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The Silver-Lead Deposits of the Waratah District

BY

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The Silver-Lead Deposits of the Waratah District.

SUMMARY.

Introduction.—The Waratah district is essentially a mineral one, and is famous for its tin and osmiridium deposits. Silver-lead ores also occur, but the district has been a disappointing one as regards the production of these ores. The Magnet Mine has been the largest producer, and has prospects of a successful future. The Mt. Wright Mine is being worked by the Mt. Jasper Copper Mines, N.L., and maintaining a small output, while the (Victorian) Magnet S.M. Co. is still carrying out prospecting work in the Godkin mines. All other mines are now idle.

The objects of this investigation were to determine the factors controlling the deposition of the silver-lead ores with a view to assisting their further exploration and exploitation.

The general manner in which the work was carried out is indicated, and acknowledgments given to those who rendered assistance in the carrying out of the investigation.

Literature.—Under this heading there is given a complete list of previous literature on the district, which includes reports by G. Thureau, A. Montgomery, J. Harcourt Smith, L. K. Ward, W. H. Twelvetrees, and A. McIntosh Reid.

History.—The history of this mineral district began with the discovery of tin ore in Tinstone Creek by James Smith on 4th December, 1871. While searching for the source of the tin he discovered small lodes of antimonial galena, and of zinc blende and galena. No important discoveries were made until many years later, but following the rich discoveries at Broken Hill, N.S.W., in 1882, and those at Zeehan at a later date, a silver " boom " commenced. The Heazlewood lode was discovered in 1885, and other discoveries followed. Many prospectors

were now present on the field, and practically the whole of the Heazlewood and Whyte River fields were pegged out. The majority of the discoveries were made during the years 1890 and 1891, since when few others have been made. During the nineties, these lodes were opened up and tested, but, although the majority produced small quantities of argentiferous galena, the results were disappointing. The Magnet Mine is the only one which has been worked, and kept up a continuous production of ore since its discovery. The Godkin mines have been worked continuously, but without any ore-production. The others have been worked at various periods, but are now idle, with the exception of Mt. Wright Mine, which has been in operation for several years past.

Geography and Physiography.—The Waratah district occurs to the west of the township of Waratah, in the north-west of Tasmania, and includes the country around the townships of Magnet and Luina (Whyte River), and the deserted ones of Heazlewood and Stafford. Access to the district is gained by means of the Emu Bay Railway from Burnie to Zeehan, and from Guildford a branch line connects with Waratah.

The topography of the district is essentially that of an extensive peneplain which has been elevated and dissected. The general level of the elevated peneplain or plateau is 2100 feet in the east, and 1800 feet in the west. A few mountains representing residual prominences above the old peneplain level rise to varying heights up to 3200 feet above sea-level. The surface of the peneplain has been covered with Tertiary sediments and basalt flows, which have formed protective coverings. Since the elevation the streams have cut deeply into the plateau, and are still in a very youthful state of development, and the topography is generally of very high relief.

The main drainage systems are those of the Pieman and Arthur Rivers. The former drainage is to the south, and includes the Heazlewood, Whyte, Castra, Ramsay, and Coldstream Rivers. The latter is to the north, and includes the Arthur and Waratah Rivers.

The climate is essentially a wet and cold one. The average annual rainfall at Waratah is 85 inches, and at Magnet 88 inches, and snow falls frequently during the winter.

Geology.—The district is occupied mainly by sedimentary and igneous rocks of Lower Palæozoic age. The oldest sediments are those of the Dundas series, consisting of purple and light-coloured slates and felspathic and micaceous breccias composed wholly of igneous material. These belong to the Cambro-Ordovician Period and may be Upper Cambrian. In faulted relation with the Dundas, the Bischoff series of black slates, sandstones and quartzites occur. They are included in the Cambro-Ordovician, and are probably of Ordovician age. In the western portion, shales, friable sandstones, and limestones of Silurian age outcrop. These three formations have been folded and faulted and intruded by igneous rocks of Devonian age. These igneous rocks vary from ultrabasic to acidic, and include peridotites, pyroxenites, gabbros, syenites, granite, and porphyries.

Typical diabase of Upper Mesozoic age is intrusive into the above formations at several localities. Tertiary sediments up to 100 feet in thickness overlie the above formations, and are covered themselves by basalt flows of Tertiary age.

Recent gravels and alluvium are forming along the courses of the present streams.

Economic Geology.—The ore-deposits dealt with are those of silver-lead and copper. The metallic minerals associated with the silver-lead deposits are argentiferous galena (1 to 2 ozs. of silver per unit of lead), zinc blende, and pyrite, while the gangue minerals are carbonates and quartz. In the copper deposits, chalcopyrite and bornite are the economic minerals. The deposits are genetically associated with the intrusion of igneous magma connected with the diastrophism at the close of the Silurian period. The original magma differentiated at depth, and the different sub-magmas produced invaded the overlying rocks. The earlier intrusions were of an ultrabasic and basic nature, and some of the copper deposits may have been formed by segregation from these magmas. The final intrusions were of an acidic nature from which the granite consolidated, and the accompanying vapours and solutions were given off. These left the cooling magma and passed into the adjacent and overlying rocks by means of various channels. When positions were reached in which the chemical and physical conditions were suitable for the deposition of their metallic contents, ore-deposits were formed. The ultrabasic and basic rocks were apparently readily attacked by the mineralising solutions, and the majority of the deposits were formed in these rocks. The granite which represent the consolidated igneous magma now outcrops along a tract of country between Wombat

Hill and the Meredith Range. This tract has a general north-east to south-east trend, and the silver-lead deposits occupy a parallel tract of country to the north-west of the granite. The solutions from which the deposits were formed must have travelled considerable distances before meeting the conditions suitable for ore-deposition. The tin deposits of the district generally occupy a belt nearer to, and actually in, the granite.

Some of the copper deposits may have been formed from these solutions, but two modes of origin would then be required which is difficult to conceive.

The Mining Properties.—Only very brief reference to the mines of the district is possible in a short summary like this one, and the conclusions arrived at in connection with each mine and prospect, and given in the text, should be read at the same time.

Mt. Jasper Copper Mines, N.L.—This company holds the Old Jasper, New Jasper, Mt. Stewart, Heazlewood and Mt. Wright mines. The first two mentioned are copper, and the others are silver-lead, mines. The Old Jasper mine could not be properly inspected, so no opinion can be expressed as to its value. The structure of the lode is described, and a system of bore-holes recommended as the best means of prospecting, should further work be contemplated. The New Jasper contains small bodies of chalcopyrite which have been stoped down to No. 2 level. These shoots are considered too small to render their extraction at greater depth profitable. The Mt. Stewart Mine has been the second largest producer on the field, two shoots of ore having been stoped to below the No. 2 level. One shoot has been tested to a depth of 200 feet and found unpayable. The other would probably behave similarly, and any future operations would be attended by more than the usual share of risks attached to mining. The Heazlewood Mine has produced a small quantity of ore from a vein not exceeding six inches wide in a wider formation. It is reported to go underfoot in the workings, but it would have to maintain a width of at least 6 inches to render its extraction profitable. The Mt. Wright Mine is being worked at the present time, the lode consisting of a vein of galena varying up to six inches in width. It is going underfoot, and is at the present time being tested to the south. Its behaviour cannot be predicted, but should the vein maintain a constant width of at least 6 inches so as to render the mining operations payable, it would be possible to test the Heazlewood lode at depth by a long crosscut from these southern workings.

(Victorian) Magnet S.L.M. Co.—This company holds the old Godkin, Godkin Extended, Discoverer, and Bell's Reward mines. Lines of gossan (oxides of iron and manganese) run through all these properties. These lines of gossan occur either at the junction of pyroxenites and syenites with Silurian strata, or else in the Silurian strata and parallel to the junction. These have been tested at depth at many points along their course, but with very disappointing results. Some of the lines parallel to the junction have been proved to represent superficial replacements of limestones, while others are associated with secondary impregnations of limestones and sandstones with galena and silver minerals. The gossan line at the junction has revealed very small amounts of ore in depth at several localities, but some of these deposits are undoubtedly secondary. The Godkin Extended lode is of a different character but has only exposed a small shoot of secondary ores.

As little of value has been exposed to the depth tested there is only one course to finally test the formations, and that is to sink to a greater depth. It is recommended that sinking be carried out at the north shaft where the gossan persists to the No. 3 level, until the zone of any primary lode should have been reached, and that further work depend upon the results obtained.

The Washington Hay and Confidence mines have been opened up on lodes representing a replaced dyke, probably different portions of the same dyke. Small shoots of ore consisting of narrow veins of galena have yielded very small quantities of ore, but no others of any economic importance have been exposed. A considerable length of the lode has not been tested but there is no reason to expect better results in this portion.

The Whyte River Mine contains a narrow, irregular vein of galena up to six inches wide in a decomposed pyroxenite. The shoot was short, and the mine appears to be of no economic value.

Gregory's Mine contains a quartz lode with very small amounts of galena and blende, and as opened up is of no economic value.

The Silver Cliff Mine contains two lodes, in both of which small shoots of ore were worked near the surface, and produced small amounts of galena. These shoots did not persist in depth, and no others have been located.

The Persic Mine contains numerous formations on the lease, but they are of no great importance. The No. 1 lode has been opened by two adits, but only very narrow veins of galena have been exposed, and no ore has been produced, and the mine has small prospects of success.

The Magnet S.L.M. Co., N.L., are working the Magnet Mine which has been the largest producer, and the most successful silver-lead mine in the district. The lode has been followed down to 1000 feet from the outcrop and is going underfoot. Reserves of first and second-class ore exist above the bottom level and a weekly production of 70 tons of crudes and 30 tons of concentrates is being maintained. The mine is well equipped and, with the present price of lead and silver, should have a very successful future. Sinking is recommended to develop the lode at a greater depth.

Numerous outcrops and prospects occur throughout the district and are described briefly in the text.

Conclusions.—The geology and geological structure of the Waratah district are such that it must be regarded as one likely to contain valuable mineral deposits. It is composed mainly of Lower Palæozoic sediments which have been folded and faulted, and intruded extensively by Devonian igneous rocks. Denudation has removed large thicknesses of these sediments, and the igneous rocks are exposed at the present surface at many places. It is in such worn-down regions that the majority of the world's ore-deposits are found.

The silver-lead deposits were deposited from solutions derived from the final granitic intrusions. The granite now outcrops, probably continuously, along the tract of country between Wombat Hill and the Meredith Range. It is in the country adjacent to this granite that these deposits have been formed, and in which they should be prospected for. The district investigated forms the greater portion of this belt to the north-west of the granite. This portion has been fairly well prospected, the result of which has been the discoveries dealt with in this report. The majority of these discoveries have been thoroughly tested by mining operations, but, while many produced very small amounts of ore, the results have been disappointing.

The Magnet lode stands out as the most important, and the Magnet Mine as the only one which has been worked continuously and has prospects of a successful future.

In spite of these disappointments, prospecting should be continued, especially in the areas of basic and ultra-basic Devonian rocks (gabbros, pyroxenites, peridotites, &c.). These rocks were readily attacked by the mineralising solutions, and the majority of the lodes formed in them, and it is in these rocks that discoveries are most likely to be made.

I.—INTRODUCTION.

(1)—Preliminary Statement.

The Waratah district in which the following investigation was carried out, is essentially a mineral district, and has become well-known throughout the world on account of the richness of the tin ores occurring at Mt. Bischoff.

In addition to the tin-ores, silver-lead ores are also found at numerous localities, and much prospecting and active mining operations have been carried out in connection with them. The Magnet Mine is the most important silver-lead mine within the district, and is, at present maintaining a weekly output of 60 tons of crudes and about 300 tons of seconds. The Mt. Jasper Mines and the (Victorian) Magnet (Godkin) Mines are still carrying out mining operations on a small scale, the former maintaining a small output of ore. All other silver-lead properties within the district are now idle.

This investigation consisted of the systematic mapping of the geology of the district, and examination of the silver-lead occurrences, the object being to determine the factors controlling the deposition of the silver-lead ores of the district. The solution of this problem will be of great benefit to the mining industry of the district in future prospecting and mining operations.

(2)—General Statement.

The field work on which the following report is based, was carried out during the period between the 23rd January, and 29th June, 1922—a total period of five months.

The mineral charts of the Mt. Bischoff and Heazlewood districts were utilised in the mapping of the district, and were of great assistance. The topography on these charts is, however, very poor, and numerous additions and alterations had to be made in this connection.

Contours at 200 feet intervals are shown on the Geological Map, and are based on aneroid readings, the datum used being the Waratah station at an altitude of 2000 feet above sea-level.

(3)—Acknowledgments.

The writer wishes to express his appreciation of the courtesy and hospitality extended to him, and also of the assistance given to him by many residents of the district.

He wishes to especially thank Messrs. R. G. Hales (manager, Magnet Mine), J. Powell (manager, Victorian Magnet Mine), W. J. Hines (agent, Persic Prospecting Syndicate), J. O'Connor (manager, Mt. Jasper Mines), and P. J. O'Connor (legal manager, Mt. Jasper Mines), for their assistance while examining their respective mines and the surrounding districts, and also for the valuable information received from them during the examinations.

His thanks are also due to the following members of the local advisory committees which were formed to assist the investigation:—

Messrs. R. G. Hales, and N. T. Gaunt, Magnet.
Messrs. J. Betts, J. Powell, and J. O'Connor for the Whyte River district.

The writer was accompanied during the greater portion of the investigations by Mr. J. Betts, as field-assistant, and desires to record the splendid services given by him. His knowledge of the district, his energy, and bushmanship greatly expedited the work of this investigation, and made possible the examination of such a large tract of difficult country.

II.—LITERATURE.

The following list of publications includes all the references to the geology and the mining properties within the district. These reports generally represent the results of very brief examinations of the mines, which did not permit of any detailed examination of the geology of the district:—

Thureau, G., Report on the Heazlewood Silver-Lead and Other Ore-Deposits in the County of Russell, West Tasmania, 1888.

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

Montgomery, A., Report on the Country Traversed by the Route of the Proposed Waratah to Zeehan Railway: Secretary for Mines' Report, 1891-1892.

Montgomery, A., Report on the Godkin Silver Mine, Whyte River, 1892.

Montgomery, A., Report on the Corinna Goldfield: Secretary for Mines' Report, 1893-1894.

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, 1896-1897.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna, 1900.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Long Plains, 1903.

Ward, L. Keith, The Silver-Lead Lodes of the Waratah District: Geological Survey Report No. 2, 1911.

Twelvetrees, W. H., Report on the Magnet Mine. This report was a confidential one, and was not published, but a brief summary is given in the Secretary for Mines' Report, 1918.

Reid, A. McIntosh, Osmiridium in Tasmania: Geological Survey Bulletin No. 32, 1921.

III.—HISTORY.

The history of the Waratah district as a mineral field began with the discovery of tin ore in the valley of the Tinstone Creek, by James Smith, on December 4th, 1871. Some days later while searching for the source of the tin ore he discovered traces of lead ore, and also lodes of antimonial lead ore and of zinc blende and galena, before actually locating the source of the tin ore on Mt. Bischoff.

Except for these and subsequent discoveries of small amounts of silver-lead ores in the vicinity of Mt. Bischoff no further discoveries were made for many years. During this period practically all of the streams of the district were prospected for gold and tin. Small amounts of alluvial gold were obtained, but no lodes were discovered.

Following the discovery of the rich Broken Hill silver-lode in New South Wales, 1882, a silver boom commenced, and the district was energetically prospected for silver-lead lodes. The discovery of the Zeehan silver-lead field in the early 'eighties also helped in the creation of this boom.

The first discovery was made by W. R. Bell, in 1885, near the site of the Heazlewood Mine. He regarded the gossan outcrop as a possible hydraulicking proposition, but this was not entertained by J. Simth, who was financing the prospecting venture. Smith detected galena in the gossan, and further prospecting by Bell resulted in the discovery of galena near the place where the main shaft of the Heazlewood S.M. Coy. was sunk. Smith and Bell obtained reward sections and developmental work was carried out, and the Heazlewood S.L.M. Coy. formed.

While engaged at the Heazlewood, Bell continued prospecting in the adjoining country, and early in 1887, discovered galena and blende in limestone near where the shaft of the Bell's Reward Mine was afterwards sunk. Smith and Bell obtained reward sections, and took up adjoining sections, from which the Bell's Reward (later the Result) and the Discoverer Mines were formed. It is also reported that Bell discovered the gossan on the Godkin leases, but confined his attention to the discovery at Bell's Reward.

In the early part of 1888 N. Godkin discovered the outcrop known as Godkin's Find. Other outcrops of gossan were quickly located and the Godkin, Godkin Extended, and numerous other leases were taken up.

Following these discoveries a considerable number of prospectors became attracted to the district, and the greater portion of the district was pegged out. Better means of communication became necessary for the working of the existing mines. The track from Waratah through West Bischoff, along the summit of the Magnet Range, and through the township of Heazlewood to Corrina had heavy grades, and was in bad order, being almost impassable in the wet weather. The present road was commenced from Waratah in 1889, and completed at least as far as the Heazlewood in 1891.

Most of the other discoveries of silver-lead ores were made in the years 1890 and 1891. Along the Whyte River, the Washington, Washington Hay, and the Washington Extended (later the Confidence), were found, and work commenced on them. The Mt. Stewart lode, some distance to the south-west of the Heazlewood and the Whyte River district, was discovered in 1890. Near Waratah, the Silver Cliffs lode and Chaffey's lode were found at the end of 1890 or beginning of 1891. On the Magnet Range, W. R. Bell discovered the Magnet lode about the same time. If hearsay is correct this would represent a re-discovery, as it is stated that Bell actually found the gossan outcrop while locating a site for the track from Waratah to Corinna during the year 1877 or 1878, but could not find it again until 12 years later.

With all these discoveries, great hopes were entertained of the field becoming an important producer. After the period of prospecting, developmental work was commenced to test the lodes. This was continued for several years but gave, on the whole, very disappointing results. Small parcels of ore were sent away from most of the mines during this period. In the majority of cases the developmental work did not reveal bodies of ore of sufficient size and value to render their extraction a profitable enterprise, and these mines ceased operations. Some were opened at a later date, but with no further success. The Magnet Mine has proved to be the largest ore-producer, and has been worked continuously up till the present time. Next in importance has been the Mt. Stewart Mine, which during the period 1905-1908 produced over 2000 tons, with a gross value of £25,000.

Apart from the Magnet, the only mines being worked at the present times are the Victorian Magnet, or Godkin, and the Mt. Jasper mines. The Victorian Magnet Company have continued operations since the failure of the Godkin Coy., but have not exposed any ore-body or sent any ore to market. The Mt. Jasper Coy. are at present working the Mt. Wright silver-lead lode, from which several parcels of ore have been sent away. The only other mine worked in recent years was the Persic, where developmental work, without any ore-production, was carried out.

In addition to the silver-lead, copper ore has also been mined in the district. The Old Jasper lode was discovered in 1899, and the New Jasper in 1912. A considerable amount of work was carried out on these lodes by the Mt. Jasper Copper Mines Ltd. since its formation in 1910. Numerous parcels of ore and concentrates were sent to market by this company, but operations ceased several years ago, and the company is now working the Mt. Wright Mine.

IV.—GEOGRAPHY AND PHYSIOGRAPHY.

(1)—Location and Extent.

The district described in this report is situated in the eastern portion of the County of Russell in the north-west of Tasmania. It lies immediately to the west of the township of Waratah, and embraces the country around the townships of Magnet and Luina (Whyte River) and the old deserted townships of Heazlewood and Stafford.

The extent of the district is about 25 square miles—that of the Magnet area being about 17 square miles, and that of the Whyte River-Mt. Jasper area being about 8 square miles.

(2)—Access.

The Emu Bay Company's Railway from Burnie, on the north-west coast, to Zeehan, passes some distance to the east of the district. From Guildford, 38 miles from Burnie, a branch line of 9½ miles runs to Waratah, which is the main centre of the district.

The Magnet Tramway of 2-foot gauge, and 10 miles in length, connects Magnet with Magnet Siding on the Guildford-Waratah line, and about one mile from Waratah.

A good road from Waratah runs in a general south-westerly direction, and provides the sole means of communication for that portion of the district. Along this road Luina (Whyte River) is situated at 10 miles, Heazlewood at 13 miles, Jasper at 16 miles, while the road continues past Bald Hill, and in the direction of Corinna on the Pieman River.

In addition to the above railways, Waratah is also connected with Wynyard on the north-west coast by a good road.

(3)—Topography.

(a)—*General Description.*

The topography of the district is essentially that of a large elevated and dissected peneplain, and is generally of very high relief. Several residual mountains rise above the general level of this old peneplain, while the present streams have made deep gorges in its surface. The surface of the peneplain is, however, easily discernible, especially where covered by flows of Tertiary basalt.

The general level of this basalt-covered peneplain in the eastern portion of the district is between 2100 feet and 2200 feet above sea-level. To the west of the Mt. Cleveland Range it does not appear to exceed 1800 feet above the sea. The most elevated part of the district is Mt. Cleveland, which reaches an altitude of 3200 feet above sea-level. The least elevated country occurs in the western portion of the district along the valleys of the Whyte and Heazlewood rivers, and has an altitude of 800 feet above the sea.

The central and eastern portions of the district form part of the divide between the large drainage systems of the Arthur and Pieman Rivers. This divide has a general direction from west-north-west to east-south-east, but within the district it is forced some considerable distance to the south by the headwaters of the Arthur River and its tributaries.

(b)—*The Mountains and Hills.*

The highest mountains in the district are those which represent old residual mountains which stood above the level of the peneplain. Many of these still stand above the level of the elevated peneplain or plateau, and form the following mountains:—

Mt. Cleveland	3200 feet above sea-level
Mt. Meredith (about)	2500 feet above sea-level
Mt. Bischoff	2598 feet above sea-level
Magnet Range	2230 feet above sea-level

Greater prominence is added to these residual mountains by the dissection of the peneplain. Other mountains of this type occurring in the vicinity of the district are:—

Mt. Ramsay...	3890 feet above sea-level
St. Valentine Peak...	3637 feet above set-level
Mt. Pearse (about)...	3000 feet above sea-level

Other mountains and hills within the district are those formed below the summit of the old peneplain by the action of the present streams. These are all less than 2100 feet above sea, and are not prominent, so that very few have been named.

(c)—*The Plateau.*

The plateau has been formed by the elevation of a peneplain covered with Tertiary sediments and basalt flows. The general level in the vicinity of Waratah is between 2100 and 2200 feet above sea-level, while in the western part of the district it is about 1800 feet above the sea. The surface has been much broken by the present streams, which have worn deep gorges in it.

(d)—*The Rivers.*

As stated above[1] portion of the district forms part of the divide between the drainage systems of the Arthur and the Pieman rivers.

The Arthur River and its tributaries flow out of the district in a general northerly direction, but eventually it turns to the west and reaches the Southern Ocean on the northern extremity of the west coast of Tasmania. The main streams of this system within the district are the Arthur and Waratah rivers, which junction one and a half miles north of Mt. Bischoff.

The Arthur River rises in the flat, elevated country south of the Waratah-Corinna Road, and flows in a general north-easterly direction. After its junction with the Waratah River it flows out of the district in a northerly direction. Its main tributaries from the west are the Magnet and Seven-mile Creeks, while Tinstone Creek, Ritchie's Creek, and several other unnamed creeks flow into it from the east.

The Waratah River rises on the plateau to the south-east of Waratah, and flows in a north-westerly direction to join the Arthur River. Its main tributary is Falls Creek, which flows into it from the east.

The main streams of the Pieman River system are the Heazlewood River, Whyte River, Castra River, Ramsay River, and Coldstream River. The Ramsay River and Coldstream River occur to the south-east of the district, and flow into the Pieman River by means of the Huskisson River. The Heazlewood River, Whyte River, and Castra River occur in the western portion of the district, and eventually unite and enter the Pieman River at Corinna.

The Whyte River rises between Mt. Cleveland and the Magnet Range, and flows in a general south-westerly direc-

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(1) p. 15.

tion to pass out of the district to the north of Mt. Stewart. Numerous tributaries enter the Whyte River, the largest from the east being the Nine-mile Creek, Falls Creek, and Deep Creek, and from the west Quinton Creek, Eleven-mile Creek, and Leven Creek.

The Castra River comes into the district from the east, and joins the Whyte River to the north-west of Mt. Stewart.

The Heazlewood River rises to the north-west of Mt. Cleveland, and flows across the north-western corner of the district in a south-westerly direction.

(4)—Climate and Meteorology.

The climate of the Waratah district is essentially a wet and fairly cold one. It varies considerably with the altitude and degree of protection given by the mountains and the valleys from the winds. Thus Waratah which is situated on the surface of the plateau, and exposed to every wind has a very cold and wet climate; while localities such as Magnet, Luina, and Jasper, which are situated in valleys and at much lower altitudes enjoy a milder climate. Snow falls frequently during the winter months on the plateau and more elevated portions of the district, but to a much less extent on the less elevated portions, such as Luina and Jasper.

That the climate is an exceedingly wet one can be readily seen from the rainfall data, given in Table No. 1. This table gives the available records for the stations of Waratah and Magnet. The average annual rainfall for Waratah during the period in which records have been taken is 8589 points, while that for Magnet is 8853 points. It is somewhat surprising that the rainfall of Magnet is greater than that of Waratah, as the former occurs in a valley of the Magnet Creek 500 feet below Waratah, and only four miles distant. The heavy rainfall of the district is due to the passage of the westerly rain-bearing winds over such an elevated region. The distribution of the rainfall throughout the year is simple, and is very similar for the two stations—the only difference being the period of maximum rainfall. This distribution is clearly shown in Plate II. The rainfall is lowest in February, and there is then a steady increase until the maximum is reached; this occurs in July for Magnet, and in August for Waratah; then follows a steady decrease until the minimum is again reached in February.

TABLE No. 1.

Rainfall Data for Waratah District.

WARATAH.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1883	160	401	587	302	405	1278	988	1151	396	673	415	753	7509
1884	642	222	119	620	836	772	910	1016	1514	767	625	1011	9054
1885	324	786	955	413	929	1152	548	1308	962	423	508	373	8681
1886	270	537	444	549	1126	354	647	1066	1054	922	523	320	7812
1887	454	170	959	841	604	624	1425	541	1082	504	346	271	7821
1888	600	291	715	475	594	1501	1044	1016	428	687	809	158	8318
1889	604	408	501	541	833	1202	523	846	668	809	522	730	8187
1890	220	400	316	391	148	692	603	990	1334	1379	576	596	7645
1891	601	325	369	296	500	100	539	631	534	928	302	872	5997
1892	292	175	353	649	824	1528	722	810	349	316	580	783	7381
1893	492	173	17	502	857	565	993	987	658	888	455	307	6894
1894	279	238	334	665	876	838	1636	725	861	816	782	335	8385
1895	—	—	—	—	—	—	—	—	—	—	—	—	—
1896	—	—	—	—	—	—	—	—	—	—	—	—	—
1897	538	300	811	584	682	697	1069	645	438	1387	1016	64	8231
1898	409	65	322	1040	263	847	1228	602	1386	482	1503	211	8358
1899	914	483	434	404	648	778	462	279	728	787	912	754	7583
1900	478	361	575	663	491	1213	981	1230	358	1189	255	797	8591
1901	695	205	619	838	863	1053	580	495	1444	1153	425	393	8763
1902	841	618	270	281	518	715	716	557	852	409	545	497	6819
1903	560	558	894	1023	836	1048	1059	1205	814	601	487	717	9802
1904	645	520	400	409	1047	1289	900	1113	934	721	1149	652	9779
1905	594	758	583	736	703	1377	1217	1025	1180	680	845	318	10,016
1906	277	313	198	1497	1147	1722	2075	839	918	1450	770	518	11,724

1907	333	302	544	1184	770	754	1416	1460	1539	1228	337	998	10,865
1908	187	364	1181	532	1406	708	791	882	859	559	549	634	8652
1909	336	110	937	1329	797	880	769	1227	371	1060	663	983	9462
1910	201	270	157	711	1442	1225	540	1508	1146	851	632	1034	9717
1911	267	600	629	979	530	1092	665	614	504	952	602	1409	8843
1912	520	57	427	536	726	843	613	1125	1358	918	836	759	8718
1913	493	278	637	216	541	560	1136	1263	1209	576	1340	600	8849
1914	489	162	313	1481	762	632	843	656	478	144	312	445	6717
1915	352	172	838	815	841	1090	759	1126	1394	1333	1613	206	10.539
1916	631	166	327	1287	907	587	532	1207	632	940	696	1115	9027
1917	411	604	533	540	1245	1152	2007	741	1198	977	838	192	10,438
1918	350	366	372	353	1131	1132	1020	487	385	969	299	799	7663
1919	426	272	610	409	682	1593	957	739	977	813	315	408	8201
1920	77	285	635	563	822	1044	1458	845	777	671	725	444	8346
1921	334	283	435	764	360	870	1332	1266	1137	466	793	322	8362
1922	316	337	661	947	795	618	—	—	—	—	—	—	—
Avge. 37 yrs. to end '21	440	340	523	687	777	960	965	925	888	822	673	589	8589

TABLE No. 1—*continued.*

MAGNET.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1907	283	283	460	1145	623	666	1279	1330	1369	1121	311	957	9827
1908	195	318	948	445	1319	740	716	984	832	517	467	561	8042
1909	301	102	891	1197	810	810	746	1145	368	847	578	934	8729
1910	206	264	202	632	1574	1110	633	1393	1125	910	600	1017	9666
1911	225	565	592	995	595	1071	594	461	426	841	483	1319	8167
1912	475	50	408	533	670	786	487	952	1190	762	801	661	7775
1913	445	251	616	173	622	536	999	1323	1103	571	1363	527	8529
1914	478	158	291	1500	739	691	972	664	579	143	286	401	6902
1915	385	211	804	749	1044	1050	745	1185	1352	1359	1671	167	10,722
1916	597	372	338	1296	879	682	543	1270	581	950	732	1142	9382
1917	430	610	595	666	1208	1160	2048	846	1113	947	834	246	10,703
1918	297	446	376	414	998	990	1080	507	404	1055	426	840	7833
1919	476	311	658	419	684	1648	1043	788	918	754	387	431	8517
1920	80	355	686	657	814	985	1477	937	803	655	763	498	8710
1921	385	242	429	880	520	1034	1240	1677	1005	516	831	345	9104
1922	343	315	699	837	783	696	—	—	—	—	—	—	—
Avge. 15 yrs. to end '21	351	302	553	780	882	931	973	1031	882	796	702	670	8853

(5)—Vegetation and Timber.

The greater portion of the district is covered by dense forests and undergrowth of many kinds. Myrtle forests cover considerable stretches of country, and consist of the following trees:—Myrtle (*fagus cunninghami*), Sassafras (*Atherosperina moschatum*), Leatherwood (*Eucryphia billardieri*), and Celery-top Pine (*Phyllocladus rhomboidalis*). Accompanying this type of forest there is found an undergrowth of tree fern (*Dicksonia*), or horizontal (*Anodopetalum biglandulosum*).

Eucalypt forests also occur at various localities throughout the district, in which several species, including stringy bark (*E. obliqua*) are found.

Besides these forests, tracts of more or less treeless country occur. Some of these are covered by a growth of button-grass, and are barren of trees. Others are covered by a dense jungle of bauera, cutting-grass, and boxwood, together with a sparse growth of eucalypts and manuka (tea-tree) trees.

The largest trees occurring within the area are the eucalypts, but they occur only in patches scattered through the district. They are used for sleepers on the tram and railways, for timbering the mine workings, and for milling purposes.

The Myrtles (red and white) are by far the most numerous tree, and are found up to five feet diameter. Enormous quantities are used for fuel, mainly for domestic purposes and in locomotives, but also in the past for power purposes in boilers.

This timber is also largely used for saw-milling purposes for use in the district.

The Celery-top Pine is the most valued tree in the district on account of its lasting qualities. It does not grow to any great size as regards diameter, but fairly long spars can be obtained. It is used for constructional work, timbering the mine workings and saw-milling purposes.

The other trees, such as leatherwood and sassafras, do not grow to any great size, and are not sought after to any great extent. Both these timbers are used for mine timber, while the former is a very valuable fuel.

The virgin forests and deep gorges combine to produce fine scenic effects. Fine areas of tree-fern occur, especially in gullies, when this growth predominates over others.

(6)—Relation of Mining to Topography.

(a)—*Mining Operations.*

The topography of the district being of fairly high relief, is generally favourable for the carrying out of mining operations. It enables the mining properties to be opened up by means of adits in which drainage and haulage expenses are very slight. This applies particularly to the early stages of development of a mine when cheap development is a very important factor.

The position of the ore-deposits has also to be considered, and where these occur on the most elevated regions, the greatest advantage can be taken of the natural features.

Generally within the district the topography and the position of the ore-deposits are such that developments by adits is possible in at least the earlier stages of a mine. As the deposits are exploited at greater depths, as at the Magnet Mine, mining by means of shafts has to be resorted to.

(b)—*Water Supply and Power.*

The rainfall of the district is heavy (86 to 88 inches per year) but, owing to the youthful nature of the topography, the water has a quick run-off. The volume of water in the streams is large after a period of rainfall, but soon decreases with a period of dry weather. Water has, therefore, to be conserved in order to maintain any large permanent supply, and this requires the construction of dams. The conditions existing for the selection of dam sites are only fair, so that long or high retaining walls have to be constructed.

The distribution of the rainfall throughout the year is illustrated in Plate II., and shows that the driest period of the year is that around the month of February. In actual practice the shortage of water occurs in February, March, and even into April. To ensure a permanent supply at all times of the year, provision has to be made in conservation schemes to store sufficient water to carry on through this dry period from January to April.

With sufficient quantities of water assured, the other conditions for the generation of electric power by means of the water are very favourable. The steep sides of the valleys and the grades of the streams render possible the obtaining of a suitable "head" for generation of power, in a very short distance.

V.—GEOLOGY.

(1)—Introduction.

(a)—*Summary.*

The oldest formations occurring in the district are Lower Palæozoic sediments which are divisible in three series or systems. The Dundas series of purple and light-coloured slates and breccias are the oldest, and may be Cambrian in age. The Bischoff series of black slates, sandstones, and quartzites, occur in faulted relation with the Dundas series, and probably belong to the Ordovician period. Following these there occurs a series of shales, loosely-compacted sandstones, and argillaceous limestones, containing fossils identical with those occurring in Silurian beds in other parts of Tasmania.

All these formations have been intruded on a large scale by igneous rocks of Devonian age. These rocks vary in character from ultrabasic to acidic, and include the following types:—pyroxenites, peridotites, gabbros, syenites, and granites with associated porphyries.

There is some evidence of an earlier period of igneous activity as completely decomposed igneous rocks are found intruding the Dundas series.

Upper Mesozoic diabase is found intrusive into the above formations at several localities.

Beds of Tertiary age overlie these formations, and are covered, in turn, by extensive flows of Tertiary basalt.

Gravels and alluvium are forming along the courses of the present streams at numerous localities.

(b) *Maps and Sections.*

A geological sketch-map of the district is shown on Plate III., and includes not only the areas investigated in connection with the silver-lead deposits, but also those surveyed by A. M. Reid and H. G. W. Keid in the examination of the tin deposits of the district.

This map shows the geographical and topographical features of the district, and is contoured at 200 feet intervals. The boundaries of the different rocks, and geological formations which outcrop at the surface are also shown.

Geological sketch sections, prepared from the above map, are shown on Plate IV., and illustrate the geological structure of the district.

(2)—The Sedimentary Rocks.

(a)—*Sequence of the Sedimentary Rocks.*

System.		Series.	Correlation.	Lithological Characters.
Ordovician to Cambrian		Dundas	Dundas Series	Purple and light-coloured slates, and breccias
	Probable Unconformity			
Ordovician to Cambrian	Probably Ordovician	Bischoff	Balfour and Mathinna Series	Greyish-black slates, sandstones, and quartzites
	Unconformity			
Silurian		Lower or Middle	Queen R., Zeehan, and Middlesex slates, sandstones, and limestones	Shales, sandstones, and argillaceous limestones
	Unconformity			
Tertiary		Lower	...	Gravels, sands, clays, mudstones, and lignites
	Unconformity			
Quaternary		Recent	..	River gravels and alluvium

(b)—*The Dundas Series.*

This series of rocks consists of slates, cherts, and breccias. The slates, where exposed on the surface, are mainly reddish in colour, and are accompanied by lesser amounts of light buff and greyish varieties. Black slates occur at only one locality—to the west of the Old Jasper Mine. The red colour of the slates is probably a result of weathering, and in depth, the colour would be bluish or greyish, as is the case with the associated breccias. These slates are not very thinly bedded as a rule. They are composed of very fine material, which cannot be identified in hand-specimens. Under the microscope the only minerals recognisable are a carbonate (calcite or dolomite), and an opaque mineral which is probably hæmatite. The carbonate occurs as small isolated areas throughout the section, while in hand-specimen narrow veins are visible, so that this mineral is clearly of secondary origin. The remainder of the section is of extremely fine-grained material, showing only very slight traces of stratification. Even under the high power, nothing can be definitely determined, although there seems to be some felspathic material present.

The cherts are red and white in colour, and clearly represent silicified slates.

The breccias contain two distinct types—one with, and the other without, mica. This distinction was made from hand-specimens in the field, and is supported by microscopic examination. Both these rocks are found apparently interbedded with the slate members of the series. In hand-specimens small ellipsoidal pieces of red slates occur in them, while in the non-mica bearing type very narrow bands of these slates occur. This evidence proves conclusively that these rocks were deposited under water contemporaneously with the slates.

The non-mica bearing or felspathic type weathers to a reddish rock resembling a felspathic sandstone or greywacke. The fresh rock has a bluish grey colour, while intermediate samples have a purple tinge, and are very similar to specimens from the Dundas series as developed near Dundas. The only minerals recognisable in hand-specimens are opaque and decomposed felspar, and a carbonate (calcite or dolomite), which occurs as narrow veins. Under the microscope the rock is seen to consist of numerous angular fragments of felspar in a finer matrix of the same material. Many of the felspar grains are remarkably fresh, but all gradations to an opaque and completely decomposed product are present. Of the fresh grains many are recognisable as plagioclase by their lamellar twinning. The remainder appear as fragments of simple crystals, which judging by the proportions of sodium and potassium in the analysis (Table No. 2), must be either soda-orthoclase or anorthoclase. A secondary carbonate (calcite or dolomite) occurs as veins and small patches throughout the section. Hæmatite appears as small opaque grains of secondary origin. Chlorite appears with a greenish colour, and is generally dark between crossed nicols, due to very low double refraction, but occasionally gives polarisation colours low in the 1st order. It appears generally as irregular areas containing small grains of limonite. It is secondary in origin, but the original mineral of which it represents the altered product cannot be satisfactorily determined. In a few cases chlorite and felspar laths appear as an ophitic intergrowth, suggesting the replacement of pyroxene, and the fragment of rock appears to be an altered dolerite or allied type. The analysis of this rock-type is given in Table No. 2. The high percentage of ferric oxide is accounted for by the hæmatite in the rock. The magnesia will occur mainly in the chlorite, as will also the ferrous oxide. Some of the lime, and possibly also magnesia will be present in the carbonate, which will probably be close to calcite in composition. The ratio of soda to potash is 6 : 1, and felspars will, therefore, be chiefly soda and soda-lime felspars, the potash being present as soda-orthoclase or anorthoclase.

The original composition of this rock must have been mainly felspar, with a smaller amount of probably augite. The augite has been completely altered to chlorite, while much of the felspar has been changed to opaque kaolin. This alteration and decomposition has resulted in the production of hæmatite and calcite in addition to the above products.

TABLE No. 2.—*Analyses of Dundas Breccias.*

Constituent.	I.	II.
SiO	46·60	48·08
FeO	0·26	0·49
FeS_2	...	0·33
Fe_2O_3	19·16	21·61
Al_2O_3	19·23	18·91
MnO_2	0·22	...
CaO	2·95	2·35
MgO	4·49	5·07
K_2O	0·54	1·20
Na_2O	3·29	0·67
Loss on ignition	4·06	1·70
	100·80	100·41

I.—Felspathic breccia. Magnet Creek, near N.E. corner of Section 5137.

II.—Micaceous breccia. No. 14 Plat, Magnet Mine.

The micaceous type is a dark-grey, fine-grained rock, with quartz and mica visible to the naked eye. It weathers to a brown or brownish-red product in which white mica is the only recognisable mineral, although occasionally decomposed felspar can also be detected. Under the microscope, this rock is seen to consist of angular fragments of quartz, felspar, and mica, in a fine groundmass of the same minerals, together with hæmatite, calcite and chlorite. The quartz occurs as the usual clear, glassy, variety. The majority of the felspars are untwinned, but others have the typical lamellar twinning of the plagioclases. Biotite occurs as brown, pleachroic flakes, giving polarisation colours of 3rd order. Muscovite is present as clear, colourless flakes, giving polarisation colours similar to those of biotite. Calcite occurs as small patches, and narrow veins throughout the section, and also plentifully as an alteration replacement of the felspar fragments. A chloritic mineral is present as flakes, and also as more equi-dimensions and rounded grains. The chlorite in the form of flakes clearly represents altered biotite, but the origin of the remaining chlorite cannot be determined. Oxides of iron occur plentifully throughout the section as secondary products, in some cases almost entirely replacing felspars. The matrix is very much decomposed, and rendered opaque by oxides of iron, and consisted mainly of felspars. This rock, therefore, consisted of angular fragments of quartz and felspar, and also flakes of biotite and muscovite, in a finer matrix of mainly felspathic material. This type differs from the other in containing quartz, biotite, and muscovite, but is otherwise very similar. It occurs as distinct beds, and there does not appear to be any gradation between the two types. The analysis of the micaceous type is given in Table No. 2, and shows it to be very similar to the felspathic type. The main difference is in the proportions of the alkalies, potash being in excess in the micaceous type. This is explained by the presence of the biotite and muscovite, which both contain potassium. The lower percentage of soda is to be accounted for by the fact that there is much less felspar in the micaceous type, while quartz is more abundant. The presence of the latter explains the increased silicia percentage in the micaceous type.

