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The Dundas Mineral Field

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SUMMARY.

A statement in brief of the practical consideration arising from the survey of the geologic relations, and of the various kinds of ore-bodies, should prove acceptable and helpful to the prospector. This account of the results so obtained presents in condensed form the salient features of the discussion that follows.

The nature of the rocks, and their relation, are favourable to ore deposition in some parts, but not in others where the conditions are different. This fact emphasises the necessity for close attention to detail in the work of geologic interpretation.

The rocks will be dealt with in the order of their formation, beginning with the pre-Cambrian. These are schists, almost barren of minerals, occupying a small area fronting Mt. Dundas. The next succeeding formation, consists of Cambro-Ordovician sediments, and tuffs of the Dundas series, which occupy the greater part of the district. No ore deposits of any considerable extent, have been found in the Dundas series of rocks, except where they are intruded by gabbro, serpentine, or quartz and felspar porphyries. The Bischoff series of rocks, on the other hand, are the repositories or hosts of nearly all the lodes. The reason of this is not difficult of explanation. Pre-Cambrian schists, and the sediments and tuffs of the Dundas series, are comparatively plastic rocks, incompetent to withstand compressive and tensional forces, while the hard quartzite, sandstone, and slates of the Bischoff series, are strongly resistant rocks, and fracture under great strain, providing channels of access for mineralising solutions. It is interesting to note that similar conditions obtain at Waratah, where the Magnet Silver-Lead Lode, and the Mt. Bischoff Tin Lodes, occur in the Bischoff series, near the line of junction with the Dundas series of rocks. The next in succession are Ordovician Read-Rosebery schists, which are favourable to the deposition of ores by replacement. In them are found few true fissure veins, but many important fissure-replacement lodes. Although the afore-

mentioned rocks contain nearly all the ore-bodies, they are not responsible for them. The serpentine, gabbro, and quartz felspar porphyry, which crop out locally, and, with granite, probably extend beneath a great part of the area, are the direct cause of mineralisation. From the basic igneous rocks (serpentine and gabbro) are derived the deposits of osmiridium and copper-nickel ore, from the porphyries, tin, arsenic, and bismuth ores, and from the underlying granites silver, lead, zinc, and antimony. Talc and chrysotile are derived from serpentine by alteration due to the action of solutions emanating from a granite reservoir. Serpentine and gabbro intruded the sediments prior to the granite and porphyry, and have since been transformed in some places into other rock compounds. The common product of serpentine alteration is the so-called dolomite, but much dolomite and its associate mangano-siderite were deposited from solution in lode form. The brownish-black ferro-manganese oxides, forming large ore-bodies, having been derived from mangano-siderite, are not carriers of tin ore, which is looked for in limonite derived from pyrite or pyrrhotite. The various secondary ores of lead, namely, cerussite, crocoite, pyromorphite, &c., are alteration products of galena deposited in cavities in the gossan. Secondarily enriched ores may be found near water-level, but below that line the primary mangano-siderite are not very rich in galena or in any other mineral of commercial value. The oxidation product, ferromanganese gossan, is a valuable basic flux and contains a little lead and silver. Ores of this kind, however, are of local value only.

I.—INTRODUCTION.

A.—Preliminary Statement.

Mining activity in Dundas District began soon after the discovery in the eighties of the rich silver-lead deposits in the Zeehan district, which is six miles west of this field. From Zeehan as a centre, prospectors spread into the surrounding country, searching every hill and valley for outcrops of silver-lead ore with a thoroughness that has never since been equalled in these districts. Some of them in due course reached Dundas, and soon found silver-bearing ironstone cappings of lead ore deposits. Nearby all the known ore-bodies were discovered by the early prospectors, and some were explored by them at depth by way of shaft and adit. During the early exploratory period, small shipments of rich ore were made to markets overseas, but it was found that the greater number of the deposits were of low grade, and two or three mines only survived the boom. Operations on the low grade ore-bodies began over a decade later, with the erection of a smelting plant near Zeehan. They were worked, not so much for there content of lead and silver, as for their value as basic fluxes. The failure of the Tasmanian Smelting Company caused the abandonment of nearly all the mines in the district.

A recent discovery of tin ore, and the re-opening of two important zinc-lead mines, have given an impetus to the industry, and the prospects are now much brighter.

B.—General Statement.

This report embodies the results of a ten weeks survey of the field during the summer of 1924. The mineral chart of the district, drawn to a scale of 20 chains to one inch, was used as a foundation for the geological map, which accompanies this report. Very few of the old mines and prospects, were accessible at the time of this visit, and as no records were kept, the information available concerning them is rather scanty. However, the descriptions of lode types are applicable to mine groups, and will serve to convey an idea of the nature, extent, and value of the deposits. The information relating to the types embodied herein, should prove of very considerable assistance to those engaged in the mining industry, especially to prospectors who desire to know which are the most favourable areas for attention, and under what conditions the ores are likely to be found.

C.—Previous Literature.

The literature on the Geology, and ore-deposits of the field is very meagre, although adjacent fields have been carefully studied and described. No attempt had heretofore been made to prepare a geologic map of the district. During the early days of the field Government Geologists paid hurried visits, and reported progress of mining developments to the Secretary for Mines.

The following is a list of the reports on the mines, and prospects of the field:—

Montgomery, A.: Report of the State of the Mining Industry on the West Coast, April, 1890

Montgomery, A.: Report on the Mt. Zeehan and Mt. Dundas Silver-Lead Fields, November, 1890

Montgomery, A.: Report on the Progress of the Mining Fields of the County of Montagu, 20th May, 1893

Montgomery, A.: Report on the Zeehan-Dundas Mineral Fields in February, 1896.

Twelvetrees, W. H.: Report on the Mineral Districts of Zeehan and Neighbourhood, 27th October, 1900.

These brief reports constitute the whole official literature descriptive of the field.

D.—Production.

No official records have been kept of the production of minerals from this district. Mining properties have changed ownership, and have been abandoned so many times, that the records of production of individual mines have also been lost. Based on complete statistics it is estimated that since the year 1890 not less than £500,000 worth of ores has been mined. Production of metals on a commercial scale, however, began in 1896. There have been several periods of depression coinciding with the collapse of the silver and lead markets, and the several stoppages of smelting operations at Zeehan. At the present time only one mine is in operation, and although profitably operated, the output is very small. Lead ores are the most important product of the district, but in quantity the production of ferromanganese gossan containing a little lead and silver far exceeds that of any other ore. This gossan was trained to the Zeehan Smelters at the rate of 200 tons per day, and was used as a basic flux. During a short period, copper-nickel ore, £16,000 in value, was mined and shipped to Europe. Tin ore, after lead, has been the chief product of the district, but the tonnage and value of the output are not known. Antimony, arsenic, and zinc ores have been mined on a small scale. Talc and chrysotile may become marketable products of the district very soon.

II.—GEOGRAPHY.

A.—Situation and Access.

Dundas is connected by rail with Zeehan, and with the seaports of Strahan and Burnie. Zeehan, which has a population of 2000, is the largest settlement in the division, and is only six miles distant. Strahan is 34 miles, and Burnie is 94 miles away. A weekly service only is now maintained between Zeehan, and the almost deserted township of Dundas. A road connects the township, but is passable for heavy vehicles only.

B.—Climate and General Features.

The area is one of abundant rainfall, and most of the valleys are occupied by perennial streams, which have their source in the Dundas Range. The township is situated in a broad flat basin, which receives all the drainage on the western side of the mountain. From the levels of the piedmont the mountains rise abruptly over 3000 feet, presenting deeply serrated flanks on the west and north sides. The streams flow rapidly to the level of Henty plain, thence the rate of fall is slow and even. Rapid erosion, however, is now proceeding in nearly all quarters.

A thick forest growth covers the flanks and summit of the range, and button-rush and scrub cover the plains. Eucalypts of various kinds and fagus are abundant, but the chief wood of the distrtct is King William pine, which is found above the 2000 feet contour.

III.—GEOLOGY.

The rock formations of Dundas, are many and varied, both sedimentary and igneous of several ages being represented. The Dundas series of Cambro-Ordovician slates, breccias, tuffs, &c., occupy the greater part, and rest upon intensely metamorphosed schists, slates, and quartzites of pre-Cambrian age. Their base is thus exposed on the west flank of Mt. Dundas. In addition, the Bischoff series is also represented, and is important in containing most of the valuable ore deposits. The Devonian is represented by quartz-felspar porhyry, and by gabbro and serpentine. It is thought that Permo-Carboniferous sediments occur near the summit of Mt. Dundas, on the south-western fall. The Mesozoic era is not represented by stratified rocks, but dykes and sills of diabase occur and form the crown of the mountain.

A.—Proterozoic Rocks.

The rocks of this age comprise hard sericite quartz schists, soft sericite schist, and dark mica and argillaceous schists. They are clearly metamorphosed sediments, which in places have been intensely crumpled and otherwise deformed. The only exposure is on the north-western front of Mt. Dundas, where they may be seen dipping at a high angle to the south-west underneath the Palæozoic sediments, but they outcrop again on the south-eastern side of the range outside this district.

B.—Palæozoic Rocks.

Cambro-Ordovician.

(*a*) Bischoff Series.

Directly succeeding, but unconformable with the Proterozoic schists, is a series of grey and black fissile slates, sandstones, conglomerates, and quartzites, which bear a remarkable resemblance to the Bischoff sediments, but whereas, in the Waratah District, the series appears younger than the Dundas, here it is definitely older, and apparently one is discordant with the other. In this series of sediments nearly all the ore-bodies occur.

(b) Dundas Series.

This suite of rocks, indefinitely assigned to the Cambro-Ordovician, has already been described in earlier publications, but there are here certain members not persistent in the formation that require special mention. This remark refers particularly to igneous members that are not found in the Bischoff series. Both acidic and basic rocks, probably belonging to the "porphyroid" group, occur, and both are intrusive into the sedimentary members. They are briefly described in a later section, but, in addition to the intrusives, there are imbedded deposits of pyroclastic material similar to that found in the neighbouring Read-Rosebery district.

This series consists of grey and black slates and quartzites, quartz, schist, and slate conglomerates, tuffs and breccias, red and purple chert conglomerate, and pyroclastic materials of acidic and basic character.

C.—Igneous Rocks.

(1) *Porphyroid Series.*

Rocks of this series occupy the backbone of Dundas Range. They intrude Cambro-Ordovician sediments, and course in a north-westerly direction in conformity with the structural axes of the intruded rocks. The typical rock is of a dull greenish-grey tint, yellowish-brown on weathered surfaces. It consists of phenocrysts of quartz set in a groundmass of chloritised and kaolinised felspar. The leucoxene alteration product of ilmenite is a prominent accessory component.

This rock is typical of the series occurring in the Read-Rosebery and Mt. Farrell districts.

(2) *Serpentine.*

The olivine-rich basic rock, peridotite, was transformed into serpentine shortly after its injection as dykes into the overlying rocks. At Dundas the serpentine dyke is over half a mile in width, and is well exposed in the central area, but southward the covering of sedimentary rocks is removed in parts only. It is part of a great intrusive body extending north and south many miles. This beautiful sea-green rock is the most striking geological feature of the district, not only because of its physical attractiveness, but because the most important ore-bodies are closely associated with it. Accompanying the serpentine as original accessory components of its parent peridotite are chromite, picotite, osmiridium, and gold. Small crystals of chromite are scattered through the serpentine in every part of its body. Picotite is not as plentiful, and osmiridium and gold are sporadic in distribution.

(3) *Quartz-Felspar Porphyry.*

In the Pine Hill and Renison Bell areas is a porphyritic rock, consisting of phenocrysts of quartz and felspars (orthoclase and oligoclase), with a little muscovite and biotite set in a groundmass of felspar and quartz. The accessory constituents, zeuxite, sericite, cassiterite, and pyrite of later formation are developed in some parts of the porphyry body. Veins of pegmatite are common at Pine Hill, and are tin-bearing as a rule. Orthoclase alteration into pinite is particularly noticeable at Pine Hill, where the soft kaolin-like substance occurs in large masses underneath porphyry talus. A sample of the material consisted of—

Silica...............	42·00	per cent.
Ferric oxide......	2·29	"
Titania	2·00	"
Lime	0·32	"
Magnesia	0·43	"
Potash, &c.	14·90	"
Alumina	39·39	"

(4) *Diabase.*

Diabase occurs here in the forms of dykes and sills. One dyke, 10 to 20 feet in width, outcrops on the summit of Carbine Hill, and is exposed at the point where the track crosses it. The dyke trends through rocks of the Dundas series, cropping here and there along its course towards Confidence Saddle. In a cutting on Wallace's tramway it is seen in contact with quartz conglomerate. At that point it appears as a hard, dark-grey rock of fine-grained texture and conchoidal fracture. It breaks into splintery pieces with sharp cutting edges, and which give a sharp metallic sound against iron or steel. Large boulders of diabase are found in Maestries Creek, on the valley sides near the mine of that name. The occurrence suggests the near presence of another dyke, for boulders in such numbers are not found higher up stream. A remnant of a large sill of diabase forms the crown of Mt. Dundas. It is an extensive body about 400 feet thick. On the north side it rests on porphyroid intrusives and Dundas slates, but on the south it is reported that the base is Permo-Carboniferous mudstone.

D.—Geologic Structure.

The Proterozoic and Palæozoic rocks are folded in anticlines and synclines having north-west axes. Some of the anticlines correspond with existing ridges and mountains, the most noticeable being that of Dundas Range. The schist exposure reveals a south-westerly dip, but in the adjacent district to the north-east it is in the opposite direction. Sharply folded quartzites, sandstones, and slates succeed them, followed by the less deformed rocks of the Dundas series. Recurring resistant rocks, such as conglomerates and quartzites, mark the axial intervals. The trend of the several intrusive bodies is generally that of the structural axes, but a transverse body of gabbro occurs at the northern end of the basic belt. Ordovician porphyrites, Devonian serpentines and gabbros, and Mesozoic diabase all trend in a north-westerly direction. Nearly all the veins and lodes likewise course in that direction, but a few bear a little east of north. The north-westerly lodes dip to the south-west, and the north-easterly to the south-east. All the important bodies not directly in contact with the intrusives are found in the lower quartzites and slates.

IV.—ORE-DEPOSITS.

A.—Mineralogy.

Ores of divers kinds occur in this district, and although formed under different conditions, they are not unrelated in origin. Some are peculiar to Dundas; others, known elsewhere as mineralogical curiosities, are wonderfully developed here. Some of the secondary minerals are exquisitely beautiful, and are valuable because of their rarity also. In the description that follows minerals are classed as primary or secondary, and are grouped according to composition. Secondary minerals are derived from primary minerals, the change being effected in most cases by the agency of surface solutions. Thus secondary minerals are found in the zone of oxidation or upper part of ore-bodies, and primary occur in the lower part where surface solutions have not penetrated. Between these two zones is a transition zone, where both classes of minerals are present. Secondary minerals are formed also by the action of ascending solutions on ores and rock-forming minerals, many of which are found in this district. As a rule the primary are commercially more important.

(1) *Lead Ores.*

Primary.

Galena.—Lead sulphide (PbS) is the most important primary ore. It commonly occurs in crystalline massive form associated with sphalerite in fissures and replacement bodies.

Jamesonite.—Sulphide of lead and antimony ($2 PbS Sb_2 S_3$) is found as a filling of fissures in slates and quartzites. In some of the metalliferous veins jamesonite is the dominant ore of lead.

Secondary.

Anglesite.—Lead sulphate ($PbSO_4$) is an alteration product of galena by oxidation. In the Dundas ore-bodies anglesite is not common.

Cerussite (lead carbonate, $Pb CO_3$), in wonderfully developed crystal masses, is abundant in replacement ore-bodies contained in dolomitised serpentine. The crystals are often acicular and of extreme delicacy, pellucid or snow-white, stellate or in long columnar clusters, and set in cavities formed in black ferro-manganese gossan. Large vughs are commonly found completely lined with beautifully developed crystals. It is found also as a thin coating on its parent galena, from which it was formed by the action of carbonic acid derived from a dolomite or mangano-siderite gangue.

Chromiferous Cerussite.—This variety is fairly abundant, filling fractures and vughs in gossan, and is invariably associated with crocoite. On the contrary, it is never found associated with ordinary cerussite. It is an opaque, canary-yellow mineral, and is of shining lustre. The variety is distinct as regards colour, composition, and crystallisation. Its occurrence with crocoite and its contemporaneous formation therewith indicates the nature of the solutions responsible for its development.

Crocoite.—The brilliantly coloured chromate of lead ($PbCrO_4$) occurs here in almost perfect crystal form, and in very great abundance. It usually occurs in clusters of crystals filling large cavities in ferro-manganese gossan, but also intimately associated with limonite. The most important bodies, both as regards quantity and quality, occur at the Dundas Extended, West Comet, and Adelaide Mines, where crystals of hyacinth-red and deep scarlet colour, 10 to 12 centimetres long, with perfect terminations, are found in vughs and sometimes mixed with masses of chalcophanite and manganese oxides.

Dundasite.—This is a local mineral found as an incrustation on ferromanganese gossan at the Adelaide Mine. It occurs in small spherical aggregates showing an extremely fine radiating structure. The composition is—

PbO	41·86 per cent.
Al_2O_3	26·06 ,,
Fe_2O_3	5·50 ,,
$H_2O + CO_2$	28·08 ,,

and the corresponding formula, omitting the Fe_2O_3, which is regarded as foreign to the substance, is $PbO\ Al_2O_3\ CO_2\ 4H_2O$.

Pyromorphite.—A chlorophosphate of lead in dark-green crystallised masses is a common but unimportant ore of lead found in the Comet and Maestries Mines.

Massicot.—A yellow oxide of lead found in association with galena, cerussite, and anglesite at the Comet Mine. It occurs massive and as a powdery coating on other lead ores, and sometimes intermixed with the oxides of iron and antimony.

Phosgenite.—This chlorocarbonate of lead ($Pb\ Cl_2\ Pb\ CO_3$) is a pale to pure white, translucent mineral with adamantine lustre. Many fine specimens have been obtained at the Comet and Adelaide Mines.

Minium.—The red oxide of lead occurs as a pulverulent coating on other lead minerals at the Adelaide Mine.

Melanchroite.—A basic chromate of lead, differing from crocoite in its darker-red colour and brick-red streak, occurs at the Adelaide Mine.

Embolite.—A chlorobromide of silver found in limited quantity in ferromanganese gossan at the West Comet and Central Dundas Mines.

(2) *Zinc Ores*.

Primary.

Sphalerite.—This is the chief ore of zinc, and is found always associated with galena. The more important deposits are on the Great South Comet and Kosminski properties.

Secondary.

Chalcophanite.—This hydrated oxide of manganese and zinc occurs in small tabular rhombohedral crystals, commonly in botryoidal masses. At the Comet and other mines it forms an intense brilliantly black coating on ferromanganese gossan.

(3) *Tin Ores*.

Primary.

Cassiterite.—The common ore of tin occurs at the Razorback Mine associated with pyrrhotite and arsenopyrite, and at Pine Hill in quartz-felspar porphyry associated with zeuxite.

(4) *Nickel Ores*.

Primary.

Pentlandite.—This sulphide of iron and nickel, is found in abundance with pyrrhotite and chalcopyrite at Leslie Junction, and at the Dundas-Cuni Mine.

Secondary.

Millerite.—A secondary sulphide of nickel, occuring in the form of delicate brass-like fibres, with pentlandite near Leslie Junction.

Zaratite.—This beautiful dark-green carbonate of nickel, is found in serpentine at the Razorback Mine, at Moore Pimple, and at Dundas-Cuni Mine.

(5) *Bismuth Ores.*

Primary.

Bismuthenite.—The trisulphide of bismuth is found at the South Curtin-Davis Mine, and at the Hecla Mine.

Secondary.

Bismite.—The oxide of bismuth occurs in small quantity at the Curtin-Davis Mine.

(6) *Copper Ores.*

Primary.

Chalcopyrite.—This mineral occurs in association with Pentlandite at the Dundas-Cuni Mines, and is widely distributed, but in small quantity.

Tetrahedrite.—A fairly abundant mineral found in the Curtin-Davis group of Mines.

Secondary.

Malachite.—The green carbonate of copper is widely distributed in small proportion.

Azurite.—The blue carbonate of copper found commonly in association with malachite.

(7) *Arsenic Ores.*

Primary.

Arsenopyrite.—Commonly associated with tin ore, in comparative abundance at the Razorback and Fraser Creek Mines.

Secondary.

Arsenolite.—While arsenious acid is a common alteration product of arsenopyrite found at the Razorback Mine.

Orpiment.—The arsenic trisulphide in reniform masses, is found in the arseno-pyritic tin ore at the Razorback Mine.

(8) *Iron Ores.*

Primary.

Pyrite.—A component of nearly all the sulphide ore-bodies.

Pyrrhotite.—The magnetic iron sulphide occurs in great abundance with pentlandite at the Dundas-Cuni Mines, with cassiterite at the Razorback Mine, and with arsenopyrite at Fraser Creek.

Mangano-siderite.—Carbonate of iron and manganese forms a great part of the large ore bodies at the Comet, West Comet, Maestries, and Adelaide Mines.

Secondary.

Marcasite.—A pyritic alteration product of pyrrhotite, well exemplified in the tin ore lode of the Razorback Mine. The transformation takes place at low temperature and out of contact with air.

Ferromanganese Gossan.—An oxide of iron and manganese, forming a large proportion of the oxidised ore-bodies at Dundas.

Turgite.—A hydrous sesquioxide of iron found in the Comet Mine. This is a common ore of iron often mistaken for limonite.

(9) *Antimony Ores.*

Primary.

Jamesonite.—The sulphantimonite of lead occurs in distinct veins in the eastern quarter of the district. It is the sole primary ore of antimony known here.

Secondary.

Bindheimite.—This hydrous antimonate of lead, commonly known as "canary" ore, is an abundant component of the ore-bodies at the Comet and Adelaide Mines.

