cent. of lead, and is worth about £5 per ton. Still the metal is more abundant than in the case of many of the lodes carrying high-grade ore, and with fair treatment the lode should pay. It requires a good concentrator, and should be worked on a large scale, in order to reduce pumping costs.

At No. 1 level a crosscut has been driven out east, with the object of testing several parallel lodes. At 250 feet a blende lode was cut, carrying 3 feet of zinc-blende and pyrites. This was driven on a short distance, and the leading stope taken out for 50 feet in length. Gossan began to come in above the zinc-blende. At 634 feet No. 2 lode was cut. This proved to be 7 feet wide, carbonate of iron, with a little galena through it. At 900 feet No. 3 lode was cut. This was 2 feet 6 inches wide, and was barren where cut. The same lode had been sunk on from the surface, and carried from a foot to 18 inches of mixed ore, but this was not seen below. Neither No. 2 nor No. 3 lode was driven on from the crosscut.

The South King Workings.—These are situated in the southern portion of Section 222-87M, just north of the boundary of the Zeehan Bell Mine. The shoot of ore was first worked from the Bell Mine by Messrs. Burridge and party, who worked from the No. 1 level of the latter. This shoot was one of the most massive bunches of galena which have been mined in Zeehan. It was 14 feet wide at best, and contained about 50 per cent. galena. From this, Burridge obtained 1882 tons of ore, of a total net value of £12,145. The ore was of better grade than the average King ore, assaying about 45 ozs. of silver to the ton, with 70 per cent. of lead. This shoot appears to cut out on a wall or slide close to the Bell boundary. The lode has been found to the south of the slide, but contains little or no first-class metal, and what there is is of lower grade, assaying only 25 ozs. to the ton.

Messrs. Fahey and party started work on a large gossan formation 400 feet north of the Bell boundary. This proved to be 122 feet long, and was 21 feet wide 30 feet from the surface. The whole mass averaged about 90 ozs. of silver to the ton. Besides the gossan, 25 tons of copper ore (malachite, &c.) were sold from this patch, assaying 17 per cent of metallic copper. The gossan only lived to a depth of 30 feet, and was then replaced by 4 feet of galena, assaying 100 ozs. to the ton, which continued down 60 feet more. Below this level the ore was not so massive, and was only medium grade, assaying on an average 45 ozs. of silver to the ton. This shoot appears to have pitched south, and junctioned with the shoot formerly worked by Burridge. It was stoped by Messrs. Fahey and party from No. 3 level (258 feet below collar of shaft) upwards. The best of the ore did not live to No. 3, but was very good in the second stope above No. 3, and from that upwards. Messrs. Fahey and party mined altogether 7488 tons of ore,

of the net value of £67.773, making the total from the South King sections 9370 tons, of a net value of £79,888.

As to the prospects of profitably re-opening the Silver King Mine: I think that any expectations of striking the continuation of the rich ore mined by Burridge and Fahey would result in disappointment. The shoot was evidently one of those local enrichments, caused by the re-deposition and concentration of galena in the upper portions of the lode. Still, as a low-grade proposition, and taking into consideration the possibility of other rich shoots being found, the mine has strong points in its favour. There is still a large amount of second-class ore obtainable from Fahey's old workings, and there is, I think, a fair prospect of payable seconds being found at deeper levels. The lode is surely worth driving on north. This ground has not been tested at all yet, and there is at least a fair chance of other rich shoots being found in this direction. These South King workings enhance the value of the King Mine very greatly. The lode has been practically only tested at two points, 50 chains apart, and in both places good ore has been found. What is in between these two shoots no one can tell, but considering the results which have been obtained, the ground is certainly worth testing. I would, however, deprecate the re-opening of the mine without adequate capital. A first-class central concentrator is an essential to success. This would enable the large bodies of low-grade ore to be treated, and although the profits from this ore would not be great, they would probably be more than sufficient to pay for the exploratory work necessary to find other and richer shoots of ore.

THE ZEEHAN BELL SILVER MINING COMPANY, NO LIABILITY.

Sections 480-87M and 298-87M (total area 158 acres). This mine is south and adjoining the Silver King Mine, and the main lode of the latter passes through the property. A main shaft has been sunk for 200 feet, and two levels have been driven for a considerable distance on the lode. The big shoot of ore mined by Messrs. Burridge and party, and later by Messrs. Fahey and party, in the Silver King Mine lived for a short distance into the Zeehan Bell ground, but was cut off by a slide dipping north. The shoot does not appear to continue to the south of this slide. Most of the ground tested by the Zeehan Bell drives consists of second-class ore. Mr. Peter Irvine, the former manager, was strongly of opinion that the lode would pay to work if the mine were equipped with an efficient concentrator. The mine was pumped out a couple of years ago by a

tributing company, but they failed to find payable ore, and shut down after a few weeks' run. Since then the mine has not been worked.

The Oceana Mine.

Section 4763-93M. This section is now vacant. The Oceana main lode is in limestone, and strikes 30° west of north. It is a very large formation, and a very massive shoot of ore was mined from it some years ago. The ore was of very low grade, assaying only 15 or 20 ozs. of silver to the ton, with 70 per cent. lead. The mine was in full swing, and maintaining a good output, when the shaft began to move, and jambed the pump-rods. It is evident that the limestone contains large vughs, and when these drained the ground began to cave in. There was not a great deal of profit to be got from mining the ore, and the company decided not to risk the expenditure on a new shaft.

There is a line of country which, I think, would be worth prospecting on the Oceana Mine, namely, the line of contact between the slate and limestone country of the flat, and the conglomerates and sandstones of the hill to the north. In the theoretical portion of this report I have shown that there is in all probability a great fault here, and this is very likely to be a large lode-formation. Unfortunately, it would be rather costly to put this theory to the test, as the water would be heavy. There is a prospecting-shaft sunk on the line of the Oceana lode, close to the contact, but I have not been able to learn what was cut. The creek to the north of the flat must run approximately along the course of this line of contact.