These two rocks may be distinguished by describing them as felspathic and micaceous respectively. They consist of minerals which were originally all of igneous origin, but the rocks themselves are of fragmentary origin. Their field occurrence proves them to have been deposited under water along with the associated slates. The rocks must, therefore, be either submarine bedded tuffs or detrital sediments derived almost entirely from igneous rocks. There is very little evidence on which to distinguish between these two modes of origin. The angular nature of the fragments rather favours their origin as tuffs. The fragments are not, however, all of the same nature and composition, which is generally a criterion for tufaceous deposits. Glass usually accompanies tuffs, but is absent in these rocks. If the rocks are tuffs, the magma must have crystallised before being subjected to explosive action. This would also explain the different compositions of the component fragments. In the micaceous type the occurrence of biotite and muscovite has to be explained. Biotite usually crystallises only under plutonic, but also sometimes hypabyssal, conditions, and is rare or absent under other conditions. Some flakes are included in quartz, and the fragment of quartz and biotite probably represents a piece of granite or allied rock.

The bulk of the evidence is rather opposed to the idea of a tufaceous origin, and the rocks, are, therefore, considered to be sedimentary breccias, composed almost entirely of igneous minerals and rocks. The types are very interesting and unusual, and the exact processes by which large thicknesses of angular fragments of igneous rocks and minerals of very uniform grain-size were accumulated, is by no means clear. The felspathic type is clearly connected with intermediate to basic igneous rocks as fragments of such rocks occur in this type. The micaceous type contains quartz and mica, and probably fragments of granitic rocks, and is therefore partly derived from acid igneous rocks. These rocks will be, as far as the present evidence goes, considered as sedimentary breccias, composed of igneous material. The igneous material was probably derived in some manner from the contemporaneous porphyroid activity, but the exact processes cannot at present be explained.

In describing these rocks as breccias they must not be confused with the breccias from North Dundas, which is the type locality for the Dundas series. The latter breccias are coarse-grained greenish types made up of fragments of a cherty nature. Only one small outcrop of these occurs within the Waratah district.

The structural features of this series could not be satisfactorily determined. Outcrops and sections where strikes and dips could be measured were limited to stream-beds and artificial sections like roads, tramway-cuttings, and water-races. In these exposures, too, the beds are massive, and great care is required to distinguish between joint and bedding-planes. The recorded strikes have a large variation in direction, ranging from 0° to 135°, the most general appearing to be east and west.

Owing to the impossibility of determining the structural features, no idea of the thickness of the series could be obtained. The members of the series are found in all parts, and occupy almost half of the present surface of the district. They occur at all elevations from 800 to 2200 feet above the sea, and the aggregate thickness of the series must be considerable.

This rock series is identical with that developed in the tinfield of North-east Dundas, and termed by Ward(2) the Dundas Slate Series. The purple slates and tuffs, and also the cherts, of the Waratah district agree with those of Dundas as described by Ward. Samples from that district seen by the writer are identical lithologically with, but appear to be intermediate in texture between, the slates and breccias of the Waratah district. On the track to the Godkin Mine, near the Washington Hay Mine, a coarse green breccia occurs, and is similar to those described by Ward. Recent work by A. McIntosh Reid in that district has also proved the identity of the two series.

As regards the age of this Dundas series very little evidence is at present available, and they are referred to the Cambro-Ordovician system on the grounds that they unconformably overlie the Pre-Cambrian schists, and unconformably underlie definite Silurian strata. In 1902, the late T. S. Hall(3), described some graptolites from the Dundas slates, but Loftus Hills states(4) "there is some doubt in regard to the reliability of this determination in fixing the age of the Dundas slates, for repeated search, both at the locality where Hall's specimens were supposed to have been procured, and elsewhere in the series, has signally failed to provide another specimen." Within the Waratah district the Dundas series are clearly older than the Silurian strata, which occur in the western portion of the district. Further, they appear older than the

(2) Ward, L. Keith, The Tin Field of North Dundas: Geological Survey (Tas.) Bulletin No. 6, 1909.

(3) Hall, T. S., Evidence of Graptolites in Tasmania: Roy. Soc. Tas., 1902.

(4) Hills, Loftus, The Progress of Geological Research in Tasmania since 1902: Royal Society of Tasmania, p. 119, 1921.

Bischoff series, which occur as a faulted block let down into the Dundas series. The Bischoff series are regarded by the writer as probably Ordovician in age([5]), and the Dundas series would, therefore, occupy a position in the lower part of the Cambro-Ordovician.

Correlation with similar occurrences in Victoria—the nearest of the mainland States—does not help greatly, although the following attempted correlation with the Heathcotian (Upper Cambrian) series may prove to be of some value. Loftus Hills ([6]) suggested the possible correlation of the Porphyroids, of which he considered the Dundas series a part, with the Heathcotian series. Later, the same investigator([7]) proved that the Dundas slates and breccias, the Read-Rosebery schists, and the felsites and keratophyres of the porphyroid igneous complex, constitute a conformable series in ascending order. The Dundas series in themselves suggest a correlation with the Heathcotian in the occurrence of the cherts which they contain. The Heathcotian series are characterised by the presence of diabasic lavas and tuffs, and also cherts which have been shown by Prof. E. W. Skeats([8]) to represent tuffs metasomatically replaced by silica. The cherts of the Dundas series undoubtedly represent silicious alterations or replacements of the slate members. The Dundas slates of the Waratah district are very fine-grained, but otherwise similar to the breccias, and appear to consist entirely of igneous (felspathic) material. The cherts of the Dundas and Heathcotian series thus appear identical in mode of origin, and can reasonably be correlated with one another.

It must be remembered, however, that the correlation is by no means complete because the Heathcotian series consist mainly of slates and sandstones, with interbedded diabase lavas and tuffs, and cherts, while the Dundas and Porphyroid series are composed mainly of igneous material (lavas, tuffs, breccias, &c.). However, consideration must be given to the occurrences of lavas, tuffs, and cherts (representing replaced igneous material and tuffs), in the Victorian and Tasmanian series, and the possible correlation of the Dundas and Porphyroid series with the Heathcotian. The Heathcotian series are now regarded as Upper

([5]) See p. 32.

([6]) Hills, Loftus, The Jukes Darwin Mining Field: Geological Survey (Tas.) Bulletin No. 16, pp. 61-62, 1914.

([7]) Hills, Loftus, Geological Survey (Tas.) Bulletins Nos. 19 and 23.

([8]) Skeats, E. W., On the Evidence of the Origin, Age, and Alteration of the Rocks near Heathcote: Proc. Roy. Soc. Vict., 1908.

Cambrian on the evidence of the Dinesus beds with associated Protospongia cherts at Heathcote, and if the correlation of the Dundas series be a true one, then this series must also be regarded as Upper Cambrian.

(c)—*The Bischoff Series.*

The Bischoff series consists of alternating beds of slates and sandstones with very subordinate amounts of conglomerate and breccia. The slates are generally dark-grey to black in colour, but light-coloured varieties also occur. They are thinly bedded, and along the valley of the Magnet Creek are very thinly laminated. The sandstones are fine to medium-grained varieties, and have been largely altered to quartzites. The fine-grained varieties are thinly bedded and flaggy, and have white mica plentifully developed on the bedding-planes. In and near the Persic Mine breccia and breccia conglomerates occur. The breccia is exposed in No. 1 adit, where it forms a three-feet bed, and consists of angular fragments of white slate and chert in a darker groundmass. The footwall part of this bed is soft, and the hanging-wall part is silicified. Breccia-conglomerate occurs with the gossan of Chaffey's lode, while another exposure is visible several chains to the east.

Owing to the comparatively small number of exposures, and the complicated structure of these beds, no accurate section and thickness of them can be given. The strike varies from 0° to 110°, but is generally between 30° and 60°. The beds are folded into a series of fairly steep anticlines and synclines, with overfolding to the south-east at some places. The longest exposure at right angles to the axes of the folds is two miles, while the outcrops of these beds vary in altitude from 1200 feet to 2500 feet above sea-level, so that the thickness of this series is considerable.

As indicated in the naming thereof this series is typically developed in the vicinity of Mt. Bischoff. Here these strata occupy a tract of country two miles wide, but which decreases in width in the direction of Magnet. They have been exposed as a result of faulting, and the whole area occupied by them represents a large block faulted and dropped against the rocks of the Dundas series. The only other exposure of this series is a very small area at the Magnet Mine, but which is just outside the apex of the above faulted block.

No direct evidence is available to determine the age of this series, as the series has not, up till the present, yielded any fossils. It is faulted against the Dundas series, and is younger than this latter series, but this relation is of little use as the Dundas series is also of undeterminable age as far as any fossil content is concerned. Within the Mt. Bischoff and Silver Cliffs area, the Bischoff series are intruded by acidic and ultrabasic igneous rocks of Devonian age, and are, therefore, Silurian or older. In comparison with the typical Silurian system as developed on the Victorian Magnet leases, on general lithological and structural features, the Bischoff series must be considered as a much older formation, and, therefore, belong to the Cambro-Ordovician System of Tasmania. In particular, the Bischoff series is probably to be correlated with the Balfour, and also the Mathinna series of slates and sandstones which are classified under the Cambro-Ordovician system([9]).

On general lithological characters and structural features, the Bischoff series could well be correlated with the Ordovician system of the State of Victoria. This would be in agreement with the placing of this series together with the Balfour and Mathinna series in the upper part of the Cambro-Ordovician system. The Bischoff series are younger than the Dundas series, and if the latter be correctly correlated with the Heathcotian (Upper Cambrian) of Victoria, the Bischoff series must necessarily be of Ordovician age.

(d)—Silurian System.

The rocks of this system which outcrop in the district consist of sandstones, shales, and argillaceous limestones. The sandstones are white, medium-grained, loosely compacted types, and are generally thickly bedded. Conglomerates occur at the Victorian Magnet Mine, but these coarser silicious sediments are not plentiful. The shales are fine-grained clayey types of a light to greyish colour. The limestones are dense, bluish rocks, and usually contain much clayey material which renders them impure.

Owing to the lack of outcrops no detailed section of the strata can be given. In the Victorian Magnet Mine these rock-types are interbedded, with the limestones occurring in the forms of lenses. Judging by the surface outcrops, the sandstones appear to be the most plentiful rock-type, but this is due to their more resistant nature,

([9]) Loftus Hills, M.B.E., M.Sc., The Progress of Geological Research in Tasmania since 1902: p. 119, 1921.

and underground works prove the presence of shales in at least equal amounts. The limestones are inferior in amount, and the conglomerates are much more so.

The beds of this system outcrop in the west, and south-west parts of the district, and occur at the following localities:—

Along the Mt. Stewart track between the Whyte and Castra Rivers.

At the 16-mile peg on the Waratah-Corinna road.

Along, and to the west of, the old track between the Victorian Magnet and Bell's Reward mines.

It is probable that these outcrops are parts of a much larger exposure of Silurian strata, but time did not permit an examination of the intervening country being made.

In the Godkin-Bell's Reward area these beds have a general strike, varying from north-north-west to north-west. The general dip is 40° to the north-east, but in the No. 5 Tunnel on the old North Godkin lease, a synclinal fold, accompanied by faulting, occurs, and the beds to the east are vertical in some places, and dipping to the south-west in others. At the 15-mile peg, on the Waratah-Corinna road, the sandstones appear to be horizontally bedded.

These beds are highly fossiliferous, but owing to the limited outcrops, collecting is practically confined to the mine workings. The fossils obtained were mainly brachiopods, and the following genera occur:—Atrypa, Orthis, Spirifer, and Rhynchonella. In addition, encrinital stem-joints, several species of trilobites, and other brachiopods, including strophomena, have been reported.

These fossils are typical of the Silurian system as developed in Tasmania, and enable these strata to be correlated with those at other localities, such as Zeehan, Queen River, Dundas, Huskisson River, Wilson River, and Middlesex.

The relation between the Silurian strata and the Dundas and Bischoff series could not be determined, as nowhere in the district examined do they come into contact. The Devonian igneous rocks were everywhere in contact with the Silurian strata, but to the west between the Castra and the Whyte River, the Silurian and the Dundas series probably come into direct contact, and the relation is likely to be a faulted one. On lithological grounds, the Silurian are distinctly younger than either the Dundas or the Bischoff series.

(e)—*The Tertiary System.*

The beds belonging to this system consist of conglomerates, gravels, sands, sandy clays, and mudstones.

The greatest thickness of these strata is about 100 feet, which occurs at the northern extremity of the Magnet Range in the district. The basal members consist of heavy conglomerates and gravels, the boulders in which have diameters up to 12 inches, and occasionally much larger. Small quantities of gold, and possibly cassiterite, are associated with these basal members. Succeeding these occur fine-grained sands, sandy clays, and mudstones, with waterworn pebbles and boulders distributed erratically through them. The boulders throughout the series are all waterworn and rounded, and include numerous rock types of which the following are most prominent:—Quartz, quartzite, cherts, slates, Dundas micaceous breccias, porphyries, and red and white granites. Many of these rocks may have been derived locally, but others, such as the red granites, must have been transported considerable distances, as none occur locally. The most interesting of these transported boulders are those of soft sandstone containing numerous typical Permo-Carboniferous fossils.

These Tertiary beds contain brown coal deposits in the vicinity of Waratah, and they extend and increase in thickness towards the north, pointing to the existence of the Tertiary land surface to the south. The Permo-Carboniferous boulders must, therefore, have been transported from the south. The nearest outcrop of Permo-Carboniferous strata in this direction is at Barn Bluff, 30 miles to the south-east, though during Teritary time there may have been other outcropse much nearer but which have since been denuded.

Besides the brown coal deposits at Waratah referred to above, similar deposits occur on the Magnet Range and are exposed where the old Pieman Track crosses the head of Kyber Creek. The relation of this latter deposit with the Tertiary basalt is not very clear in the small exposures available, and the brown coal cannot be said, definitely, to underlie the basalt.

These Tertiary deposits formerly covered nearly the whole of the eastern part of the district, but they have been largely denuded, and now only remnants are left under protective cappings of basalt.

The beds of lignite and ligneous clays within the series contain numerous fossil leaf impressions. Collections of these have been made from localities near Waratah, and have been described by Johnston[10], who referred some of the forms to the genera *Eucalyptus*, *Quercus*, *Laurus*, *Cycadites*, and *Ulmus*, and identified the following species:—

Laurus sprentii (Johnston).
Eucalyptus kayseri (Johnston).
Quercus bischoffensis (Johnston).
Ulmus tasmanicus (Johnston).
Taxites thureaui (Johnston).

Johnston states "that the character of the leaf-remains at Mt. Bischoff is very different from that of any other Tertiary deposit in Tasmania, and as yet it is impossible to determine the true position of the deposit in the Tertiary system in relation to widely separated basins."

The beds of the Tertiary system are horizontally bedded, and any earth movements which have affected them have been those of direct uplift.

These beds rest on the upturned edges of the lower Palæozoic sediments, the Devonian igneous rocks, and also on the upper Mesozoic diabase. Practically everywhere throughout the district they are covered by flows of Tertiary basalt.

(*f*)—*Recent Deposits.*

River gravels and alluvium are forming to a slight extent along the courses of the present streams. The streams are in a very youthful state of development, and the formation of alluvium cannot take place along the greater part of their length. The development is greatest at the heads of the streams on the surface of the plateau.

(3)—The Igneous Rocks.

(*a*)—*Sequence of the Igneous Rocks.*

Dundas and Porphyroid Series	Much decomposed rocks intruding the Dundas Series. Any lavas and tuffs included in the Dundas Series.
Devonian	Peridotites, pyroxenites, gabbros, syenites, granites and associated porphyries
Upper Mesozoic	Diabase
Tertiary	Basalt

(10) Geology of Tasmania. R. M. Johnston, 1888.

(b)—*Porphyroid Igneous Rocks.*

The whole of the rocks of the Dundas Series are composed of material of igneous origin. If these represent definite tuffs they are related to the Porphyroid period of igneous activity. Even if the rocks represent sedimentary breccias, the bulk of the material must have been derived from the same source.

In addition to these fragmental rocks, a limited number of exposures of ancient igneous rocks occur. These appear only in association with the Dundas Series, and are, therefore, classified with the Porphyroid Series. Along the Magnet Tram, east of the Arthur River, a number of dykes of completely decomposed material occur. They were originally either basic or ultra-basic types, but all that is recognisable now is small quantities of a brownish micaceous mineral. Another type which is much fresher resembles a fine-grained basalt, and is sometimes vesicular. Under the microscope a specimen (from a locality 60 chains south-south-west of Magnet) of this type is found to consist of felspar, augite, and hornblende. The felspar is not fresh, and consists of numerous laths without any general arrangement. A pale augite occurs in allotriomorphic form in intergrowth with the felspar laths. A large amount of the augite has been rendered opaque by decomposition with formation of oxides of iron. A brown mineral with polarisation of colours and pleochroism corresponding to that of hornblende also occurs. It appears to be hornblende replacing some of the augite. The rock type is a diabase (or dolerite). This rock is doubtfully referred to the Porphyroid Series on account of its comparative freshness.

(c)—*The Devonian Igneous Rocks.*

(i)—Acidic.

Granites and Associated Dyke Rocks.—Granite outcrops to only a slight extent within the district, but in the immediate vicinity large areas of it occur. At the south-eastern part of the Mt. Jasper Company's Mt. Stewart lease granite occurs, and is a part of the much larger mass which forms the bulk of the Meredith Range. This rock is a very light-coloured, medium- to coarse-grained variety, showing in hand specimens white felspar, quartz, and biotite. A. M. Reid[11] gives the following description of a microscopical examination:—

(11) A. M. Reid, Osmiridium in Tasmania: Geological Survey (Tas.) Bulletin No. 32, 1921.

"In their order of relative abundance the component minerals are orthoclase, plagioclase, quartz, and biotite. Orthoclase is the predominating mineral, and occurs in white, sometimes idiomorphic, crystals. Plagioclase is not conspicuous to the unaided eye, but under the microscope it is seen to constitute a large portion of the rock. Biotite, in medium-sized individuals, is scattered indiscriminately through the rock, and pellucid quartz in relatively large crystals is prominent."

Thus the rock-type is a normal biotite granite.

In association with this granite of the Meredith Range A. M. Reid has described quartz porphyry and quartz tourmaline dykes.

Granite also occurs along and to the south of the Waratah-Corinna Road to the east of the Arthur River.

Along the Arthur River between the junction of the Seven-mile Creek and the Arthur Falls, acid and intermediate porphyritic dyke rocks occur. The acid member is composed of large phenocrysts of white felspar and quartz in a fine ground-mass of felspar, quartz, and a ferromagnesian mineral which is probably hornblende. The rock-type is, therefore, a quartz-felspar porphyry.

Accompanying this quartz-felspar porphyry there is a more basic rock-type in which quartz appears to be absent in hand specimens. It is composed of phenocrysts of white felspar in a dark ground-mass of felspar and probably a ferro-magnesian mineral such as hornblende. The rock-type is a diorite porphyrite.

These rocks occur as a long narrow dyke with the quartz-felspar porphyry forming the main portion, and the diorite porphyrite the marginal portions. Small dykes of the diorite porphyrite branch off from the main dyke. To the south this dyke connects with the main mass of the granite near the head of Campbell Creek. To the north the dyke has not been located *in situ*, but from numerous boulders in School Creek and an occasional one in the intervening country it is evident that the dyke extends as far north as School Creek.

About 10 chains north of the Magnet tram bridge over the Arthur River, in a cutting on the east bank, an acid dyke is exposed. This rock is a fine-grained, greyish type felspar being the only mineral recognisable in hand specimens. It is altered to a slight extent and contains limonite. The rock-type is probably a felspar porphyry.

(ii)—Intermediate.

Syenites and Diorites.—These rocks are not developed to any great extent in the district, with the exception of an area between the Whyte and Heazlewood Rivers. This area crosses the Waratah-Corinna Road between the 12- and 13-mile pegs, and extends both to the north and the south. To the south it extends as far as the old North Godkin Mine, now part of the Victorian Magnet.

This rock is a fine- to medium-grained, light-coloured variety of even, granitic texture. In hand-specimens flesh-coloured orthoclase and a greenish mineral, probably hornblende, appear to be the sole constituents. W. H. Twelvetrees([12]) gave the following description of this rock:—

"The granitic-looking rock is to be seen most favourably at the Godkin Mine, on the Whyte River, and there it is found to be syenite (quartzless granite, the constituents of which are orthoclase, oligoclase, chloritic pseudomorphs after hornblende, and a little quartz)."

The same investigator([13]) also describes a syenite "from the bank of the Heazlewood River, a mile north of the road at the 13-mile. A light-grey hornblendic granitoid rock, with hornblende very plentiful. Constituents: Orthoclase, oligoclase, hornblende, quartz, and accessory sphene. The quartz is very miarolitic, and beautiful granophyric intergrowths of quartz and felspar are abundant. Mica absent or very rare. The orthoclase seems to predominate over the triclinic felspar, but the rock is evidently verging on quartz-diorite."

The microscopical examination of a specimen from a tributary of Bell's Reward Creek, 20 chains east of Bell's Reward Mine, gave the following results:—It has a holocrystalline, alltriomorphic, even-grained texture, and a granitic structure. The section consists of felspar, quartz, and an altered ferro-magnesian mineral, with felspar forming about 60 per cent., and the quartz slightly in excess of the ferro-magnesian. The felspar shows much lamallar twinning and is mainly plagioclase. The analysis shows that potash is absent and that the ratio of soda to lime is nearly 4 to 1, so that the plagioclase must closely approach albite in composition. Quartz occurs in the usual clear glassy variety with numerous small inclusions. Chlorite

([12]) Twelvetrees, W. H., Report on Mineral Fields between Waratah and Long Plains, 1903, p. 23.

([13]) Twelvetrees, W. H., Petrograhical Report: Report of Secretary for Mines, 1899-1900, p. ccxii.

is present as an alteration product of a ferro-magnesian mineral. The original mineral occurred as irregular flakes with one prominent set of cleavage planes. This suggests biotite as the original mineral, but in hand specimens the general appearance is rather that of an altered amphibole or even pyroxene. Further, the appearance of the altered mineral is very similar to the hornblende in the syenite-porphyry described below,(14) the hornblende appearing as irregular flake-like fragments with only one prominent set of cleavage planes. The chlorite would, therefore, appear to have resulted from the alteration of hornblende, and this is in accordance with the determinations of Twelvetrees. The rock-type is intermediate between that of a syenite and a granite, and the silica percentage (66·56) in the analysis also places it between the two groups. If anything, the rock has affinities rather with the syenites, and as this name has already been applied to the rock it will be adhered to. Soda is the only alkali present, and it exceeds the line in the ratio of 4 : 1. The type is, therefore, a soda-syenite with albite, quartz, and hornblende present.

Table No. 3 contains an analysis of a specimen from the above locality.

TABLE No. 3.

Constituent.	I.	II.
	Per cent.	Per cent.
$Si O_2$	66·56	66·72
$Fe_2 O_3$	5·58	5·43
$Al_2 O_3$	15·90	15·33
$Mn O_2$	0·22	0·22
Ca O	1·55	1·50
Mg O	2·31	2·89
$K_2 O$	Nil	1·57
$Na_2 O$	5·86	4·56
Ignition loss	2·64	2·00
	100·62	100·22

I. Syenite. Tributary of Bell's Reward Creek, 20 chains east of Bell's Reward Mine.

II. Syenite porphyry. Dyke between Heazlewood and Mt. Wright Mines.

(Both analyses by Geological Survey Laboratory.)

(14) See p. 40.

This rock occupies a considerable tract of country which extends in a general north and south direction. It intrudes on its east side strata belonging to the Dundas Series, and on the west strata of the Silurian system. In addition, it is also found intrusive into the Devonian ultrabasic rocks. A large body of these ultrabasic rocks occurs within the syenite, and divides the syenite into two parts in the central portion. The eastern arm appears to be more dioritic in type, but only extremely weathered specimens were obtainable, and the rock-type may easily be the normal syenite.

The other developments of syenite occur as narrow dykes intruding the ultrabasic rocks and their serpentinised representatives. The most prominent of these is a dyke between the Mt. Wright and the Heazlewood Mines on the Mt. Jasper properties. No solid outcrops are exposed, but the dyke appears to be about half a chain wide and has a general north-westerly direction from the Heazlewood to near the Mt. Wright Mine—a distance of about 10 chains. It intrudes decomposed pyroxenites of Devonian age, and is roughly parallel to a large mass of serpentinised harzburgite of the same age. A microscopical examination of a specimen of this rock gave the following results:—The rock is one with a holocrystalline, allotriomorphic, fine and even texture. It consists of felspar, hornblende, and quartz in decreasing order of abundance. The felspar is much decomposed and cannot be satisfactorily determined, although lammelar twinning can be detected in many of the felspars. Quartz is present as the glassy variety with small inclusions. Hornblende occurs as irregular flakes giving polarisation colours of the second order. Only one set of cleavage planes is prominent, but occasionally another set at angles of 60° or 120° can be detected. The hornblende is a light-greyish green in colour, and only faintly, if at all, pleochroic. The rock appears similar to the syenite described above, and the type is a syenite porphyry. An analysis of this rock is given in Table No. 3, and shows the composition to be very similar to the syenite described above.

Small narrow dykes of similar syenite porphyry, and also of coarse syenitic material, intrude the serpentine on the track between the old Heazlewood ore-shed and the mine.

Similar material resembling the syenite porphyry occurs in association with the gabbro near the Arthur River dam.

(iii)—Basic.

Gabbros.—Gabbros outcrop at several localities, but do not cover any large extent of the surface. The largest outcrop occurs along, and to the north of, the Godkin track 30 chains east of Boarding House Creek. It is intrusive into the Dundas series, and on the west side is in direct contact with the cherts. The rock is a medium-grained greenish one, showing in hand-specimens decomposed felspar and a ferro-magnesian mineral. Under the microscope it is seen to have holocrystalline, alltriomorphic, even texture with a granitic structure, and is composed essentially of felspar and augite. The felspar is much decomposed, and cannot be satisfactorily determined. Plagioclase is recognisable by its lamellar twinning in a few cases. The augite is a light-coloured variety, giving polarisation colours of the second order and extinction angles of 40°. The rock-type is a grabbo.

On the eastern side of this body of gabbro a narrow dyke occurs as an off-shoot. It is finer in grain, but otherwise resembles the parent body.

Along the track from the deserted township of Healzewood to the Bell's Reward Mine, a narrow dyke of gabbro occurs intrusive into the pyroxenites. It is variable in texture from fine to very coarse-grained. The rock is composed of a milk-white mineral, probably saussurite, and dark-green acicular crystals of probably hornblende, and represents a saussuritised gabbro. Similar rocks occur along the Heazlewood River to the north.

Another coarse gabbritic rock occurs in association with fine-grained syenite porphyry 50 chains north of the Arthur River dam. The two rocks occur as a dyke-like body intrusive into the pyroxenites of that locality. The relation between the gabbro and syenite-porphyry could not be determined.

Gabbro outcrops along the Mt. Stewart tram to the south of the Castra River. The rock is a fine to medium-grained variety, showing felspar and ferro-magnesian mineral in equal proportions. A specimen from the same locality has been described by A. M. Reid[15] as a gabbro-amphibolite, the augite having been altered to amphibole.

Diabase Porphyrite.—This very interesting rock falls into this group, but will be described with the other members of the Magnet Dyke under that heading[16].

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(15) Reid, A. McIntosh, Osmiridium in Tasmania: Geological Survey (Tas.) Bulletin No. 32, p. 59.)

(16) See pp. 45-52.

(iv)—Ultrabasic.

Pyroxenites and Peridotites.—Ultrabasic plutonic and hypabyssal rocks are extensively developed throughout the district. The largest outcrop of these rocks occur in the vicinity of Mt. Jasper, and extends northerly to the Bald Hill and neighbouring osmiridium fields, and easterly as far as Heazlewood. Other localities are Mt. Stewart, the spur running south from the 12-mile peg on the Waratah-Corinna road, near the old Godkin Mine, around the headwaters of the Arthur River, both to the north and south of the Waratah-Corinna road, and at the Magnet Mine. Practically all the varieties of peridotites and pyroxenites occur in the district and the adjoining country. These have been described by A. M. Reid(17), and repetition will not be made here, only a few of the rock-types in the district being described.

A common type among the pyroxenites is one showing porphyritic crystals of orthorhombic pyroxenes. This rock is generally much decomposed, and often completely so. When more or less fresh it is greenish in colour, but the decomposed specimens resemble a brown clay, from which the original porphyritic crystals stand out distinctly. Such types occur at the Magnet Mine, north of road at the Arthur River dam, north of Bell's Reward, at the old Jasper Mine, and between the Old and New Jasper mines. At the latter locality, one specimen of the porphyritic crystals showed cross-twinning.

TABLE No. 4.

Constituent.	Hypersthenite (No. 3 Adit, Old Jasper Mine).
	Per cent.
SiO_2	45·36
FeO	0·19
Fe_2O_3	11·23
Al_2O_3	16·92
MnO_2	0·44
CaO	3·15
MgO	14·92
K_2O, Na_2O	0·21
Ignition loss	8·36
	100·78

(17) Reid, A. McIntosh, Geological Survey (Tas.) Bulletin No. 32.

Associated with this type and differing from it only in the absence of porphyritic crystals, another variety occurs. The two are probably only varieties of the one rock-type, and not separate types. Apart from the above localities, where it may be associated with the porphyritic variety, it also occurs at the Persic Mine, east of the old Godkin Mine, between Luina and Heazlewood, at the junction of the Whyte and Castra Rivers, and on the Mt. Jasper leases. At the Persic mine, and north of the Arthur River dam, this variety has been rendered slightly schistose.

The remainder of the pyroxenites occur as extremely fine-grained rocks, and outcrop at the head waters of the Arthur River, along the Corinna road between the 13- and 16-mile pegs, and on the Mt. Jasper leases.

A microscopic examination of the porphyritic variety from the No. 3 adit of the Old Jasper Mine gave the following result:—The rock is holocrystalline and hypidiomorphic, with a porphyritic texture. It is composed almost entirely of an orthorhombic pyroxene, with a little augite. The orthorhombic pyroxene has been altered, and is nearly opaque in most cases. It is only slightly pleochroic, and gives polarisation colours of first and second order, and apparently approaches hypersthene in composition. Augite occurs chiefly as interstitial material. It is a light-coloured variety, giving 2nd and 3rd order polarisation colours, and extinction angles up to 40°. The specimen examined differs from the usual porphyritic type in that it is mainly composed of the porphyritic crystals, and very little ground-mass. The type is a hypersthenite.

An examination of a very fine-grained variety from between the 14- and 15-mile pegs gave the following results:—The rock is holocrystalline and hypidiomorphic, with a porphyritic texture. The phenocrysts consist of very fresh augite in eight-sided sections in which twinning is common. The ground-mass is much decomposed, and the only minerals present which are recognisable, are small amounts of fresh felspar and a pyroxene. The type is evidently a fine-grained pyroxenite, which approaches the gabbros in having felspar present.

Olivine-bearing rocks are not plentiful within the district. The border of the serpentine belt to the east of the old Heazlewood Mine appears to represent one of these rocks. Under the microscope it is seen to be holocrystalline and alltriomorphic, with a coarse granitic structure.

The rock is composed of pyroxene and olivine, with the former slightly in excess. Both orthorhombic and monoclinic pyroxenes are present, but the former predominates. The orthorhombic pyroxene is non-pleochroic, and gives first order polarisation colours, and is enstatite or bronzite. Much of the olivine has been altered to serpentine, and only a small proportion of the original material remains. The rock-type approaches that of the harzburgites.

Serpentine.—Serpentinised ultrabasic rocks occur at several localities. The serpentine east of the Heazlewood and Mt. Wright mines has apparently been derived from the harzburgite described above. Serpentines are numerous in the vicinity of Mt. Stewart, and have been described by A. M. Reid(18).

An interesting feature is noticeable in some of the pyroxenites in the district. They contain small ellipsoidal areas of quartz and carbonates up to half an inch diameter, the average size, however, being a quarter of an inch. In hand specimens these areas appear to consist mainly of a carbonate, probably calcite, but at other localities they consist of quartz.

The carbonates occur in the pyroxenites at the Old Jasper Mine, and to the north-east of Bell's Reward Mine. The specimens from the Old Jasper effervesce freely with hydrochloric acid, and qualitative tests prove the carbonate to be calcite. Under the microscope, however, these elliptical areas are found to consist of quartz and felspar. The quartz occurs on the outside as granular and roughly radiating grains. The felspars are much altered, and show no twinning, and occur in the centre of the areas. Calcite occurs to a very limited extent, and appears to replace felspar. These circular and elliptical areas must represent original features of the rock, and the quartz and felspar the original minerals in them. The occurrence of these minerals, more especially the quartz, in pyroxenites is unusual. Where the calcite occupies the whole of these areas it would appear to represent replacement of the original constituents.

Where the road crosses the saddle, one and a half miles west of Luina, the pyroxenites possess the same features, but the substance in these ellipsoidal areas is quartz. The quartz crystals radiate from the outside to the centre, and appear to represent cavity fillings. The original constituents may have been removed before the introduction

(18) Reid, A. McIntosh, Geological Survey (Tas.) Bulletin No. 32.

of the quartz. Similar areas and narrow veins of quartz are associated with the pyroxenites to the north of the Arthur River dam.

There is no term to adequately describe these original structures in the pyroxenites. For descriptive purposes, though it is not used accurately, the term "pseudo-amygdaloidal," will be used.

(v)—The Magnet Dyke.

This very interesting occurrence is being described separately, and in some detail, on account of its economic importance in connection with the Magnet Mine. The dyke is long and narrow, and has a general north-east and south-west course. Its length is 5 miles with a maximum width of 20 chains in the vicinity of the Magnet Mine, and a general average width of 5 to 10 chains. The Magnet Mine workings are on the south-eastern side of the dyke, and prove it to have a westerly dip. Here the dyke is along the continuation of the southern fault bounding the Bischoff series. To the east of the mine, where the dyke occurs along the other fault, it must have a south-easterly dip in conformity with that of the fault.

Although this occurrence is referred to as a dyke, it is a complex one with several rock-types present representing at least two intrusions along the same line. The cross-section of the dyke varies from place to place along its length. The section at the Magnet Mine has been most fully dealt with, and will be described first. This section from east to west has been described(19) as follows:—

Websterite porphyrite.
Diabase porphyrite.
Orbicular or spheroidal websterite.

The websterite porphyrite on the east of the dyke occurs as a lens-shaped body. It has a maximum width of 360 feet in the Magnet Mine workings (No. 4 adit), but thins out both to the north and south and disappears. This rock is much decomposed, and fresh specimens cannot be obtained. In hand-specimens it appears to be a porphyritic pyroxenite very similar to others occuring within the district. A specimen was sent to Prof. H. Rosenbusch for determination, and the following description(20) was given by this eminent petrologist:—" If we follow the rock back

(19), (20) Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report 1899-1900 to its original or unaltered state, we shall find phenocrysts of bronzite or enstatite (now bastite) in a ground-mass of rhombic and monoclinic pyroxenes (now a mixture of serpentine and a chlorite mineral). It is therefore a porphyritic form of websterite—a websterite-porphyry. Its nearest relations are certain bronzite serpentines (without olivine). In the structure of the ground-mass it resembles the South African kimberlite and the mica-peridotites of Kentucky, described by Diller. In this purity of form the type is quite new to me. An analysis is very desirable. It must, free of water, give the formula of the Mg-Fe metasilicates, and exclude orthosilicates. Al_2O_3 would only be present in small quantity. Also, CaO would not be prominent."

This body of websterite porphyrite also decreases in width with increasing depth from the surface. It decreases rapidly to about No. 8 level, but from here to the bottom (No. 14) level it maintains a fairly uniform but narrow width. In these bottom levels it is exposed in the face of all the south footwall drives. It appears as a dark-green, thinly-jointed rock, much altered, and consisting of bastite or serpentine. A sample from the face of the No. 10 south footwall drive was examined under the microscope, and found to consist mainly of bastite with a smaller amount of chlorite.

The diabase porphyrite and the associated variolite occur as a belt 300 to 400 feet wide to the west of the websterite porphyrite. The porphyrite is a very fine-grained, dark-grey rock, in which no minerals are visible to the naked eye. The variolite is a somewhat darker rock in which appear whitish circular nodules up to a quarter-inch diameter. It occurs as narrow, irregular bands up to 3 feet in width in the porphyrite, and also as a margin to the latter. In some places the porphyrite is veined with quartz, generally whitish, but sometimes of a blackish tinge. In the Magnet Mine the junction of the websterite and the diabase porphyrite has a bearing of 20°, and dips westerly at 50°. The following description is the result of a microscopic examination of a specimen (probably from the footwall of the diabase porphyrite) by Prof. Rosenbusch([21]):—
"If a slide be made of the soft dark-green ground-mass (which is soft enough to be scratched with a knife), it can be seen to consist of a scaly aggregate, the scales of which can often be recognised as chlorite, with very weak

([21]) Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, 1899-1900.

double refraction, and optically positive; optic axial angle very small. Pleochroism weak, normal—green for rays vibrating parallel with the surface of the flake, yellowish-white for those vibrating perpendicular thereto. In it are lying colourless sections variously bounded, but always with crystallographic contours, long, rectangular, and prismatic, also nearly quadratic, extinguishing sometimes straight, sometimes oblique. In convergent light these often show the emergence of a positive bisectrix of a not very large axial angle, sometimes the emergence of a negative bisectrix of a very large axial angle. In the first case no structure is recognised; in the second, a more or less scaly or fibrous structure. Their refractive index differs little from that of the main mass, and there are often seen lying in these apparent crystals green heaps of scales without any clear boundaries, but passing into the colourless substance and having the same optic orientation. In the colourless sections there are also lying homogeneous and homoaxial pseudomorphoses of chlorite, poor in Fe (Leuchtenbergite) after a pyroxene mineral, but I cannot say whether the latter was monclinic or orthorhombic. Further, in the green mass there are circular hollow spots (nearly always surrounded by cracks), which were no doubt originally amygdaloidal cavities, but are now filled with mixed chlorite and quartz spherulites of irregular architecture. It is quartz (optically + and uniaxial), and not chalcedony (optically − and biaxial). Finally, in the ground-mass are little aggregations of iron ore, which I have not examined more closely. They dissolve easily in HCl, which also attacks the chlorite and leuchtenbergite. Now, if a slice be made through the nodules, which are much harder than the ground-mass, and sometimes cannot be scratched with a knife, here and there chloritic spots are seen, containing small sections of chalcedony amygdules. Inside the nodules is sometimes some ground-mass. More frequently, however, the nodules consist of colourless substances. Large aggregates of granular, or even radiating, quartz are seen, sometimes without any regular external boundary, sometimes plainly, and without doubt, showing the form of felspar. These are replacement pseudomorphoses of quartz after felspar, of such beauty as I know only in quartz porphyries. Between these pseudomorphoses of quartz after felspar there are roughly-radiate bundles and spherulitic crystals of felspar, which from their optical behaviour clearly belong to orthoclase or andesine. They are partly converted into sericite, and when this happens the nodules can be scratched with a knife. Finally, the nodules are much intersected by veins of quartz, the fillings of cracks in the rock. Iron ores are absent; but, from the often quadratic and trigonal outlines of the quartz aggregates, I believe we must conclude that the ores have been removed and their place taken by quartz. After all said and done, I regard the rock as a characteristic variolite, but certainly in a much altered state."

An examination of a number of specimens under the microscope proves the rock to vary in composition from place to place. The specimens were all much decomposed, and rendered identification difficult, the above description of the ground-mass applying generally to the specimens. The fresher specimens, however, prove the original rock to have been composed of felspar and pyroxene. The felspar is generally alltriomorphic and granular, but in one section it appears in the form of small laths. Lamellar twinning is common in some sections, but generally the felspar is untwinned. The pyroxene mineral cannot be determined as it is always completely altered, but it was probably a monoclinic pyroxene. Chlorite and calcite occur abundantly as alteration products. Sometimes felspar is largely in excess, and with calcite forms the bulk of the rock. When the section is composed of nearly all chlorite it would appear that the pyroxene mineral was in excess.

Analyses carried out in the Geological Survey Laboratory of a specimen from near the face of the south adit, Magnet Mine (with the carbonate veins removed as far as possible), gave the following results:—

TABLE No. 5.