(10) *Other Minerals.*

Serpentine.—This mineral resulting from the alteration of basic intrusive rocks, occurs here in very large rock masses. It is remarkably homogeneous, both in texture, composition, and appearance. The colour varies from yellowish green to leek green, becoming yellowish white on long exposure. The lustre is greasy to pearly, and occasionally wax-like. A sample of typical serpentine has the following composition:—

Silica	SiO_2	40·52 per cent.
Ferrous oxide ...	FeO	0·52 "
Ferric oxide......	Fe_2O_3	4·49 "
Alumina	Al_2O_3	1·40 "
Lime	CaO	trace
Magnesia	MgO	40·50 per cent.
Water	H_2O	13·80 "

The mineral has not been mined for any purpose.

Retinalite.—A massive resinous yellow variety of serpentine occurs at Dundas with the normal rock.

Talc.—A soft hydrated silicate of magnesium occurs massive and fibrous in great abundance at the Razorback Mine.

Stichtite.—This mineral, first discovered at Dundas, forms irregularly-shaped masses, veins, and blebs in serpentine. It is particularly abundant in Stichtite Hill, south of the Adelaide Mine, but it occurs also in other parts of the district. In colour it varies from a most beautiful lilac shade to deep purple, and presents a strong contrast with the green of the serpentine in which it is contained. On weathered surfaces it is a deep brown. Its hardness is 1·5, and the specific gravity is 2·12.

Small blebs of stichtite often have as a nucleus minute particles of chromite, crystals of which occur also in the serpentine. As an ornamental stone this would prove of great value, were it not for the presence of hard crystals of chromite, which interfere with the development of a high polish.

Analysis show the following composition:—

Cr_2O_3............	11·5 per cent.;	9·20 per cent.
Fe_2O_3............	9·0 " ;	7·00 "
MgO	36·0 " ;	34·76 "
CO_2	7·2 " ;	5·40 "
H_2O	36·1 " ;	30·70 "
Al_2O_3	— ;	5·00 "
SiO_2	— ;	6·60 "

In texture the mineral is foliated to compact and sometimes granular. It is known in the amorphous condition only.

B.—Classification.

All the primary ore-bodies in this district are of Devonian age. They were derived either from the basic intrusives (serpentine and gabbro) or the immediately succeeding acid intrusives (granite and its offshoot, quartz-felspar porphyry).

The deposits then may be placed in two classes according to age and genesis, and may be subdivided into groups according to the order of their formation, thus:

Class I.—Deposits accompanying serpentine and Gabbro.
- Subdivision 1. Osmiridium and Gold.
- Subdivision 2. Nickel and Copper-Nickel.

Class II.—Deposits accompanying granite and porphyry.
- Subdivision 1. Tin.
- Subdivision 2. Arsenic.
- Subdivision 3. Bismuth.
- Subdivision 4. Antimony-Lead.
- Subdivision 5. Silver-Lead-Zinc.

This simple system of classification, convenient though it be, cannot be strictly adhered to as the ores of one group in some cases transcend those of the preceding group.

C.—Genesis.

The ores of the district were formed during the great Devonian period of mineralisation, and had a common origin. Differences in regard to character are due to differences in the accompanying instrusives, and also to differences in the conditions under which they were formed and the precise time of their formation. The close association of the ore-bodies with the intrusive rocks clearly indicate their genetic relationship. Ore deposition accompanied and followed the intrusions as is hereinafter shown.

In earlier publications it is shown that the basic group, consisting of serpentine, gabbro, and pyroxenite, and the acidic group, consisting of syenite, granite, and its offshoot porphyry, represent two original differentiates of one stock magma, and that the basic portion was injected first into the overlying formations. The close genetic relation that exists between the basic and acidic rocks of Devonian age has been remarked so often that the phenomenon requires no further mention. Suffice it to state that the appearance of a member of one group, may be taken as an indication of the near presence of a member of the other group, not however, of necessity as an outcropping body. Peridotite, bronzitite, their alteration product serpentine, monoclinic pyroxenites, and gabbro traverse every quarter of the district, but quartz felspar porphyry in comparatively narrow dykes is the sole representative of the acidic group, and is found in the Pine Hill and East Carbine areas only. Now, in the Dundas town area there is no record of an outcrop of granite or porphyry, yet are found minerals of many kinds, tin ore included, which can have been derived only from solutions emanating from an acidic magma. It follows that a granite batholithic body lies at no great depth in the area. In fact the carbonic acid emanations from underlying granite, are responsible for the conversion of original peridotite into serpentine, clay, and ironstone. Much of the ironstone covering of the serpentine represents iron oxide set free during the process of transformation and subsequent oxidation. The next stage is illustrated by the conversion of serpentine into chrysotile, talc, dolomite, mangano-siderite, &c. Narrow dykes are completely dolomitised, or ankeritised, larger ones exhibit these alterations along lines of contacts and fissures. Dolomite, ankerite, and mangano-siderite, were deposited also from solutions in the larger fissures, and subsequently suffered partial replacement by metallic sulphides.

D.—Ore-Shoots.

The veins and lodes are not uniformly metalliferous, comparatively short shoots of ore alternating with longer barren sections. As a rule the shoots pitch northerly, at angles of 40 to 60 degrees, and dip easterly at angles of equal magnitude. Rich shoots are found at the intersection of transverse fault fissures and lode fissures, the dip of the fault giving pitch to the shoots. In some of the large ore-bodies, the richest shoots lie across the lode, coinciding in direction and position to the intersection of the angle formed by the planes of the lode and fault fissures. Instances occur at the Adelaide Lead Mine and at the Razorback Tin Mine. Some of the lodes are large and continue unbroken 1000 to 3000 feet.

E.—Nature of the Mineralising Solutions.

The nature and composition of the vein and lode minerals and the metamorphism of the adjacent wallrock indicate the character of the mineralising solutions. Tin-laden solutions accompanying the intrusion of quartz-felspar porphyry contained abundant fluorine, chlorine, boron, silica and sulphur as witness the occurrence of pseudomorphs of cassiterite, zeuxite, and green and black tourmaline after felspar, and the silification and pyritisation of the porphyry.

Solutions far distant from the intrusions of porphyry, but which emanated from the subjacent parent granite, were predominantly carbonate in the first stage, and alkali-carbonate and chloric in the second stage. They contained much silica, sulphur, iron, and manganese, and many other common metals.

F.—Metasomatism.

This process, applied here in the restricted sense of chemical alteration of a mineral or rock, is recorded in successive stages by a number of rocks of secondary development. First, there is the transformation of original peridotite to serpentine and clay and ironstone, by the action of hot carbonated waters emanting from the granite successor of the basic intrusive. No outcrop of granite is known, but its presence is indicated by the development of chrysotile in the serpentine. The next stage of the alteration is that of serpentine to dolomite and diopside, the change being affected by the same agent but under different conditions. Another agent, namely tin-bearing solutions, produces quite different results. At the Razorback Mine, where tin ore occurs along the line of contact, between serpentine and Cambro-Ordovician sediments, the serpentine has been completely silicified in some parts and converted into talc and steatitic ironstone in other parts. The remarkable feature about the replacement tin ore deposits is the absence of tourmaline, topaz, or any fluorine or boron-bearing mineral.

At Pine Hill actinolite and magnetite, partly by metamorphic processes, have been produced from the original basic intrusive by the action of quartz-felspar porhyry and the solutions accompanying it. Applied in the other sense (replacement of a mineral by another through chemical action) the process is exemplified in many of the large ore-bodies. At Pine Hill the felspar phenocrysts of the porphyry intrusive are replaced by cassiterite and tourmaline, or by quartz. Pseudomorphs of cassiterite after orthoclase crystals are very common, and some fine specimens have been obtained. The copper-nickel and zinc-lead ore-bodies of the Cuni area have been completely replaced by quartz at a depth of 150 feet. The progressive alteration of serpentine by tin-bearing solutions along the line of contact with slates, grits, and conglomerates, as exemplified at the Razorback Mine, is indicated in the accompanying analyses:—

	Serpentine.	Alteration	Products.
SiO_2	40·52	69·08	85·20
FeO	0·52	—	0·39
Fe_2O_3	4·49	3·33	5·95
Al_2O_3	1·40	1·87	2·32
CaO	trace	trace	trace
MgO	40·50	19·75	5·00
H_2O	13·80	4·40	2·50
MnO_2	–	2·28	—

The effect of dolomitisation of basic igneous rocks is exemplified in the following analyses of narrow dyke rocks:—

Silica	48·36 per cent.;	29·96 per cent.
Ferric oxide	6·42 ,,	2·43 ,,
Ferrous oxide	0·40 ,,	6·83 ,,
Pyrite	1·41 ,,	0·57 ,,
Alumina	19·12 ,,	9·35 ,,
Lime	6·10 ,,	15·85 ,,
Magnesia	4·71 ,,	10·86 ,,
Carbonic oxide	9·40 ,,	18·10 ,,
Loss on ignition	3·90 ,,	5·90 ,,

G.—Secondary Ores and the Process of Oxidation.

As a rule primary ore has been the chief product of the veins and secondary ore of the fissure-replacement bodies. Vein fillings are comparatively narrow, and are most common in slates and quartzites; fissure-replacement bodies occur at or near the contact of serpentine, or as replacements of dolomite or mangano-siderite. Primary ore appears in the outcrop of vein fillings, but not above water level (except in small bunches) in the replacement lodes.

Except in the Dundas-Cuni quarter secondary sulphides are almost unknown in the district. No zone of sulphide enrichment separates oxidised and primary ore in any of the deeply explored lodes, and none may be expected. Ferromanganese oxides with secondary lead, silver, and antimony minerals give place abruptly to galena and antimony-bearing mangano-siderite and the so-called dolomite and ankerite. The evidence clearly shows that the secondary minerals within the oxidised ore represent fairly well the average metallic content of the primary materials, and that little is due to migration of solutions. It has been remarked that in the western quarter there are copper-nickel as well as zinc-lead deposits, and secondary sulphides are common. In the description of the Dundas-Cuni lodes, reference is made to the fact that the pentlandite-pyrrhotite-chalcopyrite ore is almost completely replaced at a depth of 120 feet by quartz—massive, white, and opaque. The replacing quartz in some places reaches the surface, where it appears as sinter, thin-celled with implanted pellucid crystals. From some of the shafts that have intersected the ore-bodies, the outflowing water contains iron, nickel, and silica in solution. This suggests that the process of quartz replacement is still going on. In the adjacent and parallel zinc-lead ore-bodies, similar conditions prevail. At a depth of 150 feet the rich galena and sphalerite ores give place to quartz, as in the copper-nickel lodes. In parts of these lodes, secondary siderite, crystallised on the joint faces, is implanted with pellucid quartz crystals and rosettes of galena and sphalerite.

The alteration of mangano-siderite to ferromanganese gossan is due largely to meteoric waters. The process of alteration is as follows:—Meteoric waters attacked the upper portion of the original galena, sphalerite, and jamesonite-impregnated mangano-siderite, converting it into ferromanganese gossan, setting free any contained silica as quartz. In so doing the waters lost their dissolved oxygen and became carbonated in which condition they readily dissolved ferrous carbonate and manganous carbonate and some of the contained silica and transferred it to lower levels. Surface oxidation having been completed, waters charged with atmospheric oxygen percolated downwards, mingled with the iron and manganese solutions previously formed, and precipitated ferromanganese gossan. In this manner also were formed the secondary ores of lead, zinc, and antimony, which are distributed through the ferromanganese gossan and fill cavities therein. It has been estimated that the alteration of mangano-siderite to ferromanganese gossan is attended by a contraction of 27·5 per cent., whence ferromanganese gossans are porous, cavernous, and vughy, and contain incrustations of quartz and secondary metallic minerals. Nearly all the ferro manganese gossan bodies are contained in or closely associated with the serpentine intrusive. Now, serpentine is an alteration product of original peridotite in which chromite and picotite occur as accessory minerals. In the process of alteration, these accessory minerals remain in part unaltered, and in small part are converted into stichtite. The next stage is the transformation of serpentine into so-called dolomite or ankerite, without any perceptible change in the chromium minerals. Dolomite was later attacked by mineral-bearing solutions, and replaced by mangano-siderite, metallic sulphides, and other minerals. (A portion of the dolomite found here, however, was deposited from solution.) Ascending mineralising solutions provided the greater part of the chlorine which was an active agent in the replacement process, possibly also in the formation later of secondary minerals. Ores of secondary origin, containing chlorine in combination, are fairly common in all the large lodes. Under these conditions of ore oxidation, the chromite became decomposed, and the chromic acid set free entered into combination with lead to form crocoite, melanchroite, and chromiferous cerussite. Cerussite, chromiferous cerussite, and crocoite were formed in that order. Specimens of crocoite crystals implanted on chromiferous cerussite are common, but cerussite has not been observed associated with crocoite. The silver sulphide of the argentiferous galena was dissolved and redeposited as chloride of silver of which concentrations have been found. It is remarkable that the secondary ores of lead are almost devoid of silver.

V.—MINING.

A.—Nickel Ore Mining.

It is only within recent years that the mining of nickel ores has become an established industry in Tasmania. Operations have been performed on a small scale only, but the industry is yet in the first stage of development. As this is the only district in Australia from which nickel has been produced, the occurrence is of more than passing interest. Few nickel lodes of such high grade as that at North Dundas are known. In recognition of this fact, the prospector should feel encouraged to persevere in his efforts to discover other and larger bodies in the main body of basic rocks traversing the area. As exploration goes on doubtless other deposits will be found in the country intervening the known deposits and in the neighbourhood.

Attention should be directed to the gabbro, norite, and serpentine rocks, for in them or near them the lodes will be found. Although in the Dundas-Cuni area the lodes at 150 feet depth have been replaced by quartz, encouragement should be given to their exploration below the level of percolating waters.

A.—DUNDAS-CUNI AREA.

INTRODUCTION.

In 1914, before the outbreak of the Great War, two copper-nickel mines in this field were in active operation. The closing of the market following this event caused the cessation of production, and in one case the abandonment of a very profitable enterprise. Prior to the war a market for this class of ore was found in Germany, and regular shipments were maintained to that country. Although similar ores were being mined and smelted in America, that market was not available to local producers.

With the return to normal conditions of trading with Germany, an effort is being made to reopen this market, and it is hoped that, as a result of negotiations at present in hand, operations will be resumed early in the new year. Before reopening the mines it is proposed by the owners to ascertain the extent of the known shoots of ore, and to test the intervening country where other ore-shoots are likely to be found. In the performance of this work a diamond drill is to be used. Desiring advice on this policy, the operators approached the Government with the object of obtaining an official report. In compliance with their request the writer was instructed to inspect the site of the proposed works, examine the ore-deposits, and report on the results of his investigations.

In the performance of this work only five days were spent on the field. The investigation was, in consequence, incomplete, but it is considered that the information obtained is quite sufficient to enable the writer to report definitely as to the future prospects of the field, and the best methods of testing and exploiting the ore-bodies.

LOCATION AND EXTENT.

The North Dundas Copper-Nickel field lies midway between Zeehan and Renison Bell, which are 10 miles apart. Zeehan is an important silver-lead mining centre and Renison Bell is the centre of a tin-producing area. As its title implies, this nickel field is situated in the northern part of the district of Dundas and is four miles from the township of that name. From the foregoing it will be observed that the nickel mining area is surrounded by well-organised mining settlements.

The country that is proved to be nickel-bearing is six miles long and half a mile wide or three square miles in extent. Up to the present development work has been confined to a narrow belt about a mile long, but surface exploration has resulted in the discovery of nickel ore, extending from Leslie Junction on the Dundas Railway, to a point west of the Emu Bay railway tunnel, a distance of six miles by air line.

ACCESS.

The field is easily accessible from Zeehan by railway and road. Zeehan is united to Strahan by a standard gauge Government railway, and to Burnie by a line owned by the Emu Bay Railway Company. The seaport of Strahan is 33 miles distant; and Burnie, the more favoured port for shipping, is 83 miles from the field. The Burnie railway passes through the centre of the area, and the North-east Dundas two-feet gauge tramway from Zeehan to Williamsford crosses the Burnie line at this point. Branch lines connect the important mine openings with the Government tramway. Thus every facility is provided for the cheap and rapid transport of the ore from the mines to the shipping ports.

PHYSIOGRAPHY.

The development of the physiographic features of this area has been governed largely by the variation in the nature and character of the rocks that occupy and surround it. Thus, the rugged hills that enclose this basin-shaped area, built of erosion-resisting igneous rocks and hard metamorphosed sandstones and slates, stand out in relief from the flat swampy base occupied by soft sediments, the tuffs and slates of the Dundas series. This swampy basin, five miles in diameter, is drained by tributaries of Little Henty River which find an outlet to the south-west through a gap in the enclosing hills.

The lines of mineral deposition pass through the centre of the swamp-lands from north to south. As yet the nickel ore has not been traced into the hills, consequently all mining operations have to be performed through shaft openings. Occurring in such swampy country, the problem of draining the mines on these lodes is one of very great concern to the operators. In other respects the conditions are favourable for cheap mining and transport, and these advantages outweigh the disadvantages alluded to.

OUTLINE OF THE GEOLOGY OF THE FIELD.

The sedimentary rocks and the associated tuffs belong to the Dundas series of the Cambro-Ordovician. In every respect they are similar to the rocks of this age occurring at Renison Bell and Waratah. They consist of:—

grey and black slates;
grey quartz-felspar tuffs;
red slates and red tuffs.

These rocks occur in intercalated beds of varying thickness, and have a north-west trend and easterly dip. Probably the red slates are pyroclastic.

At the close of the Silurian these sediments and tuffs were intruded by dykes of basic rocks of various kinds, but all were derived from one stock magma having been separated by processes of differentiation. Directly following the intrusion of the main body of the basic irruptive numerous narrow subsidiary dykes of gabbro, norite, and pyroxenite broke through the sediments and tuffs, completely fissuring them. Several of these narrow dykes are known, and probably many more traverse the swamp-lands but are covered with peat and soil. Along the course of these subsidiary dykes the copper-nickel ore-bodies are found, and parallel offset lodes of silver-lead ore occur in the slates and tuffs on either side of them.

THE NICKEL ORES AND THEIR ASSOCIATES.

This ore is generally described as a nickeliferous pyrrhotite or as copper-nickel sulphide. It is essentially a mixture of pyrrhotite, pentlandite, and chalcopyrite in that order of quantitative importance. In addition to these many accessory metallic minerals, such as pyrite, marcasite, galena, and sphalerite, occur in the lodes, and the less common nickel minerals millerite, niccolite, and zaratite are occasionally found. The pyrrhotite, pentlandite, and chalcopyrite components occur in the form of small crystalline grains in intimate association and are of contemporaneous origin. Whether the pyrrhotite is nickel-bearing in itself or whether its nickel content is due to disseminated pentlandite has not yet been determined, but pentlandite has been detected in the ore apart from pyrrhotite. These minerals of similar appearance are difficult to distinguish by eye when they are so closely associated and in such a fine state of division. Although arsenide of nickel is reported, the sulphide combination is general.

The ore is dense and massive and is, usually, free from gangue minerals. It oxidises readily when exposed to the elements, tarnishing to a dun brown, and in large heaps the conversion to sulphates of copper and nickel is very rapid. The heat generated in this chemical reaction is sufficient to induce spontaneous combustion, and fires are not infrequent in large accumulations of broken ore. Advantage is taken of this property in the process of heap-roasting. It weathers in globular and ovate forms, the exposed material gradually breaking away in thin, rounded scales.

As a rule the copper constituent of the ore is about half that of nickel, but at the Devereaux prospect the proportion is three parts of copper to one of nickel, the variation being due to the relative amounts of chalcopyrite and pentlandite in the ore.

THE ORIGIN OF THE ORE-BODIES.

At the time of the investigation all the mines were closed and the shafts were full of water, and, therefore, no opportunity was presented of examining the lodes at depth.

Very few out-crops project through the peat covering of the swamp-lands, and where the ore-bodies are exposed the minerals composing them are more or less oxidised, thereby restricting the investigation of the relationship existing between the ore and the associated igneous rocks. In the time allotted for this work it was impossible to extend the field of study to the main body of the intrusive.

On the meagre evidence at hand an authoritative discussion of the problems relating to the origin of the minerals and the processes through which they passed before final deposition would, at this stage, be premature and inconclusive. From information obtained it appears that the processes of lode formation are very complicated, and are still more obscured by the alterations resulting from the action of later mineralising solutions.

In the first place, there are two striking facts about the occurrence of this nickel-ore. One is the constant association of the minerals pyrrhotite, pentlandite, and chalcopyrite; the other is the association of the ore with narrow dykes of basic rock, consisting either of gabbro, norite, peridotite, or an orthorhombic pyroxenite. Apparently the ore minerals favour pyroxenite and peridotite in preference to gabbro, for all the important shoots of ore are associated with those rocks. This association is so striking that a causal connection is looked for between them. The explanation is that from a molten mass of irruptive rock sulphides of iron, nickel, and copper became concentrated in the more basic portion, and this partly segregated mass was injected in the form of narrow dykes into the superincumbent strata. The dykes are so narrow that the final concentration of the rich ore on the footwall side could not have been due to magmatic segregation alone. Moreover, deposits of primary nickel-bearing ore extend into the slate footwall rock. It is evident, therefore, that the concentration of the ore in the lode channel was brought about by deposition from migrating solutions. Analyses of the pyroxenite and examination of hand specimens reveal the presence of nickel, copper, and iron sulphides in this rock. Although, as a rule, these minerals occur in intimate association there is a greater concentration of the copper component near the walls of the lodes. Specimens show also galena and quartz succeeding the chalcopyrite, and chalcopyrite veins are found quite apart from any other mineral in the slate on the footwall side of the main ore-bodies.

GEOLOGIC STRUCTURE IN RELATION TO ORE DEPOSITION AND SUBSEQUENT REPLACEMENT OF THE METALLIC MINERALS BY SILICA IN THE FORM OF QUARTZ.