In conclusion, I have to acknowledge the great assistance I have received during my examination of the Zeehan Field from the various mine managers, tributors, prospectors, and mining men generally. I have always been treated with the greatest courtesy, and in many instances much trouble and inconvenience have been undergone to supply me with information. I take this opportunity of tendering my sincere thanks.

I have the honour to be,
Sir,
Your obedient Servant,

GEORGE WALLER,
Geological Surveyor.

W. H. Wallace, *Esq.*,
Secretary for Mines, Hobart.

JOHN VAIL,
GOVERNMENT PRINTER, TASMANIA.

PLATE I. 102/102

GEOLOGICAL SECTIONS MOUNT ZEEHAN

Vertical Scale of Feet. 1000 2000 1000 2000 3000

Horizontal Scale of Chains 10 0 10 20 30 40 50 60 70 80

H. A. Waller. Geological Surveyor. April 9th 1904

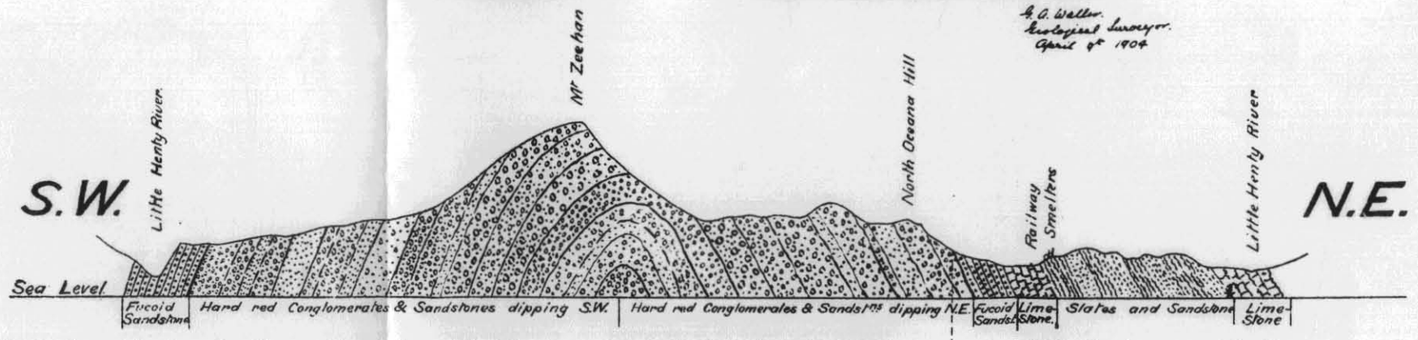


Fig 1. Ideal Section through Mt Zeehan on approximate bearing of 45° East of North

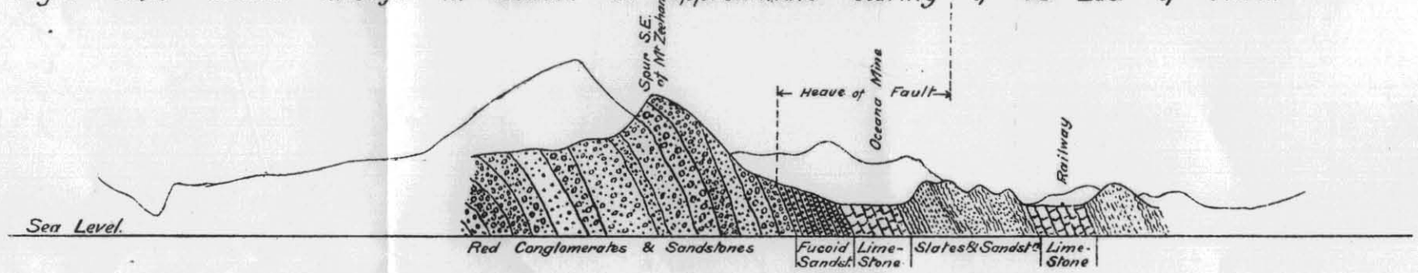
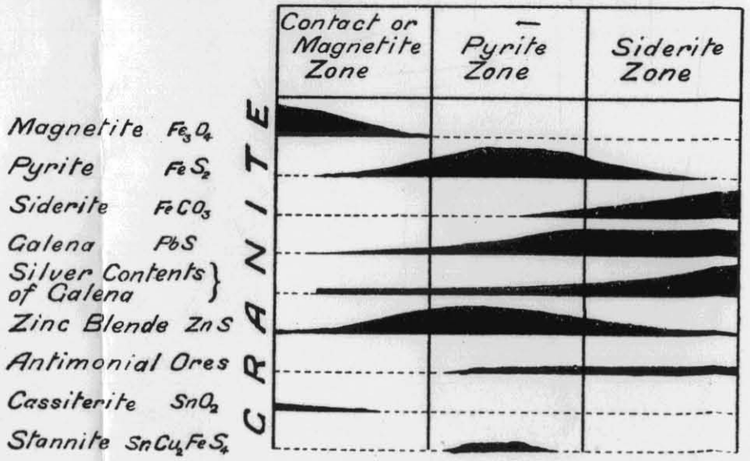


Fig 2. Section through Spur half mile S.E. of Mt Zeehan on approximate bearing of 45° East of North

PLATE 2.

DIAGRAM REPRESENTING GRAPHICALLY THE DISTRIBUTION OF CHARACTERISTIC MINERALS OF THE ZEEHAN SILVER-LEAD LODES.



H. A. Waller Geological Surveyor April 9 1904.

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