Constituent.	I.	II.
SiO_2	73·00	60·00
Fe_2O_3	5·29	7·68
FeO	0·39	0·39
FeS_2	0·57	0·24
Al_2O_3	9·95	11·97
CaO	2·30	4·35
MgO	3·84	6·50
CO_2	5·90	8·90
	101·24	100·03

The analyses are of samples from different portions of the same specimen, and differ as a result of different amounts of carbonate present. Both show a high percentage of silica, and the analyses cannot be taken as representative of the diabase porphyrite, but prove further the great variation in this rock. Under the microscope the rock is composed of a very clear and fresh mineral, a carbonate (calcite or dolomite), and pyrite. The clear mineral is either felspar (very fresh) or quartz. Some portions are definitely felspar, and though others are practically indistinguishable from these felspars, they must be quartz to account for the high silica percentage. No alkalies are present, so the felspars must be anorthite, although they occur as simple crystals. Chlorite representing altered pyroxenes is practically absent, so the specimen is not typical of the diabase porphyrite. This type in the south adit must have been largely composed of quartz.

An examination of a specimen of the variolite from the No. 14 crosscut shows it to consist of felspar, calcite, and oxides of iron. The felspar is clear and untwinned. The calcite occurs as veins and small patches, probably replacing felspar. The oxide of iron occurs as long straight needles in the felspar. These needles are arranged in all directions, and intersect at various angles. A few narow veins of calcite occur similarly, and with the oxide of iron appear to represent alteration and replacement along cleavage planes, cracks, and joints in the rock, boundaries between crystals, &c. In the section examined the white areas which give the rock its pock-marked appearance, are not prominent. Those present consist of elliptical areas of felspar, apparently identical with that in the remainder of the rock, except that it is unaltered and contains no needles of the iron oxide, though the general shape of the area may be determined by a vein of the oxide.

To the west of the diabase porphyrite a much decomposed pyroxenite occurs. It is weathered to a brownish-yellow coloured material in which decomposed porphyritic crystals of an orthorhombic pyroxene, probably bronzite, are common. At one locality, which the writer was unable to locate, the late W. H. Twelvetrees[22] found this rock to be "crowded with spheres of the same mineralogical composition, ranging from the size of marbles to that of cannon-balls. These spheres, when broken across, show no concretionary or radial structure, but are exactly similar

(22) Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines Report, 1899-1900.

in apparent texture and architecture to the enclosing rock, from which they are easily released." In a petrographical report in the same publication Mr. Twelvetrees described this rock as an orbicular or spheroidal websterite or bronzitite.

On the western side of this bronzitite or websterite a small amount of a fresh-looking rock outcrops. It is an ultrabasic rock, possibly being fresh samples of the bronzitite or websterite, but it also somewhat resembles the harzburgite described from near the Heazlewood Mine.[23]

Several questions, more or less connected with one another, at once arise in connection with the various rock-types in this Magnet dyke. Firstly, as to the relations between the websterite on the east and the websterite or bronzitite on the west of the dyke, and whether they are one and the same rock. Both rocks have practically the same mineralogical composition, but lack of fresh specimens prevents this being definitely established or otherwise. Except for the difference in weathering they would, in hand-specimens, be considered to be identical types. This difference in weathering may be due to the different positions they occupy—the western outcrop occurring on the summit of the range and the eastern one towards the bed of the Magnet Creek. There is one feature which would have definitely established their identity, but which could not be officially verified. The peculiar spheroidal structure in the western outcrop must have been local as, failing to find Twelvetrees' locality, the writer could not obtain further samples, but it was apparently typically developed in the websterite or bronzite. It is reported by hearsay that spheres were obtained in sinking the winze from No. 4 to No. 5 level in the websterite on the footwall of the lode. Unfortunately, an examination of this portion of the mine in the main shaft did not reveal any spheres, but if spheres were obtained in the websterite this unusual occurrence in similar rock-types should clearly establish their identity.

Secondly, as to the relation of the variolite to the other rock-types, its field occurrence proves definitely that it occurs in intimate association with the diabase porphyrite in which it is found as veins, small patches, and as a border to the main body. So in their relationship with other types they may be considered together.

Thirdly, as to the relations between the diabase porphyrite and the websterites. If the two bodies of web-

(23) See p. 44.

sterite are identical and represent portions of the same intrusion, then the diabase porphyrite must be considered as a later dyke intruding the earlier websterite intrusion. This agrees with the general field relations of the two rocks, and is also in agreement with the established order of intrusion in other portions of the district.

Thus, at the Magnet Mine it would appear that we had an earlier intrusion of websterites followed by a later one of diabase porphyrite along the same line. These intrusions were along the continuation of the faulted block of Bischoff series which occur to the north-east. Between the websterite on the east and the diabase porphyrite a small body of Bischoff slates and quartzites are included. A smaller body of the Bischoff strata are also included in the websterite in the No. 4 adit. Taking the dyke as a whole, it is bounded on the east and west by the Dundas series, while the inclusions of Bischoff Series are within the dyke, proving conclusively that the whole dyke occupies the faulted zone.

Turning now to a consideration of the dyke at other points along its length, it is found that the section varies. Going southwards from the Magnet Mine the width of the dyke decreases, as does also that of the component rocks. The websterite on the east rapidly decreases in width, and where it crosses the small creek south of the mine it is no more than 1 chain wide. It cannot be definitely ascertained where it peters out, although the completely decomposed material on the dump of the old Magnet Proprietary shaft may represent websterite, but it does not extend any further. The websterite on the west extends further south, and is last seen in the creek to the south of the tram near the Proprietary shaft, although it appears to be represented by completely decomposed material for several chains further. The diabase porphyrite continues further south, and is last seen outcropping boldly near the south-west corner of the Magnet Consolidated Lease No. 5637. To the south of this locality nothing of the dyke can be seen, although a small amount of completely decomposed material (probably igneous) may be found here and there, but it is extremely doubtful if it represents the Magnet dyke. It might be expected that the dyke would join up with the large area of pyroxenites to the south, but it cannot be traced on the surface.

Returning once more to the Magnet Mine, and following the dyke to the north-east, other changes are noted. The websterite on the east thins out rapidly. and is only 30 feet wide in the North Magnet No. 1 adit, while the diabase porphyrite and the websterite on the west maintain their width. From here to Matthew's Creek the section of the dyke is somewhat indefinite, owing to lack of exposures. It is doubtful if the websterite on the south-east is continuous, although decomposed websterite occurs on the track above the tram, and also near the mouth of Matthew's Creek. The diabase porphyrite continues, and boulders of variolite are visible in the creeks as far as Matthew's Creek, but no further. The websterite on the north-west continues past Healy's section (7827), and probably as far as Matthew's Creek. At Matthew's Creek the dyke is trending east and west, but changes again to the north-east and south-west direction. The section in this creek is not very distinct, and, while the dyke maintains its general section, further developments of pyroxenite and gabbritic rocks occur on the south side.

Between Matthew's Creek and Kyber Creek the dyke meets the north-western fault bounding the block of Bischoff series, and from here to the Persic Mine it occupies the fault between the Dundas and the Bischoff series. While traversing the fault the dyke maintains a uniform width of about 5 chains. It also has a fairly constant mineralogical composition corresponding to that of the diabase porphyrite, but with variations in texture up to a medium grained gabbritic type. Crossing the old Waratah-Pieman track the dyke is fine-grained at the sides with a coarse dolerite or gabbro forming the central part. At the Arthur River the dyke is a fine-grained greenish type which also appears at the north-west corner of the Persic section. Near the Persic Mine a small bulge of pyroxenite occurs on the southern side. The diabase porphyrite continues for a short distance, but appears to leave the fault-line, which continues across the Waratah River. The dyke intrudes the Bischoff series to the south of the fault, and apparently ends between the Persic Mine and the Waratah River. It was not located in the Waratah River, although a boulder of pyroxenite or gabbro was found in the gravels.

(d)—Upper Mesozoic Diabase.

This rock outcrops at several localities in the district. The largest of these occurs nearly one mile north of Magnet Mine, and extends over 60 acres. Two other smaller outcrops occur—one at the intake of the Magnet water-race from the Seven-mile Creek, and the other at the south-east end of the tunnel through which the race flows.

This rock is a hard, fresh, dark-grey one, of fine to medium grain, and composed of crystals of light-coloured augite, and plagioclase felspar. Some specimens have a typical doleritic appearance, and show platy jointing. The composition, appearance, and structure of the rock prove it to be identical with the "diabase" of Upper Mesozoic age, which occurs so plentifully in association with Permo-Carboniferous and Trias-Jura strata in the eastern portion of Tasmania.

The rock in this district is intrusive into the Dundas series, and occurs in the form of wide dyke-like bodies. These occurrences are interesting in that they show the relation of the Tasmanian "diabase" to the Palæozoic sediments.

(e)—*Tertiary Basalt.*

This rock is a fine-grained, basic variety of basalt. Olivine is often visible in hand-specimens, and the rock-type is, therefore, an olivine basalt. It is generally a very dense rock, but vesicular varieties also occur.

The largest thickness of this basalt-sheet is 110 feet at the northern end of the Magnet Range, but the average thickness is somewhat less.

These basalt flows originally occupied nearly all of the surface of the eastern part of the district. They covered the Tertiary strata, and formed the very level surface of the present plateau. Denudation has since removed much of the basalt, resulting in the formation of isolated patches, but to the east and north very extensive areas of basalt still occur. These flows now occur at an elevation of between 2100 and 2200 feet above sea-level, while similar occurrences to the west of the Mt. Cleveland Range are at elevations of only 1800 feet.

These basalts are generally regarded as being Lower Tertiary in age. They overlie the Tertiary lacustrine beds described by Johnston([24]) as Lower Tertiary, and are considered as closing the Lower Tertiary sedimentation. The relations between the close of this sedimentation, the basalt flows, and the faulting resulting in the elevation of the Waratah plateau have not yet been satisfactorily determined.

([24]) R. M. Johnston, F L.S, Geology of Tasmania, 1888.

(f)—*The Succession of the Devonian Igneous Rocks.*

The order of intrusion of these rocks is illustrated very well in the Waratah district. Where they occur in contact with other members of the series, the ultrabasic types are found to be the oldest. At Mt. Stewart the granite intrudes, and narrow quartz-tourmaline, and other dykes actually penetrate, the serpentine[25]. Along the track from Heazlewood to Bell's Reward a narrow dyke of coarse-grained gabbro penetrates the pyroxenites. A similar association occurs north of the Arthur River dam, where coarse-grained gabbro and fine-grained syenite-porphyry are intrusive into the pyroxenites. The relation between the fine-grained gabbros, which verge on the ultrabasic type, and the ultrabasic rocks was not ascertainable.

The syenite dyke between the Mt. Wright and Heazlewood mines intrudes a coarse-grained pyroxenite, as does the very similar rock north of the Arthur River dam. Between the 15-mile and the Heazlewood mine, along the Mt. Stewart pack-track, narrow dykes of somewhat similar material penetrate the serpentine. The large body of syenite between the Whyte and Heazlewood Rivers is intrusive in the pyroxenites of that locality.

The relations between the gabbros, syenites, and granites, could not be determined, as no contacts of these rocks with one another were not observable within the district. The narrow dykes of coarse gabbros and syenites appear to be associated with the ultrabasic rocks, but so also are the ore-bodies which represent the final phase of the granitic intrusion, so that this association is of little value. With the ultrabasic rocks forming the first, and the granitic rocks the final member of the series, it is more than likely that the sequence is one of decreasing basicity or increasing acidity, and is, therefore, as follows:—

Ultrabasic—Pyroxenites and peridotites.
Basic—Gabbros.
Intermediate—Syenites.
Acid—Granites, &c.

(g)—*The Differentiation of the Devonian Magma.*

The exact processes involved in the formation of all the Devonian rock-types are not by any means clear. The rocks as they exist at the surface at the present time are

(25) Reid, A. McIntosh, Osmiridium in Tasmania: Geological Survey (Tas.) Bulletin No. 32.

quite distinct from one another, and have sharp boundaries without any mergence of one type into another. The one small exception is in the case of some of the larger granite bodies, and the associated dykes, where a slightly basic margin has developed. This is, however, a common feature in the cooling of acid magmas when there is a tendency for the basic minerals to concentrate at the more rapidly cooling portion of the intrusion. Apart from these, however, the magmas from which the rocks have formed must have been produced before they reached the positions in which they consolidated. Also the sharpness of the contacts, and the absence of any absorption of one type by another, is suggestive of the consolidation of one before the intrusion of another magma of different type. This point has already been discussed by A. M. Reid[26].

The various magmas must, therefore, have been produced by differentiation at greater depths than those in which they consolidated. It is generally accepted now that differentation products arise from one original magma, and it is reasonable to suppose that the Devonian igneous rocks were derived originally from one stock magma. In the Waratah district there occurs a series of rocks ranging from ultrabasic to acidic, the succession being one of decreasing basicity. This is suggestive of a serial differentiation of the original magma. It must be remembered, however, that the acid rocks (granites, &c.), on the one hand, and the basic and ultrabasic (gabbros, pyroxenites, peridotites, &c.), on the other, form the two main series. This is rather suggestive of a differentiation into two main magmas—an acidic and a basic—with probably subsidiary differentiation of these to produce the small amounts of intermediate magma. The relation of the syenitic magma is not clear, but it is probably connected with the acidic, rather than the basic, magma.

(4)—The Metamorphic Rocks.

Contact metamorphic rocks are very limited in extent, and occur only along the Arthur River, north of the Waratah-Corinna road. The Dundas strata in this locality have been indurated, and converted into dense, cherty, and quartzitic types. The metamorphism is caused by the granite occurring to the east of the Arthur River.

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[26] Reid, A. McIntosh, Geological Survey (Tas.) Bulletin No. 32.

(5)—Structural Geology.

(a)—*Folding.*

Dundas Series.—These rocks have been subjected to forces which have involved them in close folding, but the detection and mapping of the folds is an extremely difficult matter. In river and creek beds, where the best exposures occur, the rocks, including the slates, appear very massive, and the bedding-planes are not numerous or readily visible. Jointing is prominent in these massive rocks, and further complicates the determination of the structure. In weathered exposures, such as occur in tram and race-cuttings, the strikes and dips are more easily detected, and are extremely variable. The strike of the beds may be in any direction, but the most usual range from 0° to 135°. The dips are always very high, and show a variation in direction in accordance with the strikes.

This series of rocks appeared to have possessed a property similar to brittleness, and during the folding movements they were very much fractured. This is clearly seen in nearly every section exposed, and in which bedding-planes between slates and other types end abruptly at one or other of these types. This feature of the Dundas series adds further to the difficulties of determining the structure.

Bischoff Series.—This series consists of alterations of well-bedded slates, sandstones, and quartzites, which render the elucidation of the structure comparatively easy. The limited number of outcrops, however, rendered impossible a complete and detailed determination of the folds. The strike of the beds ranges from 0° to 110°, but it is usually between 30° and 60°. The prevailing dips are high, and may be to the north-west or south-east. The beds are, therefore, folded into a series of steep anticlines and synclines, the axes of which have a general direction between 30° and 60°. Overfolding was visible in two exposures, and it was in each case to the south-east indicating that the pressure was greatest from the north-west.

The strikes were not constant even in short sections and variations, such as from 0° to 60° within a chain occur. Also the folds were not always complete, but were frequently broken and faulted, but on the whole the structure described above was typical throughout the outcrop of this series.

Silurian System.—This series of rocks consist of soft, friable sandstones, shales, and limestones, which offer little resistance to the ordinary atmospheric weathering agents. Exposures in which strikes and dips could be recorded, are very few in number, and so the structure of this series could not be satisfactorily determined. The best sections available occur at the Victorian Magnet Mines in the underground workings on the old Godkin leases. The strike of the beds is fairly constant, and ranges from 315° to 330°. The dip is generally to the north-east at medium angles, but in the No. 5 tunnel a series of folds, accompanied by faulting, occurs. Such folding is probably exceptional, and is due to the close proximity of the intrusive syenite and pyroxenite. The strike of the beds are roughly parallel to the igneous rocks, and it would appear that the earth movements associated with the igneous rocks have caused abnormal faulting and folding near their contact.

At the 15-mile peg on the Waratah-Corinna road the sandstones appear to be lying horizontally.

The series, therefore, appear to be gently folded with closer folds, accompanied by faulting in the vicinity of igneous intrusions.

Tertiary System.—The strata of this system are horizontally bedded, and so have not been subjected to earth movements involving folding. Any movements which have affected them have been those of direct uplift.

(*b*)—*Faulting.*

The rocks of this district have undoubtedly been subjected to a large amount of faulting, much of which has been located during the present investigations. Some of the faults are of considerable magnitude, and have played a prominent part in determining the geological structure of the district.

Two major faults form the boundaries of the outcrop of the Bischoff series. This series occurs as a wedge-shaped block, which has been faulted down into the Dundas series.

The more southern fault of these two has a general east and west direction, while the other has a north-east south-west trend. These faults form an apex to the east of the Magnet Mine, but their influence extended as far as the mine itself, where a small area of slates and quartzites of the Bischoff series occur among the igneous rocks of the locality. The amount of downthrow caused by these faults was not ascertainable, but it must have been considerable. The gorge of the Arthur River exposes a vertical section of 700 feet of the Bischoff series below the level of the old peneplain, so that the downthrow of the faults is at least 700 feet, and probably exceeds 1000 feet. A very interesting occurrence is associated with the more northern of the faults, The Magnet dyke, averaging five chains in width, follows the course of this fault from near the Magnet to the Persic Mine. At these localities the dyke ends in intrusions of slightly larger dimensions. These igneous rocks are of Devonian age, and proves the faulting to be portion of the diastrophism, which occurred at the close of the Silurian time.

Another large faulted area occurs in the western part of the district, where the Silurian strata outcrop. These strata occur at elevations similar to, and also less than, those at which the Dundas series are found to the east and west of this area. Devonian igneous rocks are extensively developed in this region, and separate the two series of strata, except possibly in the south-west corner. In this locality the two series outcrop in close proximity to one another, and future investigations will prove them to be in contact with probably a faulted junction between them. It would appear, therefore, that the Silurian strata occupy a faulted area which has been intruded by Devonian igneous rocks, especially along the borders of this faulted block. It is due to this faulting that the Silurian strata have been preserved in this area, while they have been completely removed from other parts of the district.

In addition to the major faulting already described, minor faulting is very common throughout the district. In the Dundas series minor faulting is visible in the majority of the exposures, and has been discussed above[27].

Minor faulting is also found in the Bischoff series. In the workings of the Persic Mine numerous vertical faults, probably of small magnitude, are revealed. The strike of these faults is 25° to 30°, and one or two inches of pug is found on these " heads " or " walls." The Silver Cliff lodes occupy fault-fissures.

Faulting is also found in the Silurian strata. In the No. 5 tunnel on the old North Godkin lease, in the Victorian Magnet property, a fault occurs, and causes a sud-

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([27]) See p. 56.

den change in the dip of the strata. This suggests a fault of some magnitude, but no trace of it has been revealed in the workings to the north-west where it should occur if its strike of 320° is maintained.

(c)—*Igneous Intrusions.*

The Palæozoic sediments have been intruded by igneous magmas at several periods during the geological history of the district. These intrusions were of various natures, and have played their part in determining the structure of the district. There is some evidence in the Dundas series of a period of igneous activity, probably corresponding with the Porphyroid series as developed in other parts of Tasmania. These intrusions are small in extent, and probably of the nature of small dykes. The Devonian intrusions were of many characters, and ranged from narrow dykes to the enormous bodies of pyroxenites and granites, as, for example, the granite of the Meredith Range, The Upper Mesozoic intrusions of diabase were in the form of comparatively small dyke-like bodies. The Tertiary igneous activity resulted in the large outpourings of basaltic lavas, which covered parts of the district as surface-flows.

(7)—Geological History.

The geological history of the district, as represented by the rocks exposed at the surface at the present time, began with the formation of the Dundas series. The floor on which these were deposited is not visible, but to the west of the district, along the Whyte and Rocky Rivers, schists of Proterozoic age outcrop, and these probably formed the old floor.

(1) *The Deposition of the Dundas Series.*—The rocks of this series were formed by the sedimentation of igneous material under probably marine conditions. They are either tuffs formed as a result of explosive igneous activity, or fragmental breccias derived solely from igneous material, or, what is more likely, as a result of the combination of both processes.

(2) *The Porphyroid Igneous Activity.*—Accompanying the formation of the Dundas tuffs, which must be considered as representing the lower phase of the porphyroid igneous activities, igneous intrusions occurred on a small scale, and

are apparently represented by the narrow decomposed dykes in the Dundas series.

(3) *A Period of Denudation.*—Between the close of the deposition of the Dundas series and the commencement of the sedimentation of the Bischoff series there possibly occurred a period of denudation accompanying slight oscillations of the land. If the correlation with the Victorian Heathcotian and Ordovician (which are conformable) be a true one, such a period may not have occurred.

(4) *The Deposition of the Bischoff Series.*—These sediments were laid down upon a floor consisting of a denuded surface of the members of the Dundas series. The beds formed consisted of alternations of sand and clay, with very small amounts of gravel and breccia. This deposition occurred under conditions of shallow to moderate depths with slight alternations in level of the floor.

(5) *A Period of Diastrophism.*—Movements of elevation accompanying other earth movements probably caused the cessation of deposition of the Bischoff Series. Folding and regional metamorphism, affecting both the Dundas and the Bischoff series, accompanied this period of diastrophism.

(6) *The Deposition of the Silurian System.*—After a period of denudation the land surface sank below sea-level, and sedimentation commenced upon the floor composed of the Bischoff and possibly also the Dundas series. In other parts of Tasmania this sedimentation commenced with gravels and sands, which have formed the West Coast Range conglomerate and the tubicolar series. These formations are not exposed in the Waratah district. The Silurian deposition, as revealed by the rocks exposed within the district, consisted of sands, clays, and clayey limestones of Middle Silurian age.

(7) *The Devonian Diastrophism.*—The close of the Silurian system was marked by the last great period of orogenic land-movements which have affected Tasmania. These movements were accompanied by great igneous activity which resulted in the intrusion of the Devonian plutonic rocks of Tasmania.

The Silurian and all older sediments were folded and faulted and left much the same as they appear at the present time. The intrusion of the molten magma into all the sedimentary formations up to, and including, the Silurian occurred, and the pyroxenites and peridotites, gabbros, syenites, and granites and related types were formed in that order.

Accompanying the final stages of the intrusion and cooling of the granitic magma, ore-bearing solutions were given off and formed the greater number of the ore-deposits of Tasmania.

(8) *Period of Denudation.*—Following the Devonian diastrophism there is no evidence in the district of any further geological events until the intrusion of the Upper Mesozoic diabase. If Permo-Carboniferous or Trias-Jura sediments were deposited over the district they have since been entirely removed by denudation. The district is, therefore, regarded as having existed as a land-surface from the close of the Devonian diastrophism, and as having been subjected to extensive sub-aerial denudation.

(9) *Intrusion of the Upper Mesozoic Diabase.*—At the close of the deposition of Trias-Jura sediments in other parts of Tasmania, igneous activity commenced on a large scale, and the Permo-Carboniferous and Trias-Jura strata were intruded by enormous bodies of diabase in various forms. Several small intrusions occurred in the Waratah district in the form of dyke-like masses.

(10) *Period of Denudation and Peneplanation.*—The period of denudation commenced at the close of the Devonian diastrophism was probably continuous through the Permo-Carboniferous and Trias-Jura times, and continued into Lower Tertiary time. Any Permo-Carboniferous and Trias-Jura sediments deposited were removed during the post-diabase period of denudation. The result of this long period of denudation consisted of a levelling of the land surface and the formation of the great peneplain, the topography of which is partly preserved, especially where covered by Tertiary sediments and basalts.

(11) *The Lower Tertiary Sedimentation.*—The final phase of the peneplanation was the formation of a large lake or lakes, and the deposition of sands, clays, gravels, and much organic material composed of land vegetation.

(12) *Extrusion of the Tertiary Basalts.*—The close of the Lower Tertiary sedimentation was marked by igneous activity and the pouring out of extensive flows of basaltic lava. These flows covered the Tertiary sediments and the surface of the old peneplain, both of which are still preserved where the basalt coverings exist.

(13) *Middle Tertiary Earth-Movements.*—Tertiary earth-movements of direct uplift elevated the Tertiary-covered peneplain and formed the Waratah Plateau at its present level of over 2000 feet. The exact relation of this uplift

to the basalt flows is not yet determined. The uplift was later than the deposition of the Tertiary sediments, which occurred as the final phase of the peneplanation. The basaltic lavas flowed over an even surface of Tertiary sediments, and thus, if the uplift preceded the basalt, the time-interval must have been short, otherwise the non-resistant, elevated Tertiary sediments would have been deeply dissected. On the other hand, the basalt may have been prior to the uplift, but there is no direct evidence either way. Thus the question cannot be decided, but it is probable that the uplift and basalt flows were practically contemporaneous.

(14) *The Present Cycle of Denudation.*—Since the uplift of the peneplain and the basaltic lava flows the surface of the district has been subjected to an uninterrupted period of denudation which has produced the present topography.

(8)—Evolution of the Topography.

The evolution of the present topography commenced in the Tertiary period, but there is observable throughout the district the remains of a former topography, viz., that of an old peneplain.

From the evidence available within the district it would appear that from the close of the Silurian until the early Tertiary times the district remained a land surface. Any Permo-Carboniferous or Trias-Jura sediments which may have been deposited on it have since been entirely removed, if they existed. During this long period the ordinary atmospheric and aqueous agencies of denudation reduced the surface of the district to a peneplain with a few residual hills and mountains standing above the general level. The preserved remnants of this old peneplain are still observable throughout the district.

The end of the period of peneplanation was marked by the formation of a large lake throughout the district and the deposition of beds of Tertiary age up to 100 feet in thickness. This deposition was brought to a close by the outbreak of volcanic activity and the covering of the district by basalt flows up to 100 feet thick. These last two events caused the burying of the old peneplain surface, and only the residual hills and mountains were left rising above the surface of the basalt. Movements of elevation also affected the district in order to bring the Tertiary beds and the basalt to their present altitude, but the relation between the basalt flows and movements of elevation has not yet been determined.

Immediately following the elevation and the outpourings of basalt, the development of the present topography commenced. It is the ordinary atmospheric and aqueous agencies of denudation, and the initiation and development of a system of drainage that have been the chief factors in the bringing about of the present topography. The streams began to corrode their way down through the basalt and the Tertiary beds, and then attack the surface of the peneplain. At the present time the streams are still in a very youthful stage of development, and have formed gorges up to 800 feet in depth below the surface of the plateau, producing a topography of very high relief below the surface of the plateau.

(9)—Relation of Topography to Geology.

Very little can be said as to the effect of the geology upon the formation of the peneplain. Practically the whole of the district was worn down to much the same level, apparently irrespective of the geological structure and the rock-types present. That the rock-types had some effect, however, in the determination of this topography is evident from the fact that the residual hills and mountains are generally found to consist of chert or other resistant rock.

Since the close of the peneplanation period the geology has played a prominent part in the formation of the topography. The Tertiary beds, and later the basalt flows, filled the depressions in, and also covered, the surface of the peneplain, forming the very level surface of the present plateau. Further, the basalt being somewhat resistant to the ordinary agents of denudation, has preserved the surface of the plateau and made very difficult the work of the present streams. They have in portions of the district denuded the basalt and the Tertiary beds, and worn deep gorges in the underlying formations, but a large proportion of the district is still protected by the basalt capping.

VI.—ECONOMIC GEOLOGY.

(1)—Introduction.

The ore-deposits described in this bulletin are those of silver-lead and copper which occur in the Waratah district. In addition to these tin and osmiridium deposits exist in the district and the adjacent parts not dealt with in this bulletin. Tin occurs at Mt. Bischoff, Cleveland Mine, and numerous other localities in the eastern part of the district, these deposits being described in a forthcoming and separate volume.(28) Osmiridium occurs in the western part of the district at such localities as Stewart or Loughnan's Creek, Castra River, Whyte River, Bald Hill, &c., and these occurrences have already been dealt with.(29)

Of the silver-lead and copper deposits the former are by far the more numerous and the more important.

(2)—Types of Mineral Deposits.

(a)—*The Silver-lead Deposits.*

Several types of silver-lead deposits occur within the district, and are divisible into two main classes by the nature of the gangue present.

Quartz gangue—

Quartz-galena type.—Occurs at the No. 1 lode, Silver Cliff Mine.

Quartz-galena-blende type.—Occurs at the Mt. Stewart and Gregory's Mine.

Carbonate gangue—

Carbonate-galena type.—Occurs at Persic Mine, Illingworth's Show, Heazlewood Mine, Washington Hay Mine, and Confidence Mine.

Carbonate-galena-blende type.—Occurs at the Magnet Mine with a small amount of pyrite showing a tendency towards a carbonate-galena-blende-pyrite type.

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(28) A publication of the Geological Survey of Tas., by A. M. Reid.

(29) Reid, A. McIntosh, Osmiridium in Tasmania: Geological Survey (Tas.) Bulletin No. 32, 1921.

In addition to these types there are two in which a gangue of metallic minerals is practically absent, although small amounts of carbonate are present.

Galena type.—Occurs in No. 1 lode, Persic Mine, and at the Mt. Wright Mine.

Galena-blende-pyrite-huascolite type.—This interesting type occurs in the No. 2 lode of the Silver Cliff Mine.

(*b*)—*The Copper Deposits.*

Only two deposits of copper ore occur within the district. Both contain chalcopyrite as the principal mineral. The New Jasper deposit consists solely of chalcopyrite without any gangue as far as could be seen from the available specimens. The Old Jasper deposit contains bornite near the surface, which occurs similarly to the chalcopyrite, and may be primary, but no direct evidence is available. Specimens from depth appear to consist of chalcopyrite with a quartzitic gangue. Both are, therefore, of the chalcopyrite type, while the Old Jasper may be of the quartz-pyrite type.

(3)—Mineralogy of the Ore-Deposits.

(*a*)—*Primary Minerals.*

(i)—Metallic.

Bornite (Sulphide of copper and iron, $3Cu_2S\ Fe_2S_3$).—Occurs in massive form in association with chalcopyrite at the Old Jasper Open-cut. Probably primary, but no direct evidence is available.

Chalcopyrite (Sulphide of copper & iron, $Cu_2S\ Fe_2S_3$).—Occurs in massive form at the Old and New Jasper Mines.

Galena (Sulphide of lead, PbS).—Occurs as the coarsely-crystalline, well-cleaved, and also as the fine steel-grained variety, but the former is much more abundant. Always argentiferous, the ratio of silver to lead being 1 to 2 ozs. of silver per unit of lead.

Galena occurs as the principal ore in the mines of the Magnet, Silver Cliffs, Whyte River, Heazlewood, Mt. Jasper, and Mt. Stewart areas, and at numerous other localities throughout the district.

Huascolite (Sulphide of lead and zinc).—In the No. 2 lode on the old Silver Cliff lease a mineral with the following composition occurs, the analysis being carried out in the Geological Survey Laboratory:—

Constituent.	Per cent.	Equivalent Sulphides.	Molecular Ratios.
Lead (Pb)	51·00	58·90	8·93
Zinc (Zn)......................	14·68	21·88	7·86
Antimony (Sb)	6·83	9·56	1·00
		90·34	

This mineral appears homogeneous in hand-specimens, and does not represent a mixture of galena and sphalerite. It resembles galena in appearance, but is more lead-grey in colour, and has little lustre. This mineral agrees closely in characters and composition with *huascolite*, especially that described by Domeyko([30]), from Morochocha, Peru, corresponding in composition to PbS (Zn, Fe) S with Zn = 16·59 per cent.

Antimony is not reported as occurring in huascolite, whereas the mineral under discussion contains 6·83 per cent. If considered as entering into the composition, the mineral would correspond to approximately 9PbS, 9 (Zn, Fe)S, Sb_2S_3. This would be much more basic than any sulphantimonite yet reported, so the mineral is considered as an antimonal variety of huascolite.

It occurs in masses up to 6 inches, largest dimension, in association with similar masses of pyrite, sphalerite and galena.

Pyrite (Sulphide of iron, FeS_2).—Occurs in usually subordinate amount in association with galena and sphalerite in the silver-lead lodes.

Sphalerite or Zinc Blende (Sulphide of Zinc, ZnS).—Occurs in association with galena throughout the district. It is generally black in colour, and is crystalline, though crystal outlines are rare. An analysis of a sample from the Magnet Mine, carried out in the Geological Survey Laboratory, gave the following results:—

Constituent.	Per cent.
Zinc (Zn)........................	50·84
Iron (Fe)	8·40
Sulphur (S)......................	30·34
	89·58

([30]) Dana's System of Mineralogy, 1906, p. 51.

This proves the mineral to be a ferriferous variety, approaching in composition that of *marmatite*, which contains 10 per cent. or more of iron. The blende at other localities is very similar to that at Magnet, and is probably ferriferous. Light-coloured or resin blende occurs at only one locality—on the east bank of the Arthur River, half a mile below the junction of the Magnet Creek. A very light-coloured blende of probably secondary origin, also occurs in the old Godkin Extended workings. An analysis of the ore, consisting almost entirely of the blende, gave the following results in the Geological Survey Laboratory:—

Constituent.	
Silver	13 dwts. per ton
Lead	4·75 per cent.
Zinc	30·16 per cent.

To satisfy the zinc, 61·23 per cent. of the sulphur would be required, bringing the total to 96·14 per cent., so that the mineral is a pure form of blende or sphalerite.

(ii)—Non-metallic Minerals.

Accompanying the metallic minerals as gangue, there occur a number of non-metallic minerals. Two main types of gangue minerals are present in the lodes of the district, viz., quartz, and various carbonates. The quartz is more plentiful in the lodes enclosed in sedimentary rocks, while the carbonates have their greatest developments in basic and ultrabasic igneous rocks. This is not a hard and fast rule, because quartz also occurs, but not to any extent, in the lodes in the igneous rocks, while carbonates occur in the lodes in the sedimentary rocks.

Quartz (SiO_2).—Occurs as the milky-white variety, typical in lodes with the usual association of the clear, glassy variety when in crystal form. Forms the gangue in No. 1 lode at the Silver Cliff, in the Mt. Stewart lode, and in Gregory's lode. Accompanies the carbonates at the Confidence and Washington Hay mines.

Carbonates.—Numerous carbonates are present in the lodes of the district, but a series of analyses would be required to satisfactorily determine all the species. The brownish carbonates have previously been described as siderites, and white ones as dolomites. These serve their purpose as field determinations, but the analysis show how difficult it is to determine the species without them. The following are some of the varieties present:—

Mangano-siderite (Carbonate of iron and manganese).—Analyses of two samples from the district gave the following results:—

Constituent.	Sample from Magnet Mine.	Sample from near S.W. Corner Section 5191.
	Per cent.	Per cent.
$Fe\,CO_3$	54·84	49·10
$Mn\,CO_3$	29·34	44·36
$Mg\,CO_3$	12·10	Not determined
$Ca\,CO_3$	3·70	Not determined
	99·98	93·46

In the Magnet Mine this carbonate is intimately associated with the galena and blende, and was introduced simultaneously. It is a very pale-brown carbonate, with a mere suggestion of a pink colouration. It occurs in narrow bands, with the galena and blende, and samples of any size are difficult to obtain.

The other sample is from a small lode on the north bank of the Waratah River, in which the carbonate is associated with galena. It occurs in a massive form, with rhombohedral cleavage. In appearance it is a typical siderite, but weathered surfaces are stained jet black by oxides of manganese. The analysis shows it to contain nearly equal proportions of iron and manganese carbonates.

These two samples represent a siderite with amounts of manganese carbonate present, ranging up to those in which it almost equals the iron carbonate. The amounts of manganese greatly exceed those reported in manganiferous siderites. They are closer in composition to the manganosiderite recorded by Dana(31), which is described as a rhodochrosite, with 38·8 per cent. of ferrous-carbonate. The above samples are more closely related to the siderites than the rhodochrosites, but manganosiderites appears to be the best term to describe them.

(31) Dana's System of Mineralogy, p. 278, 1906.

Ankerite (Carbonate of calcium, magnesium, and iron.)—This mineral appears to be the general carbonate formed throughout the district, but analyses are required in each case. It is a milk-white carbonate, occurring in the massive form. It occurs most frequently as replacement of basic and ultrabasic igneous rocks, but also as veins, and in lodes in the sedimentary rocks. At the Magnet Mine the ankerite is later than the galena, blende, and manganosiderite, and has in places replaced these minerals. Two analyses of samples from the Magnet Mine are included in the following table:—

TABLE No. 6.

Constituent.	I.	II	III.	IV.	V.	VI.
$CaCO_3$	55·98	53·75	51·82	54·15	56·64	54·60
$MgCO_3$	28·57	22·75	26 07	36·24	32·76	39·63
$FeCO_3$	14·66	22·70	22·10	9·61	8·26	6·74
$MnCO_3$	1·66	0·80	...	...	3·76	...
	100·87	100·00	100·00	100·00	101·42	100·97

I. and II.—Analyses of ankerite quoted from Dana's System of Mineralogy.

III. and IV.—Analyses of ankerite from Bendigo, taken from Bulletin No. 4 of the Advisory Council of Science and Industry, by F. L. Stillwell, D.Sc.

V.—Analysis of sample from Magnet Mine. Aanalyst, F. O. Hill, Hercules Mine.

VI.—Assayed in Tasmanian Geological Survey Laboratory. Sample from Magnet Mine.

The amount of magnesium carbonate is higher, and the ferrous-carbonate lower, than in typical ankerite, but otherwise the samples agree with those quoted from other localities, and the mineral is better described as an ankerite than as a ferriferous dolomite.

Green Staining of Carbonates.—Where the lodes occur in basic and ultrabasic igneous rocks, which have been largely replaced by carbonates, chiefly ankerite, the carbonates are often stained a bright green colour.

This colouration appears to be a typical nickel one, and has been generally reported to be due to nickel and chromium, and both these metals. The most delicate test (dimethylgloxim) for nickel did not reveal the presence of even a trace. An analysis in the Geological Survey Laboratory of a typical specimen from the Confidence Mine gave the following result:—

Constituent.	Per cent.
SiO_2	37·40
Fe_2O_3	5·56
$FeCO_3$	1·45
Al_2O_3	11·92
$CaCO_3$	22·74
$MgCO_3$	16·21
MnO	1·22
CuO	Nil
Cr_2O_3	0·16
Ignition loss	4·40
NiO	Nil
	101·06

The analysis proves that chromium is the only metal present capable of producing the green stain, and that it occurs to the extent of 0·16 per cent. of chromic oxide The chromium mineral would be derived from picotite, which occurs as an accessory mineral in the basic and ultra-basic rocks of the district. The particular form in which the chromium is present, and produces the colouration cannot be satisfactorily determined.

(b)—*Secondary Minerals.*

The secondary minerals are found occurring in the upper, oxidised portion of the lodes. Limonite is the most plentiful, and, with oxides of manganese, forms the gossan capping the lodes. Occurring with the gossan, but usually in only relatively small amounts, a host of other minerals have been formed. The following list includes all these minerals so far recorded, and for further information the reader is referred to the Catalogue of the Minerals of Tasmania[32]:—

Anglesite
Argentite
Asbolite
Azurite
Bellite
Beresowite
Bindheimite
Calamine
Carminite
Cerargyrite
Cerussite
 ditto (chromiferous)
Cervantite
Chalcophanite
Covellite
Crocoisite
Dufrenite
Embolite
Endlichite
Gœthite
Guitermanite
Hyalite
Iodyrite
Leadhillite
Malachite
Massicot
Matlockite
Melanconite
Mimetite
 ditto (chromiferous)
Minium
Pharmacosiderite
Phosgenite
Psilomelane
Proustite
Pyrargyrite
Plagionite
Przibramite
Pyrostilpnite
Pyrolusite
Senarmonite
Silver (native)
Sphalerite
Smithsonite
Stephanite
Steinmannite
Sternbergite
Symplesite
Vanadinite
Willemite
Wurtzite
Zincite
Zinkenite

(4)—Origin of the Ore Deposits.

It is now a generally accepted conclusion that the majority of ore deposits are closely associated with intrusions of igneous magma. The vapours and solutions are given off in the final phases of the cooling magma, and pass into the surrounding rocks in a general ascending direction. When conditions are favourable the metallic minerals are deposited, and form the lodes. In considering the origin of ore deposits, we are concerned, among others, with such questions as the source of the solutions or vapours, the channels used by the solutions, the position of the deposits relative to the igneous intrusions, and the

(32) Petterd, W. F., Catalogue of the Minerals of Tasmania, 1910.

exact method of formation and structure of the ore-deposits.

(5)—Nature of the Ore Deposits.

The consideration of the mineralogy of the silver-lead deposits has shown that the principal metallic minerals are galena, sphalerite or zinc blende, and pyrite, while the non-metallic or gangue minerals are carbonates and quartz. The metallic minerals are all sulphides, while the gangue minerals contain none of pneumatolytic or contact-metamorphic origin. The deposits, in fact, correspond to those developed in the transmetamorphic zone in the Zeehan district([33]). The pyritic belt is not prominent in the Waratah district, the only representative lode being the No. 2 lode at the Silver Cliffs Mine. The sideritic, or better the carbonate, belt is very well developed, the majority of the lodes having a carbonate gangue. In addition, there would be a quartz-belt if the lodes with a quartz-gangue be grouped together.

The lodes in this transmetamorphic belt have, from the character of the minerals present, been clearly derived from hydro-thermal solutions, and have been deposited some distance away from the source of these solutions.

(6)—Source of the Mineralising Solutions.

In attempting to decide the source of the solutions from which the ore deposits of the district have been formed, a brief discussion of the rocks with which the ores are associated should give some valuable data.