The zinc-lead as well as the copper-nickel ore deposits have been explored, at several points, to a depth of 100 feet. So far as exploration has been carried along the course of the ore-bodies, it has been found that the metallic minerals, at this depth, give place wholly, or in part, to white opaque quartz. Before proceeding further it should be mentioned that the sulphides of nickel, copper, and iron, and also of zinc and lead, in the parallel ore-bodies above that level, are primary, and, as a rule, associated with siderite. Secondary sulphides are of common occurrence above water-level, not in any considerable amount, but sufficient to indicate that leaching has been very extensive by silica-burdened solutions. In the parallel zinc-lead lodes secondary galena and sphalerite with secondary carbonates of iron and lime are of common occurrence in association with older siderite. The nature of the minerals composing the gangue indicate that the solutions were alkaline. Because their sulphates are so soluble, nickel and copper were readily removed from the deposits. These sulphates do not oxidise and hydrolise, like iron sulphate, to form the trivalent oxide, and so the former are carried away in solution, while the latter, where conditions are favourable, is deposited as limonite.

Very little exploratory work has been performed at the level of the quartz replacement zone owing in part to the comparative paucity of the ore in metallic minerals, and in part to the heavy cost of drainage, consequently precise information is meagre. These cavernous quartz lodes provide migration channels for underground water, and are, apparently, continuous for very long distances. The rate of flow of the water, in any of the shallow shafts, is not less than 30,000 gallons per hour, and very little of it is meteoric. Where the lodes were intersected, in the underground workings, great outbursts of water, under considerable pressure, occurred. This water was not derived from the drainage of the marshes, but from another and far-distant source. The determination of water-level is most important in the consideration of the existence of metallic ores at depth. Bearing on this matter evidence is sought in adjacent areas.

In his report on the adjoining Renison Bell tin-field, L. K. Ward refers to the difference in altitude between the several outcrops of the basic intrusive. He states: " The difference may be due in part to subsequent warping of the crust, but, when other outcrops are taken into account, besides the two cited, it becomes apparent that the upper surface of the original intrusion must have been an extremely irregular one; and the irregularities have been reduced rather than accentuated by the progress of denudation. The several exposures of the basic rocks must necessarily be regarded as possessing continuity in depth; and the slate of the greater portion of the field is, therefore, resting upon an igneous foundation, the upper portions of which are exposed at the surface here and there." This observation by Ward has been confirmed by the writer in his investigation of the nickel-bearing part of the district. The basic intrusive extends in the form of a semi-circle around the north-eastern edge of this basin-shaped area, and west of it other outcrops are known. From this, and the information referred to elsewhere, it is evident that the slates and tuffs, at no great depth below the surface, repose on a foundation of basic rock. It is considered that the plane of junction between these dissimilar formations determines water-level, and that a portion of the water finds its way into this channel from the line of outcrop along the outer edge of the basin, although the main source is evidently deeper-seated.

On the evidence obtained it is considered that below water-level the greater part of the copper-nickel and zinc-lead ores has been removed. Coursing through the centre of the field, in a direction 7° W. of N., are two narrow parallel dykes of basic igneous rocks, about five chains apart. One consists of coarse-grained gabbro, and has not been explored, the other consists almost wholly of pyroxenite, and along the footwall of this dyke the rich shoots of ore are found. The length of shoot is controlled by the presence of faults, which cross the lode line in a north-west direction, and dip to the south-west, giving to the ore-shoots a southerly pitch. Immediately to the north of the faults no ore is found, but zinc, lead, and copper minerals in some cases occur away from the lode in the fault channel in association with quartz. In all cases the rich deposits of copper-nickel ore begin at, and extend from, the points of intersection of the dykes by faults. This condition applies also to the deposits of zinc-lead sulphide ore occurring in lodes apart from, and parallel to, the aforementioned.

The information obtained was too indefinite to make a conclusive pronouncement upon the questions raised.

THE MINING PROPERTIES.

Copper-Nickel Mines.

The occurrence of copper-nickel ore in this field was first reported about the year 1900, and reward claims were granted the discoverers. At the outcrop the deposit gave promise of commercial importance, but later developments disclosed only a short shoot of ore, and the prospect was abandoned. In 1912 attention was again directed to the field following the discovery of another, and more valuable, ore-body by one William Davie, and shortly afterwards further important discoveries were made on the adjoining Dundas-Cuni properties. The leases of Davie's sections were sold to the Melbourne Copper-Nickel Co., who conducted operations with marked success until the advent of the Great War. Success also attended the efforts of the Dundas-Cuni Company in their operations. This year another body of ore was located by one J. G. Devereau at a point half-a-mile to the south-west of the old Reward Claim. The mining of these ores cannot be regarded yet as an established industry, but developments show such encouraging results that preparations are now being made for their exploitation on a commercial scale.

(1)—*The Dundas-Cuni Mining Co.*

Area, &c.

The property of this Company now comprises mineral leases 6003-M of 80 acres, 4495-M of 77 acres, and 4496-M of 80 acres.

The Ore Bodies.

South Lode.—The ore consisting of pyrrhotite, chalcopyrite, and pentlandite occurs at the contact of pyroxenite and slate, and in places small offset deposits of lenticular shape are found wholly contained in slate. At the 75-feet level of the South shaft the length of oreshoot is 90 feet, apparently contained between two faults which dip to the south-west, and give a southerly pitch to the ore-body.

The ore-body has been explored to a depth of 75 feet, and a start has been made for the sinking of the main shaft to a lower level when events compelled the suspension of all operations. At the 75-feet level very little leaching has taken place and the prospects of the continuance of the rich ore are such that the proposed sinking of the shaft is justifiable.

Analyses of specimens of the ore from the South shaft workings show the following composition:—

	Sample No. 1.	Sample No. 2.
Copper	6·45 per cent.	4·6 per cent.
Nickel..............	17·08 ,,	12·7 ,,
Iron	32·85 ,,	37·9 ,,
Sulphur	35·26 ,,	39·9 ,,
Silica	1·63 ,,	1·30 ,,
Lime	—	1·90 ,,
Arsenic	—	0·05 ,,
Bismuth	—	0·01 ,,
Zinc	—	0·50 ,,
Lead	—	0·50 ,,
Gold	—	trace
Silver	—	trace

North Lode.—Towards the north boundary of section 4495-M a lode, two to three feet wide, is exposed in a shallow trench 60 feet long. A gossan capping, consisting of limonite, with a little azurite, malachite, and melanterite, gives place, at a depth of three feet, to unaltered sulphidic ore, which differs considerably from that of the South lode. A noticeable feature is the predominance of nickel sulphide over pyrrhotite, and in hand specimens chalcopyrite appears subordinate.

The ore-body occurs on the footwall side of a pyroxenite dyke, and rests on slate.

A shaft, 65 feet deep, penetrating the ore-body, set free the large quantity of water contained in and flowing through this vughy lode. Two pumps placed in the shaft were unable to cope with the heavy flow of water, and these workings, in consequence, were abandoned until pumping machinery of greater capacity could be procured. Up to the present time no further attempt has been made to unwater this shaft.

The prospects here are decidedly encouraging.

Another shoot of ore has been cut in a cross trench (No. 5) on section 6003-M. Where cut it is small and not of high-grade, but probably this represents the end of the shoot, as it was not cut in No. 4 trench. No further work has been performed to determine its extent and value.

Developments.

Developments consist of seven long cross trenches, several shallow shafts, and two large shafts for mining operations. Up to the present time the mining of ore has been confined to the South workings, and here to a depth of only 75 feet.

A considerable amount of driving and cross-cutting has been performed, and the greater part of the ore has been stoped between the working level and the surface.

Analyses of bulk samples of the ore in the south drive at 75-feet are as follows:----

Distance from Shaft in feet.	Width of Lode.		Copper Content.	Nickel Content.
	ft.	in.	Per cent.	Per cent.
25	4	3	7·58	6·0
34	4	3	4·2	9·17
40	4	0	5·0	8·0
46	2	6	3·7	11·72
52	0	6	2·9	8·0
59	0	2	—	—
62	3	0	4·1	9·0
67	4	6	—	—
78	5	0	—	—

At 67 feet the lode was 6 feet wide, of which 4 feet 6 inches was high-grade ore and the remainder quartz. At 78 feet there was 5 feet of ore on the west wall of the lode and 2 feet 6 inches of low-grade, siliceous ore on the east. Eight feet farther on, the ore on the west wall cut out, and at 96 feet the end of the east branch was reached.

Proposed Scheme of Operations.

It is proposed by the lessees of these properties to explore the ore-bodies at depth by means of drilling machines, before new mining works of any magnitude are undertaken. If the results of the boring are satisfactory, operations will be resumed at the south shaft with the steam-driven plant now in place. First, the shaft will be sunk to 150 feet and the ore-body explored at that level.

At the same time a commencement will be made with the equipment of the north workings for the unwatering of the shaft and the development of that ore-body.

Presuming that developments warrant it, a suction gas plant of 250 h.p. will be erected at the siding to generate electricity for the transmission of power to all the mines.

This policy of exploration and development is regarded as sound and such works are fully justified by the prospects.

Production.

Details of shipments of ore to Europe are as under:— 420 tons shipped 24th December, 1913, contained 5·53 per cent. of copper and 11·57 per cent. nickel; 10 tons shipped to London contained 5·12 per cent. copper and 10·37 per cent. nickel; 59 tons shipped to Europe contained 5·12 per cent. copper and 11·66 per cent. nickel; 20 tons contained 5·53 per cent. copper and 11·57 per cent. nickel.

Estimated quantity of ore in stock on 24th June, 1914, 680 tons.

The total production to date, 1189 tons.

Ore of the grade shipped to market was worth about £5 per ton at the mine in 1914.

Preparation of the Ore for Export.

No preliminary treatment was made originally in the preparation of the ore for shipment. It was selected by hand and bagged, and in that condition sent to market. It was found that shipment of the ore as it was taken from the mine was objectionable, owing to the concretive action induced by the rapid oxidation of the sulphidic mineral components, and also to the possibility of spontaneous combustion, resulting from the rise in temperature, following this chemical change. One shipment, at least, caught fire in transit. If the ore is exposed in heaps to the action of the elements it becomes so concreted by oxidation that explosives are necessary to break it up. When dry, the minerals composing the ore are fairly stable and can be stored with safety.

In order to prepare the ore in a condition safe for shipment the preliminary operation of heap-roasting was adopted. The subjoined table gives an idea of the change that takes place in the composition of the ore as the result of roasting in heap:—

(Quantity treated 145 tons.)

	Unroasted Ore.	Roasted Ore.
Copper	5·12 per cent.	6·3 per cent.
Nickel..............	11·28 ,,	12·3 ,,
Sulphur	37·3 ,,	22·2 ,,
Iron..................	34·0 ,,	41·6 ,,
Silica	2·16 ,,	2·6 ,,

Although this ore has ben profitably mined the cost of transport to market is a big tax on its value. Concentration of the ore to a much higher grade product is necessary, but concentration by physical means is out of the question. What is required, and what is proposed, is the erection of a small blast-furnace for the conversion of the ore into a copper-nickel-iron matte. The only difficulty presented is that of supply, in order to keep the furnace in continuous operation. By this treatment a high-grade product will be obtained and any precious metals in the ore will be concentrated in the matte and will be recoverable in the refining process. Metals of the platinum group and gold and silver concentrated in the matte will add appreciably to its value.

(2)—*The Melbourne Copper-Nickel Mine.*

Area.

This property is now held under lease by J. H. S. Munro, of Zeehan. It comprises one section only of 40 acres, the old Nickel Reward lease having been forfeited recently.

The Ore-bodies.

In every respect the ore is similar to that of the Dundas-Cuni lodes and occurs under similar conditions. There are two known ore-shoots, one 60 and the other 80 feet in length. The width varies from a few inches up to 10 feet, and the rich ore has been followed to a depth of 122 feet. In these bodies the ore occurs in lenticular masses. They pitch at an angle of 52 degrees to the south and have an easterly dip of 53 degrees.

Developments.

These ore-bodies have been explored by means of trenches, two shafts, and by five bore-holes. Owing to the water difficulty it was decided by the operators to carry out the preliminary exploration by drilling, as this method would prove not only more expeditious but less costly. In the performance of this work No. 1 bore-hole was drilled to cut the ore-body at a depth of 50 feet below the exposure at surface. From the collar the drill passed through intercalated bands of slate and tuff before entering norite and pyroxenite at 64 feet. On the other side of the dyke rock, 10 feet 6 inches of ore was found resting on the slate footwall. No. 2 bore-hole was drilled to cut the ore-body at 100 feet below the outcrop. Where cut the norite was found to only 12 inches thick and the ore only 10½ inches. The remainder of the lode consisted of quartz resting on a footwall of slate as before. No. 3 bore, sunk to intersect the ore-body at 200 feet, was fruitless. Likewise, no important result was obtained by the drilling of No. 4 bore, located 50 feet to the north of No. 1 and No. 5 bores; 80 feet to the south of No. 1 failed to reveal payable ore. In order to test the Blowfly ore-shoot, outcropping some distance to the north, two holes were drilled to cut the contact country 50 feet below the surface. These operations were unsuccessful; but, afterwards, 52 tons of ore from one, and 250 tons from the other, locality were obtained from shoots occurring in short lenses near the surface. This ore contained 12 per cent. of copper and 9 per cent. of nickel, an appreciable variation from that of the main workings.

Main shaft was sunk to 127 feet, and working levels were opened at 70 and 122 feet. Between the upper level, which was driven 27 feet in a northerly and 52 feet in a southerly direction from the shaft, 2500 tons of ore, containing 10·4 per cent. nickel and 5·2 per cent. copper, was obtained. At the 122 feet, or lower level, ore was not found at the end of the crosscut, it having cut out about three feet below the point of intersection of the No. 2 bore. Instead a 3-feet vughy lode of crystallised quartz, with chlorite and a little pyrite, was found. No ore was obtained in driving northward, but, to the south, it was met at 11 feet, and was followed 30 feet, showing an average width of 3 feet. A leading stope, 18 feet long, was taken out above this level.

Production.

Prior to the sale of this property, Davie and party obtained 73 tons of ore by trenching along the lode a distance of 83 feet. This ore was sold in two lots, the particulars of which are given hereunder:—

Dry Weight.		Composition.		Value.
Tons.	cwts.	Copper per cent.	Nickel per cent.	£
19	4	4·9	11·4	94
53	12	5·2	10·0	227

The purchases were made by Elder, Smith, & Co. on the following basis:—The sum of £5 5s. per ton was offered for ore (delivered in railway trucks at Zeehan) containing 5·3 per cent. copper and 11·8 per cent. nickel. To this sum 5s. was to be added to the price for each unit of copper and 12s. for each unit of nickel in excess of the amount stipulated, and 4s. 6d. was to be deducted for each unit of copper and 11s. for each unit of nickel below the standard percentage.

The Melbourne Copper-Nickel Co. in their 15 months' operations produced 2776 tons of ore, valued at £14,026. From this sum the cost of machinery was refunded and £9600 was paid in dividends to the shareholders.

It is estimated that there are from 1000 to 1500 tons of proved ore of similar grade. In addition, about 200 tons of high-grade ore is stacked at surface ready for shipment.

(3) *Devereaux Prospect.*

Area, Situation, &c.

Lease 8851-M, of 10 acres, has recently been granted to J. G. Devereaux for the mining of copper-nickel ore. Occurring half a mile to the south-west of Nickel Reward shaft, this is an offset deposit from the main line of lode.

The Ore-Body.

At surface a foot of gossan with zaratite (carbonate of nickel) rests on unaltered sulphidic ore, which, contrary to the general rule, contains a far greater proportion of copper than nickel. The pyrrhotite component is not at all prominent, and pentlandite, usually difficult to detect, is here easily recognised in specimens not rich in pyrrhotite.

The ore-body has been exposed in a few shallow holes, but no idea of its extent can yet be formed. At surface it is 12 to 18 inches wide, and appears to follow a northerly trend, in conformity with the general course of the other lodes. No trace of this body has been found in the railway cuttings to the north, and there are no gossan indications of its occurrence in that direction. How far it extends to the south can be determined only by trenching through the marshy soil cover.

About 20 chains to the east there are indications of another lode in a quartz outcrop. Another lode, consisting almost wholly of quartz, has been exposed on the 10-acre block. This has a north-west trend, and probably it is an extension of Devereaux's galena lode held by him under Lease 6952-M.

The following analyses carried out at the Mt. Lyell Company's works show the composition of the ore at Devereaux Prospect:—

	Sample No. 1.	Sample No. 2.
Copper	18·1 per cent.	14·0 per cent.
Nickel	5·5 ”	6·6 ”
Iron	27·5 ”	29·7 ”
Sulphur	24·8 ”	—
Cobalt	0·6 ”	
Silica	7·9 ”	—
Zinc	3·2 ”	—
Lead	trace	—
Bismuth	trace	—
Alumina	3·1 ”	—
Silver	1·4 oz. per ton	1·1 oz. per ton
Gold	0·02 ”	0·04 ”
Platinum	0·10 ”	0·16 ”

(4) *Nickel Reward Prospect.*

This section lies south and adjoining the Melbourne Mine lease, and the workings are situate in the angle formed by the crossing of the Emu Bay and North-East Dundas Railways.

This lode was discovered many years ago, and was explored to a depth of 20 feet by G. Beardsley, metallurgist to the Mt. Lyell Mining and Railway Company. The deposit occurs at the contact of slate and decomposed gabbro, and is very irregular in thickness and extent. Several parcels of ore were obtained from these shallow workings, containing 8 to 12 per cent. nickel, 3 to 5 per cent. copper, a little silver, and a trace of gold. The ore is composed principally of nickeliferous pyrrhotite, with also a little millerite.

In order to test this body at depth two holes were drilled by the Melbourne Nickel Company, who at the time held the lease of this ground. In both cases these exploratory works were unproductive of good results.

(5) *Leslie Prospect.*

Similar bodies to these just described have been exposed in shafts and trenches in the flat country extending southward to Leslie Junction. They are marked at surface by sinter and in places by large boulders of milky quartz, which indicate the replacement of a large portion of the nickel ores. The secondary ore of nickel (millerite) is found in some of the lodes associated with galena and sphalerite in siderite. Niccolite also occurs in that association.

None of these bodies, apparently, is of any value.

B.—NORTH DUNDAS AREA.

(1) *Moore Pimple Mine.*

The property is now held, under Lease 8989-M, of 80 acres, by F. W. Heritage and H. E. Evenden. It was held under lease many years ago, and the lode was worked for the lead and zinc ore it contains. Lately a little exploratory work has been performed to test its value as a source of nickel.

On the south side of Moore Pimple is a dyke of dolomitised serpentine trending in a north-westerly direction towards Montezuma Falls. On the track to Dundas this dyke-rock has been opened by means of trenches, exposing the ore for examination. The rock is coloured a deep sea-green by zaratite (carbonate of nickel), which, however, occurs in very small proportion. Bulk samples of the material contained 0·15 to 0·25 per cent. of nickel. A little chalcopyrite and a larger proportion of pyrite occur in veinlets and blebs through the rock, but sulphide of nickel is not present. Zaratite impregnates quartzite and slate on one side and quartz conglomerate on the other.

Below the track, on the north side, a low-level tunnel has been driven 330 feet in an easterly direction—270 feet in slate and quartzite and 60 feet in altered serpentine. At the point of contact (270 feet) a 3-inch vein of gossan containing a little galena appears. This vein was driven on 40 feet in a southerly direction, where it widens, but is not rich. At the end of the adit is a 6-inch vein of gossan, in which are found slugs of galena. The gossan capping has been exposed in small open-cuts in which a little galena appears, and in the large ferromanganese outcrop farther south iron and copper pyrites, galena, and crocoite occur in small proportions. The ferromanganese gossan has been derived largely from the serpentine intrusive by infiltration, and does not indicate the true nature and size of the ore-body below.

It may be stated that the prospect is not likely to prove of any commercial value.

(2) *Montezuma Deposit.*

The northward extension of the Moore Pimple dyke is crossed by the railway-line on the north side of Montezuma Falls. Here the dyke is 25 feet in width, and it dips easterly at an angle of 75 degrees. A large body of pyrite is exposed in the railway cutting and in an adit driven from rail-level in a southerly direction. The pyrite is contained in dolomite stained green with zaratite. Below the railway bridge the dolomitised serpentine is of an intense green colour, but the proportion of nickel is too small to allow of successful exploitation.

B.—Tin Mines.

Tin ore, in an unusual association, is worked in the Razorback Mine near Dundas township. Its extent here has not been determined, but in a northerly direction its occurrence in alluvial deposits indicates the presence of other shoots on the same line of lode.

Tin ore associated with intrusive porphyry is found at Pine Hill and again at Fraser Creek. These bodies have been worked, the first mentioned still receiving attention. A description of the ore-bodies on the Renison Bell and Central Renison Bell properties is appended. These mines are actually outside the bounds of the district, but as the reports present a new interpretation of the structure of the deposits, and have not been recorded, their inclusion here is considered advisable.

A.—CENTRAL DUNDAS AREA.

(1) *The Razorback Tin Mine.*

Introduction.

On the 26th day of April, 1909, a reward claim of 10 acres was granted to P. P. Quinn for the discovery of tin ore at Dundas. The honour attached to the discovery is shared by Peter Hodge, his partner, who assisted also in the preliminary operations of development. This property had been held under least for lead and silver and iron oxide by many parties during the past 30 years, and ever since it has been known that tin only of the commercially important metals is found there, the ownership has changed several times. A lease of the property was ultimately obtained by O. C. Kingsley, who, with his partner, E. Woodward, subsequently recovered several tons of tin ore in sluicing the detritus of the ore-body.

In 1918 A. M. Page and C. Wood, securing an option of purchase, formed a small company known as "The Peace Tin Mining Syndicate" for the purpose of erecting the necessary machinery and developing the mine. Before these works were fully accomplished funds became exhausted and operations were suspended. Last year a controlling interest in the mine and plant was purchased by J. L. Frizoni, who, under agreement with F. Johnson and party, has since been successfully operating the mine on the share system.