At the Magnet Mine the ores occur in pyroxenite of Devonian age. In the Persic and Silver Cliff areas the lodes generally occur in the slates and sandstones of the Bischoff series, but one lode on the Persic property is found at the contact between Devonian pyroxenite and the Bischoff series. South of the Waratah-Corinna Road the small occurrences of ores are associated with Devonian ultrabasic rocks, while the lode at Gregory's Mine near Luina occurs in beds of the Dundas series. At the Washington Hay and Confidence Mines along the Whyte River the ores are associated with basic or ultrabasic dykes of probably Devonian age. Along the Godkin-Bell's Reward line the lodes occur at or near the contact of Devonian pyroxenites and syenites

([33]) Twelvetrees, W. H., and Ward, L. Keith. The Ore-Bodies of the Zeehan Field: Geological Survey Bulletin No. 8, 1910.

with beds of Silurian age. At Mace's show the ore occurs at the junction of the pyroxenite and syenite. In the Mt. Wright and Heazlewood Mines on the Mt. Jasper leases, the lodes are found in Devonian pyroxenites close to the junction of these rocks and serpentinised harzburgite. A syenite dyke occurs in the pyroxenite between the two mines and is parallel to the serpentine junction. At Mt. Stewart the lode is found in a silicified, schistose rock which apparently represents a very much altered basic or ultrabasic rock.

Thus it is seen that the ores are enclosed in rocks varying in age from that of the Dundas series to that of the Devonian igneous rocks. The majority are associated with the Devonian igneous rocks, and as there is no evidence of more than one period of mineralisation, it may reasonably be assumed that the ores are of practically the same age. The age would be later than the Devonian igenous rocks, and as no extensive mineralisation period later than the Devonian has been proved to exist in Tasmania, it is reasonable to conclude that the origin of these ores, in common with the majority of others in Tasmania, are associated with the Devonian igneous intrusions.

It has also to be decided as to whether the ores owe their origin to the earliest basic and ultrabasic intrusions, any intermediate stage, or the final phase of the intrusions connected with the granitic intrusions. In the portion of the Waratah district examined the ores occur generally in association with the basic and ultrabasic rocks, and to such an extent as to almost suggest a genetic connection. However, this association is rather due to the liability of these rocks to attack by the mineralising solutions, because, providing all the galena in the district is of the one age, further evidence proves the origin of galena solutions to be connected with the final phase of the granitic intrusions. Such evidence is the occurrence of the ores at the contact of and, therefore, later than the syenites. Of greatest importance, however, is the data obtained by A. M. Reid in his investigations into the tin ores of the Waratah district, the results of which will be published in a forthcoming publication.[34]

Mr. Reid found that the fissure lode in the Bischoff Extended Mine had been reopened and galena deposited in the tin lode. The general sucesssion of events in the Mt. Bischoff area was the intrusion of the porphyry dykes, the pneumatolyic stage, with which began the deposition of tin ores, the passing from the pneumatolyic to the hydro-

[34] Reid, A. McIntosh, Geological Survey Bulletin in preparation.

thermal, towards the close of which the galena was deposited in the reopened tin lode.

Assuming, therefore, that the galena is all of the same age, the solutions depositing this mineral must have been associated with the hydrothermal emanations from the final phase of the granitic intrusions. This is in agreement with the conclusions arrived at in the investigation of other silver-lead fields of Tasmania.

The above discussion refers only to the silver-lead deposits of the district, and the exact mode of origin of the copper deposits is not so clearly defined. Copper deposits, which occur at the New Jasper and the Old Jasper Mines on the Mt. Jasper leases, are found near the margins of intrusions of Devonian pyroxenites. It is possible that these deposits have been formed from copper-bearing solutions derived from the same source as those which formed the silver-lead deposits, but which contained copper minerals in solution instead of lead and associated minerals. In the New Jasper Mine practically all the ore has been removed from the workings which can at the present time be inspected, but it would appear that the chalcopyrite formed small lenses and masses in the pyroxenite without any gangue materials. The deposit, therefore, has the appearance of being a magmatic deposit, and the source of ore would then be the pyroxenite magma. Little can be said as to the Old Jasper deposit, as only fragments of oxidised ore can be seen in the open cut, all other mine workings being inaccessible. It appears as a formation at the surface of a hypersthenite intrusion, being separated from the intruded rocks by a narrow band of "pseudo-amygdaloidal" hypersthenite. Both deposits appear to represent marginal segregations in pyroxenites, and the origin of the ores would be magmatic, though the quartz gangue of the Old Jasper may indicate a different origin.

The granite representing the consolidation of the granitic magma from which the silver-lead ores, and possibly the copper ores, were derived is not prominent within the area examined. Granite occurs at Wombat Hill and to the south and east of this locality in the eastern part of the district, and also at the Meredith Range and the Leading Spur in the west. It probably outcrops continuously along the tract of country between Wombat Hill and the Leading Spur, forming a belt to the south of the area examined. This belt of granite would have a general course of north-east to south-west. The belt of country containing silver-lead deposits has a similar strike, and is, therefore, roughly parallel to the granitic intrusion as represented by the part outcropping. The tin deposits are developed to the south-east of this silver-lead belt, and are nearer to, and also actually situated in, the granite and porphyry outcrops. Such an association and arrangement of the granite, tin deposits, and silver-lead deposits has already been drawn attention to by L. K. Ward.[34a]

(7)—Channels Traversed by the Solutions.

In leaving the cooling igneous magma, and passing through the enclosing rocks, the mineralising solutions would utilise faults, joints, cracks, spaces between constituents of the rocks, and all other spaces which occur in the rocks. In particular it is important to recognise the channels in the regions in which the ore-bodies have been formed. The basic and ultrabasic rocks of the district have been very important channels. The solutions would traverse all available joints, spaces, &c., in these rocks, but in addition there has been something further to facilitate their passage. The compositions of the rocks and the solutions have been such as to render the former liable to attack by the latter, so that the solutions have traversed the rock by attacking and altering it chemically. A channel of this nature is in evidence at the Heazlewood, Mt. Wright, Confidence, and Washington Hay Mines, and also in the ore-body in the Magnet Mine.

Another channel used has been the junction of two rock formations which may be both igneous or one igneous and the other sedimentary. The "hanging-wall" of the Magnet lode is an example, although it may have been assisted by faulting along the same line. Other examples are the "meridional" or No. 2 lode at the Persic Mine, Mace's Show, and some of the formations along the Godkin-Bell's Reward line.

Faults are very favourite channels for the passage of mineralising solutions. Examples of lodes formed along fault-planes are the No. 1 and No. 2 lodes at the Silver Cliff Mine, and the No. 1 lode at the Persic Mine.

(8)—Nature of the Mineralising Solutions.

The solutions by which the silver-lead lodes were formed appear to have been of two main types, viz., those which

[34a] Ward, L Keith, The Silver-Lead Lodes of the Waratah District: Geological Survey Report No. 2, 1911.

formed the lodes with carbonate gangue, and those which formed the lodes with a quartz gangue. The general association of the lodes with particular rock formations is somewhat suggestive that the gangue might be connected with the enclosing rocks, but that this is not so will be seen from the following discussion. It is found that the carbonate lodes are generally associated with basic or ultrabasic rocks, as at Magnet, Persic, Washington Hay, Confidence, and Heazlewood Mines. They are also found, though certainly in small quantities, outside these rocks, as at Illingsworth's Show, while small amounts of carbonates also occur in other lodes in the sedimentary rocks. The occurrence and composition of the carbonates in the Magnet Mine throw a great deal of light on the subject. The mangano-siderite is so intimately associated with the galena and blende in the ore-bodies that it must have been introduced with them. That the iron and manganese may have been obtained from the websterite by the passage of the solutions through other portions is no more feasible than that the galena and blende were obtained similarly. Further, though the iron content of the carbonate may have been obtained in this manner, it is inconceivable that the manganese could have as the manganese content of the websterite is very small. The same thing applies to the later formed ankerite, which contains over 50 per cent. of calcium carbonate. While the iron and magnesium could have been obtained in quantity from the websterite, the lime content of these rocks is low. If the positive radicals in the carbonates were assumed to have been derived from the websterite, the carbonates should be intermediate between a siderite and a magnesite, while actually the carbonates are mangano-siderites and ankerites. It would, therefore, appear that manganese and calcium, and possibly much of the iron and magnesia were actually original constituents of the solutions.

The quartz lodes ore not confined to the sedimentary rocks where quartz could be readily obtained by the circulating solutions, though they occur in these rocks at the Persic and Silver Cliff Mines. At Gregory's Mine, the country is partly, if not wholly, igneous, while at Mt. Stewart Mine, the lode occurs in a much altered gabbro or pyroxenite.

It is, therefore, certain that the gangue minerals were formed from original constituents of the mineralising solutions, of which there were two distinct types. In addition to the materials from which the gangue was formed, the solutions contained sulphides of lead, zinc, and iron, in soluble form, and which were deposited to form the valuable metallic minerals.

No evidence as to the relations between the two types of solutions could be obtained. The only place where the two lode-fissures intersected was at the Sliver Cliff Mine. Here the lode-fissures of a quartz-galena lode, and a pyrite-galena-blende-huascolite lode intersected, but no ore occurs near the intersection. Also the fissures represent faults of probably contemporaneous origin, and no light is thrown on the relative ages of the two lodes.

(9)—Method of Deposition of the Ore-Bodies.

The formation of the ore-bodies in the igneous rocks has been by a process of replacement. The mineralising solutions acted on the minerals of these rocks, and dissolved and removed the alteration products, and deposited metallic and non-metallic minerals in their place. The replacement is not always complete, and pieces of altered rock are included in the lode in association with the gangue. The green staining of the carbonates by chromium compounds is produced during the replacement process, the chromium being derived from original picotite in the rocks. The ore occurs either in veins or isolated patches throughout the lode.

In the footwall portion of the Magnet ore body, banded ore occurs over a width of several feet, but the width is variable. The banding is very regular, and consists of separate bands of galena, sphalerite, and mangano-siderite. Ankerite occurs in bands parallel to those of the other minerals, and also in veins cutting across the bands. It also occurs in layers lining cavities in the banded ore parallel to the banding, and with crystal faces developed on the inside edges of the layers. The banded ore is strongly suggestive of crustification, and has been often regarded as such. On examination, however, little or no proof can be found to support this view. The ankerite is later than the other minerals, and has largely replaced portions of the ore-body, so that the cavities lined with this mineral may represent portions of ore which were dissolved by the later solutions, and, in place of which, only small amounts of ankerite were deposited. As far as can be ascertained from an examination of the ore without detailed microscopic investigation, the criteria for the existence of crustification are not applicable. Further, the banding on the hanging-wall side of the banded footwall ore becomes irregular, and the ore passes into irregular areas associated with altered websterite. The banding would, therefore, appear to have been formed by processes other than those of crustification, and is due, in fact, to replacement processes. The late Mr. Twelvetrees, Government Geologist, in his report on the Magnet Mine, contained in the Secretary for Mines' Report, 1918, states that:—"The lode-channel is not to be regarded as having been an open gaping fissure ready to receive in one act the lode minerals as we see them to-day, but rather as having widened slowly by the breaking down and removal of successive bands of soluble rock, which were replaced, *pari passu*, by bands of mineral."

Other lodes of the district, such as the Silver Cliff, Persic, and Gregory's, which occur in sedimentary rocks, and the Mt. Stewart lode, which occurs in an altered pyroxenite, probably represent fissure fillings. They are associated with faults and other fissures, but owing to lack of opportunities for examination of the mines, the processes of formation could not be definitely ascertained.

(10)—The Effects of Oxidation.

The outcropping portions of lodes become oxidised by descending surface waters, and as a result gossan and oxidised metallic minerals are formed. Although gossan occurred at the outcrops of the lodes in the district, primary sulphides generally outcropped at the surface. Though gossan and other oxidised products are always formed, the question as to whether they remain depends upon the rate at which the lode and surrounding country are denuded. If oxidation takes place more rapidly, then a deep oxidised zone will be formed. In the Waratah district denudation has taken place rapidly since the Tertiary uplift, and little gossan remains above the lodes, and primary sulphides outcrop. In the Magnet Mine gossan occurred in association with primary sulphides to No. 6 level, while traces were found down to the No. 8 level. The lodes of the Godkin-Bell's Reward line are marked by large outcrops of iron-manganese gossan. Some of these gossan outcrops represent replaced limestones, and cut out in depth. The gossan along the junction of the syenite and the pyroxenite with the Silurian strata, exists in some places to a depth of 250 feet, but in others it is replaced in depth by "mud" stained by oxides of iron and manganese. Very little galena occurs with this gossanous material, and it is questionable as to whether this material represents oxidised lode formation.

The effect of oxidation on the other lodes of the district has been small, due to the rapid rate of erosion. At the Mt. Stewart Mine, the secondarily enriched zone extends as far as 210 feet below the surface.

(11)—Summary of Origin of the Ore-Deposits.

The ore-deposits were associated with the intrusions of igneous magma connected with the diastrophism at the close of the Silurian sedimentation. The original stock magma differentiated at depth, and the different portions invaded the overlying rocks. The earlier intrusions were of an ultrabasic and basic nature, and the copper deposits were probably formed by segregation from these magmas. The final intrusions were of an acidic nature from which the granite consolidated, and the accompanying mineralising vapours and solutions were given off. These left the cooling magma in the final stages, and passed into the adjacent and overlying rocks by means of channels of various natures. When these vapours and solutions reached positions in which the physical and chemical conditions were suitable for the deposition of their mineral contents, the ore-deposits were formed. Generally, the silver-lead deposits were formed from solutions, leaving the cooling granitic magma, and which travelled considerable distances from the source before meeting conditions suitable for ore-deposition. The quartz-gangue of the Old Jasper Copper lode seems to indicate a similar origin for this lode, while the New Jasper deposit appears to be a magmatic one connected with the pyroxenite. It does not seem likely that the two lodes have different origins, and with the meagre evidence available it is not possible to decide on one or the other.

VII.—THE MINING PROPERTIES.

(1)—The Mount Jasper Copper Mines, N.L.

This company includes the following mines among its properties:—

The Old Jasper Mine.

The New Jasper Mine.

The Mt. Stewart Mine.

The Heazlewood Mine.

The Mt. Wright Mine.

The company was formed originally, in 1910, to work what is now the Old Jasper Mine, situated on Mt. Jasper. It also obtained other leases in the vicinity, including that of the Heazlewood mine. The outcrop at the New Jasper Mine was discovered in 1912, and worked along with the Old Jasper. The Heazlewood Mine was tested at a slightly greater depth than previous owners had tried it, but not much work was carried out. The Mt. Stewart Mine was acquired in 1914, but no work had been carried out by the present company. Quantities of copper ore were sent away from the Old and New Jasper Mines, but work at these properties ceased several years ago. The Mt. Wright section was acquired in 1919, and the company has been carrying out developmental work at that mine since then, and have shipped several parcels of silver-lead ore.

(a)—*The Old Jasper Mine.*

(See accompanying Plates VI. and VII.)

(i)—Location and Access.

This mine is situated upon Lease 1068-m, of 80 acres, held by Mt. Jasper Copper Mines, N.L. The Waratah-Corinna road crosses the Heazlewood River at the 16-mile peg, where the company's treatment plant is situated. A two-foot tramway, about one mile in length, connected the mine, which occurs that distance to the south-east, with the treatment plant, but a portion of this line near the mine has now been pulled up.

(ii)—Previous Reports.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna, Secretary for Mines' Report, p. clxxxi., 1899-1900.

In this report the mine is described by Mr. Twelvetrees under the title of Binks' Show, which had not long been discovered.

Twelvetrees, W. H., Report on Mineral Fields between Waratah and Long Plains, p. 18, 1903.

In this report the mine is discussed under the name of the Wealth of Tasmania Copper Proprietary, and the existing workings described.

(iii)—History.

Although the area in which the Old Jasper lode occurs was previously held as mineral leases, the outcrop of this lode was not discovered until the end of 1898 or beginning of 1899. Geo. Binks was apparently the discoverer, a lease being applied for by him on April 7th, 1899, and granted as 3946-93M, 80 acres. The mine became known as Bink's Show, and a small amount of work was performed on it. A trench was put across the lode, and a short adit (No. 2) commenced at a lower level. Subsequently, a Melbourne company called the Wealth of Tasmania Copper Proprietary was formed, and worked the mine during 1902 and 1903. A 60-foot shaft was sunk to the north of the outcrop, and a crosscut put out 125 feet to the east to pick up the lode, while an open-cut was commenced on the outcrop. The lease was abandoned in 1904, but was taken up again as 1068-M, 80 acres. It was held by several people, including the Mt. Waratah Copper Mines Ltd. between 1907 and 1909, but no account of any of the work performed exists. The Mt. Jasper Copper Mines, N.L., were formed in 1910, and had the lease transferred to them on June 7th of that year, and have held it continuously up till the present time. The full extent of the workings carried out by this company are shown on the accompanying plan (Plate VI.). This company have carried out considerable prospecting work, and have sent away a number of parcels of ore, but work has ceased at this particular mine for some years now.

(iv)—Geology.

The country in the vicinity of this mine is composed chiefly of Devonian basic to ultrabasic rocks, with a smaller amount of slates of the Dundas series. The section exposed at the west end of the open-cut shows a small patch of highly foliated slates or schists. Several small outcrops of purple slates are scattered over the lease, and at the south-west corner a larger exposure of the Dundas series occurs.

The greater part of the igneous rocks are of Devonian age, but the age of some of the others is undeterminate. Associated with the schists in the open-cut there occurs a small amount of completely decomposed igneous material of probably pre-Devonian age. A large body of hypersthenite of Devonian age intrudes the schists and decomposed igneous material with a flat junction. Mt. Jasper is composed of generally fine-grained ultrabasic rocks, with which are associated, towards the New Jasper Mine, Devonian types. The relation of these rocks to the schists is not visible, but they are probably intrusive. They are themselves intruded by the hypersthenite, and so, though apparently Devonian in age, they must represent an earlier phase of the Devonian ultrabasic intrusions than do hypersthenite.

(v)—The Ore-Body.

The ore-body worked in the Old Jasper Mine is one containing copper minerals, chiefly chalcopyrite and bornite. It was first exposed at the surface as a massive outcrop of chalcopyrite and pyrite in completely decomposed igneous material. A large amount of underground works have been carried out, and have proved the conditions under which the deposit occurs, but without apparently revealing any large shoots of ore.

The No. 2 adit intersected the lode at a shallow depth, and all payable ore has been removed above this level by an open-cut 50 feet in length. Several small intermediate levels were put in from a winze sunk from the No. 2 level. Nearly all of these workings have fallen in, or been mullocked up by later workings, so that practically none of these workings can be examined. They revealed a formation (the dimensions of which could not be ascertained) containing splashes and veins of chalcopyrite and bornite. This formation dipped to the east at an angle of about 50°, and had a footwall of decomposed hypersthenite with a hanging-wall of the same rock containing patches of calcite (the so-called "conglomerate").

The No. 3 adit was then driven in a generally south-south-easterly direction to test the deposit at 70 feet below No. 2 level. Altogether over 650 feet of driving in the main adit-crosscut were carried out, as well as several hundred feet of branch crosscuts, without cutting the lode, all of these workings being in the soft, serpentenised hypersthenite. The characteristics of the lode being known, the application of this knowledge would have rendered unnecessary much of the driving carried out in this level. When the lode was not cut at the estimated distance or a little beyond it, a rise should have been put up to get above the decomposed hypersthenite, and intersect the "pseudo-amygdaloidal" variety of it, between which the lode occurs. At the face of the No. 3 adit an incline rise was put up and passed through the lode and the "pseudo-amygdaloidal" hypersthenite, which was found to dip to the south at 19°. This adit has fallen in at 200 feet from the entrance, and so the remainder could not to be inspected, and the above facts are taken from plans of the Mt. Jasper Company. Pieces of ore, and the "pseudo-amygdaloidal" rock occur on the dump from this tunnel, and support the above facts. The lode judged by the pieces on the dump, and the fact that it has not been worked must have been very low-grade. The pieces of ore on the dump consist of a silicified rock-type, with white quartz, and occasionally calcite showing in patches, and containing small splashes and veins of chalcopyrite and pyrite.

The lode is thus seen to consist of a quartzitic formation, containing the copper minerals, and occurring between the hypersthenite and its "pseudo-amygdaloidal" variety. The "pseudo-amygdaloidal" variety forms the margin of the hypersthenite where it has intruded the other rocks, and the lode, therefore, follows the margin of the hypersthenite intrusion. It is the undulations in this margin that have caused the difficulty in seeking the lode in the No. 3 level. The high dip in the open-cut and the workings immediately under it was due to this part of the lode being in the oxidised zone with the resulting secondary deposition of minerals outside the actual lode formation. The flattening of the lode above the No. 3 level is in accord with the observed occurrences of the hypersthenite. The dip of the lode in No. 2 level and the intermediate level under it is at medium angles to the south. According to the section (Plate VII.), the "conglomerate" in the included rise is at the same level as that just under No. 2 level, and is dipping south at 19°. Between these points the surface of the hypersthenite must have become horizontal, and then risen with a dip to the north, and finally "rolled" again in order to produce the southerly dip in the inclined rise. It is possible that, in this last undulation, the "pseudo-amygdaloidal" hypersthenite may have been exposed on the present surface, although it could not be located during this investigation.

The lode is also exposed at the "Eastern Blow" under conditions identical with those at the Old Jasper. This outcrop is situated on the Heazlewood Lease (880-M), and is about a quarter of a mile north-east of the Old Jasper. The exposure consists of quartzite and red jasper, containing small splashes of chalcopyrite. A short trench and underlay have been put in at a bearing of 90°, the latter dipping at 30° to the east. Pieces of the decomposed hypersthenite, and the amygdaloidal variety occur on the dump, and the jasper formation apparently occupies the same postion geologically as does the lode at the Old Jasper, thus proving the lodes to be one and the same.

Between the Old Jasper and the Eastern Blow some prospecting work has been carried out by means of No. 4 adit, No. 3 shaft, and some trenching, but judging from the material on the dumps, the same characteristic lode as occurs at these localities has not been here revealed.

A short distance to the north-east from the Eastern Blow, and between this locality and the Heazlewood Mine, red jasper, similar to that at the Eastern Blow, has been located. A small shaft was sunk on this jasper, but little or no copper mineral was found in it. No further sign of the lode as represented by the jasper is visible between this shaft and the Heazlewood workings. No reports of jasper occurring in the Heazlewood are given, and the limit of the Old Jasper lode in this direction is either the Heazlewood lode or more probably the serpentine immediately to the east of the Heazlewood lode.

The limit of the lode to the south-west is the open-cut, in the south-west end of which the hypersthenite is seen intrusive into the schists without any development of the lode or the "pseudo-amygdaloidal" variety. If the hypersthenite maintained its generally flat junction with the intruded rocks it should be exposed on the eastern fall of the Healzewood Hill—Mt. Jasper Ridge. It has not been located in this position up till the present, and apparently it must dip in a general south-easterly direction, and so not reach the surface. A small outcrop of "pseudo-amygdaloidal" type similar to that at the Old Jasper, occurs near the junction of the Mt. Stewart and New Jasper tramways. No jasper or other characteristics of the lode occur here, and it is certain that this outcrop is not to be correlated with that of the Old Jasper.

(vi)—Production.

A quantity of ore must have been produced from this mine since the Mt. Jasper Company commenced to work it, but no records are available. The concentrates obtained from the treatment of the ore were mixed with those from the New Jasper ore, and no independent returns were possible. The production of these concentrates is included with those from the New Jasper in the table of production of that mine[35]. No information is available as to the amount of hand-picked "firsts," if any, produced from this mine.

(vii)—Conclusions.

The Old Jasper lode has been proved to be a silicified formation containing splashes of chalcopyrite, and to occur near the surface of an intrusion of hypersthenite, its exact position being between the main mass and a narrow marginal layer of an "pseudo-amygdaloidal" variety. In the open-cut, and the underground workings close to it, the lode was apparently sufficiently rich to mine, and a quantity of concentrates, and possibly also picked, crude ore, obtained. Owing to the lack of facilities for examination no idea could be obtained as to whether reserves of this class of ore exist. Further the value of the ore between these workings and the inclined rise could not be ascertained for the same reason, and so an expression of opinion as to the value of this mine cannot be given. The pieces of ore on the No. 3 dump which were obtained from the inclined rise are not numerous, but, if representative, the lode must be of fairly low-grade.

Should further work at any time, however, be contemplated, the structure of the lode as outlined above should be taken into consideration in evolving a scheme for prospecting the lode. Knowing that the hypersthenite

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([35]) See p 89.

occurs under the Heazlewood Hill-Mt. Jasper Ridge at a shallow depth, that its upper surface is more or less horizontal under the crest of the ridge, and that it probably dips to the east at moderate angles on the eastern fall, a series of boreholes would quickly and efficiently test the lode. The systematic location of the sites for the holes would be a very necessary and important preliminary step before any drilling campaign was undertaken.

(*b*) *The New Jasper Mine.*

(See accompanying Plates VI. and VIII.)

(i)—Location and Access.

This mine is located upon Lease 4291-M, of 41 acres, and is situated a quarter of a mile south of the Old Jasper. The best means of access is by the Mt. Stewart pack-track from the 15-mile peg on the Waratah-Corinna road, the mine being about one and half miles from the road. The mine can also be reached by the track from the 16-mile to the Old Jasper, and then along the Mt. Stewart tram.

(ii)—History.

The country in the vicinity of this mine was held under lease many years before the opening up of this mine, but the outcrop of copper ore had not been discovered. This discovery was made in May, 1912, when the lease was held by the present Mt. Jasper Copper Mines. All the underground workings have been carried out by this company.

(iii)—Geology.

This mine is situated on the southern extremity of the complex body of basic and ultrabasic rocks which occur near the Old Jasper Mine. Many of these types, such as the gabbros, decomposed pyroxenites, and the "pseudo-amygdaloidal" pyroxenites are very similar to other types in the district, which are of Devonian age, and so the greater part, if not all, of these rocks near the Old and the New Jasper may be taken as being of Devonian age. The rock in which the ore-body occurs is fine-grained, altered pyroxenite which has been serpentenised in places. To the south-west of the basic and ultrabasic rocks, the purple slates and breccias of the Dundas series occur, and it is into this series that the igneous rocks have intruded.

(iv)—The Ore-Body.

The New Jasper ore-body has been opened up by means of surface trenches and shafts, and two levels worked from adits. The surface workings exposed a quantity of gossan and oxidised copper ores. The latter included malachite (green carbonate), cuprite (red oxide), and tenorite (black oxide), and a rich patch of the black oxide yielded 14 tons of ore.

The No. 1 adit was driven in a north-easterly direction to test the ground below the outcrops, and gave about 40 feet of "backs." Slates and breccias of the Dundas series were passed through for 70 feet, then decomposed igneous material, and fresh pyroxenite at 80 feet, which continued to the face at 120 feet. The north drive near the face revealed the same rock with splashes of chalcopyrite and pyrite through it. Another drive to the north from the 80-foot mark in the adit, exposed the same formation. From the adit, stoping has been carried out above this level for a length of 35 feet, and also below it for a short distance. The continuation of this level to the north is in pyroxenite with which is associated foliated serpentine formed by alteration of this rock.

The No. 2 adit was started 30 feet lower than, and 60 feet to the south-east of, No. 1 adit. It was intended to cut the lode to the south-east of the previous workings along its supposed south-east strike. The Dundas series were passed through for 50 feet, and then decomposed igneous material for 10 feet. The lode was not intersected, and the adit was driven to the north with a very sinuous course to come below the No. 1 adit. Decomposed igneous material was passed through for some distance, and then gave place to the fresh pyroxenite. About 20 feet from the winze from No. 1 level, a two-inch seam of gossanous material was cut. Below the stoping in No. 1 level the same shoot of ore, consisting of small veins and splashes of chalcopyrite in the pyroxenite, was cut, and it was stoped over a short distance up to No. 1 level. A lens of ore was followed into the eastern side of the drive, and completely extracted. A winze was sunk 20 feet below the level, and is reported to have exposed good ore, including a vein of chalcopyrite 18 inches wide, but the winze was full of water, and could not be examined. Beyond the winze, a small amount of underhand stoping has been carried out, and near the face a little overhead stoping was performed. If these two lots of stoping represent a shoot of ore it must pitch to the south, and will represent the ore reported in the winze.

All the ore has been removed from the workings which can be inspected at the present time, and the nature of the ore can only be ascertained from pieces on the dump. This ore consists of splashes and narrow veins of chalcopyrite contained in the pyroxenite exposed in the workings, or its serpentenised derivative. The only other mineral associated with the chalcopyrite in the pyroxenite is a small amount of calcite, but this is not common. Apart from the calcite, the deposit has every appearance of being a magmatic one, formed by segration from the pyroxenite near its junction with the Dundas series. It has no definite boundaries, and except for the calcite the chalcopyrite occurs, unassociated with any other mineral, as small veins and irregular masses in the pyroxenites. The calcite may be due to secondary alteration of the pyroxenite, but otherwise processes other than those of magmatic origin must be assumed.

(v)—Production.

The production of ore from the New Jasper is given in Table No. 7 along with that from the Old Jasper Mine. In this table the ore was obtained from the New Jasper, but the concentrates were from both the Old and the New Jasper Mines. A few of the returns of ore-sales were missing so that the figures are not quite complete. The total production from the two mines was probably about 200 tons of "firsts," and concentrates, with a total value of £3000, and which yielded the company about £2000. Of this, the New Jasper must have contributed over 50 per cent., and probably nearer 70 per cent.

TABLE No. 7.—*Production of the New and Old Jasper Mines.*

Description.	Weight.			Assay Value.			Total Value.			Return to Company.		
				Copper.	Gold.	Silver.						
	Tons.	Cwts.	Qrs.	Per cent.	Ozs. per ton.	Ozs. per ton.	£	s.	d.	£	s.	d.
Ore	13	7	0	35·3	...	...	324	14	8	285	1	7
"	13	1	3	24·9	...	...	225	11	4	187	19	1
"	16	3	3	25·41	...	...	247	11	5	197	0	3
"	11	6	0	22·13	...	...	159	16	8	109	11	2
"	8	5	3	20·45	...	...	103	9	6	68	4	1
"	13	14	3	12·72	...	...	94	18	7	41	4	8
"	11	12	2	13·37	...	...	94	3	9	46	13	4
Concentrates	7	0	0	18·55	...	...	77	0	2	50	15	8
Ore	6	12	0	18·80	...	...	76	5	0	53	4	3
Concentrates	6	6	1	21·65	...	...	83	0	7	59	12	7
Ore	3	3	1	11·33	...	...	26	4	5	11	17	0
"	4	4	3	24·10	...	...	99	13	4	68	16	10
"	1	8	1	15·66	0·11	2·99	12	10	0*	83	7	2
Concentrates	6	18	3	28·85	1·04	4·07	131	0	0*			
"	4	16	0	28·50	1·25	3·95	54	0	0*	57	12	6
"	5	5	3	24·05	0·97	3·33	84	1	5	28	10	4
Ore	0	18	0	15·35	0·10	1·0	6	18	2			
Concentrates	3	6	2	18·90	1·62	2·78	84	7	5	48	19	10
"	5	3	1	10·97	0·05	0·15	56	12	2	19	14	11
Ore	1	18	2	22·20	0·02	0·43	46	3	1	80	15	6
Concentrates	2	11	1	30·00	0·66	5·84	95	19	11			
Ore	2	2	3	19·9	...	...	43	10	1	35	8	2
"	5	4	3	19·5	...	...	101	14	5	84	4	6
Concentrates	4	13	0	17·9	1·3	0·16	87	2	6	69	13	0
"	7	11	1	15·1	1·3	0·33	122	19	4	95	7	8
Ore	12	7	1	10·4	0·2	0·02	95	4	1	48	16	11
Concentrates	4	11	1	19·6	2·2	0·4	74	6	6	56	12	2
Ore	4	12	0	11·0	0·5	trace	32	7	1	12	12	8
	188	6	1	...	...	...	2740	15	7	1901	15	10

* Estimated.

(vi)—Conclusions.

The workings have revealed a very small ore-body consisting of splashes, veins, and lenses of chalcopyrite in a pyroxenite. All the ore above the No. 2 level has been removed, and from this there has been produced "firsts" and concentrates, amounting to about 130 tons, with a value of about £2000. The only ore exposed below this level is in a winze sunk to a depth of 20 feet. This could be operated by an adit from the eastern side of the hill, but a length of 450 feet is required to give 100 feet of backs. Further work would have to be by means of shafts. The shoots have been so small, however, that if they maintain their dimensions there would not be sufficient reserves to render these operations profitable, especially shaft-sinking with haulage and drainage problems. There is no reason to expect any increase in the size of the shoots or ore-body, and especially if the deposit be of strictly magmatic origin it would be found unprofitable to follow such small shoots.

(c)—*The Western Blow.*

The "Western Blow" is situated about a quarter of a mile west of the Old Jasper Mine, and is near the western boundary of lease 1068-M. A short adit, now completely fallen in, was driven under a low cliff of igneous rocks. These rocks are altered pyroxenites, and show veins and patches of calcite. Specimens on the dump show serpentinous alteration. The metallic mineral in this deposit is chalcopyrite, and, from specimens in the dump, it is seen to occur as splashes through a quartzitic formation. No other information can be given as to the nature, size, &c., of the deposit, but it does not appear to have any commercial value. No outcrop is visible on the surface, and the occurrence is probably only a very small local one, and of no economic importance.

(d)—*Claxton's Find.*

The occurrence known by this name on account of its discoverer, is situated two chains east of the Mt. Stewart tram, near the south boundary of the Heazlewood section, 880-M.

A short trench on the surface has exposed a small amount of gossan, with pyrite in it. An adit has been driven in a westerly direction for 120 feet under this outcrop. The adit shows a much decomposed ultrabasic rock all the way with the exception of a small patch of purple slates in the back near the face. At 95 feet from the entrance, pyrite, and a soft, black mineral occur erratically over a length of six feet. There is no well-defined formation, and these minerals are most plentiful in the back of the drive. On examination the black mineral proves to be magnetite in the form of a soft mass of small indefinite crystals. This formation is reported to contain copper and gold. The following analyses were carried out in the Geological Survey Laboratory:—

	Pyrite.	Magnetite.
Copper	Nil	1·15 per cent.
Gold	Nil	Nil
Silver	Trace	Trace

This formation has no connection with those in the Old and New Jasper Mines, and is of no economic importance.

(e)—*The Mount Stewart Mine.*

(See accompanying Plates IX. and X.)

(i)—Location and Access.

This mine is situated on the special consolidated lease, 3991-M, of 160 acres, which occupies the summit of the low, flat hill, known as Mt. Stewart (1500 feet above sea-level). The mine is three miles due south of the old Heazlewood ore-shed, near the 15-mile peg, on the Waratah-Corinna road, from which point all means of communication commence. Access to the mine was at first gained by means of a pack-track. About the year 1905, a wooden tramway, five and a half miles in length, was constructed in order to reduce cost of transport of the ore from the mine. Since the cessation of work in 1912, the tramway has fallen into a state of general disrepair, and it is now used as a pack-track, and forms the only means of communication with the Mt. Stewart and neighbouring osmiridium fields.

(ii)—Previous Reports.

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah, 1897.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna, 1900.

(iii)—History.

The Mt. Stewart Mine has had a long and varied, but not a very successful, career. The lode was probably discovered about the year 1890, the first lease (3037-87M, 80 acres), being taken up by Hamilton Hay in October of that year in the name of the Hamilton Hays P.A. This association probably carried out the prospecting of the lode, but no record of their work exists.

This lease was apparently forfeited, and was taken up by W. W. Stewart, as 763-93M in the beginning of 1896, and, together with an unnumbered section of 80 acres to the north-east, was worked by the Mt. Stewart P.A. The workings at this time consisted of two shallow shafts, and two adits. The lower adit (No. 2) cut the lode at 100 feet, which was then driven on for 520 feet. Four tons of ore are reported to have been sent from the mine, and this probably represented the first consignment.

This association ceased operations at the end of 1899, and the property later became known as the Mt. Hope Silver-lead Mine. Work was carried on intermittently until the early part of 1902, and was of a developmental character.

In the same year S. C. Counden took up the two leases—289-M (formerly 763-93M) and 195-M (formerly 3299-93M)—and by the end of the year the Long Tunnel Syndicate was formed to work the mine. The property experienced a period of greater activity, and much developmental work was carried out, and considerable quantities of ore were sent away, although the lack of transport facilities hampered operations. The tramway was constructed at a later date, and provided better and cheaper means of transport.

The Tasmanian Smelting Company held the leases in September, 1905, but the mine was still known as the Long Tunnel. Quantities of ore were still sent away, but not as great as formerly, and operations apparently ceased about 1910. The two leases were consolidated in 1909 into the special consolidated lease 3991-M, of 160 acres.

In 1910, the property was taken over by the Mt. Stewart Mines, N.L., and further development work carried out. A main shaft was completed to 212 feet, and crosscutting and driving at 200 feet carried out to test the lode at that depth. Work ceased in 1912, and the mine has been idle since then. The plan of the mine (Plate IX.) shows the extent of all the workings.

In 1914 the property was absorbed by the Mt. Jasper Copper Mines, N.L., who hold it to the present day.

(iv)—Geology.

The Mt. Stewart Mine occurs within an area occupied by Devonian igneous rocks. Serpentinised pyroxenites and peridotites occur to the west and the north. Granite occurs further west, forming the bulk of the Meredith Range, and also to the south and east of the mine. The lode traverses a series of intensely silicified, schistose rocks, the origin of which is very obscure. They occupy a tract of country half a mile long, and a quarter of a mile wide, and have the appearance in plan of projecting into the serpentine outcrop to the north-west. These rocks have been subjected to pressure which rendered them schistose, and appear to have been silicified as they have the appearance of quartzites. Under the microscope, however, the silicification does not appear, and the rock is an altered pyroxenite in which re-crystallisation appears to have taken place to some extent. The pressure which has rendered this rock schistose, and caused the alteration is that developed by the serpentinisation of the enclosing pyroxenites as described by A. M. Reid[36]. Other smaller areas of these schistose rocks occur to the north and north-east in association with the serpentine. All of these areas appear to represent parts of the pyroxenite intrusions which were not serpentinised, but which were rendered schistose, and altered by the pressure developed during the serpentinisation of the other parts of the pyroxenites.

(v)—The Ore-Body.

The greater portion of the mine workings is now inaccessible, and much of the following description is based on material on the dumps and on previous reports.

([36]) Reid, A. McIntosh, Osmiridium in Tasmania; Geological Survey Bulletin No. 32, page 27, 1921.

The lode is essentially a quartz-galena-blende type of deposit, the three minerals generally occurring in distinct bands. The quartz is easily the most plentiful constituent of the lode, and renders the crude ore very silicious. The quartz is often coarsely crystalline with the crystals at right angles to the veins. The galena is the common cubical variety, and the blende is the dark marmatite variety. Small amounts of carbonate, probably siderite or mangano-siderite, and pyrite are visible in specimens on the dumps.

The upper portion of the lode is within the zone of oxidation. Much of the quartz is stained brown with limonite, and some is also very cellular, due to leaching out of enclosed minerals. The phenomenonally high silver values (up to, and sometimes exceeding, 10 ozs. of silver per unit of lead), points to the presence of considerable quantities of secondary silver minerals.

The lode has a very constant strike of 20°, and is nearly vertical, dipping if anything at a high angle to the west. The strike of the enclosing schistose pyroxenite in isolated outcrops appears to be 355°, with a high dip to the west. Where visible, the strike of the lode appears to conform to that of the "quartzites," but as there is a difference of 25° between the strikes, either the general strike of quartzites must be 20°, or else the lode cuts across the planes of schistosity. Two shafts were sunk on the lode, the most northern one being 43 feet deep, and the other 19 feet deep. The 43-foot shaft showed 2 feet 6 inches of quartz, galena, and blende at the top, and at the bottom alternate bands of quartz and galena, the section from west to east being:—

6 inches—quartz.
Several inches—country rock
18 inches—quartz.
6 inches—ore—

the best band of ore being the 6 inches in the footwall. The other shaft revealed a formation two feet wide, composed of quartz with a little blende and galena.

In the upper or No. 1 level an adit cut the lode at 120 feet, which was then driven on in a northerly direction for 450 feet. The longitudinal section of the mine (Plate X.), shows stoping over this level for a distance of 300 feet. Reports state that the shoot of ore was only 100 feet long, 2 feet wide, and dipped to the east. This level gave at the most 25 to 30 feet of "backs," and it is estimated that 600 tons of ore were stoped from above this level to the surface.

The No. 2 level was started 10 chains to the south-south-west, and 60 feet lower than No. 1 level. The adit cut the lode at 100 feet, which was then driven on to the north for 1000 feet. The drive did not keep to the course of the lode all the way, but wandered off it at various points. In the first 500 feet of the drive the lode varied from a trace up to 3 feet in width, and consisted chiefly of quartz with small veins of galena and blende. In the next 360 feet the drive is reported to have been off the lode, but, at 960 feet from the entrance, the downward continuation of the 100-foot shoot of ore in No. 1 level was struck. This shoot is shown as having been stoped out to No. 1 level, and has been partly stoped out to a depth of 40 feet in Vincent's workings below this level. At 740 feet from the entrance, a crosscut was put out 20 feet to the east, and met with another shoot of ore. This shoot was stoped up to the surface for a length of 80 feet. A winze was sunk to 14 feet, and drives put in north and south to distances of 41 and 80 feet respectively. The lode in the winze is reported to average 2 feet in width. In the north drive the shoot varied from 1 to 3 feet wide, and was very silicious, averaging 28·4 ozs. silver, with very little lead. In the south drive the shoot has been stoped overhead and underfoot as far as payable and possible owing to water trouble.

In order to test the lode at a greater depth a main shaft (10 feet × 4 feet) with three compartments was sunk opposite the northern shoot of ore. The shaft was sunk to 212 feet, and a crosscut put out to the west at 200 feet. The lode was thus cut 110 feet below No. 2 level, and 70 feet below Vincent's workings. Drives were driven to the north and south, and the property well sampled. The average of the lode over a length of 210 feet was:—

Silver—30 ozs. per ton.
Lead—4 per cent.
Zinc—8 per cent.

The values were higher towards the face of the south drive, but the bulk sample at the face was very close to the average given above. The average width of the lode at this level was two to three feet, The ratio of silver to lead is still very high, and the 200-foot level is apparently in the secondarily enriched zone. The amount of lead present is low, and that of zinc is high, and renders the crude ore unpayable in its natural state.

(vi)—Production.

The total production of the mine cannot be ascertained owing to the absence of any complete record. The following figures are obtained from the records of the Mines Department, but these are apparently not quite complete.

TABLE No. 8.

Production of Mt. Stewart Mine.

Year.	Tons.	Value.	Average Number of Men Employed.
		£	
1896	4	...	...
1897	Few	...	..
1898	Few	...	...
1899	7·5	...	...
1902	81	972	...
1904	550	...	35
1905	1154	6390	20
1906	106	1027	16
1907	...	...	...
1908	44	581	6
	1946·5	9970	

The following figures have been taken from a private report, and represent the returns from the Tasmanian Smelting Company Limited, between 1905 and 1908. These give a better idea of the value of the ore produced in these years.

TABLE No. 9.

Production of Mt. Stewart Mine.

Year.	Tons.	Assay Values.		Proceeds.
		Lead.	Silver.	
		%	Ozs. per ton.	£ s. d.
1905	989·380	8·1	79·1	6710 11 5
1906	194·398	6·4	74·6	1385 5 2
1907	226·248	10	97	2380 1 5
1908	43·213	14	111	376 0 1
	1453·239	...	...	10,851 18 1

The production during these four years was, therefore, 1453 tons, which realised £10,851. Another report gives the production between 1904 and 1908 as 1490 tons, which realised gross and nett values of £16,436 and £11,123 respectively.

Thus it would appear that the total production from the mine is at least 2000 tons, with a gross value of, at least, £25,000.

(vii)—Conclusions.

From the above discussion it has been seen that two shoots of ore have been located within the mine. The northern of these is stated to have been stoped for a distance of 100 feet, and the other for a distance of 80 feet. All the payable ore in these shoots has been extracted from above No. 2 level up to the surface, while some ore has also been stoped below this level. The 100-foot shoot has been tested at greater depth by the 200-foot level, and proved to be low in lead and high in zinc values. This level is apparently in the zone of secondary enrichment as the silver values are relatively high in comparison with those of lead.

The downward continuation of the 80-foot shoot has not been tested at the 200-foot level. It has been reported that this shoot is richer than the 100-foot shoot, but this could not be officially verified. Except that it may be somewhat higher in value it is expected that this 80-foot shoot will have, at the 200-foot level, the same general characteristics as the 100-foot shoot.

The immediate future of the mine depends upon the existence of two shoots of ore, with a combined length of 180 feet (assuming the 80-foot shoot maintains its length in the downward continuation), and an average width of one to three feet. The average value of this ore is:—

Silver—30 ozs. per ton.
Lead—4 per cent.
Zinc—8 per cent.

There is practically no market for zinc ores at the present time, so the zinc content is valueless. If the lead and silver contents could be obtained the ore would be worth, with lead at £25 per ton, and silver at 3s. per oz. (both prices are slightly above the present average value), approximately £5 10s. per ton. To remove the zinc contents and obtain a marketable product, the ore would have to be treated by a metallurgical process. It has been found in all the attempts to concentrate the Mt. Stewart ore that large losses of silver have occurred. These losses vary from 25 per cent. to as high as 50 per cent., and are caused by the presence of secondary silver minerals in the ore which render it unsuitable for concentration. Thus in attempting to remove the zinc content, considerable losses of silver would be caused, which would greatly reduce the value of the ore. The decreased value of the ore would be altogether insufficient to balance the costs of mining and dressing, the excessive cost of transport from the mine to a treatment plant, treatment charges, and general expenses of management, and the venture would be an unprofitable one.

As to the prospects of the mine when the primary sulphide zone is reached, little can be said owing to lack of facilities for examining the mine. The ore at the 200-foot level is worth only £5 10s. per ton, compared with the general average of £10 to £12 per ton above No. 2 level, although the high silver values indicate that the former level is still in the secondarily enriched zone. The silver value would be much less in the primary zone, and there would need to be an exceptional increase of lead values to compensate for the decrease in silver values. However, the primary sulphide ore would be much more suitable for concentration, and nearly all the lead and silver values could be recovered. Everything would then depend upon the length, width, and value of the ore-bodies as to whether they could be profitably mined and treated. These factors can only be ascertained by further developmental work, but with the facts in hand the expenditure of large amounts of capital does not seem to be warranted.

(*f*)—*The Heazlewood Mine.*

(See accompanying Plates VI. and XI.)

(i)—Location and Access.

This mine is located on Lease 880-M, of 80 acres, situated three-quarters of a mile south-west of the 15-mile peg on the Waratah-Corinna road. The mine was formerly connected with the old ore-shed at the 15-mile by a wooden tramway, but this has fallen into a state of disrepair. The pack-track to Mt. Stewart passes through this section, and is the present means of access.

(ii)—Previous Reports.

Thureau, G., Report on the Heazlewood Silver-Lead and other Ore-Deposits in the County of Russell, West Tasmania: Parliamentary Paper, No. 143, 1888.

Montgomery, A., Report on the State of the Mining Industry on the West Coast, p. 15, 1890.

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, p. xlviii., 1896-7.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, p. clxxviii., 1899-1900.

(iii)—History.

The outcrop of the lode on this property was discovered by W. R. Bell, in 1885, or perhaps 1884. He applied for a reward claim on 3rd April, 1886, which was granted as 1309-M, 80 acres. Considerable work was carried out until 1888, in which year this lease, together with 1310-M, granted as a reward to James Smith, was transferred to the Heazlewood Silver-Lead Mining Company. Work was continued until 1893, and a quantity of ore raised. The mine was idle until 1896, when it was apparently opened for a short time and some machinery erected. No further work was done by this company, and the lease was abandoned in 1899.

The lease was held by numerous people until finally taken over by the Mt. Jasper Copper Mines in 1910, and who now hold it as 880-M. In 1917 this company sunk an air-shaft to the No. 3 tunnel, and also sunk a winze below the tunnel, and drove on the lode. Veins of galena were exposed, and a quantity of ore sent away, but work was not continued.

(iv)—Geology.

The country in the vicinity of the Heazlewood lode is composed entirely of igneous rocks. The lode itself occurs within a decomposed ultrabasic rock, probably a pyroxenite. Roughly parallel to the lode, and at a distance of several feet from it, the south-western boundary of a large body of serpentine is visible. This serpentine represents the alteration of an ultrabasic rock, probably a harzburgite. A coarsely crystalline harzburgite is associated with it near its boundary.

To the south-west of the lode the hypersthenite with which the Old Jasper lode is associated, occurs, but its relations with the rock enclosing the lode could not be determined.

Between the crest of the Heazlewood Hill, about one chain west of the Heazlewood lode, and the gully near the No. 2 adit of the Mt. Wright Mine, a dyke of syenite-porphyry can be followed. It has intruded the ultrabasic rocks to the south-west of the serpentine, and is roughly parallel to the serpentine boundary. Solid outcrops of the dyke are not visible, but pieces are scattered everywhere over the surface, and the dyke would appear to be 10 to 20 feet wide with a strike of 315°.

(v)—The Ore-Body.

The Heazlewood lode has been opened up by means of two adits—the Nos. 3 and 4 of the Old Heazlewood Company. The No. 3 adit was driven 400 feet, and connected with the main shaft at 55 feet from the surface. The main shaft was originally sunk to a depth of 60 feet, but was later deepened to 170 feet. The lode above this adit was stoped to the surface over a length of 230 feet. The lode formation varied from 4 to 14 feet in width, but the metallic contents consisted of a vein of galena from 2 to 3 inches in width, which, in places, widened out into bunches. Splashes of galena and zinc blende also occurred throughout the formation, but not in any great quantity. The formation consists of carbonated igneous rock with unreplaced fragments of the rock enclosed in the carbonates. The greater part of the carbonates is milk-white, and is probably ankerite. A smaller amount of a carbonate, tinted brown, is also present, and is probably approaching mangano-siderite in composition. Quartz occurs in subordinate amount. Much of the formation has the typical green coloration of the silver-lead lodes in the basic and ultrabasic rocks of the district.

The No. 4 adit was driven from the north-west side of the Heazlewood Hill for a distance of 350 feet at a level slightly lower than that of No. 3 adit, and connected with a 60-foot air-shaft, 220 feet from the entrance. The adit was driven in the pyroxenite close to the serpentine boundary, but in neither the adit nor the two short cross-cuts from it, was any lode formation exposed.

A lower adit was started which would have given an additional 110 feet of backs below No. 3, but was not driven far before it was abandoned.

Near the south-east corner of the section, two shafts—one of which is known as the Boxing Day—were sunk.

From specimens on the dumps, a formation analogous to that at the Heazlewood was revealed. These shafts are half a chain south-west of the serpentine boundary, the country being completely decomposed basic igneous rocks, so that, geologically, this formation occupies the same position as does the Heazlewood lode. It would appear, therefore, that these two lodes are one and the same, with a strike following that of the serpentine boundary. However, it is possible, and in conformity with the other lodes of this particular area that they should be parallel lodes, discontinuous along their strike.

The Heazlewood lode in the No. 3 adit had a strike of 340°, and had a vertical dip. To the north, the strike altered to 320°, and much the same change of strike would be necessary for the Heazlewood lode to conect with the Boxing Day shaft.

A prospecting shaft, known as Miller's shaft, has been sunk at a point 230 feet south by west from the entrance to No. 3 adit. It is reported that a formation carrying galena, with a north and south strike, was revealed. This has been regarded as the southern continuation of the Heazlewood lode, but it is doubtful as to whether this is the case. It most likely represents a small, more or less parallel formation, which may or may not junction with the Heazlewood lode and form an important branch.

In 1917, the present company sank a winze 25 feet below the bottom of No. 3 adit, when excessive water hindered operations. It is reported that 5 to 13 inches of clean shipping ore was exposed, but the winze is full of water, and this could not be verified.

The galena in this mine is of both the fine-grained and also the common cubical varieties, and has a little zinc blende associated with it. The silver contents are comparatively low, ranging from one to one and a half ozs. of silver per unit of lead.

(vi)—Production.

The Heazlewood S.L.M. Company are reported to have sent away about 230 tons of ore, assaying 56 per cent. lead, and 88 ozs. of silver per ton.

The Mt. Jasper Company report having raised 13 tons of shipping ore, and 20 tons milling ore, but the only record of a consignment is one of 22 cwts., assaying 34 per cent. lead, and 42 ozs. of silver per ton, with a value per ton at that time of £18 1s. 6d.

(vii)—Conclusions.

The Heazlewood Mine has not been a successful one up till the present time. The metallic contents of the lode at its richest portion consisted of only 2 to 3 inches of galena, occasionally widening to 6 inches, and forming bunches. This has been stoped over a length of 230 feet, and a maximum depth of 60 feet. Although surface indications exist north of the stopes, no formation has been revealed in the underground workings. The lode probably extends through the Boxing Day shaft to the south, but has not been tested in between. The lode would have to show an unexpected increase in values above that in No. 3 adit to render this part payable.

As regards the extension in depth, the reported dimensions of 5 to 13 inches of clean shipping ore would have to be maintained to return even a small profit. Even this would only be payable while the mine could be operated from adits, and would not stand the expense of pumping and hauling. At the most, only an additional 200 feet of backs could be obtained by adits of moderate length, so that even with 6 to 12 inches of galena, no great success for the mine can be predicted, and it is very doubtful if the mine warrants the expenditure of capital on it.

Providing the Mt. Wright Mine to the north-west opens up well, and is worked from a low level adit from the gully in which it is situated, this adit could be used to prospect the Heazlewood lode. An additional 800 to 1000 feet of driving would enable this to be done, and would cut the Heazlewood lode 200 to 250 feet below the surface. If successful, the ore from both mines could then be delivered to the one treatment plant, and the Mt. Wright tramway used to transport it to the Waratah road.

(g)—*The Mt. Wright Mine.*

(See accompanying Plate VI.)

(i)—Location and Access.

This mine is located on Lease No. 8442M, of 80 acres, held by the Mt. Jasper Copper Mines Ltd., and is situated three-quarters of a mile south-east of the treatment plant at the 16-mile point on the Waratah-Corinna road. A two-foot tramway, with light steel rails, and one mile in length, connects the mine with the Waratah-Corinna road at the above point.

(ii)—History.

No previous reports have been written on this mine, and no other information is available as to the date of discovery of the Mt. Wright lode. The country in the vicinity of the outcrop has been held under lease as far back as 35 years ago, but no mention of the lode near the present workings occurs, although an outcrop of gossan to the north-west was known in 1888.

It was worked prior to 1919 by a small syndicate, and when the lease was abandoned in 1919, it was taken up by the Mt. Jasper Copper Mines, who are working it at the present time.

(iii)—Geology.

The lode occurs within an area of ultrabasic rocks, the type exposed in the mine being a fine-grained, greenish, decomposed variety. In the vicinity of the lode this rock is altered to foliated, serpentinous material at some points. From two to three chains to the north-east the massive serpentine of F.G.D.'s Hill occurs, this being the northerly continuation of that near the Heazlewood Mine. The syenite dyke between the Heazlewood and this mine is not exposed in the Mt. Wright workings, and apparently does not extend to this point. In the entrance of the No. 2 adit, and also in the No. 1 adit, a peculiar rock is exposed. It is a white, soft rock, containing patches of pyrite, and also cherty material. The pyrite has been oxidised, in many cases leaving a small cavity more or less completely filled with limonite and residual pyrite. This rock occurs along the extension of the line of strike of the syenite, and represents the alteration of ultrabasic rocks probably by solutions accompanying the intrusion of the syenite.

(iv)—The Ore-Body.

The workings of this mine consist of two adits which do not give any large amount of backs. The No. 1 adit was driven north-westerly into Mt. Wright for 160 feet. At 45 feet a crosscut to the east cut the lode at 18 feet, while the adit cut the lode at 90 feet. Below this level the lode has been stoped to the south beyond the short crosscut. The stopes are three feet wide, and dip to the east at 70°. A small amount of overhead stoping has also been carried out. At the end of the underhand stopes a vein of galena with a maximum width of 2 inches is visible. From here to the face an occasional small vein of galena, together with gossanous material, is exposed. A good wall dipping east at 60° occurs to the west, and the face is in decomposed pyroxenite with veins of carbonate.

The No. 2 adit was driven in a general northerly direction for 230 feet. At 180 feet a narrow vein of galena, associated with carbonates, probably ankerite, was cut. It occurred against a wall to the east, and was followed to the face of the adit, but revealed nothing of value. The Mt. Wright lode was cut at 200 feet, and driven on north and south. The north drive followed the lode in a general north-westerly direction for 70 feet. Stoping was carried out over about 20 feet up to the No. 1 level. Past the stopes veins of carbonates occur on both sides of the drive with carbonated pyroxenite between. A little blende and galena occur with the veins on the west, but soon give out. A soft formation, one foot wide, continues to the face, the remainder of which is in foliated serpentinous material with hard kernels.

The south drive has been driven in a general south-easterly direction for 250 feet. At 55 feet a rise was put up to the surface, and a winze sunk immediately under it. Overhead stoping has been carried out over a short distance near the rise. Another rise has been put to the surface at 180 feet from the adit. The drive followed the vein or veins of galena in the lode. There is generally only one vein, which varies in width from half an inch up to 10 inches, the maximum width being seldom more than six inches, and the average two to three inches. There is sometimes several small veins, and occasionally a blank. These veins dip east at angles ranging from 30° to 60°. The enclosing rock is a more or less altered pyroxenite replaced in places by carbonates with the typical green coloration due to chromium.

Bunches of calcite and small veins of ankerite or mangano-siderite occur in association with the galena, as does also a small amount of blende and pyrites and also quartz.

Both rises proved the galena veins to extend to the surface, but only in places were they sufficiently wide to render the stoping of them payable. The winze below this level is reported to have exposed 13 inches of banded ore, but the winze was full of water, and this could not be officially verified.

On the surface towards the north-west of the workings some material of a gossanous nature has been exposed in trenches and small shafts, but little or no galena was contained in it. South-east of the workings the Mt. Jasper Company had two long trenches dug on the Heazlewood lease before they held the Mt. Wright lease. A small amount of gossanous material was exposed in the southern trench, but it did not appear to represent the Mt. Wright lode, which probably passes between the two trenches. Since the writer's visit the company have been prospecting south-east of the mine workings, and the manager reports that the lode is two feet wide, with six inches of clean galena. An adit is being driven at a lower level to test this part of the lode in depth. Lumps of gossan can be picked up along the side of the Heazlewood Hill towards the Eastern Blow, and the lode will be found to extend in this direction for several chains.

The galena from this mine is of fair grade as regards its silver contents. A sample of the clean galena assayed 74 per cent. lead and 89 ozs. of silver per ton. The knapped and hand-picked "firsts" average 65 per cent. lead and 85 ozs. of silver per ton.

(v)—Production.

The total production of the Mt. Wright Mine is given in the following table:—

TABLE No. 10.

Year.	Tons.	Assay Value.			Gross Return.			Nett Return.		
		Lead.	Zinc.	Silver.						
		Per cent.	Per cent.	Ozs. per ton.	£	s.	d.	£	s.	d.
				Crudes.						
1918	5·3125	56	...	72	152	0	0	92	16	4
1919	3·9170	54	7	75	117	19	7	71	19	10
1920	3·4000	66	...	87	141	9	0	94	17	8
1922	9·8661	67	...	95	271	16	7	152	10	8
1922	13·6900	58	...	80	356	17	8	255	6	7
	36·1856	...	...	...	1040	2	10	667	11	1
				Concentrates.						
1920	9·9750	56	...	64	319	1	1	195	15	5
1922	9·0640	54	...	65	188	8	0	84	16	8
	19·0390	...	...	...	507	9	1	280	12	1

(vi)—Conclusions.

The Mt. Wright lode has been proved by the underground workings to consist of a vein or veins of galena in an altered pyroxenite. The veins dip to the east at angles of 30° to 60°, and have an aggregate thickness ranging up to 12 inches, but the maximum seldom exceeds six, and the average is about three, inches. With the present prices of lead and silver, the galena is worth £28 per ton. With the present cost of wages, stores, transport, &c., it is considered that a vein of galena with a constant width of six inches at least is required to cover all expenses, and return a slight profit.

This has not been revealed in the mine, and stoping has only been carried out where the vein of galena has been five to six inches or more in width. There is no prospect of any great future success for the mine, and unless the developmental work to the south reveals the lode with a vein of galena with a constant width of at least six inches, the mine has little chance of becoming even a small payable one. Even under the latter conditions, it is probable that the mine could only be profitably worked while mining could be carried out by means of adit, and an exceptional increase in the size of the galena veins would be required to enable the mine to be profitably worked by shafts with the attendant high cost of haulage and pumping. The possibility of working or prospecting the Heazlewood lode from the low-level adit of the Mt. Wright, if the latter opens up well, has already been suggested.

(*h*)—*General Conclusions.*

Although the Mt. Jasper Company have carried out mining operations over a period of 12 years, they have not been rewarded with any large amount of success. Except in the case of the New Jasper, this company commenced operations on mines which had been previously worked with little or no profit. Of the mines in the possession of the company, the Mt. Stewart has been the largest producer, with an output of 2000 tons, with a gross value of, approximately, £25,000. This ore was obtained from two shoots worked above, and a slight distance below the No. 2 adit. One of these shoots has been tested at a greater depth, but the ore (30 ozs. silver, 4 per cent. lead, and 8 per cent. zinc), does not represent a marketable product. Concentration would be necessary, and a large loss of silver would result, and taking into consideration the heavy cost of transport to and from this mine, the exploitation of this shoot of ore would not be a profitable venture. The other shoot of ore has not been tested at depth, but would probably have similar values. Thus it is considered that the mine could not at the present time be profitably worked, and that any further development and prospecting work would be associated with more than the usual uncertainties and risks attached to mining operations.

In the New Jasper Mine the ore (chalcopyrite) has been extracted from above the No. 2 level, and produced about 120 tons of crudes and concentrates valued at £1800. Ore is reported in the winze from the No. 2 level. Further mining would have to be carried out by long adits or by means of shafts. Provided the shoot of ore maintained the length that it did above No. 2 level it would be too short to enable the mining operations to be profitable. The deposit has the appearance of a magmatic one, and small shoots of such an origin are too uncertain and erratic to follow.

The Old Jasper Mine has produced a quantity of milling ore from which about 80 tons of concentrates, with a total value of £1200, have been obtained. The mine workings have fallen in, and cannot be examined at the present time, and it cannot be said whether any reserve of this class of ore exists. The lode has been intersected by an incline rise off the No. 3 adit, but neither the value of the lode at this point nor between it and the place where the lode was stoped can be given. If any further work be contemplated it is recommended that prospecting be carried out by a series of bore-holes, put down from the Mt. Jasper ridge. The structure of the lode is detailed above, and this prospecting scheme would be the most economic and efficient means of testing the lode.

The Heazlewood Mine has been opened up on a formation of altered pyroxenite, which was converted into carbonates, showing in some cases the typical green staining. This formation was 4 to 14 feet wide, but the vein of galena was only 2 to 3 inches in width, with occasional enlargements to bunches. The lode was stoped from the No. 3 adit to the surface, and produced 230 tons of galena, assaying 56 per cent. lead and 88 ozs. of silver per ton. A winze has been sunk below the No. 3 adit, and is reported to have exposed ore in the bottom. Long adits could be employed to test the downward continuation of the lode, but it is considered that at least a six-inch vein of clean galena would be required to make the operations payable.

The Mt. Wright lode consists of a vein or veins of galena, with little or no gangue contained in a pyroxenite. The veins are not always continuous, and vary considerably in width. The average width of the vein varies from 2 to 3 inches, but occasionally enlarges to 6 inches or even more. Where sufficiently wide it has been stoped out above the No. 2 adit. A winze below this level is reported to have followed ore all the way down. At present the lode is being tested to the south by the No. 4 adit, which should cut the lode at any time now. As in the case of the Heazlewood Mine, it is considered that at least six inches of galena are required to make mining operations payable.

It is thus seen that considerable developmental work has been carried out at the mines in possession of the Mt. Jasper Copper Mines Ltd. Small quantities of ore have been produced during this work, but no large reserves of ore with a value sufficient to render their extraction payable, have been revealed. The mines must, therefore, still be considered as being in the developmental stages, and the proving of payable reserves, if they exist, is a matter for future work.

The present operations of the company are confined to the Mt. Wright lode. If this opens up well to the south a crosscut from the south drive could be driven towards the Heazlewood lode. This would test the Heazlewood lode at depth, and prosepect the intervening country. This crosscut would be a long one, but if started when the drive on the Mt. Wright lode had progressed some distance to the south, considerable saving in its length would be effected.

(2)—The (Victorian) Magnet Silver Mining Company, N.L.

(See accompanying Plates XII., XIII., XIV., XV., and XVI.)

(a)—*Location and Access.*

This company holds two consolidated leases—Lease 4007M, of 183 acres, and Lease 5760M, of 278 acres. These leases occupy a tract of country nearly 2 miles long and half a mile wide, extending from near the deserted township of Heazlewood in a south-east direction to the Whyte River. The present workings are at the old Godkin and Godkin Extended Mines at the south-eastern end of the leases. The present means of communication to these workings is by a sledge track, 3 miles in length, which joins the Waratah-Corinna-road at Luina (Whyte River), 10 miles from Waratah. This track for the greater part of the distance follows the old, and now completely broken-down, wooden tramway constructed by the Godkin Company. From the former township of Heazlewood, at the 13-mile peg on the Waratah-Corinna-road, a track ran through Bell's Reward and the Discoverer and as far as the Godkin properties, but it is now blocked by fallen trees and is overgrown in places.

(b)—*Previous Reports.*

The following list of reports deal with some, or all, of the mines now held by this company:—

Thureau, G., Report on the Heazlewood Silver-lead and other Ore Deposits in the County of Russell, West Tasmania, 1888.

Montgomery, A., Report on the State of the Mining Industry on the West Coast, pp. 16-18, 1890.

Montgomery, A., Report on the Godkin Silver Mine, Whyte River, 1892.

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, pp. xlix-l, 1896-1897.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, pp. clxxiv-clxxvii, 1899-1900.

Twelvetrees, W. H., Report on Mineral Fields between Waratah and Long Plains, pp. 20-26, 1903.

(c)—*History.*

Although the lode or lodes on this property became known as the Godkin line, the original discoveries were made by W. R. Bell and J. Smith. W. R. Bell received a 20-acre reward claim (44-87M), which was granted on 8th June, 1887, and J. Smith the adjoining one (45-87M) to the east. Smith took up 916-87M, of 40 acres, and Bell 887-87M, 40 acres, in March, 1888.

The two sections, 44-87M and 887-87M, became known as the Bell's Reward Mine, while 916-87M became known as the Discoverer Mine.

The discoveries which became known as the Godkin Mine were made by Norman Godkin, either in the latter part of 1887 or early in 1888. The lease (1615-87M, 40 acres) to include Godkin's Find was applied for on 24th June, 1888, by A. Spencer, the one to the north (1599-87M) being applied for on the following day. The Godkin Extended lease (1076-87M, 80 acres) was taken up prior to the Godkin leases by J. H. Horne in April, 1888.

The Godkin Silver Mining Company was formed in 1889 with a capital of £100,000 in £1 shares, to develop Sections 1599-87M and 1615-87M, which were transferred to the company in 1890. Work was energetically carried on on both sections, and the wooden tramway constructed first to Luina (Whyte River) and later to the Arthur River. Two shafts were sunk and equipped, and five adits were driven, and a considerable amount of crosscutting and driving and other prospecting work was carried out. Only a few small parcels of ore were sent away from the mine, and in 1894 the company got into financial difficulties and work ceased. The Victorian shareholders still had faith in the mine, and in November 1895, they formed the Magnet Silver Mining Company, N.L. This title is confusing, and it is generally known as the Victorian Magnet S.M. Co., N.L., to disinguish it from the company of the same name which owns the Magnet Mine. The Victorian Magnet Co. bought the Godkin Mines and immediately started work, which has been carried on almost continuously up till the present.

The Bell's Reward, Discoverer, and Godkin Extended Mines were vigorously developed after their discoveries. Work continued until the early nineties, when, due to the absence of any ore-bodies which could be profitably extracted, operations ceased. A small amount of work was performed at the Discoverer in 1897, and again in 1900-1901. Bell's Reward was worked during 1901 and 1902, and several small parcels of ore sent away. In 1903 a syndicate called the Godkin Extended Amalgamated was formed to develop the three properties of Bell's Reward, Discoverer, and Godkin Extended. Work continued during 1903 and 1904, a low-level adit being driven to test the downward continuation of the lode found in the No. 1 adit. Nearly 800 feet of driving was required, and it is reported that work ceased before the lode was actually reached.

In 1912 the Magnet S.M. Co. took up these leases, together with several adjoining ones, as a consolidated lease (No. 5760M, 278 acres). Since its formation this company has thoroughly tested the lode or lodes on the Godkin sections, and their work in recent years has been devoted to testing the Godkin Extended section. In addition a long drainage tunnel has been put in from the Whyte River to drain all of the workings.

(d)—*Geology.*

The geology of all the mines in the tract of country held by the company is very similar. One, and sometimes two, lines of gossan exist between the Godkin and the Bell's Reward Mines, with a general strike from south-east to north-west. The gossan occurs in sedimentary strata of Silurian age at or near their junction with intrusive igneous rocks, and is parallel to this junction when not actually along it. The Silurian strata consist of sandstones, limestones, and shales, and occur to the south-west of the lines of gossan. The igneous rocks are of Devonian age, two distinct types being present, and they occur to the north-east of the gossan. At the Godkin and the Bell's Reward Mines the rock is a decomposed pyroxenite, while between these two localities it is a syenite. Both rocks have intruded the Silurian strata, and the syenite is later than the pyroxenite. A small dyke of pyroxenite projects from the main mass into the Silurian strata near the main shaft on the Godkin lease.

(e)—*Godkin Section.*

The original discovery was made on this section, and consisted of gossan with veins of pyromorphite. Exploratory work proved this to be a superficial body, but other formations were disclosed by the workings. The gossan and underlying formation at the contact of the pyroxenite and Silurian strata continues through to this section from the one to the north (described as the North Godkin). The geological conditions on this south section are somewhat different to those at other points along the "Godkin" line of lode. This is due to the existence of a dyke of pyroxenite extending outwards from the main mass. Formations, not always containing valuable minerals, occur at nearly all points round the contact of this dyke with the sedimentary strata, and considerably complicated prospecting work.

The underground workings on this section are extensive, but cannot be entered at present, and the following descriptions are taken or quoted from other reports, mainly those by Montgomery in 1891 and 1892.

The No. 3 adit was driven south-westerly for 80 feet, dioritic (pyroxenitic) clay being passed through for 12 feet, and then sandstones and shales containing a thin bed of coarse grit. These beds strike north 30° west and dip south-west at 42°, but steeper near the face. The bed of coarse grit is probably the continuation of the conglomerate exposed in the No. 5 adit and in the workings on the old Godkin Extended section. No lode was exposed in this adit, which appears to be located on the west side of the pyroxenite dyke.

The No. 1 adit was driven under the gossan which represented the original discovery, and was continued to 300 feet in a general westerly direction. This adit and other cuts in the gossan proved that the latter was superficial and did not extend down. For 50 feet from the entrance the adit passed through gossanous material, much of which is stained black with oxides of manganese. This black portion is stated to have given good assay results, but as it has not been mined it was probably not rich enough in bulk to render extraction profitable. Between 50 and 80 feet there was a layer of ferruginous material in the back, but under it appeared broken and stained country. At 80 feet a piece of weathered shaly material was exposed in the bottom of the drive. Between 80 and 140 feet the adit passed through decomposed clayey dolerite, and then to 230 feet through brown clay with occasional curious wavy markings, the clay being similar to that under the gossan at the entrance. From 230 to 314 feet the adit passed through clayey dolerite, the face being in sandstone mixed with clay, and traversed by ferruginous veins. This was probably the eastern side of any lode formation which occurs at the contact of the west side of the dyke and the sedimentary strata.

The No. 4 adit is connected with the 45-foot level of the main shaft. The adit was driven at a bearing of 340° for 230 feet, and connected with an air-shaft. For about 200 feet the adit passed through clayey material, stained in places with oxide of manganese, and then through limestone. This clayey material represents the contact between the east side of the dyke and the limestones.

From the 230-feet mark two crosscuts were put in to the west and north-east respectively. The western crosscut passed out of the limestone at 12 feet, and entered the clayey material again, which continued to 160 feet. Weathered dolerite was then encountered and continued to 220 feet. About 20 feet of lode formation was then cut and sandstone entered. The lode consisted of lumps of sandstone mixed with oxide of iron, clay, and quartz, but no metallic contents are reported. This lode represents the formation at the contact on the west side of the dyke, and is the downward extension of the clay cut by No. 3 adit, and the formation in the face of the No. 1 adit.

The north-eastern crosscut from the No. 4 adit is 160 feet in length and connects with a drive from the main shaft. The crosscut passed through limestone except for a 10-foot bed of sandstone at 80 feet. A short drive was put in on the western edge of the sandstone and followed a seam of clay which cut obliquely across the strata. At 100 feet the crosscut connects with an air-shaft in the upper part of which a vein of galena was found, but which was lost lower down and was not located in the crosscut. The crosscut continues past the drive connecting with the main shaft, and between 20 and 30 feet serpentinous pyroxenite was cut.

The drive from the shaft to the crosscut, and further to the south-east, was driven on the course of a supposed lode. The best ore was found between the shaft and the crosscut, and a quantity of it has been stoped out. The ore consisted of veins of galena and blende in limestone, with which native silver was also associated. A parcel of 27 tons of " firsts " were shipped and gave an assay of 103 oz. of silver per ton, but the lead content was low, being reported as 27 per cent. A smaller parcel gave 107 oz. of silver per ton. This formation was termed " The Native Silver Lode," but has been proved to have no lateral extension, and the association of minerals suggests that it is rather a secondary impregnation of limestone than an original lode. In the continuation of the crosscut from the No. 4 adit this " lode " has been cut, but it consists of practically barren limestone. The drive south-east from the crosscut passed through limestone for 75 feet, and then exposed a formation of brown and grey clay, stained with oxides of iron and manganese, and containing silver chloride in parts. The clay shows wavy lines and markings similar to that in the mouth of No. 4 adit. Where the drive met the side of this clay a crosscut was driven to the north-east 30 feet through it, and exposed weathered pyroxenite in the face. The drive continued through the " Chloride Lode " (probably represented by the clayey material at the contact) and entered weathered pyroxenite again. The short crosscuts at the end of the drive are in pyroxenite, as is also the inclined rise.

From the main shaft at the 45-foot level a crosscut was driven to the north-west. This passed through limestone with clayey material in the joints, for 140 feet. Between 140 and 200 feet black pug containing pieces of limestone was passed through. From 200 to 233 feet there was a great deal of gossan, which where first met was lying rather flat, resting on whitish clay, and this again on the black pug. The gossan was largely composed of oxides of iron and manganese, but also contained clayey material and some quartz. There is no record of what the crosscut encountered on the west of the gossan, but it is probable that the east side of the pyroxenite dyke was met.

In the main shaft below the 45-foot level another level—the 90-foot—has been opened out. A crosscut was driven to the east for about 100 feet through limestone and then entered serpentinous pyroxenite. A drive was put in to the south-east for 85 feet on the course of a lode which would represent the downward continuation of the Native Silver Lode, also known as the East Lode. It is reported to have been stoped over a width of 10 feet, and that a bulk assay of 300 tons gave 49 ozs. of silver per ton, 15 per cent. lead, and 27 per cent. zinc, but these figures could not be officially verified. The position of this lode is not stated, but it is either at, or very near, the contact of the limestone and the pyroxenite.

Another level has been opened out at 110 feet in the main shaft. A crosscut was driven 170 feet to the north, and drives put in from it to the south-east and north-west. The south-east drive was driven along the course of the East or Native Silver Lode, and is reported to have exposed a shoot of ore 40 feet in length, which would represent the downward extension of that stoped in the 45-foot and 90-foot levels. The north-west drive followed this lode into the north section, and ultimately connected with No. 5 adit by a winze from the latter. No records are available as to the country met with in this drive, but it is probable that the contact of limestone and main mass of pyroxenite was followed until the dyke of the latter was met. The drive must then have cut through the dyke and connected with a drive on the opposite side of the dyke, and then followed the contact of the main mass to the north shaft.

A crosscut was also driven at the 110-foot level to the south-west. It passed through limestone for 116 feet, fossiliferous sandstone from 116 to 171 feet, and soft sandy pug from 171 to 189 feet. A drive was put in 100 feet along this pug to the north-west, but apparently the formation contained no valuable contents. The crosscut was afterwards continued to a distance of 700 feet from the shaft. About 300 feet from the shaft a lode formation was reported as having been cut, and it is stated that it was 50 feet wide with a footwall of sandstone and a hanging-wall of pyroxenite, and contained quartz and gossan. The lode was driven on to the north-west, and probably connected up with the north-west drive from the main shaft at this level, but no plans or records are available. The absence of records also prevents the locating of this lode, but it is extremely probable that it was situated on the west side of the dyke and at its contact with the sandstones.

(f)—North Godkin Section.

Gossan is exposed near the north shaft at the north-west corner of the section, and a line of it outcrops, with a general strike of 315° across the section. The mine workings consist of two adits and a shaft, together with a considerable amount of driving and cross-cutting.

The No. 2 adit was driven under this gossan for 100 feet at a bearing of 280°. It is reported[37] "that it passed through 12 feet of dioritic (pyroxenite) clay, 33 feet of mullocky lode material, and 55 feet of sandstones striking N. 30° W. and dipping to the south-west at 87°. The lode material consisted of white clay with oxides of iron and manganese, and is said to have contained some silver chloride."

The No. 5 adit was driven from the western fall of the ridge in a north-easterly direction for 880 feet. For 150 feet the adit passed through a series of sandstones and shales striking at 315° and dipping at 50° to the north-east. At 150 feet there is a band of iron-stained material adjacent to a bed of conglomerate, 1 foot wide, standing vertically and striking at 315°. This conglomerate is undoubtedly the same bed as that with which the Godkin

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[37] Montgomery, A., Report on the State of the Mining Industry on the West Coast, 1890.

Extended lode is associated, but no metallic contents are visible in this adit. The change of dip from north-east to vertical or high angles to the south-west proves the presence of a synclinal fold or a fault at this locality. Past the conglomerate 6 feet of quartzites appear, and then sandstones, much iron-stained in places. At 207 feet Montgomery reported the occurrence of a fault with a strike of 320° and a dip of 85° to the north-east, showing slickensided surfaces. From here, as far as the adit can be entered at present, quartzites with interbedded shales occur. Montgomery reported that broken and iron-stained sandstones were cut at 348 feet, which became impregnated with oxides of iron and manganese at 355 feet, the lode being cut at 396 feet and passed through at 424 feet. This formation is thus 28 feet wide, and dipped to the north-east at 45°, and corresponds with that exposed in the No. 2 adit above. The No. 5 adit was driven over 400 feet further, and passed through pyroxenite, decomposed at first, but becoming more solid towards the face.

A drive was put in along the course of the lode from the No. 5 adit in a north-westerly direction, and ultimately connected with the north shaft. This drive cannot be entered from either end at present, and the following description is taken from Montgomery's report(38):—"It is rather crooked, having been diverted from time to time from one course to another as the walls of the lode seemed to be at hand. In the first part of this drive, though there is much nice-looking gossan, there is also a great deal of clay and country rock, but towards the north-eastern end the appearance is much more favourable, the gossan being spongy and nearly all made up of iron and manganese oxides. Two winzes have been sunk—the first 34 feet, and the second nearly 40 feet. In the first one a little galena and cerussite were obtained, and in the second one ore came in at a depth of about 10 feet, and continued to be got for about 8 feet, and then dipped to the north-east out of the winze, but was cut again by a small crosscut from the bottom of the winze. Just beside this winze a crosscut has been put in to the south-west, but not far enough to reach the footwall of the lode. Some very nice cellular gossan is seen in the mouth of this, probably corresponding to the ore-vein cut in the winze."

The north shaft was sunk on the eastern side of the large gossan outcrop on the surface. It is 210 feet deep, and the

(38) Montgomery, A., Report on the Godkin Silver Mine, Whyte River, 1892.

bottom is in gossan, which would therefore appear to dip at a high angle to the north-east. From the bottom of the shaft drives and crosscuts have been driven in several directions. The crosscut to the west connects with the No. 3 level on the old Godkin Extended lease, and passed through 30 feet of gossan at the shaft. Another crosscut was driven 30 feet to the south-west through gossan, and a drive from the end of it 30 feet to the south-east. The crosscuts to the north-west and north cannot be entered, but it is reported that the one to the north passed through gossan and afterwards entered limestone.

It is reported that No. 1 winze was sunk to 80 feet and a short crosscut put in. A drive was driven south from the north shaft to test the lode reported in this winze. This drive met the back of the crosscut and revealed a small amount of galena, but the quantity could not have been large, as the lode has not been worked and the workings have fallen in.

A drive from the 110-foot level of the main shaft enters the section at the south-east corner, and ultimately comes into the north shaft opposite the No. 3 level. This drive is connected with the No. 5 adit by a winze from the latter. This drive was put in along the junction between the Silurian strata to the west and the igneous rocks to the east, but this course was not strictly adhered to. It can only be entered from the north shaft at present and followed to a short distance south of the winze from No. 5 adit. Going along the drive from the north shaft, the gossan at the shaft continues for 15 feet, the eastern edge dipping to the east. Completely decomposed material occurs to the east, and is succeeded by fine-grained decomposed pyroxenite. At 170 feet the drive turns in a southerly direction, and at 210 feet syenite comes in and is passed through at 280 feet. The junction of the syenite and pyroxenite dips to the east, the syenite occurring to the east and the pyroxenite to the west. From this point to near the branch drive decomposed pyroxenites, giving place to soft clayey material containing in places oxides of iron and manganese, occur. Near the branch drive sandstones and shales are visible to the west. The branch drive was put in to prospect the ground below the No. 1 winze, but as far as it can be entered at present, only soft mud was revealed. Continuing south along the main drive, decomposed pyroxenite and soft, stained mud continues past the winze from No. 5 adit. About 100 feet past the winze the drive departed from the contact and entered the sandstones to the west, but picks up the contact some distance ahead, and exposes the same soft mud at the junction. This mud continued for several hundred feet, as far as the drive could be entered, owing to bad air.