Area, Situation, &c.

The property comprises Mineral Lease 7771-M, of 80 acres; Machinery Lease 8243-M, of 5 acres; and Water Right Lease 2036-W, of 10 sluiceheads.

The southern boundary of the mineral lease is only 8 chains from the Dundas Railway, and not more than half a mile from the township. Zeehan, the chief mining centre of the western district, is 6 miles distant by rail, and is connected with the ports of Strahan and Burnie and with the chief industrial centres of Tasmania.

The industrial activities of Dundas in the past depended upon the production of iron and manganese oxide fluxing material and silver-lead and zinc ores. Since the closing of the works of the Tasmanian Smelting Company at Zeehan the township has been abandoned by all but a few of the residents, and many houses are now vacant. The population of Dundas is now only 25, and there is housing accommodation for 100. A train runs from Zeehan one day (Friday) a week.

The Tin Ore-Bodies.

Tin oxide ore (cassiterite) is at present the only product of the Razorback Mine. It occurs at or near the contact of slate and serpentine, and, in the unoxidised portion of the lode, always associated in intimate relationship with arsenopyrite, pyrrhotite, and quartz. The first change noticeable in the sulphide ore is that of pyrrhotite to marcasite (there termed pyrites), followed by the separation of the arsenic as oxide, the rapid conversion of iron sulphide to sulphate, and ultimately into limonite or gossan. The oxidation of the sulphides and the dissolution of the sulphates by percolating waters bring about the release of the cassiterite and the binding of cellular quartz which appears as gritty friable material resembling ashes. Where the " ashes " appears in the oxidised portion of the ore-body the tin content is invariably high. Incipient oxidation of the ore out of contact with air results in the transformation of pyrrhotite into marcasite and part of the arsenopyrite into orpiment. When these secondary minerals are brought into contact with the air, oxidation is intensified, and the material rapidly disintegrating, releases the contained tin ore. Cellular ferromanganese oxide generally represents the oxidation product of mangano-siderite and is usually devoid of tin.

In addition to the common accessory minerals, the ore contains crystalline chromite, a foreign mineral derived from the serpentine gangue. It is not easily perceptible in unwashed material, but it shows up prominently on the concentrating tables.

The ore here found occurs in a lode at or near the line of contact between slate and serpentine. The lode material consists dominantly of ferro-manganese oxides and quartz, and is essentially of the replacement-fissure type. It is of great extent and width, passing in a north-north-west direction through this and the adjoining property. Ore occurs in the lode in shoots, erratic in size and distribution and likewise in value. The shoots dip north-easterly at a fairly high angle, and pitch northward at an angle of much lower degree. Their location appears to be governed by the occurrence of cross-fractures, which form an angle of 45 degrees with the strike of the lode and the dip of which gives pitch to the shoots. It seems reasonable to assume that at such junctions the greatest deposition took place.

Development

Exploratory works consist of a large number of deep trenches, cut at regular intervals across the outcrop of the lode over a distance of 2000 feet, and two shallow shafts. Developments of a more permanent character consist of seven adit-crosscuts with occasional short laterals driven on the course of the lode. These are all indicated on the accompanying plan. In addition to these works, the main ore-shoot has been well exposed in two open-cuts, one of considerable dimensions, from which supplies are now being drawn for treatment in the milling and concentrating plants.

No. 1 adit, driven on a north-westerly course, penetrated the ore-body at 130 feet and passed through it at 140 feet from the entrance. The ore-body consists of ferromanganese oxide and interlacing quartz, and is contained in massive crystalline talc. Where intersected the ore contains very little tin. At 169 feet the dark-grey slate wall-rock is entered, and the adit penetrates it a distance of 29 feet.

No. 1 *Open-Cut.*—This is the most important work yet performed on the property. The opening is 80 feet long and 50 feet wide at the top, converging to 25 feet at a depth of 30 feet from the original surface. With the exception of a few wonderfully rich boulders of sulphidic material, the ore here is completely oxidised and very soft. The width varies from 6 to 12 feet, and is becoming narrower in the northern end of the cut. It is not expected that this shoot will continue much further northward at that level, as it pitches sharply in that direction. Below the floor of the open-cut, two shallow winzes have been sunk on very rich sulphidic ore, but very little has been removed. One of these winzes is accessible for inspection.

Forty feet below this open-cut, No. 2 adit passes through the southern end, but does not reach the ore-body. At the time of the examination this adit was not accessible. According to report the end is in very hard dolomite, which effectively arrested progress and caused the operators to attack the ore at another point. As the ore-shoot pitches northward, this adit, if continutd on its present course, would not intersect rich ore.

No. 3 adit is 136 feet long, and bears a little south of west. It passes through a body of massive talc and dolomite before reaching the lode, which here contains pyrrhotite and pyrite. The value of the ore here is not known.

No. 4 adit was driven directly underneath a body of rich ore exposed in a trench at the summit of the ridge. It is parallel to No. 3, and reaches the slate footwall at 193 feet. At 140 feet a rise was cut to the surface. Rich ore occurs in the rise from the outcrop to 20 feet, where it passes on its northerly pitch. Analyses in the table indicate the value of the material between the rise and the slate wall-rock. An inch band of grey selvage on the slate wall is rich in tin ore; this was not sampled. (It is worthy of note that the wall of contact between the serpentine and slate is nearly upright wherever it has been exposed for examination.) The ore here is completely oxidised, and consists largely of ferromanganese oxides.

No. 5 adit has not exposed any payable ore. At 56 feet massive serpentine gives place to decomposed lode material, which continues to the end at 115 feet.

No. 6 adit was driven 121 feet on a bearing of 278 degrees. At 24 feet hard, dark-green serpentine gives place to soft, impure talc, and at 70 feet a 4-foot band of gossanous lode material is entered. This abuts hard cherty quartz, evidently a complete silicification of serpentine, which continues to 121 feet. No. 7 adit was driven many years ago by prospectors for silver-lead ore. It is situated on the other side of the ridge. From the main crosscut, bearing 75 degrees, a drive leads on a course of 20 degrees on a band of friable quartz. The slate wall is left a few feet from the entrance, and is succeeded by talcose material to 70 feet, where a 10-foot band of friable quartz breaks the continuity of the decomposed serpentine. Farther ahead the adit is not accessible.

These constitute all the works of any importance. As crosscuts they have a prospective value, but they have been cut without regard to geological conditions. The situation of these works clearly shows that the operators considered that the rich ore at the outcrop would continue directly below, whereas the short shoots of ore have a northerly pitch, and the adits therefore pass below them. It is a striking fact that not one drift has been cut on the lode from any adit crosscut. In so far as the investigation has been carried there appears to be no reason why other shoots comparable in richness with that exposed in No. 1 open-cut should not be found. Such shoots are indicated along the outcrop at several points, and should be explored immediately on the line of pitch.

The following analyses are representative of samples taken at the mine, not for the purpose of ascertaining the value of the mine as a whole, but to determine the grade of material at the two points of operation. A systematic sampling could not be undertaken in the time available. Calculations based on these analyses cannot be made because development has not been carried far enough to estimate the quantity of ore at the points mentioned.

Table of Analyses

No. of Sample.	Description of Material.	Place at which Samples were taken.	Width of Ore Sampled.	Tin content.
			feet.	per cent.
173	Ferromanganese oxides	At rise, No. 4 adit	4	0·20
174	Ferromanganese oxides	West of rise, No. 4 adit	15	0·18
175	Quartz & ferro-manganese	West of No. 174	5	0·08
176	Decomposed serpentine	At end of No. 4 adit	3	0·10
177	Gossan	South end of No. 2 open-cut	4	2·15
181	Decomposed serpentine and marcasite	End of small prospect drive below No. 2 open-cut	3	0·18
182	Gossan & quartz	East of No. 181	3	0·89
183	Gossan & quartz	East of No. 182	5	1·07
184	Decomposed serpentine	South of No. 183	6	0·05
185	Decomposed serpentine	South of No. 184	6	0·05
186	Gossanous serpentine	South of No. 185	6	0·66
187	Marcasite	North of No. 186, end of winze	3	0·84
188	Gossan	North end of No. 2 open-cut	4	0·51
189	Gossan	East of No. 188 in open-cut	4	3·51
190	Gossan	East of No. 189 in open-cut	4	0·79

Samples 173 to 176 were taken from the ore-body and wall-rock exposed in No. 4 adit. This adit was driven directly underneath a rich body of ore exposed in a trench on the summit of the ridge. The small proportion of tin in the lode material at adit-level indicates that, in accordance with other occurrences here, the ore-shoot pitches in a northerly direction at a high angle.

Samples 177 to 190 indicate the tin content of the ore-shoot exposed in the open-cuts and workings a few feet below.

The Milling and Concentrating Plant.

The milling section of the plant consists of a battery of ten stampers, each weighing 800 pounds, and a Forward-Down grinding pan. The stamp-battery is of the old screw-head type, but is fairly efficient and capable of much useful work. The grinding pan is of late design, and is in good order.

The crushed ore is concentrated on two Card, one Wilfley, and one Curvilinear table, and the slimed material is further treated on a canvas strake. Accessories to the plant consist of hydraulic classifiers and a sand-pump.

The plant is driven by means of a low-pressure turbine, operating under a head of 40 feet. Water is obtainable from Dundas Rivulet over a mile upstream, and conveyed to the plant in a well-constructed ditch and flume at the rate of 200 cubic feet per minute. This supply is insufficient for the purpose, as the battery and grinding pan cannot be operated together; but at the intake of the water-race a dam of large capacity could be constructed, thereby providing an ample storage during the periods of low rainfall.

The milling and concentrating plant is incomplete and not well designed, but the machinery will serve as a nucleus for the modern plant which it is proposed to erect shortly. Owing, in the first place, to the clay nature of the matrix and to the fine grain of the ore, and also to the inefficiency of the plant, the loss in treatment is heavy, and is estimated at not less than 40 per cent. These losses could be greatly reduced by the addition of more slime-saving appliances and large settling vats, and by the provision of another power unit to operate the concentrating section independently, and thus ensure smooth running conditions. The containing rock, consisting largely of talcose material, passes through the battery very quickly, being easily reduced to slime, thereby causing overloading of the tables. This difficulty is aggravated by the lack of settling tanks, which should be used to remove a large portion of the waste material held in suspension by the water. Despite the heavy loss, no serious attempt has been made to arrest the tailing sands in boxes or in dams for further treatment.

Only five heads of stamps were employed by the tributers, and the battery was in operation for 80 days only last year. The average crushing capacity of the mill is 11 tons per day of eight hours.

Transport and Water-Supply.

Ore is transported from main open-cut to the treatment works in a truck of $1\frac{1}{2}$-ton capacity, running on a wooden-rail 2-foot gauge tramway. The grade of this tramway, which is 28 chains long, is so steep that the brakes have to be applied to the trucks all the way. A horse draws the truck on the return journey to the mine. A stout horse is employed for this work, and the strongest animal requires two stoppages for rest on each journey. By this means as many as 25 truckloads have been conveyed in eight hours. A lower level steel-rail tramway on a gentle grade would make light work for the horse, double the capacity, reduce the cost by half, and enable the operators to erect storage bins at the mine. Part of the formation of a low-level tramway has already been completed.

Reference has already been made to the water-supply, and there is little further to add. During all seasons of the year the supply for the milling and concentrating plants is ample, but not for power purposes. The suggestion is offered that the concentrating machinery be run by water power, and that a Diesel oil-engine be employed to drive the crushing and grinding machinery. This would obviate the necessity for dam-construction, and allow the present mill site to be retained. The adoption of this plan would provide facilities for continuous operation and perfect control.

Production

No details are available concerning the production of tin ore from this mine during the early period of its development, but it is reported that in sluicing the detrital material P. P. Quinn and Peter Hodge saved five tons of concentrated ore. The records during the Kingsley regime are incomplete; details concerning the operations of the Peace Syndicate, however, are available and are given herein. Since its acquisition by J. L. Frizoni and party, it has been worked with advantage to all concerned on the leasing system. The lease applies to oxidised materials only, and is tenable for two years, of which one year has already expired. Under the agreement the lessees receive wages at the rate of 14s. per diem, and, after deducting the total amount, the remaining portion of the revenue is equally divided between the lessee and the lessor. Renewals of plant are paid out of general revenue, but all other expenses are met by the lessee. Under this arrangement a profit of 16 per cent. on working costs has been made. Since April of last year the work of four men has produced ore to the value of £1020. Actually production commenced at the end of June, as a large amount of preliminary work had to be performed before the ore could be attacked. The tin content of the crude ore mined and milled is shown in the table given hereunder. In this table no account is given of the ore won in sluicing the detrital material.

Table Showing Quantity and Value of Tin Ore Produced.

Date.	Name of Producer.	Condition of Ore.	Quantity of Crude Ore Milled.	Tin Content of Crude, Ore per cent.	Number of Bags.	Weight of Parcel.				Tin Content of Concentrate, per cent.	Value at Mine.		
			Tons.			Tons.	cwt.	qrs.	lbs.		£	s.	d.
—	Kingsley & party	Lump	—	30 to 60	—	4	2	0	0	30 to 60	*360	0	0
1920	Peace Tin Synd.	Concentrate	-	—	—	0	3	2	1	70·0	28	17	2
1920	Peace Tin Synd.	Concentrate	—	—	—	0	10	2	23	67·0	84	1	1
1920	Peace Tin Synd.	Concentrate	—	--	—	0	8	3	11	60·0	53	8	5
1923													
9 June	Johnson & party	Concentrate	—	—	9	0	9	1	15	67·1	50	1	1
24 Aug.	Johnson & party	Concentrate	265	0·51	27	1	7	0	6	65·8	149	9	4
14 Sept.	Johnson & party	Concentrate	51	1·17	12	0	12	0	18	70·0	68	12	5
28 Sept.	Johnson & party	Concentrate	125	0·6	15	0	15	0	13	71·3	92	13	7
12 Oct.	Johnson & party	Concentrate	80	0·9375	15	0	15	0	17	71·8	93	3	11
2 Nov.	Johnson & party	Concentrate	93	1·34	25	1	5	2	0	71·6	166	19	10
7 Dec.	Johnson & party	Concentrate	136	0·88	24	1	4	3	6	70·9	176	7	4
21 Dec.	Johnson & party	Concentrate	124	0·766	19	0	19	3	21	69·1	148	2	3
1924	Johnson & party	Concentrate	—	—	8	0	8	1	9	69·4	74	17	2
					Total...	13	2	2	0	...	£1546	13	7

* Estimated value.

Ore Reserve.

On the basis that a body of ore is required to be open on three sides to estimate the quantity in sight, the ore reserve is very small. Under the present system the lessee cannot be expected to keep development well ahead of mining—to look a month ahead is sufficient for his purpose. The lessor, likewise, cannot undertake the necessary work of development and intends to seek outside assistance. A very considerable outlay is necessary in order to ascertain the true value of the property and to provide additions to the plant. At present on the rigid basis mentioned, the reserve is not more than 200 to 300 tons, but the probable reserve, of course, is very considerable.

The value of the crude ore cannot be estimated because of the rapid variations from point to point. In an ore-body of this kind, value based on production is the only sound guide. From the table it will be seen that the proportion of tin (metallic) in the crude ore varies from 0·51 to 1·34 per cent.

In the sulphidic ore exposed for examination, the proportion of tin is much higher, some of it being of extraordinary richness; but the extent of this grade of ore is not known. In the early stages the tributors rejected everything save the richest boulders of sulphide ore.

Although the lode continues unbroken over 2000 feet in length, and is from 5 to 30 feet in width, pay ore occurs only in short shoots separated by lode materials almost barren of tin.

By-products.

Some of the sulphidic ore contains a large proportion of arsenic, the saving of which in future operations on a more extensive scale may be worthy of consideration.

This depends in the first place on the quantity available, and also on the ultimate necessity for a calcining plant when the oxidised ore shall have been removed and the sulphidic zone shall have been entered.

The oxidation of arsenopyrite, if associated with marcasite under natural conditions is very rapid and is sufficient to set free the contained tin ore; but it must be kept in mind that the zone of primary sulphides, where pyrrhotite takes the place of marcasite, lies at no great depth below the surface. If developments warrant it provision should be made for the treatment of an ore consisting largely of pyrrhotite. Assuming that a calcining furnace becomes a necessary adjunct to the existing plant, long flues should be attached to collect the arsenious oxide that volatilises in the process of roasting.

The roasted ore, after having been reground and treated on concentrating tables for the tin ore it contains, becomes of value as a paint material. The complete oxidation of pyrrhotite and arsenopyrite, whether under natural conditions or by the direct application of heat, produces a red pigment of considerable value. If this residual material is dumped and exposed to the atmosphere for a few months, the colour deepens in tone and the value is enhanced accordingly.

The arsenious oxide and the iron pigment may prove valuable by-products in the process of tin-ore concentration—that depends upon the quantity and quality.

A selected specimen of tin-ore with arsenic was composed of:—

	Per cent.
Silica	8·60
Ferric oxide	22·06
Alumina	1·94
Lime	Nil
Magnesia	2·89
Arsenic	20·93
Antimony	0·43
Tin	11·33
Sulphur	0·13
Loss on ignition	21·80

The analysis is interesting in showing the comparative proportion of the various constituents.

Chrysotile Deposits.

On the eastern side of the section the chrysotile variety of serpentine is fairly abundant. Chrysotile comprises the bulk of what is locally termed asbestos, and usually occurs in the form of slip-fibre several inches in length. In dry condition it does not present many peculiarities, having a silky texture and yellowish-green colour; but in wet condition the lustre increases to a light golden sheen, and in appearance and feel the mineral becomes like the fresh skin of a sheep.

The composition of the chrysotile occurring here, that obtained in the Beaconsfield district, and that in Canada is given hereunder for the purpose of comparison:

Constituent.	Dundas.	Beaconsfield.	Canada.
SiO_2	32·80	42·80	39·20
Al_2O_3	3·83	2·24	0·99
Fe_2O_3	4·64	2·01	2·97
FeO	8·44	3·03	4·02
MgO	27·52	41·86	44·02
MnO	0·90	8·46	8·85

Loss of H_2O at 100° C. 6·30
" " " 150° C. 1·70
" " " 250° C. 1·50
" " over 250° C. 12·70
} 22·20

The proportion of water is high, but over six per cent. is hygroscopic. The iron constituent is also very high, and the proportion of alumina above the average. However, it has the same properties of high tensile strength, flexibility, and fineness of fibre possessed by the Beaconsfield mineral.

Picrolite, the peculiar splintery variety of serpentine of no commercial value, is associated with it.

Chrysotile is notoriously erratic in occurrence. In small areas it appears to be prominent, but no works of any kind have been performed to ascertain its extent and value. Serpentine containing less than two per cent. of chrysotile is of no commercial value at present market rates.

Talc Deposits.

Large bodies of massive talc, resulting from the alteration of serpentine, have been developed on the hanging-wall side of the ore-body. The mineral is white to light pink in colour, the variation being due to the presence of rhodonite. It is well exposed in No. 3 adit where it attains a width of 30 feet, and is there associated with dolomite. An analysis of an average sample showed the following content:—

Silica	SiO_2	47·56	per cent.
Ferrous oxide	FeO	1·12	"
Ferric oxide	Fe_2O_3	4·00	"
Alumina	Al_2O_3	1·46	"
Manganese dioxide .	MnO_2	1·58	"
Lime	CaO	5·90	"
Magnesia	MgO	26·75	"
Water	H_2O	13·00	"

Talc of this composition and quality can be applied to a number of uses and should find a ready market. The presence of so much iron, however, prevents its application to switch-boards and other electrical uses. All the talc, except that stained with extrinsic iron oxide, grinds to a white powder free from grit. It is suitable for cutting into pencils and for cutting into the many kinds of vessels for which talc is used.

(2)—*Section* 3756-*M*.—*Lessee, Peter Hodge.*

This is a 20-acre block lying north and adjoining the Razorback property and on the same line of lode. It occupies the northern extension of Lewis Hill, a low ridge flanking Razorback Mountain.

Like the occurrence just described, the lode here is of the replacement-fissure type and occurs close to the line of contact between serpentine and brecciated slate and conglomerate, which also is impregnated with tin ore. The main ore-body is 20 to 30 feet wide and consists dominantly of limonite and interstitial quartz with a little cassiterite. Manganese oxide is not at all prominent in any part of the ore-body. (The presence of much ferro-manganese oxide is often indicative of a manganese-siderite origin in which tin ore is not found in profitable proportion.) The limonite suggests a derivation from pyrrhotite, a common companion of tin ore.

The intrusion of the serpentine is probably responsible for the brecciated condition of the wall-rock. Into this crushed material, tin-bearing solutions found easy access, depositing their burden in the interstices between the detached particles. Thus were formed the blebs and veinlets of clean ore exposed in sluicing the detritus of the brecciated rock. In these deposits pyrite takes the place of pyrrhotite as the associated mineral. This formation has provided the bulk of the ore won on the section.

The principal development is an adit crosscut which passes obliquely through the main lode near the entrance and continues 150 feet further into the brecciated wall-rock. A drift leads from the adit-crosscut along the foot-wall of the lode, but has not revealed ore of commercial importance. It is stated that fair prospects were obtained at many points in the crosscut, but this was not verified. The other development works consist of a small open-cut and one or two trenches.

Sufficient work has not been performed to test the value of the deposits. Prospecting along the course of the lode by adit is recommended as the cheapest and most expeditious way of obtaining the desired information.

(3) *Great Nevada Lode.*

Many years ago, in the early history of the Dundas field, a considerable amount of exploratory work was performed on three sections leased by the Great Nevada Company to test the value of a large outcrop of ferromanganese gossan coursing N. 50° E. This lode has been traced over 20 chains, but no concentrations of lead ore of any kind were found at any point. An adit exposes a very wide ore-body consisting of ferromanganese gossan and quartz.

At the time these works were performed tin ore was not known in the district. The high proportion of quartz suggests the possibility of tin ore-shoots in the lode, and the occurrence of alluvial tin ore nearby may be regarded as confirmatory evidence in favour of that idea.