Although these workings on the North Godkin section are extensive, they have revealed no lode of any value. The winzes from the north drive from the No. 5 adit exposed a little galena and oxidised ores, but this ore must have been of small dimensions, and no lateral extension has been proved in the other workings at the No. 3 level. The only other metallic contents were a very small amount of galena in the drive connecting the main and the north shafts, while the gossan contains a small amount of silver minerals. Apart from these, all that the workings have revealed is practically barren gossan and the more or less stained mud. This mud is the product of complete decomposition of the pyroxenite, shales, and possibly limestones, which occur at the junction of the pyroxenite and the Silurian strata. This mud is often mixed with oxides of iron and manganese, and resembles gossan, and it is this formation that underlies the massive gossan (oxides of iron and manganese) which outcrops at the surface.

(g)—Godkin Extended Section.

The line of gossan between the Discoverer and the Godkin crosses the north-east corner of this section. From the north-east side of the ridge near the north shaft an adit was driven 105 feet in a south-westerly direction under this gossan. It passed through 65 feet of clayey material much stained with oxides of iron and manganese, which represents the gossan, and then through 45 feet of sandstones. A shaft was also sunk in this locality to 80 feet, and exposed broken sandstones and gossanous material.

On the south-western fall of the ridge three adits have been driven. The upper or No. 2 adit (now the No. 1 level) was driven 150 feet in a northerly direction through sandstones slightly iron-stained in places; and which have a strike of 115° and dip 50° to the north. No lode or gossan was exposed by this adit. It is connected to the surface by a rise, and to No. 1 adit (No. 2 level) by a winze 115 feet in depth.

The No. 1 adit (now No. 2 level) was driven from the west bank of Doctor's Creek in a northerly direction for 827 feet. This adit passed through soft slates and sandstones to 400 feet, whre a lode was cut, and continued in broken sandstone to 600 feet, and then in limestone to the face. The lode was loose and cellular, and enclosed a bed of conglomerate, the rounded quartz pebbles in the latter being cemented by the metallic minerals of the lode. This lode was driven on to the north-west, but it cut out over the back at 40 feet, and the drive was continued to 150 feet without revealing anything further. The lode was stoped over the back of the drive, and a small parcel of ore (reported to be 40 tons) was sent away. A winze was sunk on the east side of the adit, and has since been connected with a rise from No. 3 level. The lode is reported to have contained slugs of silver sulphite and to have given very high assay values, the parcel sent away, however, bulking only 120 ozs. silver per ton. The portion of the lode still visible consists of a very cellular mass of light-coloured zinc blende with a small amount of galena. A sample of this ore from beneath the junction of adit and drive was analysed by W. D. Reid, Government Assayer, with the following result:—

Constituent.	Per cent.	Dwts. per ton.
Silver	...	13
Lead	4·75	...
Zinc	30·16	...

From a point in the drive directly below the rise to No. 2 adit a winze has been sunk to a depth of 60 feet. This is connected with the north shaft on the Godkin lease and these workings form the No. 3 level.

From the bottom of the winze, the No. 2 drive extends 140 feet to the south-east through shales. Short crosscuts to the south-west revealed shales, except in the last 10 feet of the crosscut nearest the winze, where argillaceous limestones appear. A rise from the second crosscut connects with the winze on the lode from No. 2 level. At 25 feet up a short cuddy revealed 18 inches of lode, consisting of the conglomerate bed stained black by a soft black mineral, with sandstones to the east of the formation. Another cuddy 10 feet lower entered sandstones without intersecting any conglomerate or black formation, which is still ahead of the face, due to a decreased dip.

In the crosscut between the No. 2 and No. 1 drives shales and limestones are passed through, and a black formation cut 6 feet before the No. 1 drive.

The No. 1 drive was driven along this black formation for 190 feet in a south-easterly direction, and then through 100 feet of sandstones to the face. At 110 feet a crosscut was driven to meet the one from the No. 2 drive, and at the time of the writer's visit was 15 feet in length, and still in the black formation.

This black formation consists of slates and sandstones stained more or less black, and with the spaces between the angular pieces of these rocks filled with a soft black material. The conglomerate bed exposed in the upper workings is contained in this formation, and is visible along the greater part of the drive. As the ground is freshly broken the black material oozes out on to the freshly-exposed faces and solidifies to a bright black solid, but which, on exposure to the air, becomes dull. An analysis of this substance in the Geological Survey Laboratory gave the following results:—

Constituent.	Per cent.
Silica (SiO_2)	23·40
Ferric Oxide (Fe_2O_3)	1·12
Pyrite (FeS)	9·20
Alumina (Al_2O)	8·86
Lime (CaO)	0·88
Magnesia (MgO)	0·72
Ignition loss	56·20
	100·38

The ignition loss is due to any combined water and to carbonaceous material. There appears to be carbonaceous material present, as the black colour disappears on heating, and the familiar odour of heated organic material can be detected. The black material would then appear to be a mixture of carbonaceous matter, silica, clayey matter, and pyrite.

The only metallic minerals present is galena, which occurs as narrow veins not exceeding a quarter of an inch thick, and six inches in other dimensions.

In the main crosscut from the north shaft, the same black formation is exposed for a length of 40 feet from the No. 1 drive, but does not contain any metallic minerals. Going towards the north shaft, the crosscut passes through the following strata—interbedded shales and sandstones, quartzites, and shales—and enters gossan 30 feet from the shaft.

This black formation, which is opened up in the No. 2 and No. 3 levels does not represent the lode, if any, which underlies the gossan on the surface. This gossan was opened up by the 105-foot adit, and its downward extension should have been cut by the No. 1 adit, but all that was exposed, which could in any way represent such extension, was broken sandstone country with brown slime in the joints, reported to have been revealed at 490 feet.

The black formation is a very peculiar one. Except for the small shoot of ore in the No. 2 level, and an occasional very small stringer of galena in the No. 3 level, no other minerals of value have been revealed. The origin of the black material, which has been shown to consist of carbonaceous or organic material, clay, quartz, and pyrites, is uncertain. In No. 3 level it occurs about 250 feet below the surface, and could represent a superficial product. It impregnates the conglomerate, sandstones, and shales, and the main channel for its passage from the surface could be the porous conglomerate bed, from which it could pass into the joints in the sandstones and shales. The small amounts of galena and blende associated with this formation must be taken into consideration, and though they are undoubtedly secondary, their source cannot be determined. They may have been derived from original impregnations in the conglomerate or from a source outside the conglomerate zone. The conglomerate bed occurs in the No. 5 adit, and a bed of coarse grit probably representing the same bed is reported in the No. 3 adit on the Godkin leases, but does not contain any metallic minerals or show any trace of this black formation.

Since writing the above, the writer has found several references to similar black formations. At the Mt. Merton Mine in the Stanley River Tin Field. L. L. Waterhouse described an occurrence in Silurian strata under very similar conditions to those at the Godkin Extended. Veins of black material traverse the rocks, and in the vicinity of the veins the country is stained black. The material resembles brittle, bright, black bituminous coal in appearance. It occurred as "narrow seams, which varied in width from point to point, up to 2 inches. Frequently veinlets of $\frac{1}{8}$ to $\frac{1}{4}$-inch are seen running through the sandstones, the fissures corresponding in strike and dip with the enclosing strata. Where it occurs the zones of sandstones seem much shattered, and therefore porous." An analysis of the material by W. F. Ward, Government Analyst, is reported as follows:—

	Per cent.
Fixed carbon	36·9
Ash	7·2
Gases, &c., lost at red heat	38·4
Water, lost at 212° F	17·5

This sample must have been a much purer carbonaceous one than that obtained from the Godkin Extended.

The Mt. Merton material contains pyrite, as does the Godkin Extended. Narrow veins of galena occur near the formation at Mt. Merton, while small amounts of secondary galena, blende, and silver minerals are associated with the Godkin Extended formation. Tin is reported in association with the formation at Mt. Merton.

Mr. Waterhouse regarded the lignite as secondary, which conclusion was also arrived at by the writer with regard to the Godkin Extended formation. The association of tin would probably be accidental, but the association of galena, &c., might be connected in some way with the carbonaceous material, but only to the extent that both are secondary.

(*h*)—*The Discoverer Mine.*

This mine is situated on the two sections—916-87M, 40 acres, and 45-87M, 20 acres—originally held by J. Smith. The workings are situated on the 40-acre block, across which run the lines of gossan between Bell's Reward and the Godkin Extended. The workings are now blocked up by falls of earth and are full of water, so that they cannot be entered. The following descriptions have, therefore, been taken largely from the reports by Twelvetrees.

The lowest, or No. 2, adit was driven south-westerly for 370 feet into the ridge known as Mt. Bell. It passed through 150 feet of completely decomposed syenite, and then through 100 feet of gossan consisting of oxides of iron and manganese, and enclosing lumps of kaolin, but which contained no ore. This band of gossan dipped to the east at 50°. It was succeeded by clay, representing decomposed shales, and then limestone dipping easterly.

The No. 1 adit is 120 feet above No. 2 adit, and was driven for 170 feet. It passed through 100 feet of gossan, then the shales, and finally limestone, and apparently passed through the same gossan and strata as the No. 2, but higher up the beds along the dip.

Vertically above the end of No. 1 adit, another one was driven. It passed through the hill-drift and clay for 50 feet, then a gossanous patch, followed by clay, and finally through limestone dipping easterly. Above this limestone, a large amount of gossan occurs, but does not go underfoot, and it would appear, therefore, to represent a superficial replacement of the limestones by oxides of iron and manganese.

A fourth adit has been driven into the ridge 90 feet below its crest, and 250 feet above the No. 2 adit, for 170 feet. The gossan in the roof of the last described adit was passed through for 45 feet, then 25 feet of limestone, succeeded by 70 feet of clay, and finally 25 feet of fossiliferous sandstone.

These underground workings have thus shown two lines of gossan. Practically the whole of the surface on the eastern fall of the ridge is covered with lumps of gossan, but the greater part of it must be slip-material. The upper band of gossan has been shown by the second highest adit to be purely superficial. The lower band of gossan occurs at the junction of the syenite with the Silurian strata, and is, therefore, the same as that on the Godkin leases. It cannot be traced at all points between these two localities, but it is visible on the eastern boundary of this section, where an open-cut has exposed it, and where it consists almost entirely of limonite. To the north-west of the Discoverer workings it is visible on the track, and passes into the Bell's Reward section.

As far as can be gathered from the reports, no metallic minerals were found in these workings on the Discoverer section.

(i)—Bell's Reward or Result Mine.

This mine is situated on the sections which were originally taken up by W. R. Bell as 44-87M, 20 acres, and 887-87M, 40 acres. The workings are on the 20-acre block which adjoins the Discoverer section on the north, and consist of a main shaft and numerous adits, only one of which is of any great length. These workings have completely fallen in and filled with water, so that entrance is impossible. The following descriptions are taken from the previous reports by Twelvetrees.

The main adit was driven in a south-westerly direction for 600 to 700 feet. It began in soft shales, and then passed through barren limestone for 130 feet. A few feet of decomposed sedimentary rock, followed by soft material with traces of silver, was then passed through, some of this apparently being sandstone containing a little silver chloride. Gossan was then met with, but did not apparently go underfoot. At 140 feet a drive to the north ran in, and a short one to the south exposed only soft muddy material. Limestone occurred to the west of the gossan, and it carried galena, blende, and native silver over a distance of 15 feet. Drives to the north and south were put in on this formation, but apparently revealed nothing of value. This limestone is 130 feet in width, and is succeeded by 200 feet of quartzite. Soft slate succeeds the quartzite, and the soft material at the contact contains galena deposited probably along the bedding-plane. The adit continues for a further 150 feet or thereabouts, and the face is in limestone. The only lode formation in this adit is the gossanous material with impregnated limestone on the west, and possibly impregnated sandstone on the east.

The main shaft was sunk 154 feet from a point 150 feet west of the entrance of the main adit. At 140 feet crosscuts were commenced to the north and south, but a sudden burst of water flooded the workings, and caused the cessation of work. The bottom of the shaft is said to be in limestone, and the downward continuation of the gossan in the main adit was probably being sought for. Unless it exists where the water was met, this gossan was not, according to previous reports, cut by either of the crosscuts.

An adit south of the Bell's Reward huts was driven 60 feet without cutting any lode formation.

Beveridge's, or the northern upper adit, was driven 80 to 100 feet, and passed through puggy limestone, sandstone containing silver chloride and galena, 24 feet of gossan, and limestone. About 100 feet south of the main adit, but a little higher up the hill, another adit was driven to cut this silver chloride-bearing sandstone. It passed through a black oxidised formation in sandstone sprinkled with galena. The same black formation was intersected by another adit, 60 to 70 feet in length, and contained bright galena and vughs of crystallised ore. This black formation and the silver chloride-bearing sandstone would appear to represent impregnations of sandstones somewhat similar to the conglomerate, sandstones, and shales in the Godkin Extended workings.

South of the tip a zinc carbonate formation was exposed by a cut, 13 feet in length, put obliquely across the formation. A sample assayed in the Government laboratories is quoted by Twelvetrees to have contained 1½ oz. of silver per ton, and 25 per cent. of zinc. This formation occurs near the contact of the syenite and Silurian strata, and so occupies, geologically, the same position as the gossan in the lower tunnel of the Discoverer, and that on the Godkin section. This formation has not been proved other than by this cut, but it certainly does not extend as far as the Discoverer, where the gossan is barren. It may represent the oxidised portion of a zinc-blende lode, but if the dimensions are similar to other shoots of ore along this line, the deposit will be of little or no importance.

Thus on the Bell's Reward sections there would appear to be two formations. One of these is the gossan at the contact of the Silurian strata and the syenite, and which contains oxidised zinc ores at one locality. The other formation represents impregnations of sandstones and limestones, but as work has long since ceased on it, it is probably of no economic importance.

(j)—*Mace's Show.*

These workings are situated on the consolidated Lease No. 5760, held by the (Victoria) Magnet Silver Mining Company, about 15 chains north of Bell's Reward workings. They consist of two short adits, a shaft, and surface-trenching. The trench exposed a small quantity of gossan, but no metallic minerals. The upper adit has been driven north-westerly for about 40 feet. and connects with the shaft at the face. The lode occurs at the contact of pyroxenite to the west, and syenite to the east, and has a north-west strike, with a dip of 45° to the north-east in conformity with the contact of these two rocks. The lode consists of narrow veins of galena, together with small amounts of quartz, pyrite, and blende, the whole being contained in decomposed pyroxenite. Stoping has been carried on in this adit, and a parcel of ore (galena) sent away. The lower adit was driven at a bearing of 330° to test the lode at greater depth. It is 70 to 80 feet in length, and is in pyroxenite all the way, and has not reached the syenite contact.

The workings have so far revealed only narrow veins of galena, and the property is of little, if any, value. Any future work should be; firstly, the driving of the lower adit to cut the syenite contact; secondly, prospecting along the contact of the pyroxenite and syenite as mapped on Plate III *(k)—Conclusions.*

It will be seen from the above descriptions that a large amount of developmental work has been carried out without proving more than very small amounts of ore. Gossan outcrops all along the junction of the igneous rocks—syenite and pyroxenite—with the Silurian strata, but nothing of value has been proved to exist under it. In depth, it generally gives place to a fine "mud" stained with oxides of iron and manganese, with little or no galena. This appears to represent stained and decomposed rock at the junction of the above formations, and not the oxidised portion of a lode which contained metallic minerals. The small amounts of galena, blende, and silver minerals prove that mineralisation has taken place to a slight extent, however, and this cannot be disregarded. The developmental work has proved nothing of value to the depth at which it has been carried out, and there is clearly only one procedure to adopt before abandoning the search for any ore-bodies. This procedure is to prospect at depth where the gossan occurs strongly—as at the North Shaft. If no evidence of a primary lode is obtained when the zone of oxidation of any such lode must have been passed through, then no further work should be undertaken. It is, therefore, recommended that prospecting at depth be carried out at, say, the North Shaft, and that further work depend on the results of this. If no lode is revealed, then all work along this line should be abandoned.

As regards the lines of gossan parallel to that at the contact of the syenite or the pyroxenite and the Silurian strata, they appear to have even less prospects of revealing underlying ore-bodies. Some of these lines have been proved to be merely superficial replacements of limestones, and not to extend down to any depth. At Bell's Reward galena, blende, and secondary silver minerals are associated with some of this gossan and adjacent limestones, but not in sufficient quantity to form a deposit of economic importance.

The black formation in the old Godkin Extended workings is different from the others. In the No. 2 level a short shoot of secondary galena, blende, and silver minerals occurred, but did not continue in depth. Apart from this only traces of metallic minerals (galena) have been found in this formation, and further work on it is not justified.

(3)—The Washington Mine.

(See accompanying Plate XVII.)

(*a*)—*Location and Access.*

The mineral section upon which this mine is situated is not leased at the present time, but when last held it was as 2999M, 80 acres. This section is situated one and a half miles south-west of Luina (Whyte River). The sledge track to the Godkin Mine crosses the Whyte River a quarter of a mile to the east, but no communication at present exists between this track and the mine.

(*b*)—*Previous Report.*

Only one report has been written on this mine, and is included in the "Report on the Mineral District between Corinna and Waratah," by J. Harcourt Smith, B.A., 1897.

(*c*)—*History.*

The ore-body on this property was probably discovered in the year 1888, the first lease—2067-87M, 80 acres—being taken up in April, 1889, by A. W. Johnston. It was later transferred to James Washington Arnold as 1150-93M, 80 acres, and the mine became known as the Washington Mine. Much developmental work was carried out between the above date and the end of 1893 or commencement of 1894, two tunnels being driven and a large amount of driving and crosscutting carried out. As far as can be ascertained, no work has been performed since 1894, although the section has been held by numerous people up till recent years.

(*d*)—*Geology.*

The country-rock within the vicinity of the mine consists of purple and other slates, cherts and breccias of the Dundas series.

Considerable amounts of completely decomposed igneous material are also found and have been opened up in some cases in mistake for gossan. Decomposed slates and hornstones (cherts) are reported by Harcourt Smith to have occurred in the upper or No. 2 tunnel (No 1 in the previous report). In the lower or No. 1 tunnel good sections of the rocks are exposed. From the entrance to the cross drives completely decomposed igneous material, similar to that on the surface, occurs. This material also occurs in the two drives as far as they can be examined. It also continues along the tunnel for 50 feet past the drives and passes into a hard diabasic (greenish igneous) rock. This is succeeded by 20 feet of soft serpentinous rock, which gives place 25 feet of the diabasic rock. The serpentinous rock then comes in again for 30 feet, and is succeeded by red cherts, which continue to within 40 feet of the face, where the diabasic rock again appears.

(e)—*The Ore-body.*

No ore is visible in the workings at the present time. The north-east drive from the No. 1 tunnel has followed a smooth wall which has a high dip to the north-west. Up to 1 foot of pug occurs against this wall, and behind the wall the material is of a gossanous nature, but no ore or gangue is visible. The same conditions are found in the south-west drive, but it can only be followed for 60 feet, where it is blocked by a fall of ground. Ore is said to have been met near the end of the drive, and Harcourt Smith[39] states that "a little galena is said to have been obtained from a winze sunk 11 feet below this level (now full of water), and some stoping was done above the drive on a vein of oxidised matter, which is said to have yielded a little high-grade ore, but I could see nothing of any value in the drive." The material on the dump is mainly greenish decomposed igneous material with which is associated quartz and some sulphides as well as a quantity of gossan.

(f)—*Conclusions.*

There has been no output of ore from this mine, neither does there appear to have been anything of value exposed in the workings, so that the mine is valueless.

(4)—The Washington Hay Mine.

(See accompanying Plates XVII. and XVIII.)

(a)—*Location and Access.*

The mineral section upon which this mine is located is not leased at the present time, but was last held as 8126M,

(39) Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah, 1897.

49 acres. This section is situated one and a quarter miles south-south-west of Luina (Whyte River); and the mine is reached by means of the sledge track from this township to the Godkin Mine.

(b)—*Previous Reports.*

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, p. li, 1897.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, p. clxxiii, 1899-1900.

Twelvetrees, W. H., Report on Mineral Fields between Waratah and Long Plains, p. 29, 1903.

(c)—*History.*

The ore-body on this property was probably discovered in the year 1890, and the first lease was taken up by J. Conway and W. Hunter on January 21, 1891. The section became known as the Washington Hay, and a considerable amount of work carried out up till 1893 or 1894. A shaft was sunk 80 feet on the lode, and an adit, 110 feet lower, was driven 250 feet along the course of the lode. No work was performed between 1894 and 1902, but in the latter year operations were commenced by McCreery and carried on more or less continuously until 1905. Further devolepmental work was carried out, and some ore was won by underhand stoping below the level of the adit. As far as can be ascertained no work has been performed since 1905, although the lease has been held almost continuously until recently.

(d)—*Geology.*

The country within the vicinity of the mine is occupied by members of the Dundas series. Cherts are found on the summit of the hills and ridges, while purple and other slates and breccias (the typical fine-grained one of the district and also a coarse-grained greenish one) outcrop on the flanks of the hills and at other parts of the area. Material closely resembling decomposed igneous rock occurs on the surface above the adit of the mine. In the first 80 feet of the adit slates and indurated slates are encountered. From this point to near the face the drive is in the lode formation consisting of material heavily charged with carbonates. The determination of the nature of the original rock is difficult, but the bulk of it appears to have been igneous, although some fragments are definitely indurated slates. The presence of large quantities of carbonates, together with the apple-green staining characteristic of lode material in igneous rocks in other parts of the district, *e.g.*, Magnet, is evidence in favour of most of the material having been igneous, and it is probable that the ore-body occurs mainly within a narrow dyke. The dyke was probably of a basic type but verging towards the ultrabasic.

(*e*)—*The Ore-body.*

The 80-foot shaft sunk on the lode was in the oxidised portion. Gossan is reported to at least 50 feet below the surface, and with it were associated cerussite and crocoite. Veins of galena and blende also occurred, and in the bottom of the shaft it is stated(40) that 2 feet of carbonate of iron with a little galena and blende were exposed.

The adit intersected the lode at 80 feet and was then driven southerly along the course of the lode. A short crosscut to the east was put out from a point 30 feet from the entrance, and intersected the trace of the lode at 10 feet, but without exposing anything of value. At 100 feet from the entrance of the adit a smooth vertical wall occurs to the west, and the lode consists of material veined with carbonates and stained green. At 150 feet another crosscut was put out to the east, but soon passed into slates and other members of the Dundas series. Between 150 and 200 feet stoping has been carried out both overhead and underfoot. At 200 feet the lode has very definite walls both to the east and west. Between these walls the lode is 9 feet wide and is composed mainly of carbonates with green staining containing angular fragments of more or less unreplaced material. Galena, with small amounts of blende associated with it, occurs as a narrow vein up to 1 inch wide on the east wall and as occasional splashes throughout the lode. From 200 to 250 feet the drive follows the western wall, but at 215 feet a short crosscut was put out to the eastern wall, and proved that the vein of galena had practically disappeared. At 250 feet the drive crosses to the eastern wall, and follows it to the face—a distance of 50 feet. In these 50 feet the eastern wall loses

(40) **Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, p. li, 1897.**

its prominence, and the amount of carbonates in the lode decreases in amount. The face is in slates and greenish igneous material.

A winze was sunk 40 feet below the adit and a drive put in to the south, and two blocks of ore were stoped up to the level of the adit. It was reported to Twelvetrees[41] that 4 or 5 inches of galena were exposed in these workings.

The lode presents features very similar to those at the Magnet Mine, and probably represents a replacement of a basic dyke. The mangano-siderite does not appear in this mine, and the carbonates resemble the ankerite of the Magnet, but it is more than likely that they are manganiferous. White quartz forms part of the gangue occurring as isolated patches and as veins. Galena is the principal metallic mineral, and occurs as the common coarse-grained cubical variety. Blende is present in subordinate amount as the dark variety (marmatite), while a small quantity of pyrite also occurs.

(*f*)—*Production.*

The amount of ore produced from this mine has been very small. It is reported that about 10 tons of excellent ore were sold by the Washington Hay Company prior to 1894. During the period 1901-2 the output was 20 tons, with a value of £250. The following figures[42] show the assay values of this last consignment:—

Silver.	Lead.	Zinc.
Ozs.	Per cent.	Per cent.
98	76·5	2·7
78·4	59·8	4·6
91	63	...
104	75	...
100·5	76·2	...

Eight tons, the "firsts" realising £22 10s. per ton and the "seconds" £14 7s. per ton, were produced in 1904, and 2 tons in 1905.

Thus, apart from a quantity of low-grade milling ore lying on the dump, the total ore produced and sold from

[41], [42] Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Long Plains, p. 29, 1903.

this mine is about 40 tons, and probably does not exceed 50 tons.

(g)—Conclusions.

Although nothing of importance has so far been located on this property, it must be remembered that the length of the lode-channel tested is relatively small. The shoot of ore revealed in the workings is very small, but, according to reports, it was still underfoot in the winze from the tunnel. Shaft-sinking would have to be carried out to work the continuation of this shoot, and considerable quantities of water would probably have to be handled, so that unless the shoot developed an exceptional increase in dimensions with depth, it would be far from a payable proposition.

The Washington Hay lode is probably identical with the Confidence, although it cannot be traced continuously between the two mines. Even if this is not the case, the Hay lode can be followed some distance towards the south boundary of the section. Trenches to the south of the shaft have not revealed anything of importance, but during this investigation some gossan associated with the typical greenish-stained material of the lode was discovered. This gossan was located several chains due south of the trenches and would appear to be slightly to the east of the Hay lode, which has a strike of 10° to 20° west of south. Either this gossan is from a parallel lode or, what is more probable, represents the continuation of the Hay lode with a strike altered to due south. Nothing further could be observed to the southern boundary owing to the surface being occupied by chert shed from the top of the hill or by thick accumulation of soil.

It is recommended that any future work on this property should be devoted to prospecting the southerly extension of this lode. In view of the disappointing results so far obtained, the prospects are by no means bright, but this can only be decided by prospecting work.

(5)—The Confidence Mine.

(See accompanying Plates XVII. and XVIII.)

(a)—Location and Access.

The mineral section upon which this mine is located is not held under lease at the present time, but when last held it was as 6669M, 40 acres. This section is situated a mile and three-quarters south-south-west of Luina (Whyte River). Access to the mine is gained by the sledge track to the Godkin Mine, the mine being two miles from Luina by this track.

(*b*)—*Previous Reports.*

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, p. li., 1896-97.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, p. clxxi., 1899-1900.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Long Plains, p. 29, 1903.

(*c*)—*History.*

The lode upon this property was probably discovered in 1890 or 1891, the first lease (837-91M, 40 acres), being taken up on the 10th August, 1891. The Washington Extended Company was formed, and considerable developmental work was carried out. In 1894 the mine passed into other hands, and became known as the Confidence. The mine was idle for some time previous to 1897. By this time three tunnels had been driven. The upper or No. 1 tunnel cut the lode at 200 feet, and was then driven north for 120 feet. About 100 feet below the No. 2 tunnel cut the lode at 160 feet which was then driven on for 180 feet in a northerly direction. An intermediate tunnel between Nos. 1 and 2 was driven 100 without cutting the lode.

In 1897 work was commenced by a small syndicate, the section (671-93M), now being held by H. P. McCreery. Further developmental work was performed, and a few tons of ore were sent away during 1897. Operations were carried on intermittently until 1902, the No. 1 and intermediate levels being further extended. In 1902 and 1903 activity was renewed, and the No. 2 level was driven several hundred feet to bring it under the ore in the upper levels.

The attention of capitalists was attracted to the mine in 1903 and 1904, but apparently it was not taken over, and work ceased in 1904 or 1905, although the section was held until recently.

(d)—*Geology.*

The greater part of the country in the vicinity of the mine is occupied by slates, cherts, and breccias of the Dundas series. To the west of the mine, at a distance of 8 to 10 chains, an intrusion of gabbro occurs. A narrow dyke projects from the larger mass, and strikes north-north-east, being approximately parallel to the lode in the Confidence Mine. The lode in the mine occurs in a dyke, probably similar in composition with the above, and emanating from the same source. Within the lode this dyke has been much altered by the ore-bearing solutions, and outside the lode it has been converted into serpentine. This dyke is of very variable width, as revealed by the mine workings. In the intermediate tunnel it is reported ([43]) "to have been 8 to 10 feet wide, and of a hard and massive nature." In the No. 2 tunnel the western crosscut, near the face, entered the Dundas series at 15 feet, proving the dyke to be at least 15 feet wide. The western crosscut, about 110 feet behind the face, was driven 50 feet without entering the Dundas series. Only one short crosscut has been put out to the east, and the face was in serpentinous material.

(e)—*The Ore-Body.*

The lode in this mine is a silver-lead one contained in the dyke referred to in dealing with the geology of the mine and vicinity. The gangue of the lode is the altered material of the dyke sometimes completely converted into carbonates and stained green by a chromium mineral. Calcite and siderite occur, the quantity of the latter being much in excess of that of the calcite. The siderite is to all appearances the ordinary variety, but it is more than likely that it is similar in composition to the mangano-siderite from Magnet, and near Mt. Bischoff. Quartz is also present in the gangue. The metallic minerals present are argentiferous galena, blende (as the dark variety marmatite), and pyrite. The galena has been proved by assays to contain from 2 to 5 ozs. of silver per unit of lead,

([43]) **Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, p. clxxii, 1899-1900.**

but the average silver content is between 2 and 3 ozs. per unit of lead, so that the galena is of good grade. The pyrite is reported to contain up to 70 ozs. of silver, and a grab sample from the dump of the No. 2 tunnel was assayed in the Geological Survey Laboratory with the following results:—

	Per Ton.		
	Ozs.	Dwts.	Grs.
Gold	...	2	15
Silver	38	5	9

The No. 1 and the intermediate tunnel have both fallen in, and cannot be entered at the present time, so the description of the lode in these workings is taken from the previous reports referred to above([44]).

No. 1 *Tunnel.*—This tunnel was driven eastward into the hill, and intersected the lode at 200 feet. Before cutting the lode a belt of broken country, about 50 feet wide, was passed through, much stained with oxide of iron, and in places approaching a true gossan. A sample across this is said to have assayed 56 ozs. of silver per ton. The lode has been driven on both to the north and to the south. The south drive is a short one, and has no galena in the end. The north drive has followed the lode a little east of north for 157 feet. At 30 feet a rise to the surface—a distance of 60 feet—gave some good ore, and underfoot there is said to have been 12 to 15 inches of galena. A seam of galena 2 to 8 inches wide was, at a later date, reported to occur along the hanging-wall for a distance of 85 feet, commencing from near the adit. Between 90 and 100 feet the lode split into two branches, the western branch being followed in the drive. Several shoots of ore were cut and, at 120 feet, two feet of gossan containing carbonate and phosphate of lead, and two inches clean galena, was exposed. At the point where the lode split, a winze was sunk, and 6 tons of ore raised. At the time of Twelvetrees' visit in 1900 the eastern branch had not been driven on, and this investigator states that the "wrong branch had apparently been followed." This branch may have been driven on at a later period but, if so, no record remains. The following assays indicate the

([44]) p. 133.

value of the ore (picked samples and parcels sent to smelting works) from this level.

	Silver.	Lead.
	Ozs. per ton.	Per cent.
Galena	252	52
Mixture equal quantities of above galena and of gossan. Sold to Queensland Smelting Company	171	45
Parcel of one ton of "Seconds" sold to above Company	107	25
Ore from winze	94	...
Galena on hanging-wall between drive and winze	106	43
Pug, ditto	95	8
Parcel of three tons sold to Queensland Smelting Company in 1892	98	37
Parcel of three tons sold to Dry Creek Smelting Works several years prior to 1899	144	48

Intermediate Level.—This level is 40 feet below No. 1, and the tunnel was commenced 250 feet south of the No. 1 tunnel. It was driven for 187 feet, and cut the lode and continued across it. The dyke was 8 to 10 feet wide, had a westerly dip, and contained a little galena. The dyke was hard and massive, and apparently unfavourable for mineral. It was tested a short distance to the north, but without result. The face of the north drive is 100 feet south of the No. 1 tunnel, so that at least 100 feet of driving would be necessary to reach any downward continuation of the ore in the No. 1 level.

No. 2 Level.—The No. 2 tunnel cut the lode at 160 feet, and continued a few feet across, the face being in serpentinous material. A drive was put in to the north along the lode for a distance of 600 feet. For 80 feet a wall on the east side of the drive was followed in a direction bearing 8°, a few inches of the pug being exposed against this wall. Another wall came in on the west, and both were carried in the drive to 145 feet, the material between being stained dyke with carbonates and narrow veins of galena and pug on both walls. At 145 feet the drive turned slightly to the west, and followed the west wall at a bearing of 0°. At 167 feet a crosscut of 10 feet to the east intersected dyke-material, veined with carbonates, and in the face exposed a wall of serpentinous material, this wall being that from which the drive turned off at 145 feet. The drive followed the western wall to 200 feet, the lode varying greatly in width up to that point. At 200 feet, the drive was deflected further to the west, and was driven at 346° for 100 feet. The walls were very indefinite, and the lode material very narrow in this part of the drive, the country being serpentinous material with veins of carbonate. At 310 feet the drive turned to the east, and for the next 300 feet it was driven practically due north, commencing at a bearing of 358°, and later changing to 0°, and then 5°. From here to the face the walls were generally very definite, and three to four feet apart. In between the walls the lode material was largely carbonates, with occasional splashes of galena, blende, and pyrite. Quartz-veins also occur in the lode, and narrow veins of galena make here and there on both walls, more especially on the western. The face of the drive is in the lode-carrying dyke 15 feet east of its junction with the Dundas slates on the west. The face shows green decomposed dyke carrying a large amount of carbonates, together with quartz and pyrites.

The faces of the north drives of the mine are 400 to 500 feet south of the northern boundary of the section. Several chains west of the north-east corner a long deep trench had been excavated, but has now fallen in. It appeared to be mainly in surface soil, and decomposed slates, with no trace of the dyke. Four chains east of the corner along the south line of the Washington Hay section apparently igneous material is visible, but it is hard and massive, and shows no alteration by ore-bearing solutions. Examination under the microscope proves this apparent igneous rock to be a variety of the Dundas breccias and not a dyke-rock.

(*f*)—*Production.*

No records of the production from this mine are available, but the quantity of ore sent away could not have been large. Montgomery, who visited the mine in 1897, states that several small parcels, amounting to about 50 tons, were sent away prior to that date. The only other record is that of a three-ton parcel in the latter half of 1897. The total production of the mine probably does not exceed 53 tons.

(g)—*Conclusions.*

Although small shoots of ore were located in the No. 1 level, the mine has not been a success. The intermediate level has not been extended far enough to the north to test the downward continuation of these shoots, this work being allowed to stand over until the No. 2 level had accomplished this prospecting work.

The face of No. 2 level is advanced further to the north than that of No. 1, and would have intersected the shoots descending from the latter unless these shoots had a very flat pitch to the north. The shoots are reported to pitch to the north, but the angle of pitch was not specified, but it is probable that it is greater than the 45 degrees which is necessary to bring the shoots ahead of the face of No. 2 level. Thus it would appear that the shoots of ore located in No. 1 do not live down as far as No. 2 level. Whether they extend as far as the intermediate level could only be determined by the extension of that level.

Although the lode has been tested along roughly half its length on the the section in No. 2 adit, only narrow veins (up to 3 inches) have been proved. These are not continuous for any length, and are of no economic importance. There is no apparent reason why better results should be obtained in the northern portion of the lode. This could, however, only be proved by further prospecting work, but there is no basis on which such work could be recommended. The lode is almost certainly continuous with that in the Washington Hay Mine, but the small content of metallic minerals makes it one of no economic importance as far as it has been developed.

(6)—The Whyte River Mine.

(See accompanying Plate XIX.)

(a)—*Location and Access.*

The lease upon which this mine was located was originally taken as 1083-87M, 34 acres. It was taken up later as 109-93M, and more recently the southern part of it has been included in the consolidated lease No. 5760, held by the (Victoria) Magnet S.M. Company. The mine is situated 30 chains south of the deserted township of Heazlewood on the Waratah-Corinna road, and the track from the latter to Bell's Reward passes close to the mine.

(*b*)—*Previous Reports.*

Montgomery, A., Report on the State of the Mining Industry on the West Coast; p. 16, 1890.

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report; p. xlix., 1897-1898.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, p. clxxvii., 1899-1900.

(*c*)—*History.*

The upper adit of this mine was driven to test a quartz-vein, which was supposed to contain gold. Silver-lead ores were discovered in 1887, and lease No. 1083-87M, taken up, and work commenced. Developmental work was carried out until about 1896, but very little ore was produced as, according to records, only two tons were shipped away. Work apparently ceased about 1896, although the lease has been held since.

(*d*)—*Geology.*

The country within the vicinity of the mine consists of more or less decomposed and serpentinised pyroxenite. The decomposed diorite dyke exposed in the workings probably represents a dyke of syenite connected with the main mass of the latter, which occurs 4 to 5 chains to the east. This syenite weathers to a type very closely resembling a diorite in hand-specimens. Slates are also reported in the workings, and must be a small body enclosed in the pyroxenite. The pyroxenite is of Devonian age, as is also the latter syenite, which is intrusive into the pyroxenite.

(*e*)—*The Ore-Body.*

The workings on this abondoned mine consist of three adits connected by rises and winzes. The two upper ones have been driven from the north side of the hill, while the third and lowest has been driven from the south side.

The No. 1, or uppermost, adit was driven to prospect a quartz-reef exposed on the surface, and supposed to contain gold. A white, barren quartz is common in this locality, being derived from narrow veins in the pyroxenite. This adit was driven 200 feet in a south-westerly direction, and intersected the silver-lead formation, to test which the other workings were carried out, at 100 feet. The lode was 5 to 6 feet wide, and consisted of decomposed pyroxenite, much stained with oxides of iron and manganese, and carrying disseminations of cerussite and crocoite. A short drive was put in to the north along the lode which has a strike of 340°, and dips to the north-east. This adit was 30 feet below the crest of the hill, and exposed part of the oxidised portion of the lode.

The No. 2 adit is 60 feet below No. 1, and was driven 155 feet in a south-westerly direction. The lode was cut at this distance, and was driven on to the south-east for 200 feet. The adit and drive passed through country consisting of decomposed and serpentinised pyroxenites, and also a type described by Twelvetrees as a diorite. The lode was similar to that exposed in No. 1 adit, and contained in serpentinous material without any definite walls. It consisted of crocoite and cerussite with oxides of antimony and lead, as well as antimonial galena reported to contain 3 ozs. of silver per ton to the unit of lead. A winze below this level proved the lode to be 6 inches wide, with a smooth footwall. Stoping is said to have been carried out in this winze, and to have produced galena mixed with blende, but the vein or veins were probably narrow, and the quantity produced small. A drive from this winze (afterwards connected with a rise from No. 3 level) proved the lode to contain a vein of galena which had a maximum width of 6 inches, but was very irregular. An assay (whether of the lode or of the galena is not stated) yielded 63 ozs. 17 dwts. of silver per ton and 22·7 per cent. of lead.

The No. 3 adit was driven 110 feet below No. 2 in a northerly direction from the south side of the hill. The lode was cut at 500 feet, and driven on to the north-west for 170 feet. The adit passed through serpentine for 300 feet, then a dyke of diorite, again through serpentine, followed by black slate, serpentine, and finally the lode. The lode was contained in serpentine with walls about 6 feet apart, the footwall being defined, and the hanging-wall ragged. Bunches of pyrite, galena, quartz, and calcite are reported, but nothing of value was apparently revealed.

The lowest level appears to have been below the oxidised zone, although the evidence is not very definite. If this is the case, the mine has little or no chance of revealing anything of greater value at depth. The decomposed and serpentinous material is altered pyroxenites. The decomposed diorite dyke exposed in the workings may represent an offshoot of syenite from the main mass which occurs 4 to 5 chains to the east. In strike and dip this lode is parallel to the contact of the syenite and pyroxenite. It is, therefore, also parallel, in these respects, to the lode and Mace's Show, and represents a lode parallel to the latter, but contained in the pyroxenite.

(*f*)—*Conclusions.*

The above descriptions of the workings and the ore-body are taken largely from previous reports, and apparently nothing of value was revealed in the mine workings. The shoots of ore were small and erratic, and of no economic importance, and further work on it does not seem to be justified.

(7)—Gregory's Galena Mine.

(*a*)—*Location and Access.*

This mine is located upon the lease originally taken up as No. 3590-87M, of 80 acres, and last held as No. 2692M. The workings are situated by the side of the Waratah-Corinna road, one mile north-east of Luina (Whyte River).

(*b*)—*Previous Reports.*

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, pp. li.-lii., 1896-1897.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, p. clxxi., 1899-1900.

(*c*)—*Geology.*

The country in the vicinity of the workings consists mainly of decomposed and serpentinised ultrabasic rocks.

probably pyroxenites, intrusive into the slates, and cherts of the Dundas series.

(*d*)—*The Ore-Body.*

In a small creek on the south-east side of the road an adit was driven, but has fallen in. An open trench, also fallen in, exposed a formation striking north-east and south-west. The formation consisted of quartz, with splashes of zinc-blende and galena, and was 15 to 24 inches wide, with well-defined walls. A more recent trench further to the north-east along the strike exposed 9 inches of quartz, with splashes of blende and galena on the north end of the cut, and 6 inches of quartz and gossan on the south end. Another adit was driven from the road level to the south of the creek. It was driven in a south-westerly direction for about 260 feet, cutting the lode at 241 feet. Near the entrance the adit passed through completely decomposed ultrabasic rocks, which gradually gave place to less decomposed serpentinised types. These continue past the lode, and appear to form the bulk of the country-rock, although Smith([45]) reports altered slates to the east of the lode. The lode was driven on to the north-east, and reported to be bunchy, and contained lead carbonate, as well as galena, banded with carbonate of iron. The drive cannot be entered, and the lode, where exposed in the adit, is 9 to 12 inches wide, and consists of almost barren quartz.

(*e*)—*Conclusions.*

The workings have not, therefore, exposed anything of value, and, although the formation appears to be well-defined, it is extremely doubtful as to whether anything of greater value can be expected.

(8)—Section 6179.

This section, with the adjoining ones to the north (No. 6181) and to the south (No. 6180), are located one and a half miles south-west of the Arthur River dam. This area is covered with a thick jungle of bauera, cutting-grass, boxwood, &c., and very little can be seen of the surface, but wherever visible the rock formation consists of

([45]) Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah : Secretary for Mines' Report, 1896-1897.

Devonian basic and ultrabasic rocks, including very fine-grained varieties, porphyritic pyroxenites, and the latter in a much decomposed state.

On Section 6179 a short trench has been put across a formation containing galena, blende, and chalcopyrite. These minerals are accompanied by a small amount of quartz, and occur in a much decomposed fine-grained pyroxenite. They occur over a width of about three feet as small masses in the altered pyroxenite, but the formation does not appear to have any definite walls. The formation has a rough north and south strike, but has not been followed along its strike. The formation, as it is exposed, has no commercial value, but occurring as it does in the pyroxenites, a small amount of prospecting may be warranted.

(9)—Section 3119-m, 40 Acres.

This section is situated south of the Waratah-Corinna road, near the site of the old Magnet ore-shed, 7 miles from Waratah. This section was taken up by J. C. Matthews, who discovered an outcrop of gossan on the section in 1907.

The greater part of the section is occupied by pyroxenites, which are, however, covered with alluvium to the east. The Dundas series of slates, &c., occur near the north-west corner, and it is into this series that the pyroxenites are intrusive.

The outcrop of the lode occurs in the decomposed pyroxenites, and is of a gossanous nature, with a strike of 165°. The formation has been opened up by means of several shallow shafts and trenches. These have shown the lode to consist of iron-stained quartz, together with altered pyroxenites, with the typical green-staining characteristic of occurrences in these rocks in the district. A small quantity of pyrite and blende is visible, and galena is also reported to occur, but cannot be detected in the material on the dumps.

Nothing of value has so far been proved to exist in the formation, although the formation occurs in the pyroxenites which are favourite repositories for the silver-lead ores of the district. While additional work is not recommended, prospecting work along the strike of the lode to the south might lead to the discovery of something of greater value.

(10)—Campbell's Galena Prospect.

These small workings are located near the head of Campbell's Creek, which flows into the Arthur River, and are situated about half a mile north of the Waratah-Corinna road, at a point one and a quarter miles east of the Arthur dam.

The country in the vicinity of the workings is composed of quartzites and cherts, representing members of the Dundas series, which have been metamorphosed by the intrusion of the granite, which occurs to the south-east. In the workings in the creek greenish foliated material, probably representing altered slates, is associated with the quartzites.

In the bed of the creek a quartz-vein containing pyrite can be traced for several chains. It has a strike varying from 240° to 250°, and dips to the north. A trench has been put along the vein in the bed of the creek, but revealed nothing of value. Small trenches south of this exposed small veins and splashes of pyrite, galena and blende in the quartzites, which appear to branch off the pyritic quartz-vein. Several small trenches on the south bank of the creek have exposed further quantities of these minerals, and a little gossan. In one of these trenches galena, blende, pyrite, arseno-pyrite, and siderite have been revealed. This last series of trenches could not be located, so that no description of this lode can be given.

(11)—Arthur River.

A vein of carbonate is exposed in the bank of the Arthur River, one mile downstream from, or half a mile north-east of, the junction of the Seven-mile Creek with the Arthur River. It occurs in the north bank of the stream is 18 to 24 inches wide, and has a strike of 340°.

The vein occurs in the slates and breccias of the Dundas series. Several chains west of the vein a belt of completely decomposed rocks are exposed. These are only exposed in the river, and their exact nature could not be determined, but they appear to be either completely decomposed slates or a fine-grained basic igneous rock.

The carbonate closely resembles the ankerite which occurs at Magnet Mine. The ankerite appears to be barren, but a small quantity of gossan occurs on the bank above it, and it may possibly contain some minerals at other points along its strike. While a small amount of prospecting may be warranted, the fact that the ankerite is not accompanied by any quantity of mineral at the Magnet, does not make the prospect of valuable discoveries very hopeful.

(12)—The Six O's Section (7589-m, 80 Acres).

This section is located at the junction of the Arthur River, and Magnet Creek. Galena was discovered at this locality, and the section taken up in 1914. Prospecting work was carried out near the south-east corner, but revealed nothing of importance, and the lease was forfeited in 1920.

The greater part of the lease is occupied by the slates, sandstones, and quartzites, of the Bischoff series, and it is in these that the workings have been performed. The dyke of igneous rocks from the Magnet crosses the north-west corner of the section, and appears to be all "diabase porphyrite" at this point. To the north-west of the dyke the slates and tuffs of the Dundas series occur.

The workings consist of an adit and several surface trenches and shallow shafts. The adit has fallen in, but specimens on the dump show galena associated with quartz and siderite (probably manganiferous). These appear as veins and splashes in sandstones. The adit had a bearing of 260° as far as could be seen from the fallen in entrance. A trench from above the entrance of the adit has a bearing of 220°, and connects with a shallow underlay shaft 50 feet from the adit. This underlay shaft has a strike of 270°, and dips north at about 70°. Only narrow veins of galena, quartz, and siderite in a bed of sandstone are visible. A trench further to the south-west did not expose anything of importance.

The deposit, therefore, is one consisting of small veins and splashes of galena, quartz, and carbonates, in a bed of sandstone. It has a strike of 220°, with probably a high dip to the north-west. The portion so far exposed has no economic value, and does not warrant further expenditure.

In the creek through the centre of the section a small trench has been driven on a 9-inch vein of coarsely-crystallised calcite, about 5 chains south-east of the dyke. The calcite is barren, and does not warrant further work on it.

(13)—Magnet Creek.

A shaft has been sunk on the north bank of the Magnet Creek, near the Magnet school, on a formation which is said to have contained galena and blende. The shaft has now fallen in, and cannot be inspected. The country consists of the black slates and sandstones of the Bischoff series. In addition to these the only materials on the dump are small amount of pyrite and bluish-grey carbonate, probably dolomite, no galena or blende being visible.

To the north, apparently along the strike of the lode in the shaft, a few trenches and small cuts have exposed a small amount of gossanous material, but nothing of value.

In the east end of the cutting, near the school, the slates are somewhat iron-stained and decomposed, and a small amount of blende is alleged to have been obtained during the construction of the cutting, but there is none to be seen at present. This formation in the cutting is roughly in alignment with the shaft, and the cuts to the north, and would, therefore, appear to represent the same lode which would have a strike of 25°.

A short adit occurs to the south, and was probably driven to cut the continuation of this lode, but without any result.

Only very small amounts of galena and blende have been reported in this lode, and from what can be seen of it, it is of no importance.

(14)—Fawkner's Show.

This show is situated just below the old track from Waratah to Corinna, about 60 chains west of the bridge over the Arthur River. It is located about the centre of the old lease, 373-91m, 40 acres, held in 1891 and 1892.

A shaft was sunk on an outcrop of gossan above the track, and an adit driven to test this gossan at depth. The adit was driven in a general south-westerly direction for about 200 feet, but nothing of value can be seen in it. This adit is situated on the south-eastern side of the dyke, which trends between the Magnet and the Persic Mines, and was driven at or close to the contact of this dyke with the Bischoff slates and quartzites, the adit not keeping strictly to the contact.

It is reported that a small amount of mineral was obtained from the floor of the adit, and which yielded values of copper and silver on assay, but this could not be officially verified. Only small veins of quartz and carbonate minerals occur in the material on the dump.

The deposit could be easily tested at greater depth by adits from the valley of the Arthur River below the track, but, although it may be said that it occurs in a favourable position at the contact of the dyke, so little mineral has been revealed that any further work does not appear to be justified.

(15)—Arthur River.

A small amount of blende occurs on the east bank of the Arthur River, 20 chains north-east of its junction with the Magnet Creek. A short trench in the bank of the river has exposed an indefinite body of gossan. This gossan has a strike of 40°, and dips to the north-west, but does not appear to persist in depth. On the bank above this trench the dump shows pieces of greyish carbonate, probably dolomite, with splashes of blende, and possibly also galena in small amount. No dolomite is visible in the trench, and probably represented an isolated body in the gossan.

About one and a half chains to the south a shallow shaft has been sunk in fine-grained sandstones and quartzites. On the dump some of the pieces of quartzites contain splashes of resin blende.

These two exposures are enclosed in the Bischoff series, but represent two different formations. The amount of blende in both is very small, and the formations have no extent, and are of no economic importance.

(16)—The Silver Cliffs Mine.

(See accompanying Plate XX.).

(a)—Location and Access.

The mine is located on Section 7167M, of 40 acres, situated two miles north-west of Waratah. Access to the mine is gained by the road to the Bischoff Extended Mine, and then by a track, the total length of road and track being two and a half miles.

(*b*)—*Previous Reports.*

Montgomery, A., Report on the Country Traversed by the Route of the Proposed Waratah to Zeehan Railway: Secretary for Mines' Report, p. 24, 1891-92.

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, p. liii, 1896-97.

Ward, L. Keith, The Silver-Lead Lodes of the Waratah District: Geological Survey Report, No. 2, 1911.

(*c*)—*History.*

Though within two miles of Waratah the outcrop of silver-lead ore was not discovered until early in 1891. The first lease was applied for by W. J. Reed, on 14th March, 1891, and granted as 28-91M. Work was carried out until 1894, the section being held by the Silver Cliff Company, and later by R. Bayley, and small quantities of ore produced. The No. 1 lode outcropping in the cliff face was the first discovered and worked, the other lode (No. 2) to the south being found and worked at a later period. It was taken up again in 1896 as the New Silver Cliff (1209-93M), and worked spasmodically until 1901. The work was confined to the No. 2 lode, but no ore was shipped away. The lease was held almost continuously from 1903 until 1917 by various people and syndicates. Further work was carried out in 1904, and a few tons of ore were won, but little more work has been carried out on the section. This section was last held as 7167M, 40 acres, but was declared void in 1917.

(*d*)—*Geology*

The whole of the section is occupied by the slates, sandstones, and quartzites, of the Bischoff series.

(*e*)—*The Ore-Bodies.*

Two lodes have been worked on this property, and are known as the No. 1 and No. 2 lodes respectively.

The No. 1 lode outcropped on a cliff face which gave the mine its name. All the ore has been removed from this face, and as the two adits driven lower down the hill have fallen in, the following description is taken largely from the earlier reports. The old workings in the cliff show that the lode traversed a bold outcrop of quartzites, with slates to the east. The slates and quartzites have a general strike of 50°, while the lode cuts across them with a strike of 35°, and a dip of 70° to the south-east. The western or footwall of quartzites has horizontal striations on it suggestive of faulting in a horizontal direction. The lode was two to three feet wide, and consisted of a gangue of quartz and silicified slate with galena, blende, and pyrite. Galena was the predominant metallic mineral and occurred as the coarsely cubical variety in veins and pockets throughout the lode. Zinc blende and pyrite were present in only small quantities, as probably also was an antimonial mineral, such as huascolite (which occurs in the No. 2 lode) from which the yellow staining of oxide of antimony was derived.

The upper of the two adits driven cut the lode at shallow depth, and revealed the same general features as at the outcrop, but with a much smaller quantity of galena present. A drive was put in to the north, and passed beyond the ore-shoot, and continued along the lode-fissure. The lode-fissure was not driven along to the south. According to the reports, the lower adit was not driven far enough to cut the lode.

Thus it is seen that while a good shoot of ore occurred at the surface, it had neither an extension in depth or along its strike. The lode has not been traced on the surface to the south of the cliff, nor has the lode-channel been followed in this direction underground owing to the lack of mineral content.

On the surface to the north small patches of gossan and an occasional small vein of galena and pyrite have been located, but cannot be definitely connected with the No. 1 lode.

The No. 2 lode occurs to the south of the No. 1 lode, and near the south-west corner of the section. This lode has a strike of 352°, and a high dip to the east, while the enclosing slates and sandstones have a strike varying from 35° to 65°, and a dip of 60° to 80° to the north-west. The width of the lode was variable, with a maximum of 4 feet. It consisted of galena, pyrite, zinc-blende, and huascolite in that order, but without any great difference in the amounts present. The gangue is relatively small in amount, and consists of siderite (probably manganferous) and quartzitic material representing silicified slates and sandstones.

Alongside the track to the Persic Mine, a shaft was sunk 50 feet on the lode, which was two feet wide, and composed of galena, huascolite, janesonite, blende, siderite, and quartz. A little driving was carried out at a depth of 40 feet in this shaft.

Two chains to the north a short adit cut the lode, which was driven on to the north for 90 feet. Where cut the lode was four feet wide, but it pinched out in the end of the drive. This shoot of ore was stoped out to the surface over the greater length of the drive, and the galena picked out and shipped away. A winze was sunk to a depth of 50 feet below the drive, and was later connected by a rise from a lower level.

Another level was driven 130 feet below the shaft. The adit-crosscut was put in for 220 feet, and a drive started north on a vein carrying pyrite, which was cut at 196 feet. The lode exposed in this drive was very disappointing. Bunches of metallic minerals made at several points along the drives. These consisted of pyrite and blende, with a small amount of galena, and were associated with a little siderite and quartzite. At 260 feet from the crosscut a rise was put up to connect with the winze from the upper level, and a small amount of stoping was carried out over the drive near the rise. Beyond the rise little, if any, mineral was exposed, and at 340 feet a fault was intersected. The drive continued past the fault in slates containing no metallic minerals. The fault was a vertical one, with a strike of 40°, and a short drive along it to the south-west revealed only contorted slates to the north-west of the fault.

This fault has been considered to be the continuation of the No. 1 lode channel. It agrees with the latter in strike and dip, and its position on the plan makes it almost certain that the two are one and the same. No minerals have been deposited in this portion of the channel of the No. 1 lode. The exact relation of the two lode-channels is not definite. That of No. 1 lode strikes across that of No. 2 without any interruption, while that of No. 2 does not continue beyond the other. However, the No. 2 channel is indefinite before being intersected by the No. 1, and it cannot be determined whether it merely junctions with the No. 1 channel or whether it is faulted by it. There has been horizontal movement along the No. 1 lode channel or fault, and it may have displaced the other if it was an older fault. It is probable that both lodes were formed by the one period of mineralisation, and the faults were in existence prior to the lode formation, so that it cannot be said that the No. 2 lode has been faulted by the other.

A third adit was started from the adjoining section to the south. It was driven along the course of the lode towards the north. A small shoot of ore was encountered, but petered out. Further small veins were exposed in the slates, but were not of any value.

The surface to the north of the No. 2 lode has been prospected by trenches, but nothing of value exposed. A few narrow veins of quartz, siderite, pyrite, and blende in quartzite show in one of these trenches. These occur a short distance to the west of the line of No. 2 lode, and have a strike of 305°. If these represented the continuation of the No. 2 lode, support would be given to the belief that the latter had been faulted by the No. 1 lode-channel. This, however, is not probable, as the veins are are small and unimportant, and are such as may be expected anywhere in the vicinity of other mineral deposits, and do not necessarily represent the continuation of the No. 2 lode.

(*f*)—*Production.*

A small quantity of argentiferous galena has been produced from both lodes. The total amount sent away is reported to be about 160 tons, valued at, approximately, £3200.

(*g*)—*Conclusions.*

The two lodes on this property represent simultaneous mineral depositions along faults. A small shoot of ore occurred in each of these lodes near the surface, but further underground work failed to reveal anything further of value. In view of the large amount of prospecting work carried out with the above poor results further expenditure is not justifiable. No other shoots were located, and there is no indication of the possibility of others occurring.

(17)—The Persic Mine.

(See accompanying Plate XXI.)

(*a*)—*Location and Access.*

This mine is located on Lease No. 7455, of 80 acres, situated two miles north-west of Waratah. Access to the mine is by means of the track through the Bischoff Extended, and past the Silver Cliffs Mine, the total length of track to the Persic Mine being three miles.

(*b*)—*Previous Reports.*

The only report on the mine is included in the following publication:—

Ward, L. Keith, The Silver-Lead Lodes of the Waratah District: Geological Survey Report, No. 2, 1911.

(*c*)—*History.*

The ground included in this lease was taken up in its present form by Chaffey, in April, 1891. It was held previously as portions of other leases, but these were probably taken up for other metallic minerals than those of silver and lead. Chaffey discovered the outcrop of gossan, which now bears his name. The other lodes were probably discovered at a later date, but no records of these are available. The property was held by various syndicates and companies, including the Arthur River Silver Mining Company in 1907 and 1908, and the Bischoff Balfour Prospecting Association in 1910, 1911, and 1912. It was more recently held by the Persic Prospecting Syndicate, who carried out further work, but these operations have now ceased.

(*d*)—*Geology.*

The northern part of the lease is occupied by the dyke of "diabase porphyrite," which extends as far as the Magnet Mine. Near the north-east corner a small body of pyroxenite occurs as a bulge on the south side of the dyke. The remainder of the section is occupied by the slates, sandstones, and quartzites of the Bischoff series. Breccia and breccia-conglomerates occur in association with the Bischoff series, but their relationships cannot in all cases be satisfactorily determined. In a trench along a small creek to the south-east of the huts, silicified breccia-conglomerate occurs with its eastern boundary parallel to the bedding of the slates, and undoubtedly represents an interbedded breccia-conglomerate. Near the face of the No. 1 adit-crosscut, a three-foot band of breccia occurs with a strike of 34°, and a dip of 65° to the south-east. The footwall is soft, but the hanging-wall side has been silicified. The strike is similar to that of the slates and sandstones, and the breccia is probably an interbedded one of sedimentary origin. A third body of breccia-conglomerate is associated with Chaffey's lode. It is very similar to the first outcrop described, but is not silicified to the same extent, and consists of rounded (or, as far as can be ascertained, waterworn) and angular fragments of quartz and quartzite in a matrix of the same composition. The strike of this band is east and west, and it cannot be correlated with either of the other two bands unless it occurs in a very narrow faulted zone, which is very probable.

(*e*)—*The Ore-Bodies.*

Several outcrops of gossan and galena-bearing formations occur on this property, and which have been developed to a great or less extent.

(i)—Chaffey's Lode.

This outcrops prominently on the surface as a body of gossan, with a general east-west strike. This gossan is associated with a band of breccia-conglomerate. At the eastern end of the outcrop an adit has been driven 25 feet at a bearing of 290°. It passed through slates and then gossan associated with the breccia-conglomerate at the face. Another adit, about 60 feet to the south-east, was driven apparently to cut this lode, but it has fallen in, and only slates are visible on the dump.

In the outcrop on the summit of the ridge two shafts, each 12 feet deep, have been sunk, and revealed the same association of gossan and breccia-conglomerate.

The outcrop continues on to the western fall of the ridge, and appears to be nearly a chain wide. The only trace of it crossing the track to the mine is to the north-west of Wynn's adit. Wynn's adit, which is almost below the outcrop on the ridge, did not expose this formation, the only occurrence which might correspond with it being three feet of gossan 18 feet from the face of the north drive.

This gossan is, however, associated with decomposed slates, and except for a few hard pieces of quartzite in the gossan there is no material present resembling the breccia-conglomerate.

(ii)—The No. 1 Lode.

This lode has been opened up by several surface-trenches and two adits.

The trenches exposed narrow veins of galena, sometimes with siderite or ankerite, occurring in slates, sandstones, and quartzites.

The No. 1, or upper, adit was driven at a bearing of 110° to give 40 feet of backs. Slates were passed through until the lode was cut at 110 feet. The adit-crosscut was continued for 175 feet, and drives were put along the lode to the north and south. Where cut, the lode consisted of a few inches of pug lying against a smooth wall on the east side.

The north drive followed this wall for 40 feet, and revealed only an occasional small vein of galena and siderite traversing the slates.

The south drive also followed this wall, and exposed only narrow veins of galena in the country to the west, and also in the pug seam. This wall represents a fault. On the west side of the drive the strata have the usual strike of 40°, and are vertical, while those behind the wall to the east have a general east-west strike, and dip northerly. This fault is shown clearly in the short drive off the No. 3 east crosscut, where the slate beds to the east are crumpled and abut against the wall or fault. Narrow veins of galena run behind the fault, as in the No. 1 east crosscut, and in a cuddy between it and the No. 2 crosscut east. Near the No. 2 east crosscut the fault branches at an acute angle, and the drive continues between the two branches. A small vein of galena occurs at the entrance of No. 3 crosscut east, and the east branch of the fault was cut, and then followed by the short drive south off this crosscut. The best make of ore occurs in the No. 1 west crosscut, where on the north side galena occurs as veins and impregnations over a width of one foot in quartzite. On the south side of the crosscut only narrow veins of galena and carbonate occur. A winze has been sunk on this make of ore, and connects with the No. 2 level. Traces of galena continue in the drive to near the No. 2 west-crosscut, in the face of which narrow veins of quartz and siderite with a little galena occurs. The drive continues with a slight bend to the east, and intersects the east branch of the fault, and crosses behind it to the east, no galena being present in the last portion of the drive. The west branch of the fault does not extend south of the No. 1 west crosscut, and was apparently only a minor off-shoot of the other.

The No. 2 adit was started to the west of the No. 1 adit, and gave an additional 40 feet of backs. The adit passed through slates and quartzites, and at 220 feet intersected quartzite, carrying veins of quartz and pyrite. At 300 feet, a drive was driven to the south, and connected with the winze from the No. 1 level. At 20 feet north of the winze a small patch of quartz, pyrite, and galena was struck. The ore in the No. 1 level above the winze did not maintain its dimensions in depth. Only small impregnations of pyrite and galena in quartzite are visible at the foot of the winze. Very little galena is visible past the winze, and the face of the drive is in slates and quartzites, carrying a little carbonate. The fault is not in evidence in this level, and is probably slightly to the east of the drive.

Thus it is seen that the No. 1 lode consists of narrow veins and impregnations of galena, pyrite, and siderite in quartzites, and to a less extent slates. The formation follows the line of a fault, which has a strike of 30°, and is practically vertical, dipping, if anything, at a very high angle to the west. This fault, and therefore the lode formation, forms the western boundary of a faulted area representing a collapsed anticline. The ore so far exposed consists of a very small quantity of low-grade ore. Concentration would be necessary to form a marketable product, and there is neither the quantity or quality of ore to jusify erection of a plant for this purpose.

(iii)—The No. 2 or Hines' Lode.

About 100 feet east of the No. 1 lode, another one outcrops, and has been opened up by a trench and adit. This lode occurs at the junction of pyroxenite, and the slates and sandstones of the Bischoff series. The junction has a bearing of 130°, and dips north at a low angle, but the lode, in the short section visible, appears to have a strike slightly oblique to the junction. On the north side of the trench at the mouth of the adit, 18 inches of galena and a carbonate (probably a manganiferous siderite) are exposed. The galena occurs in veins and circular patches in the siderite. Only a small amount of carbonate and galena occurs on the south side. The adit was driven across the lode, and exposed only decomposed pyroxenite to the face.

The extension of the No. 1 adit was driven to test this lode in depth. The face of the main adit-crosscut is in decomposed pyroxenite. The pyroxenite is veined with siderite, carrying a little pyrite, but no lode occurs. A branch crosscut (Dunn's) to the north-east has not properly entered the pyroxenite. The face consists of slates, with carbonates and a little igneous material, but no lode is exposed.

This lode has not been exposed at other localities on the surface. A trench to the north, near the northern boundary has exposed some gossanous material. This is located in the pyroxenite, and cannot be definitely correlated with the No. 2 lode.

(iv)—Other Outcrops.

In a creek to the south-east of the huts several outcrops of gossanous material occur, and have been exposed by trenches. These have no connection with any of the lodes discussed above, and do not represent discoveries of importance.

In addition, a trench along the creek has exposed a bed of breccia-conglomerate interbedded with the slates. The breccia-conglomerate contains narrow veins of quartz and siderite, and splashes of galena and pyrite. It has not been tested along its strike, but the occurrence is of no economic importance.

(f)—Conclusions.

Although several formations outcrop on this property, they have proved, when opened up, to be of little importance. The outcrop of Chaffey's lode is prominent, but the lode has been shown not to possess any metallic contents. The largest amount of work has been carried out on the No. 1 lode. This has been proved to consist of very narrow veins of galena in Bischoff slates and quartzites formed along a faulted zone. While a very small amount of milling ore may be considered to exist, there is neither the quantity or value to justify the erection of any plant to treat it. The No. 2 lode is of a more promising appearance, but is of very limited extent. A small amount of prospecting along the strike of this lode, and in the pyroxenite, should be carried out. Other than this, the lodes are of little value, and no further work is recommended.

(18)—The Magnet Silver Mining Company, N.L.

(See accompanying Plates XXII., XXIII., XXIV., XXV., XXVI., XXVII.).

(a)—*Location and Access.*

This company holds two consolidated leases—No. 5636M, of 117 acres, and 5637M, of 162 acres—situated on the Magnet Range, 4½ miles west of Waratah. The workings were commenced on the northern part of the present 162-acre block, but underground they have progressed into the 117-acre block.

The mine was formerly connected with the Waratah-Corinna road by a tramway, 3 miles in length, which joined the road at the 7-mile peg from Waratah. It is now connected with the Waratah-Guildford Railway by a two-foot steel tramway, 10½ miles in length, which connects with this railway one mile from Waratah.

(b)—*Previous Reports.*

Smith, J. Harcourt, Report on the Mineral District between Corinna and Waratah: Secretary for Mines' Report, p. lii, 1896-1897.

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, pp. clix-clxix, 1899-1900.

Waller, R. F., The Magnet Tramway: Secretary for Mines' Report, pp. cxix-cxxx, 1901-1902.

Twelvetrees, W. H., Report on Mineral Fields between Waratah and Long Plains, pp. 30-35, 1903.

These reports deal with the mine in its earlier stages of development, and describe the upper workings of the mine only. The only later report is a confidential one, by the late W. H. Twelvetrees, then Government Geologist, in 1918, a very brief summary of which is contained in the

Report of the Secretary for Mines for 1918. This report describes the workings down to the No. 12 level, and is the most important of the previous reports.

(c)—*History*.

According to hearsay, the gossan capping of the Magnet lode was discovered by W. R. Bell, while engaged in the task of marking a track from Waratah to the Pieman River, in 1877, or thereabouts. In trying to take the track up the valley of the Magnet Creek, he is alleged to have found the gossan in dense horizontal country, but proceeded with the marking of the track, and did not follow up the discovery. It is further stated that it was not until 12 or 13 years later that he was able to locate the position of his earlier discovery. It is certain, however, that he either discovered, or rediscovered, the gossan outcrop in 1890, and took up Lease No. 3705-87M, on the 16th February, 1891. Prospecting work was commenced, and the lumps of galena and carbonates found on the surface traced up to the gossan outcrop, which was then opened up by trenches.

Sections 2074-91M and 2075-91M, both of 40 acres, were taken up to the north and south respectively, by W. F. Petterd, in December, 1893. The Magnet Silver Mining Company, N.L., was formed in 1895, with a capital of £1024, in 4096 shares of 5s. each, to work sections 3705-87M and 2075-91M. Access to the mine was provided by the construction of a pack-track, 3 miles in length, to connect with the Waratah-Corinna road, 7 miles from Waratah. Developmental and other works were pushed ahead, and in 1898 the capital of the company was increased to £2500 in 25,000 shares of 2s. each. In 1899 the pack-track was converted into a two-foot steel tramway.

Up till the end of 1900 only first-class ore was being sent to market, and the poorer second-grade ore left in the mine, only sufficient being broken to permit of the stoping of the richer ore. Cheaper means of transport were required in order to render the marketing of the second-grade ore a profitable venture. The capital of the company was increased to £4000 in 40,000 shares of 2s. each, in order to construct the present tramline from Magnet siding, on the Waratah-Guildford line, to the mine. This tramway was completed early in 1902, and with the erection of a crusher and drying plant, considerable quantities of first-class ore and gossan were sent away from the mine. By the end of 1904 a concentrating plant was erected to treat the otherwise unprofiitable second-class ore, which was accumulating. The mine began to yield dividends, although these were not as great as they might have been owing to the expenditure on mine and plant. Shaft-sinking had now to be resorted to to develop the ore-bodies, and involved pumping and winding appliances. The mill had also to be enlarged in order to efficiently handle larger tonnages. A dam was constructed on the Arthur River, and races to bring the water to the mine. This additional water was required not only for milling, but also for power purposes, much power now being required for the operation of mine and plant. In 1908, the capital was further increased to £5000 in 50,000 shares of 2s. each. From this time until 1914, the mine just about paid its way, without providing any dividends, several calls being necessary. The war interfered with operations in 1914, and the capital was further increased to £10,000 in 50,000 shares of 4s. each. The dividend-paying stage was entered again in 1916 and 1917, but this was not continued. The construction of the present hydro-electric plant, and the construction of the No. 2 dam involved a large amount of expenditure, and in conjunction with high costs following the war, the working of the mine was not profitable. The capital was increased to £24,000 in 60,000 shares of 8 shillings each, and several calls made.

With the advent of higher prices for silver and lead at the beginning of the year, the mine and plant which are now efficiently equipped should have a profitable run in the near future.

(*d*)—*Geology*.

The Magnet lode occurs within the Magnet dyke, which has been described above(46). This dyke, or dykes, are intrusive into the slates, cherts, and breccias of the Dundas series, which occur to the east and west of the dyke.

Included within the dyke there are two bodies of slates and sandstones of the Bischoff series. One of these occurs between the websterite porphyrite on the east of the dyke, and the diabase porphyrite to the south of the open-cut. The other body is included in the websterite porphyrite on the east of the dyke, and is exposed in the No. 4 adit.

(46) See p.p. 45-52

The Magnet dyke is about 20 chains wide at the mine, and the section from east to west is, approximately—

360 feet websterite porphyrite,
400 feet diabase porphyrite with associated variolite,
400 feet bronzitite or websterite porphyrite.

The dyke on its eastern side dips westerly, as does also the junction of the websterite porphyrite, and the diabase porphyrite.

At the mine, the dyke occupies a narrow fault zone, representing a narrow faulted block to the south-west of the very large faulted block of the Bischoff series. The inclusions of the two bodies of the Bischoff series within the dyke is due to the intrusion of the latter along this faulted zone.

(e)—Geology of The Ore-Bodies.

At the surface the Magnet lode occurs on the west or hanging-wall side of the websterite porphyrite. At the northern end of the open-cut it is located between the websterite porphyrite and the diabase porphyrite. At the southern end of the surface workings, *e.g.*, in the adit which connects with Scheer's rise from the No. 1 south level, the Bischoff slates and quartzites occur to the west of the lode. The occurrence of these strata adjacent to the lode is not a characteristic feature, but is due to the inclusion of a body of them between the websterite and the diabase porphyrite as explained above(47).

The underground workings down to, and including, the No. 8 level can only be partly entered, while some of the levels cannot be entered at all. From the surface down to No. 4 level the lode is described(48), as occurring at the hanging-wall of the websterite porphyrite, and near the junction of the latter with the diabase porphyrite. From the No. 4 to the No. 8 levels the same conditions probably exist.

From No. 9 to No. 14 levels practically all of the workings can be inspected, and the ore-bodies exhibit the same characteristics throughout. These characteristics are illustrated in Plate XXVI., which serves to make easy the understanding of the following description. The cross-cut from the shaft is driven through the strata of the Dundas series, with a general bearing of 270°. At a point

(47) See p. 159.
(48) Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, 1899-1900.

in the crosscut 40 to 60 feet before the lode is cut the country becomes broken, and the crosscut has to be timbered. The eastern side of this disturbed country is generally indicated by a wall which is parallel to the footwall of the lode, and has the same westerly dip. Several inches of pug occur on the western side of this wall, and the latter may represent a plane along which slight movement has taken place, and which has been traversed by solutions. The Dundas series continue past this wall, and the altered websterite porphyrite is generally exposed immediately before the lode is cut. The footwall of the lode is then cut, and has a general north and south strike, with an average dip of 55° to the west. The crosscut is carried through the lode until the hanging-wall of "dolomite" is met with. This wall has the same average dip as the footwall, but the strike is 33°. All the country between the foot and hanging-walls is mineralised, and consists of websterite porphyrite almost completely replaced by white ankerite ("dolomite"), and often stained green by a chromium mineral.

The largest and most important ore-body occurs on the footwall, but narrower veins and smaller bunches of ore occur throughout the lode.

Three drives are usually driven on the lode to both the north and south. These are put along the footwall, hanging-wall, and in the centre of the lode. The north footwall and central drives are continued until the hanging-wall is reached. Good to fair grade ore usually occupies all the space between the foot and hanging-walls north of the crosscut, but does not pass beyond these walls. In the lower levels ore does not extend along the hanging-wall to the north beyond its intersection with the footwall.

The south footwall drive or drives prove the footwall ore-body to extend for 100 feet and over in that direction. The south central drives follow a vein or veins of ore which are roughly parallel to the footwall ore-body. The south hanging-wall drive follows the hanging-wall of ankerite to the south. Veins and bunches of ore may be proved by this drive. The value of the lode, apart from the footwall ore-body, depends upon the number and size of the veins or ore, and while second-class ore of poor to good grade may be obtained from this part of the lode, some portions are too low in values to render their extraction payable. This portion of the lode is richest near the apex formed by the foot and hanging-walls to the north, and decreases in value towards the south, where it becomes unpayable.

The footwall ore-body thins out towards the south, and gives place to a seam of pug contained in dark foliated websterite, which may be traversed by veins of ankerite. The south central drive usually ends in an igneous rock (probably the websterite porphyrite), largely replaced by ankerite, but the No. 12 south central drive ends in foliated websterite similar to that in the south footwall drives. The south hanging-wall drives end in the altered country of the lode, but the degree of alteration decreases somewhat to the south, though the hanging-wall is still prominent.

(f)—The "Dolomite" Hanging-wall.

This wall consists of a smooth face of solid white ankerite, with a seam of soft pug up to two feet in thickness lying against it on its south-east side. At some points the surface of this wall is grooved or slickensided, and where thin layers of the ankerite can be knocked off the wall this may be found on the underlying surface with the grooving running in a different direction. This wall has a strike of 20 to 30 degrees, with an average dip of 55° to the north-west.

When broken into for a short distance the material behind the wall is found to consist of solid crystalline ankerite. Further into the wall dark patches appear, and represent areas of only partially replaced rock. This wall has been penetrated by underground workings in a very limited number of places. In the crosscut off the hanging-wall drive at No. 6 level, and also in the cuddy of the hanging-wall drive at No. 12 level, dark-grey igneous rock, veined with ankerite, is exposed. On microscopic examination these rocks prove to be the "diabase porphyrite." In the continuation of the main crosscut beyond the hanging-wall in No. 14 level the varolite associated with the "diabase porphyrite" is exposed.

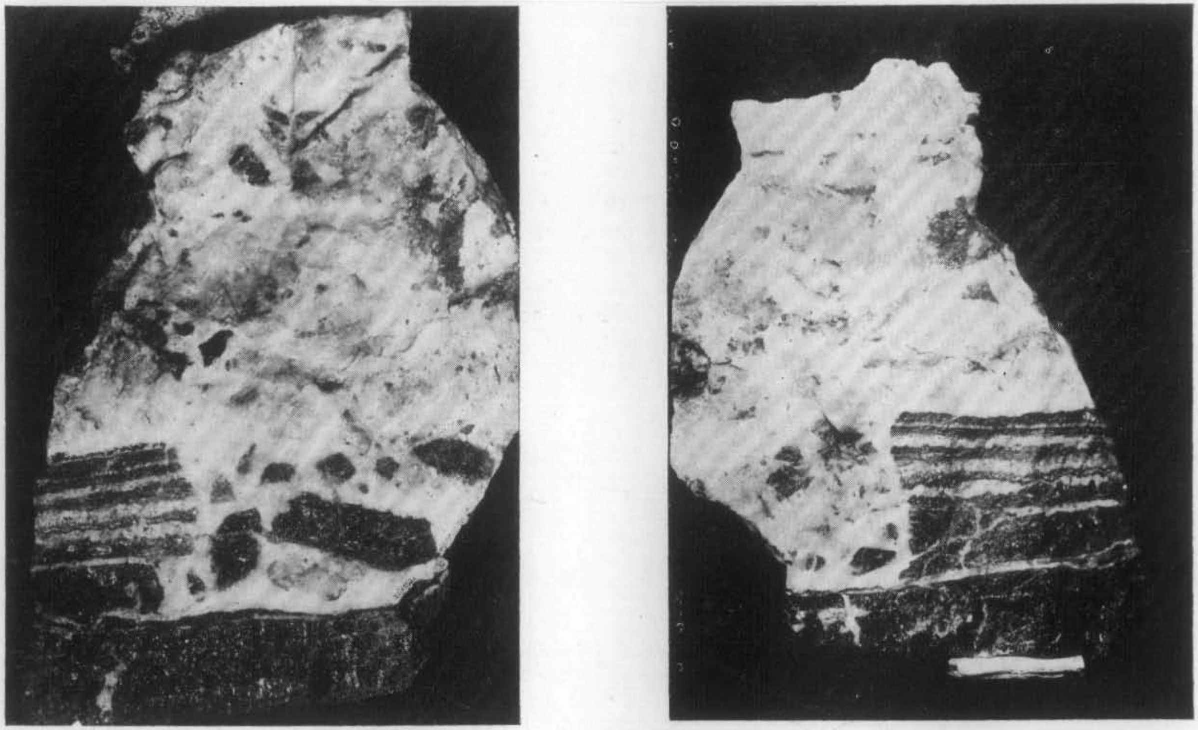
As the lode occurs in the hanging-wall of the websterite porphyrite, the ankerite hanging-wall must occupy a position between this rock and the "diabase porphyrite," and, in fact, represent the actual contact between the two rocks. While this conclusion is almost certainly the correct one, it cannot be satisfactorily proved owing to the few places in which the hanging-wall is broken into. For example, at the face of the north drive at No. 12 level, the country against the east side of the hanging-wall consists of members of the Dundas series. This means that either the websterite porphyrite has thinned out and vanished, which is characteristic of this occurrence, or else it occurs to the

To face page 162. Photo. No. 2.—PORTION OF MAGNET LODE. [S. Spurling, Photo.

5 cm

5 cm

Fig. 1. Fig. 2.



To face page 163.

Photo. No. 3.—MAGNET ORE.

[*H. A. Graham*, *Photo.*

west of the hanging-wall, in which case the hanging-wall would represent a fault-cutting through the websterite porphyrite. As the websterite porphyrite decreases in width in depth and laterally, and at other localities along the dyke the "diabase porphyrite" is directly in contact with the Dundas series, there is little doubt that the hanging-wall represents the eastern boundary of the "diabase porphyrite." The grooving of the ankerite on this wall is suggestive of faulting along the junction of the two rocks. The grooves probably represent original ones in the rock, and have been preserved in the replacement of the rock by the ankerite. The amount of displacement in any faulting which took place could not be ascertained, but it was probably small.

(*g*)—*Mineralogy of the Ore-Bodies.*

The ore in the Magnet Mine consists of the metallic minerals—galena, sphalerite or zinc-blende, and pyrite—and the non-metallic minerals—mangano-siderite and ankerite. In addition, there is the gangue material formed by the more or less completely replaced country-rock. The websterite porphyrite has been completely altered, the porphyritic crystals of bronzite being changed to bastite, and the groundmass of orthorhombic and monoclinic pyroxenes being altered to serpentine and chlorite. Further, this rock has been altered by the mineralising solutions, and practically all gradations up to the complete replacement by ankerite can be obtained.

The galena is generally of the coarse, cubical variety, with subordinate amounts of the finer-grained variety. The blende is black, and of the marmatite type. The pyrite occurs in the usual form as narrow bands and stringers, but is quite subordinate in amount. Galena is the most abundant metallic mineral, and the following assays show the proportions of lead and zinc present in the lower levels:—

Constituent.	No. 11 Stope.	Footwall Ore No. 13 Stope.
Silver	12·75 ozs. per ton	45·73 ozs. per ton
Lead	10·10 per cent.	29·70 per cent.
Zinc	4·46 per cent.	12·88 per cent.

These figures show that the zinc contents at these levels are 43 to 44 per cent. of the lead content.