(4) *Section* 3558-M.

In Melba Flat alluvial tin ore has been worked up to a large gossanous ore-body that crosses through Section 3558-M. This ore contains tin in small proportion. It evidently represents the northward extension of the Razorback line of lode, and, like that, the shoots of rich ore are probably short and occur at long intervals. The lode passes through Section 2339-M—where it has been trenched—and continues southward towards Razorback Hill. A fairly large quantity of tin ore has been won in sluicing the gravels in the bed and banks of Nevada Creek. Its source has not been found, but doubtless it has been shed from the same lode farther eastward. The occurrences of alluvial tin ore marks the positions of shoots in the main lode.

B.—PINE HILL AREA.

Penzance Mine.

This area has been the subject of brief mention in the daily press and of articles in the mining journals at many times. The earliest record is contained in "The Zeehan and Dundas Herald" of 13th November, 1893. In that issue of the newspaper reference is made to the discovery of the famous Gormanston nugget by Thos. Strong and R. Bennett, prospectors in the employ of the Gormanston Tin Mining Company. The following dimensions were given:—Length, 3 feet 4 inches to 5 feet; width, 3 feet 6 inches; thickness, 1 foot 4 inches; and the weight was computed at 19 cwt. Accompanying this nugget were many others of similar character but of smaller dimensions, from 50 to 250 lb. in weight, containing tin in the proportion of 60 to 65 per cent. These boulders of tin ore were found in the bed of Gormanston Creek reposing on iron-cemented detritus and covered by talus materials from the quartz-felspar-porphyry cliffs of Pine Hill.

The largest nugget was purchased by the Government for £50, and was shown at the Hobart Exhibition in the year 1894. It was then placed in the Museum, but lately it has been added to the collection of minerals for the British Empire Exhibiton.

Since the time of the discovery many attempts have been made to locate the source of the nuggets and to uncover the lode that shed them. Interest in the occurrence has been revived of late, following the discovery of many similar boulders near the base of the talus 50 feet west of Gormanston Creek. With the object of assisting the prospectors in their search, the writer was detailed to investigate the area and report the result of his researches to the Mines Department.

Geography.

Situation and Access.—Pine Hill area is the southern quarter of Renison Bell tinfield, and is 3 miles distant from the settlement of that name. Zeehan, which has a population of 3000, is the supply centre, and is only 11 miles distant by rail. From Zeehan the area is easily accessible by the Government-owned North-East Dundas Tramway, of 2 feet gauge, by way of Confidence Saddle, or by the Emu Bay Railway Company's Railway through Renison Bell. The railway system connects with the port of Strahan on the West Coast, and with Burnie on the North.

Physiography.—This is the part of a high mountainous area traversed in a northerly course by numerous tributaries of the Pieman River. Precipitation is heavy and fairly general throughout the year, and most of the streams, even the minor ones, are perennial. After uniting to form the Ring River to the east and Argent River to the west, both stream systems flow northerly to the main channel beyond Renison Bell. Commonwealth Hill, on the western side of the area, rises 2100 feet above sea-level, and Pine Hill is nearly 1900 feet in altitude. The hillsides are very steep, even precipitous, and the lower slopes are covered deeply with talus from the porphyry backbone of the hill. Investigation has shown that there have been three distinct slides of talus material from the base of the porphyry cliffs on the north side of Pine Hill. These materials have completely covered the rock-formation and the contained lodes, thereby impeding exploration.

Geology.

General Features.—The rock formations include several thousand feet of Cambro-Ordovician slates, sandstones, and tuffs belonging to the Dundas series of sediments. They have been intruded by dykes of Devonian gabbro, gabbro-amphibolite, and pyroxenite, and later by narrower dykes and sills of quartz-felspar porphyry. The basic and acidic intrusive represent two distinct products of differentiation from one stock magma. The gabbro-pyroxenite intrusion was unaccompanied by mineralising solutions, and had little effect on the invaded sedimentaries; but the later intrusion of porphyry, besides introducing the ores of tin and other metals, greatly affected the sediments, and, near the line of contact, completely transformed the basic dyke-rock. The comparatively large basic dyke trends in a south-westerly direction, whereas the acidic dyke, which intersects it, strikes in a south-easterly direction. These intrusions caused two sets of fractures, each parallel to the course of the respective dykes, and consequently nearly at right angles to one another. At Pine Hill the regular course of the porphyry dyke is disturbed, and the width there is much greater than elsewhere. Connected with the main body are several sills which have a general north-easterly dip at angles of 40 to 50 degrees, and on the northern side they have a crescent-shaped outline. Below this embayment the large nuggets of tin ore were found.

Nature of the Ore and Its Occurrence.—Gormanston nugget and all the smaller nuggets of tin ore found with it in the bed of the creek, and also the rich boulders recovered by Coleman in sluicing the porphyry talus immediately to the west thereof, are quite unlike the specimens found in direct association with the porphyry dykes. The former are all of extremely fine grainsize, intimately associated with equally dense greenish-black tourmaline and hard bluish quartz. In occasional cavities the cassiterite is coarser and well crystallised, in a felted mass of extremely fine acicular crystals of tourmaline. As a rule the tin ore occurs in blebs and patches with the quartz and tourmaline, but disseminated ore is always in evidence. The boulders are angular and sharp-edged, showing little sign of attrition. They exhibit all the characteristics of replacement phenomena, simulating the habit and texture of the replaced rock. Careful examination shows that the original rock was of basic character conforming to gabbro-amphibolite, and in places serpentine. The talus materials in which these boulders of tin ore occur overlie decomposed basic rock, but, strangely, no dolomite is reported. This is extraordinary, as in the process of transformation the dolomite phase is usual. Farther removed from the porphyry intrusive, actinolite and fibrous magnetite with a little axinite, have been developed at the expense of the original basic rock.

The cassiterite (tin ore) directly associated with the porphyry dykes and sills is of quite different character. It is coarse-grained as a rule, sometimes in well-developed drusy crystals, and is commonly found attached to altered porphyry. Perfect pseudomorphs of cassiterite after felspar are so common as not to excite attention. These replacements usually occur near fissures and joints in the porphyry or near the line of contact. Where cassiterite is abundant the bluish-green zeuxite variety of tourmaline is highly developed and replaces the original felspar component of the rock. Topazisation of the felspar, and even of the quartz, is prominent at certain points. It may be taken as a safe criterion that the occurrence of zeuxite is indicative of the near presence of cassiterite.

The Ore-Bodies.—Tin-bearing ore-bodies occur on all sides of the main mass of porphyry at Pine Hill, and some of them actually intersect both dykes and sills. These ore-bodies have been explored by means of trenches and adits, but none of the exposed deposits has proved of phenomenal richness at any point. In this, as in every other mine in the district, the work of exploration has not been designed to the best advantage, consequently the ore-bodies may still be regarded as unprospected, and their value unknown. On the accompanying plan the several ore-bodies are marked, and the workings are shown, but that from which the nuggets were derived is not indicated, because the precise position is unknown. It is a north-easterly bearing lode, passing close to the dam near the south-east corner of Heywood's block, and may be connected with the ore-body exposed in No. 10 tunnel. On this line a rich tin-bearing vein passes through the porphyry sill.

It will be noted that there are two groups of lodes and veins, one coursing east of north, the other west of north. One group represents lode fissures, the other fault fissures. Where a fault fissure intersects a lode fissure, material rich in tin ore occurs, and the other part of the lode is comparatively poor. It is not uncommon to find several fault fissures traversing one lode fissure, in which event recurring shoots of ore may be looked for. Some of the ore-bodies have not been traced far, but others have been proved to extend half a mile. The lode on Carlson and Riley's section, for instance, extends beyond No. 11 tunnel, south-east of Albury's block, more than half a mile.

In a cutting and shaft near the western boundary of Albury's block, a very rich body of tin ore occurs. It is, however, comparatively small, and not of much importance. Nearby, in No. 9 tunnel, rich stone was obtained from a shoot nearly 100 feet long, but as the workings were continued north-easterly in quartz-felspar porphyry instead of along the line of contact, the tin ore petered out. It should be noted that the fresh felspar in the porphyry at this point clearly shows that mineralisation was not important. If it had been, the felspar would have been transformed into tourmaline, or topaz, or cericite.

Fairly rich ore was obtained from veins intersected in Nos. 1 and 3 tunnels, but developments generally were discouraging.

The most important of the known ore-bodies are contained in porphyry. One of these trends in a north-westerly direction from the summit of Pine Hill, and is clearly indicated by a broad, white line of secondary quartz associated with zeuxite. These veins have shed most of the alluvial ore found in Penzance Creek. The so-called actinolite-magnetite lodes are not likely to contain important bodies of ore.

As the actual purpose of the visit was to locate the source of the Gormanston Creek boulders of tin ore, attention was directed particularly to that end; but, in so far as time allowed, a survey of the whole area was attempted. For certain reasons, which will be given later, it is considered that the north side of the hill presents the most encouraging features, and on that side the nuggets are found. These nuggets are confined to a narrow strip embracing Gormanston Creek and Coleman's open-cut, a width of 300 feet. Many years ago, in sluicing the "wash" lower down the stream, many large nuggets were recovered, but these evidently were carried there by flood waters, and were derived from the same ore-body as the Gormanston boulders. The size, richness, and nature of these boulders, their association with large blocks of sulphidic material consisting of marcasite, chalcopyrite, and arsenopyrite, and their unworn appearance, suggest that the parent ore-body is dominantly sulphidic, that it occurs in the immediate vicinity south of Coleman's workings, and that sections of it are unusually rich in tin ore. It appears at first glance that the winning of this prize should prove such a strong incentive to exploration that a sustained effort would be made, but when it is realised that the water-supply at this elevation is very small, and that the covering of detritus and talus material is very deep, the reasons for the failure of the operators is at once apparent. However, the prospectors are mindful of the importance of their work, and are prosecuting the search by the gradual removal of the covering material. They are working in the right direction, albeit very slowly.

The conclusions arrived at in this report are based on the evidence which follows.

The hummocky nature of the topography clearly indicates a number of landslides. Proof or this is found in examining Albury's and Coleman's workings in the talus material, where slickensides are sharply marked and the broken rock is distributed in tumultuous confusion. The section in Coleman's workings, which follows a narrow ridge, may be employed in explanation of these occurrences. The upper part of the section is represented as an inverted segment showing 4 feet of broken porphyry resting on 12 feet of dun-coloured material derived from decomposed basic rock. The slickensides on the bottom and sides of this material, and the presence of much oxide of iron dividing it from the underlying porphyry and lode detritus, show that the ridge occupies the course of an old gutter. A little tin ore occurs in the upper bed of porphyry boulders, very little in the clayey material, but very considerable in the lowest bed, on and in which are also found the large nuggets. It appears that the gradual disintegration and removal of the lode materials and the soft containing rock resulted in the undermining of the sharp ridge of porphyry on Pine Hill, and its partial collapse. The landslip that followed passed over the lode, carrying with it large blocks of tin ore and boulders of sulphidic minerals. The exposed lode was then open to renewed attacks by oxidising agents —the marcasite component suffering complete transformation, the others in less degree—and the resultant oxide of iron carried away in solution and redeposited, formed the cementing medium of the agglomerated material. Some of the large nuggets were found resting directly upon tne cemented rock. These were shed subsequent to the first landslide, and probably were carried down by the succeeding one. The direction is marked by the slickensides which course 10 degrees west of north. Continued southward the course leads over a depression in the landslip known as "the crater" towards three lodes exposed on the track near No. 2 tunnel. These lodes apparently junction at "the crater," and may prove to be offshoots from the main body, which, on the evidence at hand, should pass through "the crater" in a north-easterly direction.

In Gormanston Creek, up to the northern boundary of Albury's section and towards the south-western corner of Heywood's section, the bedrock exposed by the sluicing of the detritus overburden is completely decomposed basic rock. At the north-eastern corner of Albury's, the rock is hard actinolite, which continues unbroken 10 chains to the southward; at Nos. 1 and 2 tunnels the rock is apparently fairly hard altered slate and tuff, which in places appears very similar to altered actinolite, and may be so; at none of these places has any rich ore been found, nor has the decomposed gabbro been seen so far south. (It is at the gabbro junction or near it that the rich body is expected.)

About 150 feet south of the south-west corner of Heywood's section the bedrock is exposed. It consists of sericite, pinite, a little talc, and much limonite, and appears to be close to the lode line, which here is not likely to prove of any considerable dimensions. Farther to the north-east, on the southern boundary of Heywood's section, similar materials are exposed, but pinite predominates. In these workings large blocks of lode material, consisting almost wholly of marcasite, are frequently uncovered, but no nuggets of the dense tin ore are found. Slickensides, trending almost due north, and evidently of the same age as that recording the landslip at Coleman's, are marked on the clay-like bed of the porphyry talus. At Coleman's the clayey material represented a "false bottom" to the porphyry boulders, but here it appears to represent the bedrock of gabbro completely decomposed. If such be the case, the location of the ore-body should not prove difficult.

In the foregoing evidence it is considered that the ore-body occurs in the crater-like depression marked by the dam beyond the southern end of Heywood's section, and that it courses in a south-westerly direction conforming to the strike of the basic dyke.

Comparison with the Mount Bischoff Deposits.

A brief inspection is sufficient to disclose the remarkable similarity between the Mt. Bischoff and Pine Hill occurrences. In the first place, the formations represented there are represented here, and secondary minerals associated with the ore-deposits are identical, thus clearly indicating like conditions of development. Moreover, the outlines of these formations show an extraordinary resemblance, especially is this so in comparing Brown Face deposit of Mt. Bischoff with the crater-like area on the northern end of Pine Hill, where the dykes and subsidiary sills almost encircle the ore-body. The general dip of the dykes in both cases is north-easterly, but the sills dip towards a common centre. The complexity of the intrusion produced by the sills caused the complete dislocation of the invaded slates and basic igneous rocks, thereby providing an easy way of escape for the accompanying mineral-bearing solutions. On the footwall side of the dykes (south side at Pine Hill) mineralisation is not so intense, and is confined to the immediate contact. The more important deposits, then, occur on the hanging-wall side of the dykes, and are associated with the sill offshoots. At Mt. Bischoff the narrow tin-bearing veins intersect all formations, including the porphyry dykes and sills, and continue for long distances without perceptible deflection from their course. These have their counterpart in the Pine Hill area, where veins containing tin ore in profitable proportion intersect the dykes and sills. They are marked by the almost complete silicification and partial topazisation of the quartz-porphyry wallrock.

It is not expected that the Pine Hill area will prove to be comparable in importance with the renowned Brown Face deposit of Mt. Bischoff, but the indications are very encouraging, and the necessary exploratory work should be undertaken as soon as possible.

The Work of Exploration.

The location of the ore-body from which the boulders of tin ore were shed may be ascertained by one of three methods, namely:—

1. The removal of the covering of talus materials by sluicing.
2. Sinking through the talus.
3. Crosscutting southward from Heywood's section.

The first appears the most simple and expeditious way, but there are two objections to this method. One is the difficulty in obtaining an adequate water-supply; the other is the possibility of mistaking the false for the true bottom of decomposed basic rock.

Sinking through the talus is risky, because the ore-body may not prove to be very wide, and there is no definite indications at surface. Moreover, the inflow of water would prove troublesome.

Crosscutting in a southerly direction from Heywood's section, or from a point on the side of Gormanston Creek immediately below the northern boundary thereof, is considered the best way of attack. The bedrock, consisting largely of clayey materials, is very soft, and could be penetrated by adit at the rate of 1 foot per man per day. This clayey substance has the appearance and composition of pinite, and may not represent the bedrock. In fact, it is considered that this secondary mineral was formed subsequent to the deposition of the tin ore.

C.—RENISON BELL AREA.

Renison Bell and Central Renison Bell Tin Mines.

Introduction.

Since the discovery of tin ore at Renison Bell in 1890 many official examinations of the deposits have been made, and the results of these works have been recorded in publications issued by the Department of Mines. These reports have proved of great value to operators as aids in the design of the mines and treatment plants. In the later publications attention was drawn to the fact that the mines were being rapidly depleted of their reserves of rich free-milling material, and that provision should be made for the treatment of the sulphidic ore.

Up to the present time operations have been confined almost exclusively to the excavating and mining of the richer ore contained within the zone of oxidation. At the Renison Bell Mine a small calcining plant was erected for the purpose of converting the concentrated sulphide ore into the oxide condition, thereby liberating the contained tin oxide and enabling a complete separation to be made by means of mechanical appliances, but only the richest of such material could be treated at a profit. Unfortunately, the depletion of the rich oxidised ore and the commencement of operations on the sulphide material synchronised with the collapse of the tin market, and the company was compelled to temporarily close this section of the treatment plant.

The richer portions of the ore-bodies having been removed, the companies have now reached a stage in their operations at which a complete change of policy is imperative. Successful operation depends on the solution of the sulphidic ore problem.

In this report the various ways of dealing with the question at issue will be discussed.

The writer presents here a new interpretation of the origin of the ore-bodies and the structural relationship existing between them and the associated rock formations. The various workings have been fully described in other publications, therefore there is no need to add to the volume of this report on that account. Attention will be confined to descriptions of the ore-bodies and the proposals for their future development and exploitation; but no details will be given in regard to particular ore-bodies, as there is a similarity in the nature of them all, and the remarks to be made will apply generally.

Area, Situation, &c.

The Central Renison Bell property consists of three mineral sections held under Leases 7783-M, of 20 acres, 8495-M, of 39 acres, and 1215-M, of 36 acres, by H. E., H. J., and C. A. Brock. Each of these sections adjoins on the the north-east side part of the Renison Bell Company's Consolidated Lease 5865-M, of 318 acres.

Renison Bell township is situated 9 miles from Zeehan and 78 miles from Burnie.

Access and Transportation.

The Emu Bay Company's Railway passes through the centre of both properties. The mines are, therefore, easily accessible, and every facility is provided by th Emu Bay Company for the rapid transport of the products of mining to the markets.

Geology.

Summary.—With the exception of unconsolidated Quaternary gravels, the sedimentary rocks of this area consist of slates, sandstones, quartzites, grits, and breccias with intercalated beds of volcanic ash, the whole belonging to the Dundas series of the Cambro-Ordovician. Intrusive into these sedimentaries are igneous rocks of four kinds and ages. First there are representatives of the porphyroid suite so prominent in the neighbouring Rosebery district. These are not extensive and have no bearing on the formation of the ore-deposits. The recognisable components are phenocrysts of quartz and felspar in a groundmass of chlorite with the ilmenite alteration product leucoxene. The next are rocks of basic constitution ranging from gabbro to serpentine, forming part of the great belt of basic rocks that outcrops in large masses from Heazlewood to Dundas. They were intruded in early Devonian time, and represent the basic differentiate of the stock magma, of which the closely following granite forms the complementary acidic part. Associated with this basic intrusive are ores of nickel and also osmiridium and gold. Interest is directed particularly to the granitic or acidic rocks in so far as this investigation is concerned, because these intrusives are responsible for the deposits of tin and silver-lead found in the district. This group of rocks is represented at Renison Bell by dykes of quartz-felspar porphyry and aplite.

Another igneous rock-type, separated by a long period of time from the last-mentioned, occurs in this area. This is a diabase probably belonging to the Mesozoic intrusion of this rock so prominent in the eastern half of Tasmania. It occurs here in the form of a narrow dyke extending from the Boulder Mine along Dreadnought Hill to Renison Bell township. So far as can be seen, this intrusive has not affected the ore-deposits in any way.

Structural Geology in Relation to the Deposition of the Ore.—The general direction of dip of the sedimentary rocks is toward the north-east at angles varying from 9 to 15 degrees. In the small area examined the strata have not been compressed into close folds, but they have been greatly disturbed and dislocated, mainly by the intrusion of igneous rocks and the faulting that has resulted therefrom. They have been completely fractured in two directions: one along a north-west line; the other almost at right angles thereto, a little north of east. The former are lode fissures whose trend lines are roughly parallel to those of the basic and acidic dykes; the latter are fault fissures or slides. As a rule, the lode fissures closely follow dykes of dolomitised pyroxenite, but they occur also between slates and tuffs and other sedimentary rocks of dissimilar character, and in places cut through them. The fault fissures are the older and they have produced a lateral displacement of the strata.

All the important ore-deposits are associated with the thrust faults. Among the most valuable of this type thus far developed are the North Workings, Railway ore-bodies, Scott's workings, Big Blows, Summit, and Hetherington's workings on the Renison Bell properties, and O'Brien's, Hetherington's, Evenden's, and North Workings on the Central Renison Bell properties. Outside the small area under examination similar conditions apply at the Montana, Dreadnought, Boulder, and Federal properties. This may be taken as an established fact.

The rocks adjacent to the thrust zones have been rather highly brecciated, especially where a hard rock-like quartzite or dolomite has been thrust upon hard slates and tuffs. This brecciation has been favourable to mineralisation, and replacement has been complete in some parts of the dolomite. The ore-deposits were formed where these zones are crossed by the mineralising fissure, and the ore-shoots dip with the intersections of the fissures and the fault zones to the east of north. Where the angle of crossing or intersection is oblique the ore-bodies appear to flatten, giving rise to the idea of their occurrence in the form of "floors." These so-called "floors" occur on the Central Renison Bell and Boulder properties, and their origin has been the subject of much speculation by resident mining engineers and visiting geologists. A proper understanding of this lode structure would have proved of material assistance to operating engineers. The occurrence is illustrated in the accompanying sketches. Having given this explanation, the writer leaves the details of the effects of these thrust faults on the fissured rocks at each particular mine-opening to be worked out by the several operators. Unfortunately, the time at his disposal was insufficient to enable him to give a minute description of the structure at each point.

The Nature of the Ore-Bodies.—As already mentioned, the largest ore-bodies in the mine are associated with the cross-fractures, suggesting that these have influenced the formation of the rich shoots. The loose brecciated rock along these " crush " planes or " breaks " furnishes the easiest course for the passage of solutions, and, as the brecciation occurred prior to ore-deposition, replacement of favourable rock and impregnation of metallic minerals in less favourable rock may be attributed to this cause.

The ore-bodies occur along strong north-west fissures, which extend right through these into the neighbouring Montana and Dreadnought-Boulder properties. They may be classed in two general divisions, namely:—

(*a*) Replacement-Fissure Deposits.
(*b*) Fissure Fillings.

The former are the more important, and have provided the large bulk of the ore thus far mined. Although this classification of type of ore-deposit is convenient, a sharp line of demarcation between the two cannot be drawn, for there are places where both kinds occur. The former are considered to be replacements of dolomitised pyroxenites which were intruded in the form of narrow continuous dykes prior to the intrusion of the tin-bearing porphyries. A little doubt was felt as to the origin of this dolomite, as it is in places very narrow, and it is associated with bands of mangano-siderite, of considerable size and extent, evidently deposited from mineralising solutions. Again, the course of the dolomite conforms more or less to the strike of the strata, and crystalline limestone, possibly of sedimentary origin, has been exposed in one tunnel. Against this there is a good deal of evidence in favour of an igneous origin of the dolomite. Platinum has been detected in two of the dolomite replaced ore-bodies; microscopic examination of some of the replaced rock reveals the presence of partly-altered pyroxenite, and suggest its derivation therefrom. The writer admits that although the evidence is decidedly in favour of the igneous origin, it is not conclusive. However, so far as the economic view-point is concerned this question is of little importance.

The degree of replacement varies with the distance from the main channels of circulation; that is, the points of junction between the lode and fault fissures. Such replacements are made by tin-bearing pyrrhotite, and to a lesser extent by tin-bearing pyrite; and where action by mineralising solutions has been greatest a complete silica-tin oxide replacement of the dolomite occurs. The pyrite ore is abundant also at these points, but is, nevertheless, usually found as replacements and impregnations of slates. In contradistinction, pyrrhotite not only occurs as a replacement mineral of dolomite at such points, but is, as a rule, the only sulphidic mineral found in the dolomite away from the fault intersections. It was thought that the pyrrhotite occurring in dolomite was formed by the action of sulphuretted hydrogen on the residual iron of the original pyroxenite in the process of dolomitisation, but this origin is certainly not universal, as pyrrhotite occurs also in association with siderite, and again as the tin-carrier in the quartzites of the Big Blow lode and in the slates of Main lode. It is, nevertheless, a striking fact that pyrrhotite is almost invariably the particular mineral form of iron sulphide found as a replacement of dolomite. This is illustrated in the ore-bodies below the zone of oxidation, and the information obtained by drilling is of particular interest in this connection. In borehole No. 1 the drill passed through 135 feet of pyritic slate, 5 feet of pyrrhotite, 10 feet of siderite, 10 feet of pyrrhotite, 5 feet of siderite, 30 feet of dolomite, and again entered pyritic slate. In No. 2 bore the association is slightly different: 21 feet of pyrrhotite, 5 feet of siderite, 6 feet of dolomite, 3½ feet of pyritic slate, 7 feet of dolomite, then pyritic slate again.

The large bodies of marcasite that occur at the point of intersection of fault and lode fissures almost certainly represent the first alteration product of pyrrhotite. It is found usually at the margin of pyrrhotite bodies that are covered by a few feet of soil and rock debris. When exposed to the action of the atmosphere it rapidly oxidises to sulphate of iron, and under favourable conditions ultimately to limonite, leaving behind a soft friable mass locally termed " ashes." This residue is the remains of the skeleton of quartz always found in the pyrrhotite of these ore-bodies. In some cases the quartz occurs as a network of perfectly formed acicular crystals; in other cases it is not well crystallised, but is likewise of contemporary origin with the associated pyrrhotite. On the oxidation and removal of the pyrrhotite the peculiar mosaic of quartz crystals has the appearance of lattice-work. Under pressure of the fingers the cementing silica breaks, and the crystals becoming detached, are found to be almost perfect in form. The quartz-pyrrhotite ore of this kind is obviously a replacement product in this case of dolomite. In some of the large marcasite-pyrrhotite ore-bodies it is not uncommon to find spherical-shaped bodies of pyrite, from 2 to 6 inches in diameter, standing out in relief from partly replaced dolomite. Probably these represent a replacement of orbicular bodies similar to those obtained in the basic rocks at Magnet. A noticeable feature of some ore-bodies is that when the brecciated rock is slate it is generally found that the interstices between the broken rock are filled with quartz, pyrite, and cassiterite, and not pyrrhotite.

At Scott's workings ore of a different kind occurs in association with pyrite and quartz fillings of a fissure between dolomite and black slate. This is a fine-grained tin oxide replacement of an original pyroxenite, recognisable as such only under the microscope. It appears at first glance a fine-grained felspathic sandstone, but the microscope reveals an abundance of monoclinic pyroxene in some specimens, with also considerable felspar and much secondary quartz.

It is worthy of note that platinum has been detected in the dolomite ore-bodies of Renison Bell, thus providing further evidence of its igneous origin.

Noticeable features of the deposits are: the low tin content of the manganese iron ore, or the so-called "black gossan"; the comparatively rich limonite or brown gossan, especially where accompanied by much silica in the form of quartz crystals; and the localisation of the rich ore at certain definitely fixed positions in the ore-bodies.

Referring to the accompanying sketches showing sections of bore holes with nature of materials and analyses, it will be observed that the mangano-siderite—from which the black ore is derived—is poor in tin content, while the associated pyrrhotite and pyrite, especially where accompanied by much quartz, are comparatively rich. Doubtless the association of these sulphides of iron with the carbonate of iron and manganese was similar to that found in drilling main ore-body below the zone of oxidation. Probably the mangano-siderite bodies represent replacements of dolomite. The presence of the tin-rich, brown gossan in association with the black gossan ore-bodies is easily explained. Pyrrhotite and pyrite associated with the siderite were the tin carriers. They are readily attacked by meteoric waters and are thereby converted into limonite (brown gossan) setting free the contained tin oxide. Oxidation of these sulphides followed closely that of the associated siderite (carbonate of iron), and the medium of this transformation found an easy way of access through the channels thus provided.

The reason why the manganese-iron oxide (black gossan) ore-bodies are poor in tin content is that they were derived from siderite which was deposited from aqueous solutions during the waning period of mineralisation and after the great bulk of the tin oxide ore had been deposited.

A reference to the records of bore holes Nos. 2, 3, and 4 will show that pyrite and pyrrhotite are not everywhere tin-bearing. The reason for the localisation of the rich ore in them at fault intersections has already been explained as due to the easy access for solutions of high temperature at these points; and the paucity of the lodes in metallic minerals of commercial value—other than those of lead and zinc—beyond the faults is due to the circulation there of the solutions of lower temperature only.

In an earlier publication reference was made to the association of one of the ore-bodies with a so-called "red" rock. Megascopically this rock appears to be a jasperised felspathic sandstone or a tuff, but this identification should be received with hesitation, as the writer in the field has no means of making an exact determination. Its association with the ore-body referred to is due to its position on one of the lines of thrust faulting, and for no other reason.

Evidence of Selective Replacement.—Replacement and impregnation along fissures are fairly uniform in the sedimentary rocks (sandstones, quartzites, grits, and slates), producing tabular deposits parallel to the fissure. Where the rock formations differ in physical character and chemical composition, ore deposition extends out from the fissure in particular rocks, such as dolomite, for considerable distances, but leaves adjacent sediments largely unaffected. This selective replacement is due in part to physical and in part to chemical differences in the rocks. Where fault fissures intersect lode fissures access for solutions is far greater and replacement conditions are far more favourable, the resultant deposits forming boomerang-shaped "chimneys" that follow the intersection of the ore fissures and the fault fissures. In the deposits in slate and other siliceous or argillaceous sediments the reason for this selective deposition seems to be largely physical. In these rocks the fissures are narrow, and in places closed up, and are relatively impervious to solutions, consequently it is natural to find that the ore-bearing solutions have not been so active and did not extend so far into the wall-rock.

Mining Development.

Nowadays it is the object of every reputable mining engineer to eliminate, as far as possible, the element of chance from any mining undertaking and to consider the proposition of the exploitation of the ore-deposits from a purely business point of view. In the early days of its development it was suggested that leaseholders of mineral areas in this small field should amalgamate their interests and form one, or at the most two, operating companies. If this advice had been followed Renison Bell would have enjoyed a far more prosperous career, and the mine or mines would still have been in active operation. Instead, a number of small, under-capitalised companies were formed, each to develop the portions of the ore-bodies contained within the boundaries of its leases. Each mine that showed any promise was equipped with a milling and concentrating plant, in some cases before development works warranted such expenditure.

An important advantage in placing these mines under the control of one company is that all expenditure at the beginning of operations can be applied to exploration underground, so that any particular mine may be abandoned at any stage of development without incurring undue loss. Not only would the cost of supervision and control be greatly reduced, but one large treatment plant only would be required, and the water supply would be concentrated at one power station at a comparatively small cost. In the case of the mines under consideration, three of the richest ore-bodies occur along boundary lines between the properties. Each mine had to provide lines of transport and full equipment to operate on the particular portion lying within its boundaries.

Not one mine on the field possessed, at any time, reserves of oxidised ore material sufficient to warrant the erection of more than five heads of stampers and the necessary concentrating machinery. The Renison Bell Company, for instance, erected a 20-head milling plant and could not keep it in operation. Moreover, provision had to be made for a more continuous and larger water-supply for power and treatment purposes, and during the summer months an auxiliary steam plant was required to augment the power when supplies of water were low.

The only disadvantage in having a central milling and concentrating plant to treat the product of all the mines is the cost of transport; but such would prove small in comparison with the great cost of equipping a number of small mines with the necessary machinery for this purpose.

So far as the future development of the mines is concerned, an amalgamation of interests is an imperative necessity in order to obtain successful results. It is of no use making an attempt to carry on operations under existing conditions for the grade of the ore is too low, and the available supply too small, to keep a large plant in continuous operation for any considerable length of time. Large ore-bodies are known on the Renison Bell property, but only one or two have been developed by mine openings of any considerable extent, and a great deal of work is required in order to bring the mine to the productive stage.

Exploration.

Future exploratory works should be based on the information given in this report. In the past a considerable amount of useless work was performed owing to the failure of operators to appreciate the significance of geologic structure. The unproductive cross-cut openings on the Central Renison Bell property in particular are monuments to this incapacity. If from a main, centrally situated, cross-cut the lode fissures had been followed in both directions the several faults would have been intersected in succession, exposing rich ore-bodies of tin at these points. In the past a gossan boulder at the surface provided sufficient inducement to commence a cross-cut to see what lay hidden underneath, and no serious attempt was made to explore the lode fissures along their course. The only solatium to operators is the knowledge that they can profit by past mistakes in the design of future works.

Preparation for Market.

As already pointed out in the introductory remarks oxidised ore only has thus far been excavated in quantity. There are three reasons for this: the ore at and near the surface is softer and more easily accessible, and, consequently the cost of excavation is lower; in oxidised ore the tin oxide component is free and is easily separated from gangue materials by water processes of concentration; the tin content is higher.

Although, doubtless, other bodies of oxidised ore will be found by prospecting on the lode fissures at fault intersections, these will not add much to the permanency of operations. It is on the sulphide bodies that the future of the mines depend. In the first place it should be fully realised that the average tin content of the sulphidic ore—excluding small bonanzas which are of no ultimate moment—is too low to allow of profitable production at normal market rates for tin. Again it should be noted that the exploitable ore occurs in bodies, of no great lateral extent, separated by comparatively barren material of much smaller dimensions. From the foregoing it will be seen that a number of mine openings, with all the necessary equipment, will be required, thus adding considerably to the cost of mining and transport. From many hundreds of bulk samples it has been estimated that the average tin content of the pyrrhotite ore-bodies is 0·76 per cent. Sulphide ore of this grade cannot be prepared in a marketable condition at a profit to mining companies. In fact pyritic ore material containing less than one per cent. tin cannot be regarded as of any potential value at the present market rate; but considered as an ore of sulphur and iron oxide, or as a source of sulphate of iron as well, there is a possibility of restoring the industry to its one-time importance.

If the tin contents of the sulphidic material were separated by ordinary mechanical means the metallurgical problem would prove simple of solution. Unfortunately the tin oxide occurs in an extremely fine state of division and is enclosed in the body of the pyrite, marcasite, or pyrrhotite as the case may be. This tin oxide, when set free by calcination of the sulphides, is so fine that it will pass through a 200-mesh screen, that is a screen containing 40,000 holes to the square inch.

With modern plants, in the hands of skilled operatives, to be found only at such places as Renison Bell, this slime tin can be separated and concentrated to marketable grade without difficulty. The problem is to recover the other marketable products of the ore. Sulphide of iron, considered as an ore of sulphur for the manufacture of sulphuric acid, is valueless for export if it contains less than 40 per cent. sulphur. Some of the Renison Bell ore cannot be concentrated to this grade. Moreover, the marcasite variety is unstable and is liable to spontaneous combustion. One shipment of such ore from the neighbouring Boulder property caught fire at Burnie, in transit to Melbourne, and the shipping companies, since then, have refused to carry material of this kind. Even if it were possible to ship the sulphide ore it would be necessary to erect a plant at the sulphuric acid works in Melbourne to separate the contained tin oxide after burning. This confines the utilisation of the sulphur and iron content within narrow limits, and makes their conversion to marketable products at the mines a matter of necessity. There are two ways in which it is possible to effect this result:—

(1) The conversion of the sulphur constituent of the gases from the calcining plant to the elemental condition.

(2) The conversion of the sulphides of iron to sulphate of iron.

Of these the latter appears the more attractive. The present market rate of sulphate of iron is £13 per ton and the demand is strong. If the value of this material falls it could be converted into the highest-grade iron oxide pigment simply by a process of reduction.

The other possible product (manganese-iron oxide) of these mines is worthy of further investigation. Although the samples of hard material taken from the big lodes on the Central Renison Bell property contained manganese in the proportion of 5 per cent. only, the soft, wad-looking ore contains a much larger proportion, and may prove of commercial value.

Production and Reserves of Ore.

The total production of tin oxide concentrate containing over 66 per cent. tin from the Renison Bell mine exceeds 1000 tons.

The cost of production is remarkably low taking into consideration the difficulties under which the mining is performed.

Mining, transport, and milling of crude material cost in all six to eight shillings per ton, or an average of seven shillings. The average cost of mining and treating sulphidic ore is eight shillings and nine pence per ton. Results such as these require no comment, except that it is doubtful whether operations could be performed to such advantage again.

The output of the Central Renison Bell mine is not known. It has been roughly estimated at 150 tons of high-grade tin oxide concentrate.

An attempt to estimate the reserves of ore on these mines cannot be made for reasons that are perfectly obvious. Although the quantity of available sulphidic material is undoubtedly very large, the lodes have been nearly depleted of free or oxidised ore-bearing material.

C.—Silver-Lead Mines.

The mining of lead ores is closely bound with that of silver ores, as they are always associated. As a rule the silver content of lead ores is high, and the combined ore is of great value. It is considered, in this district, that an ounce of silver to a unit per cent. of lead is the average proportion. In the galena ores silver occurs as a sulphide, and in their concentration by machinery through the medium of water at least 50 per cent. of the sulphide of silver is lost. From this it seems that the silver sulphide occurs on the cleavage faces of the galena. In support of this suggestion it has been observed that the loss of silver increases in accordance with the degree of fineness of the crushed and concentrated material. The lead and silver mining industry has passed through many vicissitudes due to fluctuation in market rates and to the suspension of smelting at Zeehan. Influences that have affected the production of lead apply also to that of silver, it having been observed that there is a definite correspondence in the market fluctuations of the two metals. Recent improvements in mining and metallurgic methods are making available much material that formerly was not of commercial value. The much enhanced prices of the metals and the provision of electric power, in addition, should result in the reopening of many of the mines.

CENTRAL DUNDAS AREA.

(1) *The Comet and Maestries Mines.*

Area, Situation, &c.

These mines, originally operated by two separately organised companies, have lately been controlled by the Comet Tribute Prospecting Syndicate, and worked in conjunction. At the time of visit no work of any nature was being performed, and the underground workings were inaccessible. These were the foremost producing mines in the district for many years, yet a small portion only of the ore has been removed above the 300-foot level, and not any below.

The mines are situate near the Maestries Station, the terminus of the Dundas Railway, and are consequently easily accessible. A small part only of the original area is now held under lease, namely, two sections, 7632-M and 7633-M, each of 20 acres, charted in the name of A. G. Omant, of Devonport.

The Ore-Body.

The ore-body, coursing north 30 degrees west, extends diagonally through the properties, and is continuous both ways over 20 chains. It is from 15 to 60 feet in width, and dips at 40 to 50 degrees in a south-westerly direction. It consists essentially of mangano-siderite and galena, with the upper part altered by the action of meteoric waters Oxidation extends to a depth of 400 feet, or to a point 600 feet above sea-level. The secondary ores developed in this lode are remarkable for their beauty and rarity, and most of them have an intrinsic value. It appears that the ore-body is a replacement of dolomitised serpentine. Much dolomite yet remains unaltered, and the secondary ores are largely carbonates and chromates of lead, thereby suggesting a dolomite derivation from an original serpentine. A striking feature is the small proportion of zinc ore in the lode. As a rule the galena is massive and crystalline, coarse in grain, and occurs in short shoots, bunches, or as disseminations in the mangano-siderite gangue. In the upper or oxidation zone chloride of silver occurs in concentrations of fairly large size, having been derived evidently from the galena during its transformation into cerussite and crocoite, which are almost devoid of silver.

Development.

The mines have been opened by open-cuts, adits, and shafts. Main shaft is 405 feet deep and 280 feet below ground water-level. Ferromanganese ore was not cut at the 400-foot level, work at this level having been confined to the southern or galena section of the ore-body. Here the lode is 18 feet wide, and contains lead, 14 per cent., silver, 12 oz. per ton. At the time ore of this quality was not profitable, and operations were then directed to that section lying between the 335-foot level and the surface. The ferromanganese ore is as rich at the 335-foot level as at any other part, but the proportion of clean galena decreased from the 260-foot level downward. This decrease in quantity of clean lead ore is partly compensated by a progressive increase in its content of silver. As operations were carried lower and lower the galena, although maintaining its average proportion of the mixed ore, became more widely distributed through the gangue materials, and at the time was considered unprofitable. At 180 feet from the surface a body of clean galena (lead 70 per cent., silver 40 oz. per ton), 21 feet wide and 20 feet long, was cut in a crosscut from the main shaft. Shoots 5 to 6 feet in width and 40 to 100 feet in length were worked to the 335-foot level. There yet remains between the 350-foot level and the surface an enormous quantity of ferromanganese ore, and below that level a very large body of primary ore of unknown extent is available.

Equipment.

At one time the mines were well equipped with pumping and winding machinery, milling and concentrating plants, and all the accessory machinery required in the profitable operation of a large establishment. All that remains is the skeleton of the milling and concentrating plant and the building in which it is housed.

Power.

In the past steam power was used for all purposes. Now it is proposed to employ a pelton wheel, operated by water conducted to the summit of the ridge separating the two mines. A water-race has been cut and is in a fair state of repair. The water-supply is sufficient during winter, and could be augmented by diverting other streams into this course for summer requirements.

Productions.

The following particulars relating to the production of ore have been furnished by Gerald Ahern, chemist, and (later) superintendent of the mines:—

During the period 1891 to 1893 the Comet ore-body was worked by the Maestries Company, and a large quantity of ore was produced. Ore, containing 26 per cent. lead, and silver in the proportion of 35 oz. per ton, was railed to the old smelters near Lake Fisher at the rate of 60 tons per day. When the smelting company closed their works the richer sections of the ore-body only were worked, and the output was reduced to 50 tons per week of ore, consisting of lead 58 per cent., and containing 38 oz. of silver per ton. Operations ceased in October, 1893. At that time 9000 tons of ore had been sold, and 1000 tons of second-grade ore, consisting of 35 per cent. lead and containing 27 oz. of silver per ton, had been stacked.

The Comet Company, during the periods 1894 to 1898 and 1904 to 1913, produced 9000 tons of first-grade lump ore and 12,000 tons of concentrated galena. The first-grade ore contained lead in the proportion of 65 per cent., and silver at the rate of 41 oz. per ton; the concentrate, 60 per cent. lead, and silver 37 oz. per ton. In addition over 90,000 tons of ferromanganese gossan has been mined and shipped to the smelters at Zeehan for use as a flux for siliceous ores. This ore, valuable also for silver and lead, has been a source of considerable revenue. The average content of the material is:

Iron	38 per cent.
Manganese..........................	12 ,,
Silica	5 ,,
Lead	5 ,,

Silver in the proportion of 2·5 ozs. per ton.

It was worth nine shillings per ton in the railway trucks at Dundas. The greater part of this ore was mined by G. Ahern, who paid tribute of 12½ per cent. of the value to the company. An equal rate was paid also on the value of the galena produced by him. In this way the company received £10,000 in royalties. Production of galena ceased in 1907 owing to the high cost of mining and the low prices of lead and silver. From 1907 to 1913 mining was confined to the ferromanganese ore-body. The net value of the ores produced exceeds £220,000. At present market rates for these metals the output would have been worth £700,000.

(2) *Platt Prospect.*

Situation.

This property is situated at the south-east corner of the Dundas Prospecting Syndicate's section (West Comet). It is now held under prospector's licence by Charles Platt, who recently discovered another ore-body there.

The Ore-Bodies.

The lode, not prominent at surface, consists of galena, sphalerite, jamesonite, crocoite, and cerussite set in ferromanganese oxide and quartz. It is a replacement ore-body, the metallic minerals taking the place of dolomite along the line of contact with fresh serpentine. This is the one known occurrence of primary sulphidic ores in dolomite replacement bodies appearing at the outcrop and at such a high elevation. The sulphidic components do not show a progressive increase with increase in depth, nor are they regular in distribution. The ferromanganese body is about 80 feet in width, but the lead- and zinc-bearing portion is confined to 4 feet on the hanging-wall side. The valuable ore occurs in short shoots with a northerly pitch and an easterly dip. The course of the shoots is N. 10° E. Another and parallel lode, consisting largely of ferromanganese gossan, lies 200 feet to the east. It contains a fair proportion of crocoite and some bindheimite rich in silver. This lode outcrops strongly at surface, and, like the other, is a replacement of dolomite.

Development.

Developments on the western ore-body consist of a few shallow pits and an adit crosscut with lateral drifts on the lode. The crosscut, on a bearing of 142 degrees, intersects the ore-body at 123 feet, and enters massive serpentine at 141 feet. The shoot pitches below tunnel-level on the north side, but is exposed for 30 feet in the southern drift. A rise exposes 2 feet of gossanous quartz with crocoite and cerussite, and 2 inches of galena on the footwall. A sample of the galena contained lead in the proportion of 76 per cent., and silver at the rate of 103 oz. per ton. The end of the south drift is in fresh serpentine, and there is no indication there of the lode or the line of continuation. On the north slope of the hill, 15 chains distant, an adit croscut, bearing 125 degrees, intersects the eastern ore-body at 48 feet, passing through it at 80 feet into decomposed serpentine. Ferromanganese gossan here contains much crocoite and cerussite. This crosscut was driven to intersect a body of rich bindheimite exposed in an underlay shaft higher up hill. On the eastern side, opposite Platt Prospect, an adit has been driven and a shaft has been sunk to explore another parallel and similar ore-body. The average course of the adit is 220 degrees, and the length is 305 feet. It is considered that the footwall of the lode is ·20 feet farther on. The shaft lies a little north of west from the end of the adit, and is distant therefrom 110 feet.

General Remarks.

The saleable products of these lodes at present are galena and jamesonite, but if the smelting of ores is resumed at Zeehan the secondary ores of lead will become marketable. Moreover, the gangue of ferromanganese gossan in which the lead ores are contained is a valuable fluxing material. Successful operation depends upon the marketing of all the materials comprising the ore-bodies.

The several lodes may be attacked at depth by means of adit crosscuts from the north-western side of the hill. An increase in the proportion of lead and zinc ores is not expected at depth.

(3) *Anderson Mine.*

This mine lies between the West Comet and the Adelaide Mines, and is opened by means of a three-compartment shaft, 100 feet deep. At surface the ore-body consists of gossan, manganese oxide, and quartz, and is encased in serpentine. An examination of the material in the dump reveals the presence of crocoite, which, according to report, occurs in considerable abundance at a depth of 50 feet, and it is reported also that galena is sporadically distributed through the lode gangue at a lower level. The ore-shoot, however, is short and erratic, and is not likely to increase in richness nor in size at greater depth.

(4) *Adelaide Mine.*

Area, Situation, &c.

An area of 10 acres, enclosing the mine workings, is held under Lease 7755-M by the Comet Prospecting Syndicate No Liability. The mine is situated 1½ mile south-east of Dundas township and within 5 chains of a branch line of the Dundas Railway.

The Ore-bodies.

The lodes on this property were discovered early in the history of the field. They closely resemble the Comet and Maestries lode, but differ in the relative proportions of crocoite and cerussite. Like that ore-body, they consist largely of ferromanganese gossan, and are contained in dolomitised serpentine. The proportion of crocoite is far greater, and of cerussite much less, than in the Comet lode. Crocoite occurs here in such wonderful development that it is mined for exhibiton as specimens. Beautifully formed crystals, interlocked, and from 3 to 6 inches in length, partly fill cavities in the gossan. A large part, however, is intermixed with the ferromanganese ore, indicating contemporaneous formation. In the upper part of the ore-bodies crocoite and gossan are the chief components, but melancroite, chromiferous cerussite, dundasite, phosgenite, minium, and bindheimite are not uncommon. Below the zone of oxidation the ore consists of galena, sphalerite, pyrite, and jamesonite set in mangano-siderite and associated with dolomite and unaltered serpentine. Much of the dolomite is stained green with chromic acid.

The lodes are 20 to 40 feet in width, and over 400 feet in length. They course 15 degrees west of north, and dip east at 50 to 65 degrees.

Development.

The lodes are opened by means of three shallow adits and a shaft of three compartments, 280 feet deep. They are well exposed above the level of the shaft collar, but at the time of visit the expensive shaft workings were inaccessible. The lower levels are in primary ore, which is of low average grade.

Production and Reserve.

Accurate statistics relating to production are not available, the records of successive operators having been destroyed. It has been computed, however, that the value of the output of galena and crocoite-ferromanganese ore is not less than £50,000. The ore in the lower levels of the mine is not of high grade, and at the time of operation was not profitable. In the upper levels a very large quantity of oxidised ore of low grade is available for excavation. This ore is of value only for direct smelting.

(5) *Ahern Prospect.*

On the north side of the tramway leading to the West Comet Mine, and opposite the Anderson shaft, an adit was driven on a gossan ore-body by G. Ahern some years ago. The gossan is clayey and light-brown in colour, consisting largely of limonite, and therefore, derived from pyritic ore. Lead ore, which is usually associated here with mangano-siderite and its derivative, is not present. It is more likely to contain tin ore, being on the line of the Razorback lode, but samples yielded not a trace of tin.

However, as the tin ore on this line occurs at long intervals and in short shoots, sections of the lode in this part may prove to be tin-bearing. The lode is encased in serpentine.

(6) *Lucky Star or Bonanza Prospect.*

This property, now vacant, lies north and adjoining Platt Prospect. The lode, contained in hardened sandstone, outcrops on the southern extension of Sitchtite Hill, between two exposures of serpentine. It consists of cerussite, quartz, and a little galena and sphalerite contained in ferromanganese gossan, and is opened by three adits. The upper adit passed through the ore-body near the entrance, and entered serpentine; the lower adits were not accessible. At the outcrop the ore-body is large (38 feet wide), and is of the Comet and Maestries type. The ore, however, is of low grade, and is valuable only for local smelting.

Farther northward an adit has been driven on a galena-blende lode in dolomite on a bearing 55 degrees east of south. The commercially valuable metallic minerals are associated with pyrite and mangano-siderite, and are disseminated in blebs and veinlets through the gangue rock. The lode appears at surface as a massive body of ferromanganese gossan and quartz, the latter in fibrous form, and is contained in contorted grey slate and sandstone. At the time of visit the adit was not accessible, and the lode could not be investigated underground at any point.

(7) *West Comet Mine.*

Area, Situation, &c.

This mine is enclosed in a 115-acre section held under lease by the Dundas Prospecting Syndicate. It is situated a mile east of Dundas township, and is easily accessible by rail or road. The main line of the railway passes through the northern end of the block, and a branch of it passes through the southern end to the main workings.

The History of Development.

The West Comet ore-bodies, of which there are two important ones, were worked originally by the Mt. Dundas Prospecting and Mining Company No Liability in the year 1890, and later by the Central Dundas Prospecting Association. In the year 1896 the Comet Mining Company acquired the property, and thoroughly explored the ore-bodies to water-level. The operations of this company revealed very large ore-bodies, the main one being 50 to 70 feet in width and over 600 feet in length. At that time the richest ore (galena) only was marketable. The West Comet Company subsequently operated the mine for the ferromanganese fluxing material, of which very large quantities were sent to the Tasmanian Smelting Company's works at Zeehan. This company ceased operations 15 years ago, and little work has been performed since.

At the outcrop the ore is similar to that of the Comet Mine, except that the lead occurs there as carbonate, whereas here it occurs as chromate. The section in main adit shows 322 feet of slate and quartzite, 61 feet of sintery quartz, coursing N. 20° E., and dipping easterly at 45°, 43 feet of ferromanganese gossan and crocoite, and 179 feet of clayey gossan and cellular quartz of little value. The strike of the lode is N. 12° W. and the dip is easterly at a high angle. The body of sintery quartz at the slate contact represents the complete silicification of serpentine and is a conspicuous feature also of the adjacent Razorback deposits. The clayey gossan and cellular quartz body is a decomposition product of serpentine, which, at the walls, is quite fresh. Montgomery, writing in 1896, states that the rich shoot of gossan, containing chloride of silver, occurring near the surface was not found in the shaft workings, but northward the proportion of crocoite increased and a rich shoot of galena, encased in ferromanganese gossan, was revealed. The following analyses recorded in Montgomery's report convey an idea of the composition of the ore mined at that time:—

Nature of Ore.	Remarks.	Lead, per cent.	Silver, per ton.	
			ozs.	dwt.
Gossan and Galena.	Average of 31 bulk samples	31	66	14
Gossan	Average of 18 samples	5	21	18
Gossan & Crocoite .	Average of 17 samples	4·5	18	3
Gossan and Canary Ore	Average of 4 samples	8·5	78	12
Gossan and Siderite	Average of 4 samples	13	14	6
Crocoite, Galena, & Gossan	—	6	17	9
Galena......	—	25·5	106	16
Galena	—	35	107	16
Galena............	Clean	75	107	2
Galena and Gossan.	95 tons 8 cwt.	39	94	10
Gossan and Cerargyrite	48 tons	10	450	—

These results show that the ores are of high quality, and that the gossan contains little lead but a fairly large amount of silver. Some of the richest galena was obtained from a winze sunk from the floor of the main adit. The ferromanganese gossan is the main ore-body, and the clayey gossan represents the alteration or decomposition product of serpentine. It may be stated that the greater part of the galena was mined from the deepest workings, only 45 feet below water-level. Mining Engineer Gerald Ahern reports that a vein of galena, 18 inches in width, is showing at the end of the deep workings. Although secondary enrichments of lead and silver ores are not expected at the base of the oxidation zone, it is considered that the primary ore will prove to be of fairly high average quality with occasional exceptionally rich shoots.

Mine Workings.

In 1890 a low level adit, 640 feet in length, was driven across the main ore-body. Passing through 322 feet of sharply folded slates and quartzites, and 61 feet of sintery quartz, a large body of ferromanganese gossan and crocoite was entered. This body proved to be 43 feet in width, and the extension of the crosscut exposed a body of clayey gossan on the hanging wall over 100 feet in width. As very little rich ore was discovered attention was then directed to the other ore-body. Subsequently a shaft was sunk to a depth of 45 feet below water-level, and the pumping plant stationed at this point allowed of the successful mining of the richer shoots of galena at the deepest level As the mine openings were being extended it was found that the increasing inflow of water gradually overtaxed the pump and operations were suspended. In the year 1896 the Company erected a 12-inch pump in main drive and sunk a winze below water-level. The pump, connected by 200 feet of flat rods, was operated by a water-wheel, which was effective during winter only. Under these conditions the highest-grade ore only could be mined at a profit to the Company. Of late years low-grade ore has been excavated in open-cuts. Two lodes occur near the eastern boundary of the property and are opened in small cuts on the western bank of the creek. The lodes occur in crushed, highly-contorted slates and sandstones, and consist largely of galena and siderite. They course N. 15° W. and dip easterly at 65°. The galena and siderite, in intimate association, follow the tilted plane of bedding and fill connecting veinlets which cross at right angles to the dip. Chalcopyrite, sphalerite, and quartz are accessory components. The lode formation is 4 feet in width, but the average content of galena is small. A sample of clean galena contained:—Lead, 71·90 per cent., and silver at the rate of 98 oz. per ton.

On the south bank of the creek, and opposite the main open-cut workings, a galena-siderite vein, in grey and black slates and grey sandstones, is opened by a short adit. The vein represents a crush plane in the rocks and is irregular, in places indistinct, and is faulted. The adit courses S. 40° W. a distance of 15 feet, then follows the fault, S. 7° W. 20 feet, then resumes its original course. A sample of the clean ore, which varies from 1 to 6 inches in width, contained:—Lead, 77 per cent., silver, 33 oz. per ton. In a small creek, 3 chains west of that just described, is another vein of similar nature. The galena is associated with sphalerite, siderite, and pyrite and occurs as veinlets in graphite slate. The vein material mentioned and quartz appear to conform in strike and dip to the bedding planes of the strata. It is not an important body.

Production.

All records of the output have been lost, but a fairly close estimate can be given from information obtained from J. B. Scott, State Mining Engineer, and Gerald Ahern, Chemist and Assayer to the Company. Not less than 500 tons of high-grade ores (galena and cerargyrite), has been mined. These ores consisted of lead, 70 per cent., silver, 70 oz. per ton; and lead, 10 per cent., silver, 450 oz. per ton. It is estimated that over 50,000 tons of ferromanganese ore was mined and railed to the smelters at Zeehan. This ore contained:—3 to 6 oz. silver per ton; 3 to 6 per cent. lead; 30 to 40 per cent. iron; 11 to 16 per cent. manganese; 10 per cent. insoluble substances.

Reserve.

There is yet, above water-level, a very large reserve of ferromanganese ore of average grade, a large proportion of which could be removed by open-cutting and quarrying. The primary ore, containing occasional rich shoots of galena, has been mined to a depth of 45 feet only. In this lode, 600 feet in length, rich shoots of ore may be expected, and, probably, a large proportion of the main body will prove suitable for treatment in concentration plants.

(8)—*Red Lead Mine.*

On the south side of the Adelaide Hill adits have been driven on a ferromanganese gossan lode containing crocoite and minium, the red oxide of lead. No rich bodies of ore were discovered in these exploratory works, and the cost of mining and transport was too great to allow of profitable operation.

D.—Lead-Antimony Mines.

North Dundas Area.

The mining of antimony ores has not been a profitable undertaking, and production has been small. Jamesonite, the sulphide of lead and antimony, is the one important ore of antimony occurring in the district. Although this ore contains a high proportion of silver it has not been marketable. Lately a profitable market has been found for antimony-lead ores, and, in consequence, production is likely to become important.

(1)—*Wallace's Prospect.*

About 20 chains south of the terminus of the wooden-rail tramway leading from Confidence Saddle a vein of jamesonite outcrops near the summit of a ridge, at an elevation of 2200 feet above sea-level. The vein is contained in slates and quartzites coursing N. 30° W., and dipping to the south of west. It has been proved to extend 30 chains on a bearing N. 20° W., and on the dip eastward it has been traced 300 feet. The vein filling is 30 inches in width but the walls of the enclosing slates are impregnated with quartz and pyrite, two feet or more. The ore consists of massive jamesonite, through which are distributed bright laths and needles of the same mineral, and blebs of pyrite and quartz. Jamesonite occurs generally as a distinct band, with parallel bands of pyrite and quartz, but in places jamesonite and pyrite are intimately associated. A considerable proportion of clean jamesonite can be separated in mining. A sample of the material consisted in part of:—

Lead	35·6 per cent.
Antimony	17·85 ,,
Silver	18 ozs. 5 dwts. 20 grs. per ton.

Insufficient exploratory work has yet been performed to estimate its value and the prospect of its improvement. However the facilities for mining are so favourable and the ore-body so easily accessible that development could be performed at a small cost to the operators.

(2)—*Johnson Prospect.*

On the northern fall of Dundas Range another body of jamesonite is exposed on the bank of a small stream. In many respects it is similar to that of Wallace Prospect, but it is not as large nor as well exposed. The conditions here, for mining, are equally favourable and the prospect is worthy of more attention.

E.—Lead-Zinc Mines.

Sphalerite, or zinc blend, the chief ore of zinc, is invariably associated with galena, and is mined with that mineral. Zinc blende is regarded as detrimental in lead ores, not only because it is difficult to separate, but because a penalty is imposed on producers if the lead ores contain above a prescribed proportion of zinc. In some lodes zinc is the dominant metal component, in others the proportion of lead exceeds that of zinc. Hitherto zinc ores have been regarded as of no value and have been dumped. Future production will be derived from the mixed lead and zinc sulphides by separating and concentrating machinery, the zinc ore then becoming a valuable by-product.

A.—Central Dundas Area.

(1)—*Great South Comet Mine.*

Area, Situation, &c.

This property consists of two 20-acre sections held under consolidated lease 6459-m by the Comet Tribute Prospecting Syndicate N.L. It is situated south-west and adjoining the Kosminsky lease, about three miles from the township.

Access.

Many years ago tramway connection was made between the mine and a branch line of the Dundas railway. It is well-graded tramway, and, although overgrown with scrub, the earthwork is still in good repair, but the bridges and culverts have collapsed. The present tributor, J. J. Hill, of Zeehan, considers the existing tramway unsuitable to his purpose, and proposed to construct a tramway through the adjoining Kosminsky property to the summit of the next ridge, and convey the crude ore from that point to the Comet mill by aerial ropeway. The object of this plan is to make use of the mill aforesaid, and at the same time deliver the ore at Maestries Station.

Nature and Occurrence of the Ore.

In this lode, which is remarkable for its persistency along the strike, the chief ores are galena, sphalerite, and jamesonite. They occur in intimate association with jamesonite and siderite and frequently exhibit banded structure. The following order of mineral banding has been observed:—Jamesonite, sphalerite, jamesonite and siderite, siderite, galena, siderite. More commonly they are intermixed, or distributed with pyrite in blebs, veinlets, and bunches through the siderite base. In some parts the sphalerite and galena occur in distinct bands, and can not only be separated easily from the siderite but from one another. Where intermixed the minerals occur in blebs and individual crystalline grains, either coarse or fine, and are easily distinguishable; galena and sphalerite, jamesonite, pyrite, and chalcopyrite being everywhere subordinate. The ores occur in alternate rich and poor shoots, and the vein pinches and swells. In one shoot galena is the chief component, in the next sphalerite; in some these minerals are found in equal proportion. The vein has been opened at points along its course a distance of 30 chains. It outcrops boldly as a ferromanganese body on both sides and summit of a hill rising over 400 feet above the valley floor. The average course is 325° and the dip south-westerly at 60°. The ore-body is contained in slates, sandstones, grits, and conglomerates.

Development.

The main workings are on the northern side of the hill and comprise three long adits, one shaft, and two connecting winzes. On the southern side of the hill the ore-body has been opened on both sides of Adams's Creek by two short adits, where it appears similar in nature and tenor to that on the north side.

No. 3 or Low Level Adit.—This is a drift, 440 feet in length, commenced about 30 feet above creek level. It exposes a 2-foot to 3-foot vein containing shoots of galena and sphalerite in varying proportions. A specimen of this mixed ore contained 21 per cent. lead, 15·6 per cent. zinc, and silver at the rate of 14 oz. per ton. The analysis is of value only as an indication of the comparative proportions of these metals in the higher-grade ore. Stoping has been confined to the galena-rich sections of the vein. At the end of the drift the vein material is

3 feet 3 inches in width and consists of sphalerite, galena, and pyrite in siderite. At this point sphalerite predominates over the other components.

No. 2 Adit.—This, likewise, is a drift on the vein, 605 feet in length, and is 220 feet higher than No. 1 adit. At 280 feet from the entrance is a winze of unknown depth. Here the ore occurs in shoots, some consisting predominantly of sphalerite, others of galena. One shoot of zinc ore is nearly 200 feet in length, and, it is stated, contains zinc in the proportion of 38 per cent.

No. 3 Adit.—A little farther south, and 160 feet higher, No. 3 adit has been driven on the vein over 200 feet. The ore at this level does not appear to be of equal value to that exposed in the lower adits, but the workings are of smaller dimension and rich shoots may yet be entered as exploration is carried forward.

No. 4 Adit.—From the north bank of Adams's Creek, on the south side of the hill and at the level of No. 2 adit, a vein of similar materials, and evidently identical with that exposed on the other side, has been driven on northerly a distance of 50 feet. On the other side of the creek another adit leads in a southerly direction. Neither of these adits is at present accessible. The nature and tenor of the ore, however, may be learnt from the dumps. A sample of the mixed ore contained 21·35 per cent. lead, 25·48 per cent. zinc, and silver at 17 oz. per ton. On the north side of the creek galena predominates, on the south side the vein material consists almost wholly of sphalerite of high grade.

Reserve of Ore.

The rather extensive workings have proved the length of the vein over 800 feet and have provided evidence to indicate its existence in the intervening unexplored part. Moreover, these workings show that the vein maintains its width and the quality of its ores to a depth of 400 feet. Allowing for 50 per cent. of poor ore it is estimated that 72,000 tons of crude ore is available above No. 1 adit level. The average value of the crude ore has not been determined, but the analyses given herein are fairly representative of the quality. The dumps at the entrances to the several adits contain altogether about 1000 tons of ore of milling grade.

General Remarks.

This well developed ore-body has not been successfully exploited because galena-sphalerite ore has not been marketable and because the prices of the metals, lead and zinc, were formerly much lower. Moreover, producers of lead ore were subjected to penalties for zinc contamination. At present rates these ores can be mined and treated profitably. It is the intention of the tributor to transport the ore to the Comet Mill and there separate the zinc and lead components of the ore and concentrate them.

(2)—*Kosminsky Property.*

Area, Situation, &c.

There is a 74-acre section now held under lease by J. J. Hill, of Zeehan. It is proposed by the lessee to operate the ore-bodies on this section in conjunction with those on the adjoining Great South Comet property. The Kosminsky ore-bodies were worked on a small scale in 1890, and more extensively in later years, but the aggregate output was not large.

Nature of the Ore-bodies.

Two lodes are known on this property, both coursing N. 35° W. and dipping S.W. at 65°. They commence at the creek where the Great South Comet lode ends, and possibly the main one marks the faulted extension of that body. The creek follows a fault in the containing strata, but the lateral displacement is not known. The lode material consists of galena, sphalerite, quartz, siderite, pyrite, and a little chalcopyrite, in every essential similar to that of the Great South Comet. It is contained in grey and black graphitic slates bearing 10° and dipping westerly at a high angle. The lode has been traced nearly 20 chains, but it pinches and swells, and the ore shoots are short. The eastern lode is much wider, but the proportion of marketable ore is smaller.

Development.

The western lode has been opened at three levels by adits 40 to 50 feet apart. No. 3 or low-level adit is a little above creek-level, and about 300 feet in length. At the entrance the lode materials are poor, but as the adit advances the quality improves, and some high grade lead-zinc sulphide ore appears. Rich shoots are short and erratic. Near the end of the adit the lode is laterally displaced, and its northward continuation is not known. No. 2 adit exposes 18 inches of ores, 100 feet in length, half of it consisting of galena and sphalerite and half of quartz and mangano-siderite studded with pyrite. In No. 1 adit it is of equal size, and is composed of zinc-lead sulphide and quartz in two distinct bands. The hanging-wall is of graphitic slate and the footwall is of quartz resting on grey slate. The quality of the higher grade ore is indicated in the following analysis:—

Lead	55·2 per cent.
Zinc	13·18 "
Silver	24 ozs. 16 dwts. 12 grs. per ton.

(3) *Ainslie Mine.*

A mile south-west of the Comet Mine is a 20-acre section, recently held under Lease 7627-M, on which a galena-sphalerite vein has been opened in three adits. This ore-bearing vein was discovered many years ago by one W. Ainslie, and a company was formed to explore the vein at depth. The records of the work of this company were not available, and at the time of visit the mine-openings were not accessible. However, the nature of the ore is revealed in the outcrop. It consists of galena, sphalerite, pyrite, siderite, and quartz, and is contained in an irregular channel cutting across argillaceous schist. At the faulted junction with slates, breccias, conglomerate, and quartzites, the vein peters out at surface. The vein is worthy of further attention.

(4) *Banner Cross Mine.*

West and adjoining the Ainslie section is a 20-acre block, recently held under Lease 7628-M. The vein minerals and the nature of the occurrence are almost exactly similar to the Ainslie. Adits, now inaccessible, have been driven to explore the vein along the strike and dip. Apparently developments were not up to expectations, but the extent of the workings show that the vein is of considerable length. In addition to galena, sphalerite, pyrite, and siderite, the mineral jamesonite is an important component. The lead, zinc, and antimony minerals occur in intimate association and in banded arrangement with the more abundant siderite. The lode varies in width from 1 to 3 feet.

B.—Dundas-Cuni Area.

(1) *Mt. Zeehan (Tasmania) Silver Lead Mines Limited.*

Area, Situation, &c.

On the east side of the Dundas Cuni Nickel Mines are the properties of this company. They consist of Leases 6361-M, 6360-M, and 6359M, each of 10 acres. Argentiferous galena was discovered here by Wallace Bros. and Ferguson, who, in 1910, sold their lease of the mining rights to the company. The operations, undertaken on a considerable scale shortly afterwards, were unsuccessful.

The Ore-bodies.

The several silver-lead veins occur in black and grey slates and tuffs of the Dundas series. They are closely associated with dykes of serpentine and gabbro, which evidently are offshoots of a much larger body of basic igneous rock underlying the sedimentary rocks. The primary ore consists of galena and sphalerite in a siderite gangue. At a depth of 60 feet quartz becomes prominent, and at 120 feet secondary quartz almost completely replaces the metallic ores. Secondary galena, sphalerite, quartz, and siderite, all crystallised, are commonly found in the upper parts of the ore-bodies. Water-level here is about 530 feet above the sea, and apparently all the primary ore has been replaced at that level. All the lodes—both nickel and lead-zinc—in this area of low-lying country have been affected. It is common to find sintery quartz and blocks of secondary galena and siderite at surface unconnected directly with any ore-body. The ore in the veins occur in short shoots at long intervals.

Development.

Underground works are extensive to a depth of 120 feet. The only means of attacking these veins is by shaft-openings, aided by heavy pumping machinery. The inflow of water is at the rate of 60,000 gallons per hour, increasing as the mine-openings are extended. Overcoming this difficulty proved a severe handicap in the operations of the company.

(2) *Allen Prospect.*

On the same vein line, a little further south, shafts were sunk on a body of galena, which petered out at a shallow depth. Nearby a large slab of secondary galena, 8 feet long, 3 feet wide, and 6 inches thick, was found at surface It is evident that the ore at this point has been leached and redeposited near the surface.

(3) *McKimmie Mine.*

The description given of the veins on the Mt. Zeehan Company's properties is applicable also to this vein. At the outcrop a body of rich galena in black slate gave promise of continuance at depth, but at 50 feet quartz and siderite became prominent, and at 70 feet occupied the vein channel. A very large influx of water hampered operations.

(4) *Other Prospects.*

About 12 chains west of the Five-Mile Station is a pyromorphite vein, 9 inches in width, which has been exposed in trenches and shallow shafts. Another vein, 2 chains farther on, contains besides pyromorphite, a fair proportion of cerargyrite. In the section north-west of that just referred to a trench in decomposed gabbro and black slate exposes a well-defined lode containing niccolite (arsenide of nickel), galena, and sphalerite. At surface the solid niccolite patch was 6 feet long and 1 foot wide, tapering out at a depth of 10 feet, but a little niccolite remained in the puggy lode matter to the bottom of the shaft.

C.—NORTH DUNDAS AREA.

Kapi Mine.

The North-East Dundas Tramway from Zeehan, between the 8½ and 10 mile pegs, is cut through two sections, Leases 8682-M and 8980-M, charted in the names of G. W. D. Hamilton and G. V. Chapman. These sections enclose the workings of what is known as the Kapi Mine. For many years the Kapi has produced high-grade galena in fairly large quantity. The lodes are of the galena-sphalerite type, and the gangue rocks are siderite and dolomite. They are contained in Dundas slates and quartzites, and are very persistent. Ore-shoots, however, are short and vary greatly in size.

F.—BISMUTH-LEAD-COPPER MINES.

Marking the transition stage between tin and lead ore deposits are certain complex bodies containing bismuthenite and tetrahedrite. In these deposits the mineral association is rather extraordinary. For instance, in the Curtin-

Davis group, set in a siderite gangue, are found bismuthenite, tetrahedrite, chalcopyrite, pyrite, galena, sphalerite, and arsenopyrite, the relative proportions varying in different lodes and in the same lodes. The veins are fairly persistent in their strike, generally a few degrees west of north, but none is of any considerable size. They are contained in the Dundas series of the Cambro-Ordovician rocks in which large ore-bodies are not found, except those in direct contact with dykes of serpentine or porphyry. Some of the veins, especially those containing tetrahedrite (fahl ore), are very rich in silver, picked samples having assayed nearly 3000 oz. per ton. The rich shoots, however, are very small, and the mining of these ores has not been commercially successful.

A.—NORTH DUNDAS AREA.

(1) *Heckla Mine (Lease* 7402-M, 80 *Acres).*

This ore-body, which was discovered many years ago, marks the transition stage between tin and lead deposits. It is not of any present economic importance, nor is it likely to improve in value, yet it is one of very great interest.

Situation, &c.

The North-East Dundas Tramway passes across the northern boundary of the lease near the bridge over Great Northern Creek. It is easily accessible, and only 12½ miles from Zeehan.

The Ore-body.

The lode components are chalcopyrite, bismuthenite, pyrrhotite, and pyrite set in a matrix of siderite. There does not appear to have been any particular order of deposition, but chalcopyrite and bismuthenite, always in intimate association, are found in reticulating veinlets traversing siderite. Long disconnected acicular crystals of bismuthenite are scattered through siderite. Pyrrhotite is not prominent, but pyrite is abundant. Carbonate of bismuth and copper are common secondary minerals.

Development.

No. 1 adit, over 200 feet in length, and bearing S. 57° W. to S 14° W., is the chief mine opening. It enters a cliff of slate and grit overlooking the bridge crossing Great Northern Creek. At 90 feet from the entrance a winze has been sunk from the floor of the drift, and at 100 feet another winze has been cut a few feet wide into the floor.

Here the lode is 27 inches wide, and consists largely of siderite, but carries a little copper and bismuth. A bulk sample contained:—

Silver	5 ozs. 15 grs. per ton.
Copper	0·85 per cent.
Bismuth	1·28 ,,

Farther on the vein becomes thinner though well defined, and at the end of the drift consists of a 6-inch and a 3-inch band separated by 3 feet of slate. The vein is sharply defined throughout, and is contained between two clean-cut walls. Stoping has been carried up to 20 feet. A bulk sample of the ore in the dump at the entrance contained:—

Copper	2·85 per cent.
Bismuth	2·77 ,,
Silver	25 ozs. 4 dwts. 8 grs. per ton.

The lode is cut again just above the railway, on the east side of the bridge, and is exposed in an adit 60 feet in length. At the entrance the ore-body is 4 feet wide, and dips westerly at 82 degrees. It consists largely of pyrite, pyrrhotite, and chalcopyrite, and contains a little arsenopyrite and bismuthenite. The clean material is hard and dense. A large part consists of disseminated ore in slate and schistose grit. Traces only of the vein appear in the railway cuttings.

(2) *Fraser Creek Mine (Lease* 6294-M, 80 *Acres).*

The lode on this property was originally worked for its content of tin ore by James Dwyer, and later by R. Ruggeri. A block of ore weighing 3 tons, found by Dwyer, contained tin in the proportion of 12½ per cent. The lode from which the loose ore had been shed was unearthed and opened by means of a short adit. It was found that the ore-bodies consisted largely of arsenopyrite, and that the average content of tin ore was small. Ruggeri sold his lease of the mining rights to the Edwards Metallurgical Company, of Ballarat, who produced a large quantity of arsenopyrite in the subsequent operations. The mine was ultimately abandoned by the company.

Situation and Access.

The mine is situated in the valley of Fraser Creek, immediately below Fraser Station of the North-East Dundas Tramway, by which it is easily accessible from Zeehan, 14 miles distant.

The Ore-body.

The ore-body is of the pyrrhotite-cassiterite type, and contains also the primary minerals arsenopyrite, chalcopyrite, and quartz. In some sections arsenopyrite, in others quartz, dominates all other components. In the upper workings marcasite takes the place of pyrrhotie; pyrite is nowhere prominent. The order of deposition is not easily distinguishable. Pyrrhotite, arsenopyrite, and chalcopyrite appear in intimate association, the first apparently preceding the others. Some of the quartz is studded with arsenopyrite. Perfectly formed pellucid crystals of quartz, with implanted crystals of arsenopyrite, are common. As a rule the quartz is white opaque or smoky in colour. The lode courses north 23 degrees west, and dips north-easterly at angles of 70 to 85 degrees. The slates in which the lode is contained strike N. 20° E., and are nearly vertical.

Development.

The lode has been explored by means of five adits and long lateral drifts. It has been proved to extend a distance of 500 feet, and to maintain an average width of 2 feet. No. 1 adit exposes 6 to 18 inches of ore resting on a hard slate footwall of 120 feet. At the entrance quartz is the chief component, gradually giving place to the sulphidic minerals near the end of the adit, where arsenopyrite dominates the other components, chalcopyrite and marcasite. At the end of the adit the lode is broken. Part of the ore has been stoped. A bulk sample of the ore, 1 foot wide, contained:—

Gold	Nil
Silver	2 ozs. 12 dwts. 6 grs. per ton.
Arsenic	20·02 per cent.
Copper	0·85 ,,
Tin	Nil

No. 2 adit is 40 feet lower than No. 1, and south of it. A cross-cut bearing S. 65° W. intersects the lode at 100 feet whence drifts lead north and south. The drift on the north side follows a clean slate wall 200 feet, exposing alternate rich and poor sections. A shoot of ore, 134 feet in length, has been stoped. At the end of the drift the ore is small and poor. The drift on the south side is 100 feet, and exposes a shoot of ore 75 feet in length, the greater part of which is stoped. At 70 feet a winze was sunk to a depth of 20 feet. The lode peters out in the end. At this level marcasite gives place to the primary mineral, pyrrhotite, arsenopyrite predominates, and chalcopyrite is subordinate. No. 3 adit is 30 feet lower than No. 2. The cross-cut on the bearing S. 60° W. intersects the lode at 70 feet, and a drift exposes it 15 feet south and 3 feet north of the point of intersection. The ore consists of arsenopyrite, marcasite, chalcopyrite, and quartz, all intimately associated. The following analysis indicates the average composition of the ore:—

Gold	Nil
Silver	4 ozs. 16 dwts. 16 grs.
Arsenic	7·23 per cent.
Copper	4·08 ,,
Tin	0·30 ,,

No. 4 adit workings lie south of the group described and consists of an 80-feet drift on the lode, which, in the north end, is small and poor. The average width is 18 inches, and the components are arsenopyrite and quartz with pyrrhotite and chalcopyrite. A bulk sample contained:—

Arsenic	16·80 per cent.
Copper	0·09 ,,
Tin	Trace.

No. 5 adit is a small opening leading from a long trench and is above No. 4 adit. The ore here is predominantly arsenopyritic. In addition to the workings described short adits have been driven on a gossan vein, one from rail level of the tramway, one below it. The ore is poor in its content of tin, silver, and gold.

(3)—*Curtin-Davis Mine.*

Situation, &c.

This is one of a number of mines opening a series of parallel veins in the neighbourhood of Ringville. It is accessible by the North-East Dundas Tramway, and is 15 miles by that route from Zeehan. Not one of these mines is in operation, and not one is of any considerable value.

The Ore-bodies.

The veins are enclosed in a series of sharply folded slates, quartzites, grits, conglomerates, and tuffs, the more important being on the east limb of the anticline. As might be expected the richest ore and the widest part of the vein occurs near the apex of the fold, that is, near the summit of the very steep and high hill. At the lowest level, 1430 feet below the summit, the ore is very poor and small. Two openings were made in the west limb vein with unsatisfactory results.

Developments.

Development works consist of nine adits, nearly all of which penetrate the hill from the north side. 100-feet level:—This adit, 255 feet in length, exposed a shoot of gossan containing patches of tetrahedrite and chalcopyrite, and, near the end, galena, sphalerite, cerussite, and native copper. 180-feet level:—This is an adit cross-cut which cut the vein at 100 feet. The vein was followed southward, 143 feet, and was found to consist of similar ore as that at the 100-feet level. 420-feet level:—Three shoots of tetrahedrite and siderite were cut in this adit, which was driven 465 feet. At the end of the adit the vein material consists almost wholly of carbonate of iron, in thin streaks, through hard black slate. 560-feet level:—At this level the vein has been exposed 370 feet in length, showing chalcopyrite and tetrahedrite in a siderite gangue. Some high-grade ore was obtained, but the bunches were erratically distributed. 680-feet level:—The vein at this level is very erratic in its content of the valuable minerals. It is exposed 456 feet in length, and peters out at the end of the adit. 840-feet level:—The adit at this level was driven a distance of 256 feet on the vein, which is from 3 inches to 2 feet in width, and which is contained between slate walls. A little tetrahedrite was obtained. 1000-feet level:—This adit was driven 137 feet on ore containing bismuthenite and silver in gossan. The vein is very small and irregular, and consists largely of pyrite near the end of the adit. 1150-feet level:—This is an adit cross-cut, 123 feet in length. No ore was found at this level. 1430-feet level:—The lode was exposed here, 88 feet in length, and was found to be barren of any of the commercial minerals. It is quite evident that the operators did not understand the nature of this occurrence. The ore, obviously, becomes poorer and smaller at depth, in veins of this kind. Recurring bodies at the apices of succeeding folds are insignificant, because the lower strata are too plastic to allow of fracturing and the formation of channels of percolation. The truncation of the anticline shows that the richest part of the ore-body, namely, that at the apex, has been removed by erosion.

(4)—*South-West Curtin-Davis Mine.*

This vein, which has been traced a long distance at surface, trends 140° E. of N., and dips to the east at a high angle. It has been opened in two adits, 100 feet apart, the upper one being about 50 feet below the highest outcrop of the ore. In No. 1 adit the vein was cut at 90 feet, and driven along 140 feet north and 210 feet south. In the south drive gossan and tetrahedrite, of high quality, was exposed in a shoot 50 feet in length, and 15 feet from the end a short shoot, containing a large amount of bismuthenite, was cut and stoped. A 40-feet shoot of rich ore was stoped from the level of the north drive, but the vein generally was poor and consisted largely of siderite. The rich ore in the vein varies, in width, from 1 to 16 inches, and is contained in very hard slate and conglomerate. Bulk samples of the ore contained 10 to 20 per cent. copper, and silver at the rate of 150 to 200 oz. per ton. About 600 tons of ore, worth £6000, has been won from this vein.

(5)—*South Curtin-Davis Mine.*

Many years ago three adits were driven on a vein consisting largely of tetrahedrite and galena in siderite. In the excavation of these openings about 200 tons of very rich ore was obtained, and about 40 tons of clean galena was mined from a branch vein. However the shoots of rich ore were very patchy, and the operations, generally, were unsuccessful.

(6)—*Evenden Prospect.*

A mile south of the Curtin-Davis mine an adit has been driven from the south bank of a tributary of Great Northern Creek, on a galena-sphalerite-pyrite vein encased in slate and sandstone. At the time of visit the workings were not accessible, but, from reports received, the ore-body is one worthy of more attention. The content of silver is low, however, and the ore requires treatment by machinery to separate and concentrate the lead and zinc minerals. An advantage is its nearness to Wallace's tramway

(7)—*Ramsdale Prospect.*

South of the Evenden Prospect, on the Carbine Hill Track to Dundas, a gossan lode, 2 to 3 feet in width, and coursing N. 20° E., has ben opened in a deep trench and a shaft. Samples of the gossan show a silver content from 30 to 100 oz. per ton. It is a promising lode, but requires further exploration.

(8)—*Tramway Veins.*

Between Confidence Saddle and the terminus of Wallace's tramway a number of narrow veins of galena and siderite are exposed in trenches and short adits. None of them is likely to improve much in size or in mineral content, as they are all contained in the rather plastic Dundas series of tuffs and slates.

(9)—*Carbine Mine.*

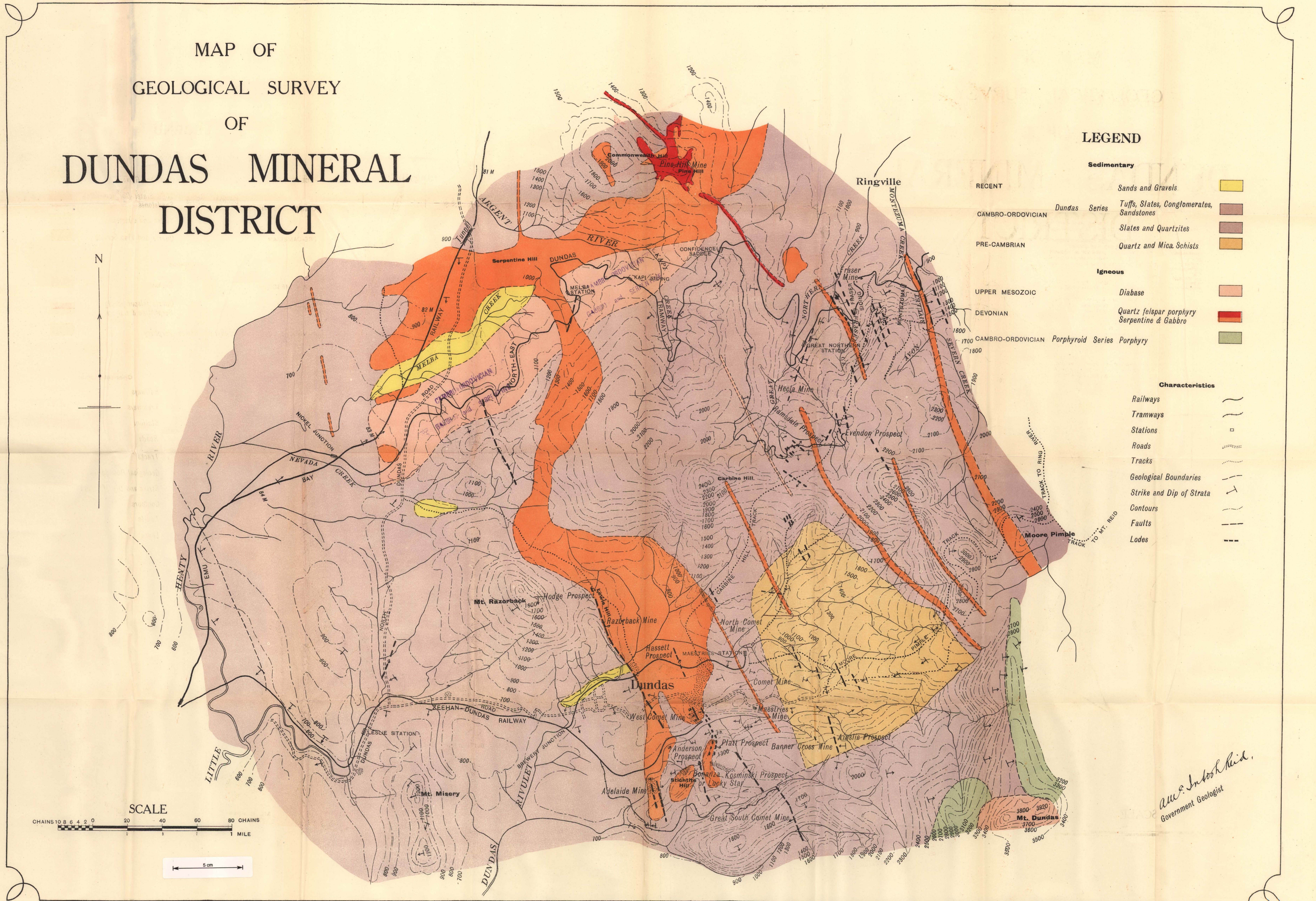
Trenches and adits on two outcrops on the north-western slope of Carbine Hill reveal the nature of the primary ore and the size and extent of the veins. They are from 1 to 10 inches in thickness, and course N. 60° W. The materials consist largely of galena and siderite, with, also, a little tetrahedrite and pyrite. Further west is a large pyrite lode which contains also jamesonite, tetrahedrite, chalcopyrite, and sphalerite. The valuable contents are so sporadic in their distribution that the ore, as a whole, is of no commercial value.

There is no prospect of these ore-bodies improving appreciably in size or value at any point.

A. McINTOSH REID,

Government Geologist.

8th October, 1924.



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