The ore is typically a banded one, and provides excellent examples of this type of ore-deposit. The bands consist of galena, zinc-blende, and mangano-siderite, with a much smaller amount of pyrite. These four minerals belong to one period of mineralisation, although there may be a slight difference in age between the various bands. The white ankerite also seems to be associated with this banding, but this is due to replacement of an original band or precipitation along the joint between two of the bands. The ankerite is distinctly later in origin than the other minerals, as it cuts across the bands. Photos. 3 and 4 show clearly the relation of the ankerite to the other minerals. The ankerite has also replaced portions of the lode, and rendered them valueless. A brecciated appearance has been imparted to the lode by the white ankerite. This is owing to the angular and irregular-shaped pieces of ore being enclosed in the ankerite. The specimen (Fig. 1, photo. 4), from the south end of No. 13 footwall stope shows how the veins of ankerite penetrating the blende have produced this appearance. Figures 1 and 2 in photo. 3 show the back and the front of the same specimen obtained from the south end of No. 13 footwall stope. Figure 1 shows the abrupt termination of portion of the banded ore by almost complete replacement by ankerite, while the adjacent portion of the ore (blende) continues unreplaced and undisturbed. Figure 2 shows the same effect, but the replaced portion of the ore contains several angular pieces of blende. Further, it will be readily seen that the two pieces near the banded ore have been actually displaced, and occupy positions which must have been occupied by banded ore prior to replacement. The longest pieces shows a displacement at one end of half an inch, while the other piece has been orientated through a larger angle, and represents a larger displacement.

These specimens establish beyond doubt that the ankerite has replaced portions of the ore. The processes involved were those of substitution or replacement, accompanied by a subordinate amount of growth from fractures (or even from narrow replaced veins formed by replacement) where fragments have been displaced from their original positions. These processes and their results are very similar, despite the differences in the materials and minerals concerned, to those which F. L. Stillwell[49] regarded as having operated in the Bendigo goldfields in the formation of the quartz reefs.

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[49] Stillwell, F. L., The Factors Influencing Gold Deposition in the Bendigo Goldfields, Parts I., II., and III., Advisory Council of Science and Industry Bulletins, Nos. 4, 6, and 8.

5 cm

Fig. 1.

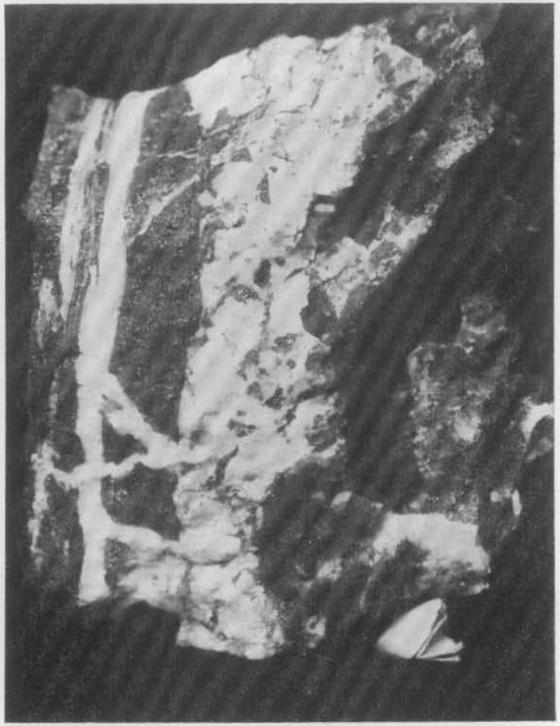


Fig. 2.

To face page 164.

Photo. No. 4.—MAGNET ORE.

[*H. A. Graham, Photo.*

(*h*)—*Paths Traversed by the Mineralising Solutions.*

It has been shown above(50) that the silver-lead ores of the district have been formed by deposition from solutions derived from the final phase of the Devonian igneous intrusions. The paths that these solutions have chosen in the formation of any particular lode or lodes should help in the deciding of where to prospect for further lodes or ore-bodies in the vicinity.

In the Magnet Mine it is obvious that the ore-bearing solutions travelled along the rocks immediately under the ankerite hanging-wall. In the northern ends of the upper levels of the mine the greater part of the minerals were actually deposited against this wall. In the southern parts of the upper levels the solutions partially departed from this course, and traversed north and south planes in the websterite porphyrite in which minerals were deposited. The remaining portion of these solutions still traversed the hanging-wall, and deposited minerals. In the lower levels the same two paths—along the hanging-wall and north-south planes in the websterite porphyrite—were traversed, but the greater part of the deposition took place in the websterite porphyrite. These planes intersect the hanging-wall at angles ranging from 20° to 30°. The deposition was greatest along the course from which the footwall ore-body was formed.

The later solutions from which the ankerite was deposited, traversed the same paths as the earlier ones, which formed the ore-deposits. In addition to these paths, the ankerite solutions traversed, and replaced to a more or less degree, the country between the footwall ore-body and the hanging-wall.

(*i*)—*Treatment of the Ore.*

The treatment of the ore commences in the underground workings where the first and second-class ores are trucked separately from the stopes, and where much of the barren mullock is picked out of the second-class ore and retained in the stopes for filling.

The "seconds" are tipped on the sorting floor, and shovelled on to a shaking-screen of one and a half inch mesh. The undersize goes to a hopper, from which it is trucked to the mill-bin. The oversize is fed on to a picking-belt, from which both gangue, and pieces of first-class ore are picked off. The gangue is trucked to the dump, and the "firsts" are barrowed to join the crudes from the

(50) See p.p. 71-79.

mine. The "seconds" from the belt fall into a bin, and are crushed to $1\frac{1}{2}$ inch in a 16" × 9" Blake crusher, and are then trucked into the mill bin, and mixed with the undersize from the shaking-screen.

The "firsts" from the mine and picking-belt are passed through a Jacques crusher, and broken to $1\frac{1}{2}$-inch size, and are bagged ready for market. At the present time this product averages 53 oz. of silver per ton, and 32 per cent. of lead.

The "seconds" from the mill bin pass through the concentrating mill, the flow sheet of which is given in Plate XXVII. The seconds pass from the bin by means of an automatic feeder to No. 1 shaker. This has a screen with 3-inch square holes, and separates large pieces of ore, chips, &c. The undersize is fed to the No. 1 rolls, which are 30" × 15" Jacques rolls, set at $\frac{1}{2}$-inch. The material is elevated by No. 1 elevator to two lines of trommels, with six trommels in each line. These screen to the following sizes respectively:—over $\frac{3}{4}$-inch, between $\frac{3}{4}$ and $\frac{1}{2}$-inch, between $\frac{1}{2}$ and $\frac{3}{8}$-inch, between $\frac{3}{8}$ and $\frac{3}{16}$-inch, between $\frac{3}{8}$ and $\frac{3}{64}$ inch, and under $\frac{3}{64}$-inch. The screened ore from the trommels passes to 10 corresponding two-compartment Hartz jigs, which produce only firsts and tailings. The concentrates are barrowed away to the draining floor preparatory to bagging. The oversize from the trommels and the tailings from the jigs are delivered to an unwatering screen, with slots $\frac{3}{8}$-inch by $\frac{3}{64}$-inch, from which the unwatered oversize passes to No. 2 elevator, and the undersize and water to a settling-box below. This undersize is lifted by an ejector to a 3-inch slime pump, where they mix with the undersize from the trommels.

The No. 2 elevator delivers the material to No. 2 bin, from which it passes per roller feed to No. 3 shaker and No. 2 rolls (Jacques 30" × 15"), set at $\frac{1}{8}$-inch. No. 3 elevator lifts the material to No. 4 shaker, which produces the following products:—over $\frac{7}{32}$-inch, between $\frac{7}{32}$ and $\frac{3}{64}$ inch, and under $\frac{3}{64}$-inch. The oversize passes to No. 3 rolls (Jacques 20" × 12") and back to No. 3 elevator; the undersize is taken to a spitzkasten, and mixes with the material from the slime pump; while the other product passes through four 5-foot Bigelow grinding-pans, and then to No. 5 shaker, where it is joined by the product from one spigot of the spitzkasten. The overflow from the spitzkasten passes to five single compartment spitzkasten.

The No. 5 shaker gives over $\frac{3}{64}$-inch, and under $\frac{3}{64}$. The former goes back through No. 4 rolls, together with oversize from No. 4 shaker, and then to No. 3 elevator. The under $\frac{3}{64}$-inch product passes to a pair of 30-mesh Callow-screens. The oversize goes to two single compartment May jigs, which produce firsts and tailings, of which the firsts go to the draining-floor, and the tailings to waste. The undersize from the screens passes to two 60-mesh Callow-screens, from which the oversize goes to two Card tables, producing firsts, middlings, and tailings. Of these, the firsts go to the draining-floor, the middlings back through the No. 3 elevator, and the tailings to waste. The undersize from the 60-mesh screens goes to a single compartment spitzkasten, giving two spigots to two Card tables producing firsts, middlings, and tailings, are dealt with asabove.

The overflow from the spitzkasten joins with that from the spitzkasten next to the slime-pump, and passes to five single compartment spitzkasten, giving one spigot each to corresponding Luhrig vanners giving firsts, middlings, and tailings. The firsts go to the draining-floor, the middlings back to No. 1 elevator, and the tailings to waste. The overflow from the spitzkasten passes to an eleven-compartment spitzkasten, which gives eleven spigots, and the overflow to waste. The eleven spigots pass to a single compartment spitzkasten, the overflow of which goes to waste, and the underflow to a Luhrig vanner, giving three products, which are dealt with as in the case of other vanners.

All the concentrates from the above processes are dumped together on the drying-floor, and form an argeniferous galena product assaying at the present time 91·4 oz. of silver, and 59·2 per cent of lead.

The zinc contents of the ore at present goes to the dump along with the tailings. The galena and zinc-blende in the ore are not intimately associated, and there should be no difficulties in the way of obtaining a good separation of the two minerals and two marketable products. The company are at present investigating this problem with the object in view of installing a flotation plant to give a better recovery of galena, and to save the zinc-blende.

The mill is driven by three Pelton wheels, giving respectively 67 h.p., 86 h.p., and 14 h.p.

(j)—*Water Supply.*

The first supply of water for the mine was obtained from the Magnet Creek, the water being collected at a point immediately above the Magnet Falls, 30 chains upstream from the mine. The water was led through a short tunnel, and then fluming and a race to a point above the mine. A head of 250 feet was obtained, and the water was used to generate power as well as for mill and mine purposes.

In 1904, the supply, especially during the dry summer period, was not sufficient, and a short race was cut from the Seven-mile Creek to conduct the water from this creek into one of the head-waters of the Magnet. The water flowed down the Magnet, and was utilised as above.

In 1906, further supplies were required, especially for power purposes. A temporary dam was erected on the Arthur River, at the place where it crosses the Waratah-Corinna road, and a race, about a mile long, led the water into the Seven-mile Creek, from which it was picked up lower downstream, and utilised as before. The water was picked up from the headwaters of the Magnet by a race, one mile long, and conducted to above the mine. A 20-inch pipe-line was installed, and, with the 400-foot head, about 200 horse-power were generated. Later, a permanent dam, with a capacity of 28,000,000 gallons, was constructed in place of the temporary one at the Arthur River.

In 1916, the need for larger supplies, and also for the installation of a large hydro-electric plant became apparent. Another dam was constructed at the intake of the water-race from the Magnet Creek. This dam was constructed of earth and rocks, as was also the Arthur River dam, and was designed to have a storage of 126,000,000 gallons for a breastwork 70 feet high. At present the breast is 60 feet, but is now being raised to the 70 feet. A supply tank was also built at the intake of the pipe-lines from the race, and the pipe-line and the hydro-electric plant installed. For about nine months in the year there is sufficient water for all purposes, and the whole of the mine plant, except the mill, is driven by the power generated in the hydro-electric plant.

There is generally a shortage in the water supplies during the dry period in the summer. The raising of the No. 2 dam will tend to relieve this by the conservation of a further 46,000,000 gallons. Further supplies will, however, be found necessary to carry the mine over these dry spells. During the present investigation it was found that further supplies could be obtained from the Arthur River at a point one to one and a half miles downstream from the No. 1, or Arthur River dam. Even in the driest period of the present year (1922), there was a flow of, approximately, 50,000 gallons per hour at this place. A race with a length of a mile or thereabouts could be constructed to lead this water to the flood-gate on the Seven-mile Creek, from which the race conducts the water to the No. 2 dam. The intake at the Arthur River need be just sufficient to deflect the water into the race. This scheme would, at very little cost, supply the No. 2 dam with an additional daily supply of about 1,000,000 gallons when required, and should enable the mine to carry on throughout the year without the aid of the auxiliary steam-plant.

(k)—Hydro-Electric Plant.

This plant consists of a large Pelton-wheel and an alternating current generator, and other necessary equipment. The Pelton-wheel is of the enclosed pattern, with a steel runner, 42 inches diameter, and fitted with 20 ground and polished buckets, 13 inches by 9½ inches. The water is delivered through two fixed rectangular nozzles, 3⅝ inches wide, with movable tongues. The opening and closing of the tongues are controlled by a Voith oil pressure duplex relay governor, fitted with automatic relief valves for bye-passing the water in case of sudden changes in the load. The wheel has a normal output of 530 B.H.P., with a maximum of 670 B.H.P. at 500 revolutions per minute. The wheel is directly coupled to the generator, which is a three-phase revolving field type, with an output of 500 K.V.A., 550 volts, 50 cycles, 578 amps. The stator is hand-wound, and the rotor has 12 poles of usual type. An exciter is mounted on the main shaft, and there is also an independent generator as an emergency exciter. The exciter on the main shaft has an output of 6·3 K.V.A., 115 volts, 55 amperes at 500 revolutions per minute.

(l)—Production.

The total production of the Magnet Mine amounts to 143,750 tons of ore, containing 25,937 tons of lead and 5,923,711 ounces of silver. The nett value of this ore amounts to £1,277,079.

The nature of the ore produced has varied with the development of the mine. At first it was chiefly high-grade oxidised ore, and also sulphide (galena) ore. Later, some of the lower-grade oxidised ore was treated, and converted into a marketable product. The oxidised ore gave place to the primary sulphide ore in depth, and, from this, crudes, and second-class ore were produced. The question of concentrating the lower grade sulphide or second-class ore soon came into evidence, and so concentrates were produced.

Table No. 11 gives full details of the production from 1910, during which period practically the whole of the ore mined has been primary sulphide ore, from which first and second-class ore, giving crudes and concentrates, respectively, have been produced.

TABLE

Production of Magnet

Half-yearly Period Ending.	Total Quantity Ore.	Crudes Produced.					
		Quantity.	Assay.		Metallic Contents.		Quantity.
			Silver.	Lead.	Silver.	Lead.	
	Tons.	Tons.	Ozs. per ton.	Per cent.	Ozs.	Tons.	Tons.
28th Feb., 1910	12,870	1546·5	40·0	12·2	61,860	189·0	...
31st Aug., 1910	12,544	2568·0	41·9	13·3	107,599	342·0	...
28th Feb., 1911	18,092	2795·0	43·1	13·1	120,464	366·1	...
31st Aug., 1911	15,681	1901·0	39·4	12·1	74,899	230·0	...
29th Feb., 1912	20,131	2423·0	44·4	14·2	107,643	345·0	...
31st Aug., 1912	14,138	1868·0	47·4	14·8	88,543	276·4	39·0
28th Feb., 1913	13,635	1210·0	48·6	15·8	58,879	191·2	102·0
31st Aug., 1913	15,177	2111·0	50·2	21·1	107,834	446·5	51·0
28th Feb., 1914	9638	1842·7	51·7	19·7	95,275	362·6	20·2
31st Aug., 1914	11,109	1961·2	51·3	21·0	100,609	411·8	4·3
28th Feb., 1915	2182	493·5	53·3	18·7	26,321	92·2	...
31st Aug., 1915	8350	1670·0	45·2	18·8	75,475	314·0	...
29th Feb., 1916	5097	968·0	50·0	20·7	48,478	200·0	...
31st Aug., 1916	7921	2045·1	47·2	23·2	96,531	474·5	9·3
28th Feb., 1917	7373	2239·0	53·3	30·1	119,066	672·4	...
31st Aug., 1917	7082	2161·5	58·7	31·3	126,880	677·5	...
28th Feb., 1918	4680	266·7	58·8	18·2	15,682	48·5	...
31st Aug., 1918	5138	1109·4	60·7	29·8	67,340	380·6	...
28th Feb., 1919	8330	701·0	66·4	33·3	46,546	233·4	...
31st Aug., 1919	4776	304·0	58·1	30·6	17,662	93·0	...
29th Feb., 1920	3741	505·9	51·2	29·7	25,902	150·2	...
31st Aug., 1920	3090	494·7	57·3	36·4	28,446	180·0	...
28th Feb., 1921	49·4	590·0	57·9	33·7	34,161	198·8	
31st Aug., 1921	406						...
28th Feb., 1922	...	...	...	...	...	...	...
31st Aug., 1922	8968	1334·0	57·5	34·4	76,705	458·8	...

No. 11.

Mine since 1910.

Firsts Produced.				Concentrates Produced.					
Assay.		Metallic Contents.		Quantity of Seconds Treated.	Quantity of Concentrates Produced.	Assay.		Metallic Contents.	
Silver.	Lead.	Silver.	Lead.			Silver.	Lead.	Silver.	Lead.
Ozs. per ton.	Per cent.	Ozs.	Tons.	Tons.	Tons.	Ozs. per ton.	Per cent.	Ozs.	Tons.
...	...	...	...	10,824	687·9	123·3	42·4	84,818	292·0
...	...	...	...	9576	707·0	109·8	40·4	77,629	286·0
...	...	...	...	14,897	840·1	119·3	41·7	100,224	350·3
...	...	...	...	13,480	640·0	108·4	40·7	69,376	260·5
...	...	...	...	12,850	712·9	113·8	42·2	81,164	301·0
140·0	22·8	5460	8·89	11,831	630·0	106·7	38·8	67,221	244·4
141·6	29·4	14,391	29·94	9687	358·0	100·0	40·0	35,848	143·1
145·7	38·0	7447	19·4	10,295	515·0	98·2	47·6	50,599	245·3
189·6	34·0	3829	6·8	6743	406·7	100·6	49·0	40,396	199·5
160·5	54·5	690	2·3	7494	470·2	100·7	48·6	47,349	228·5
...	...	...	...	1526	126·1	97·2	42·0	12,263	58·1
...	...	...	...	6380	442·0	95·1	46·3	41,106	205·0
...	...	...	...	3460	247·0	107·3	48·0	26,606	119·0
174·0	47·4	1621·6	4·40	4645	406·3	103·8	49·9	42,177	202·7
...	...	...	...	3908	291·0	102·5	55·8	29,827	162·3
...	...	...	...	4232	388·8	100·6	52·7	39,113	204·8
...	...	...	...	2843	250·5	114·6	50·1	28,707	125·3
...	...	...	...	3558	278·5	100·2	51·1	27,905	142·3
...	...	...	...	3790	325·3	100·4	55·5	32,660	180·5
...	...	...	...	3915	334·0	93·8	52·3	31,403	175·1
...	...	...	...	2317	197·5	93·9	57·3	18,545	113·2
...	...	...	...	2726	259·1	90·2	54·4	23,370	140·9
...	...	...	...	3642	318·0	93·6	57·5	29,764	182·8
...	...	...	...		14·0	86·0	57·0	1204	7·9
...	...	...	...	6603	584·0	96·3	64·5	56,239	376·6

Table No. 12 shows the details of production during a period of seventeen weeks of the present year. The crudes averaged 53·0 oz. of silver per ton, and 31·9 per cent. of lead, while the concentrates averaged 91·4 oz. of silver per ton, and 59·2 per cent. of lead. The grade of the ore is discussed later, and the first-class ore is considered to contain 45 oz. of silver per ton, and 29 per cent. of lead, while the seconds average 6 oz. of silver, and 4 per cent. lead.

TABLE NO. 12.

Weekly Production of Magnet Mine from June 28th till October 18th, 1922.

Crudes.			Amount of Seconds Treated.	Concentrates.		
Amount.	Value.			Amount.	Value.	
	Silver.	Lead.			Silver.	Lead.
Tons.	Ozs. per ton.	Per cent.	Tons.	Tons.	Ozs. per ton.	Per cent.
60	53·4	33·0	333	30	92·5	58·7
60	53·1	32·4	277	30	90·4	58·4
60	53·6	33·1	326	30	92·2	58·7
60	53·6	33·4	262	30	93·6	58·4
60	52·2	32·3	346	30	90·3	58·4
60	50 4	30·0	455	30	90·3	58·3
60	50·3	30·0	380	30	90·4	58·9
60	51·9	31·8	503	30	92·6	59·3
60	51·6	32·0	493	30	90·3	59·2
60	55·4	33·2	474	30	93·2	59·4
60	53·9	31·4	393	30	92·6	59·8
60	51·3	31·2	390	30	90·5	59·6
60	54·4	32·0	423	30	90·4	58·9
60	53·8	32·4	275	18	92·2	59·9
60	56·7	32·0	470	30	90·0	58·7
60	51·2	30·4	453	30	92·5	59·8
60	54·2	33·0	450	30	90·6	59·4
1020	53·0	31·9	6803	498	91·4	59·2

(m)—Reserves.

No accurate estimation of either the quantity or value of the reserves is possible owing to the variable nature of the ore as regards values. The following description will, however, indicate in a general way the reserves existing in the mine. The ore is divided into two grades—firsts and seconds. The firsts are hand-picked, and yield the crudes which are marketed as such, the remainder of firsts then being treated as seconds. From the seconds mullock is hand-picked, and goes to the dump, and a small quantity of crudes is also obtained by hand-picking, the remainder of the seconds being concentrated.

Quantity.—The firsts are obtained mainly from the footwall ore-body, although small quantities are obtained from parts of the lode being stoped for seconds. From the surface down to No. 12 level practically all the footwall ore-body has been stoped out. Small quantites may exist in the old stopes between Nos. 9 and 8 levels, and possibly also between Nos. 8 and 7 levels. The main reserves of firsts are between Nos. 14 and 12 levels. The footwall ore-body between these levels in approximately 200 feet long. The southern end wedges out, and a short length of it may not be stoped. At the north end the apex between the foot and hanging walls is stoped out to a maximum width of 36 feet. Firsts occur principally on the footwall over a width of 5 to 6 feet, but also occur throughout this apex. This footwall ore-body would, therefore, be stoped over a length of at least 150 feet, with a maximum width of 6 feet, and an average width of 3 to 4 feet. This body is almost intact between the Nos. 14 and 13 levels, and has an average of 90 feet of backs (110 feet along the dip). At the present time, probably at least half of the block of ground between Nos. 13 and 12 levels has been stoped out, so that the remaining backs are not more than 40 feet vertical.

Second-class ore is obtained from other parts of the ore-body between the footwall and the "dolomite" hanging-wall, where the galena content is sufficient to render the extraction profitable. Various grades of seconds from good to poor are thus obtained, and sent to the concentrating plant. The bulk of the seconds is obtained from the apex of the lode between the foot and hanging walls, and from the poorer portions of the footwall ore-body. They are also obtained along the south central and hanging-wall stopes, where the galena content is sufficiently high, which is generally towards the apex. Considerable quantities exist in the block of ground between the Nos. 14 and 13 levels in the 90 feet of backs, where no stoping has been carried out. About 40 feet of backs in the footwall ore and the apex of the lode occur between Nos. 13 and 12 levels, while quantities of seconds may also exist in the central portion south of the apex, and also along the hanging-wall, where up to 20 inches of banded ore is exposed. Between Nos. 12 and 11 levels quantities of seconds may probably be obtained from the apex and the central portion south of the apex. Between Nos. 11 and 10 levels the apex has been stoped up for some distance, and 30 to 40 feet of backs still exist. In the central portion, south of the apex, no stoping has occurred, and quantities of seconds will probably be proved to exist. Between Nos. 10 and 9 levels only a small amount of stoping has been carried out in the apex and south central portions of the lode, and quantities of seconds probably exist in these parts. Above No. 9 level quantities of seconds exist in the south central portion of the lode, and in the old stopes between Nos. 9 and 8 levels, and between Nos. 8 and 7 levels. Above these the workings cannot be fully examined, and it is doubtful if any reserves exist.

As regards the possible reserves below No. 14 level, it is confidently expected that considerable quantities will be proved to occur. The lode has maintained the same general features from the No. 9 down to the No. 14 level—a distance of approximately 400 feet, and there is no reason why it should not continue below No. 14 level for a similar distance. The exact behaviour of the lode as regards dimensions and values cannot be accurately predicted, but the lode should maintain its same general features. Whether there will be an increase or decrease in dimensions and values can only be proved by developmental work.

Value.—The value of the ore is best obtained from the production of the mine. The production of the mine during the 17 weeks from June 25th to October 18th of the present year, is given in Table No. 12. The total production during this period was 1020 tons of crudes, assaying 53·0 oz. of silver per ton, and 31·9 per cent. of lead, together with 498 tons of concentrates, assaying 91·4 oz. of silver per ton, and 59·2 per cent. of lead, obtained from 6803 tons of milling ore.

Allowing for the milling ore obtained from the firsts after the crudes have been hand-picked, the value of the firsts is probably slightly under 50 oz. of silver, and 30 per cent. of lead. A sample across the footwall lode in No. 13 stope, from which firsts were being stoped, gave the following value on assay in the Geological Survey Laboratory:—

Constituent.	
Silver	45·7 oz. per ton
Lead	29·7 per cent.
Zinc	12·88 per cent.

This result agrees fairly well with that obtained from the production, and the value of the firsts may be taken at 45 oz. of silver, and 29 per cent. of lead.

The value of the milling ore from the above production has an average of 6·69 oz. of silver, and 4·33 per cent. of lead. As the seconds are enriched by the hand-picking of mullock, and impoverished by the removal of crude ore, it may be taken that these roughly balance, and the grade of the seconds is equal to that of the milling ore. The average value of the seconds from the mine may, therefore, be safely regarded as 6 oz. of silver per ton, and 4 per cent. of lead. A sample across five feet of good grade seconds from No. 11 stope, gave the following results in the Geological Survey Laboratory:—

Constituent.	
Silver	12·7 oz. per ton
Lead	10·1 per cent.
Zinc	4·46 per cent.

This sample was, however, good grade seconds, and much above the average grade of the mine, so that some of the seconds produced must be considerably below the average, and some of the poor grade seconds may be as low as 3 oz. of silver, and 2 per cent. lead.

(*n*)—*Recommendations for Future Prospecting.*

There is no doubt that the company are working the whole of the ore-body in the mine. It peters out naturally both to the north and south in the lower workings, and there is no faulted portions to search for. However, the lode-channels continue in both directions, and it is along these tracks which the solutions have traversed that other ore-bodies may have been formed, and along which future prospecting should be carried out. The mineralising solutions have moved along the "dolomite" hanging-wall, and also north-south channels in the websterite porphyrite, the main one of the latter being that along which the footwall ore-body was formed. The prospects along these various tracks are different, and will be discussed separately.

(i)—Along the Hanging-wall to the North.

In the upper parts of the mine, ore was formed along this portion, and constituted the greater part of the ore-body. In the bottom levels, however, no ore was formed in this position. This difference is explained by the occurrence of websterite porphyrite to the east of the hanging-wall in the upper parts, and not in the lower, where the diabase porphyrite is in contact with the Dundas strata. The northward continuation of the hanging-wall has been tested to shallow depth by the North Magnet workings, but no ore was found to occur, even though a small thickness of websterite porphyrite occurred to the east of the hanging-wall. As regards any northward continuation in depth it must be borne in mind that the websterite porphyrite, which was the apparently the controlling factor in the ore-deposition does not exist. As to whether ore may have been deposited under other conditions, nothing can be said, and such a point could only be settled by prospecting work.

(ii)—Along the Hanging-wall to the South.

In addition to occurring along this wall to the north in the upper levels, ore also occurred along it to the south of the split or, in other words, where the footwall ore channel branched off the hanging-wall. This deposition was greatest in the upper levels, but it also occurred in lower levels, *e.g.*, along the No. 13 H.W. drive, where up to two feet of ore exists to the south of the apex of the lode.

The southward continuation along this wall has been prospected at numerous localities and depths. On the surface trenches have exposed ankerite with a little blende and galena several hundred feet south of the open cut. Other trenches, still further south, have exposed gossanous material, but no further carbonates or metallic minerals.

Exactly how far the websterite porphyrite extends on the surface to the south cannot be definitely stated. Some of the decomposed material on the Magnet Proprietary shaft dump may represent this rock, but it certainly does not continue as far as the creek to the immediate south of this shaft. The small trenches and adits, near the south boundary of the Magnet Lease, No. 5637, are in the diabase porphyrite. The small amounts of pyrite, quartz, and carbonate in these are of no importance, and these formations have no connection with the Magnet lode.

The Magnet lode had its greatest length in No. 1 level, where it extended considerable distances to the south of the open-cut along the hanging-wall. This southern continuation only extended a short distance above and below this level, and was not in evidence at the No. 2 or lower levels.

The south adit was driven to test the southern continuation of the lode 800 feet south of No. 4 adit, and at approximately the altitude of No. 5 level. It passed through the Dundas series to 1247 feet, where ankerite and gossan were intersected. It is extremely doubtful whether any websterite porphyrite occurs before this formation is cut. Some of the ankerite immediately preceding this formation may represent replaced websterite, but this cannot be stated definitely. This ankerite and gossan formation represents the southern continuation of the hanging-wall, which, therefore, at this point, contains no ore. The adit continued through altered igneous material much replaced and veined with ankerite, which eventually gave place to less altered material resembling the diabase porphyrite.

In the lower levels of the mine, the south hanging-wall drives, when they have followed ore, have always proved it to peter out. At the faces the hanging-wall still occurs to the west with pug under it, and altered igneous material to the east. Solutions have undoubtedly travelled along this portion, and with the websterite porphyrite occurring to the east, conditions should be favourable. However, south of the apex of the lode, the greater part of the solutions probably traversed the footwall ore channel, and so the possibilities of large deposits along the hanging-wall to the south are not so great.

(iii)—South Along the Footwall.

Deposition was not very prominent in the footwall ore channel in the upper levels, but with increase of depth it became predominant with the exclusion of any along the hanging-wall north and south of the footwall channel. In the bottom levels the footwall ore-body always peters out, and gives place to a seam of pug in the foliated and altered websterite porphyrite. At the faces of the south footwall drives these condtions always exist, and so should be favourable to formation of other ore-bodies. Whether any were formed depends upon whether the solutions still contained metallic minerals after the deposition of the footwall ore-body. This can only be actually decided by prospecting work, and the continuation of the south footwall drives would be the best prospecting work in the mine.

(iv)—Between the South Footwall and Hanging-wall Drives.

All this area has been traversed by the later ankerite solutions, and to a less extent by the earlier mineralising solutions. Any veins of minerals, especially those with the brownish mangano-siderite should be followed. These will be found generally to leave the hanging-wall or the apex of the lode, and have a course roughly parallel to the footwall ore-body, such as the vein or veins driven on in the south central drives. Other veins may have junctioned with the footwall instead of coursing parallel to it.

(v)—Outside the Footwall and Hanging-walls.

The crosscuts from the shaft have prospected the country to the east of the lode without proving any lodes to exist. As regards the country to the west of the hanging-wall very few crosscuts have been driven in this direction. On the surface to the west of the lode, some limonitic material is exposed, but probably does not overlie anything of value, nor has any lode been exposed in the adit at the south-west corner of the original Magnet lease. The long crosscut to the west off the hanging-wall drive at No. 6 level revealed only diabase porphyrite veined with ankerite.

At No. 9 level the ankerite hanging-wall is not definite at some portions, and some of the short crosscuts may be behind this wall. The winze from one of these has exposed a formation containing up to 9 inches of fine-grained galena, but for the above reasons the exact position of this cannot be determined.

A short cuddy off No. 12 hanging-wall drive did not reveal anything of value.

The continuation of the No. 14 crosscut past the hanging-wall exposed a two-foot formation carrying veins of galena. A nine-inch vein on the hanging-wall of this formation gave the following results in an assay of a sample in the Geological Survey Laboratory:—

Constituent.	
Silver	137 oz. per ton
Lead	70·10 per cent.
Zinc	10·08 per cent.

While the conditions to the west of the hanging-wall are generally not favourable, the following of veins similar to the above is certainly recommended. Short crosscuts off the hanging-wall drives would easily prospect for a continuation of these veins.

(o)—*Conclusions.*

The future of the Magnet Mine depends upon the prices for lead and silver, and with those ruling at present the immediate future should be very successful. The lode has been followed down to approximately 1000 feet below the outcrop, and is still underfoot. Reserves of first-class ore (approximately 45 oz. silver, 29 per cent. lead, and 12 per cent. zinc) occur between the Nos. 12 and 14 levels. Considerably larger quantities of second-class ore (6 oz. of silver, 4 per cent. lead, and 1·5 per cent. zinc) occur between the Nos. 7 and 14 levels. From these the mine is maintaining a weekly output of 60 to 70 tons of crudes (53 oz. of silver, and 31·9 per cent. lead) and 30 tons of concentrates (91·4 oz. of silver, and 59·2 per cent. lead).

At No. 13 level, and probably No. 14, the ore-body is 200 feet long, and can be stoped over at least 150 feet. The firsts are mainly obtained from 5 to 6 feet on the foot-wall, while the seconds are obtained over varying widths at different portions of the lode. The same general characteristics of the lode have been maintained from the No. 9 to the No. 14 level, and there is no reason why the lode should not continue a similar distance at least below No. 14 level. Certainly, half this depth may be relied upon, and so another 200 feet of backs may reasonably be expected below No. 14 level, and further developmental work at depth is recommended.

As regards the locating of other ore-bodies besides that worked in the mine, this has been discussed above, and south of the footwall ore-body recommended as the most likely direction.

The mine is well-equipped, and the hydro-electric plant supplies power very cheaply to all departments. With the additional supplies of water about to be obtained from the Arthur River, there will probably be sufficient water to enable the plant to supply power all the year round to the mine and treatment plant.

The investigations now in hand with a view to saving the zinc content of the ore should not meet with any difficulties, and, if a market could be obtained for this zinc product, it would add considerably to the revenue of the mine and its financial success, as the zinc content of the lode is approximately 40 per cent. of the lead content.

(19)—North Magnet Section.

(a)—*Location and Access.*

This section was last held as 6816M, of 40 acres, and is north of, and adjoining, the original 20-acre section on which the Magnet Mine workings are situated.

(b)—*Previous Reports.*

Twelvetrees, W. H., Report on the Mineral Fields between Waratah and Corinna: Secretary for Mines' Report, p. clxx, 1899-1900.

Twelvetrees, W. H., Report on Mineral Fields between Waratah and Long Plains, p. 35, 1903.

(c)—*History.*

This section was taken up in 1893—two years after the Magnet. A shaft was sunk in gossan near the southern boundary, and an adit driven to test the lode at depth, but without disclosing payable ore. In 1900 a lower adit was driven in conjunction with the Magnet S.L.M. Company to prove the lode, 90 feet below the Magnet No. 4 adit. If successful this would have been used as a haulage way by the Magnet Company. Payable ore was not cut, and the south drive to the Magnet Mine was not put in. The section was transferred to the Magnet Company in 1907, but was forfeited in 1908. It was taken up again as 3838M, and held principally by the New Magnet Company until 1914, when it was declared void. It was taken up by Healy and Cairns as 6785M, and later by Healy as 6816M. An upper tunnel was driven during this latter period, but disclosed nothing of importance.

(*d*)—*Geology.*

The broad dyke of igneous rocks from the Magnet section crosses this section in a north-easterly direction. The "diabase porphyrite" has a width of about 8 chains, but the websterite porphyrite on the east is very narrow, and appears to wedge out against the "diabase porphyrite." The pyroxenite to the west of the "diabase porphyrite" is still prominent. The north-west and south-west corners of the lease are occupied by the slates and breccias of the Dundas series.

(*e*)—*The Ore-Bodies.*

The two lower adits were driven to test the continuation of the Magnet lode. The upper or No. 1 adit was driven westerly for 300 feet. The entrance was in surface material, and then slates and breccias of the Dundas series were passed through to 200 feet, where the websterite porphyrite was cut. This continued to 217 feet, when barren ankerite came in, and continued to 233 feet. Succeeding the ankerite was two feet of decomposed puggy igneous material, with soft corbonates. The adit continued in "diabase porphyrite" to the face. The ankerite dipped west at about 45°. A drive was put in to the south-west, but is now blocked up. It is stated by Twelvetrees to have been driven 64 feet on the hanging-wall of the ankerite, and at the face, 94 feet from the surface, to have carried 14 feet of gossan. No sulphide ore was exposed, but the gossan assayed not more than 9 per cent. lead and 12 oz. of silver per ton.

The lower or No. 2 adit was driven westerly for about 470 feet from an altitude 186 feet below No. 1 adit. It is now completely blocked up at the entrance, and the following description is taken from the reports by Twelvetrees. The adit passed through the slates and breccias of the Dundas series before cutting the websterite. The drive cut "the northern extension of the Magnet dyke. At this point it intersected 8 feet of white-banded dolomite (ankerite), and passed into 9 feet of soft puggy rock, which seems to be part of the dyke. It would be desirable to extend this tunnel further in to make sure that the whole of the dyke has been intersected, or the cuddy west at the end of the drive could be extended beyond the pug. A drive has been put in south for two chains, first following the puggy rock on the hanging-wall side, leaving hard, massive, white dolomite (ankerite) on the east side. Towards the end, however, the level bears obliquely across to the dolomite (ankerite), and carries it to the face. At the face a cuddy, or short crosscut has been driven east and west for 17 feet. To the east it is in massive white dolomite (ankerite), with a speck or two of mineral, but carrying no banded carbonate of iron (mangano-siderite). To the west it is in the soft, hanging-wall rock, seamed with dolomite (ankerite)." It is very probable that the conditions here are the same as in the No. 1 adit, and that the white ankerite occurs between the websterite and diabase porphyrite, with only a narrow width of websterite porphyrite present.

These conditions, except for the absence of metallic minerals, are the same as those at the north end of the Magnet lode in the upper workings. If ore ever existed in this continuation of the Magnet lode, it has since been completely replaced by the ankerite. While this is possible it is more likely that only the later barren ankerite was deposited in this channel.

To the north-east of these workings the websterite porphyrite does not appear, and the "diabase porphyrite" is in direct contact with the Dundas series. Variolite makes its appearance here and there along the contact, and, on the foot-track from the Magnet to the newly reopened track on the summit of the range, a small amount of gossan associated with dark quartz is visible. Nothing further can be found, and apparently the lode does not extend further in this direction, although solutions may have moved along the boundary of the "diabase porphyrite."

A third adit has been driven near the northern boundary of this section. It is north of No. 1 adit, and about 200 feet above it. The adit is driven in a general north-westerly direction for 240 feet through igneous rocks, consisting of the "diabase porphyrite" with bands of variolite, and also fine-grained varieties. Two drives have been put in to the north at 200 and 240 feet respectively. The one at 200 feet starts on five feet of gossanous material, and decomposed igneous rock. This thins out to the north, and at the face hard, diabase porphyrite occurs to the west, and the same rock, decomposed, and with a little gossanous material to the east. The other drive starts on two feet of gossanous material associated with what is probably a rock with platey structure formed by decomposition of one of the fine-grained varieties of the "diabase porphyrite." This continues for about 70 feet with a vertical wall to the west, when the drive turns to the north-west, and follows a narrow vein of ankerite. At the face the "diabase porphyrite" occurs to the west, and forms a wall dipping west at 50°. Under this wall is two inches of pug and four inches of decomposed rock, with two feet of variolite to the east. Thus these workings have not revealed any metallic minerals. They were put in to test at depth an outcrop of gossan, which occurs on the north boundary of the section. The drives have come below the gossan, but whether this gossan lives down, and represents either of those bodies cut in the workings, is not certain. In any case these bodies of gossan are quite independent of the Magnet lode, and are of no economic importance. They are situated on the west side of the "diabase porphyrite," close to the pyroxenite-porphyrite.

(20)—Section 7827m, 20 Acres.

This section is situated north of, and adjoining, the North Magnet section, and occupies part of the summit of the Magnet Range.

The "diabase porphyrite" and pyroxenite on the west of the dyke cross the south-east corner of the section, the remainder being occupied by slates, cherts, and breccias of the Dundas series.

Prospecting work has been carried out at two parts of this section, namely, near the south-east and the north-west corners respectively. Near the southern boundary, and close to the foot-track to the top of the range, an adit has been driven. This extends at a bearing of 257 degrees for 130 feet, and passes through a fine-grained, slightly porphyritic rock, representing the pyroxenite on the western side of the "diabase porphyrite." From the end a drive has been put in at a bearing of 340° for 15 feet. At the face a shallow winze, now filled with water, was sunk on a formation about 15 inches wide, and dipping westerly. Practically nothing is visible in the drive, but from specimens on the dump, the formation consisted of igneous material veined with white carbonate, resembling the ankerite of the Magnet Mine, and with which was associated galena and quartz. This apparently represents the downward extension of the gossan exposed on the south boundary. The quantity of galena obtained in these workings must have been very small, and further work does not seem to be justified.

Near the north-east corner another adit and several trenches have been put in. There is little to be seen in the trenches, and apparently nothing of importance was cut. The adit has been driven westerly for about 70 feet from a point within a few yards of the north-east corner. In the approach 18 inches of carbonate, resembling the ankerite at the Magnet Mine, was exposed. This ankerite dips west at 50°, and has a strike of 355°. It does not appear to extend to the south, but a trench has been put along its course to the north. At the northern boundary it is 30 inches wide, and carries a small amount of galena and blende. The adit was driven through the slates and breccias of the Dundas series, and bunches of chalcopyrite were obtained. None are visible in the adit at present, but specimens are obtainable from the dump. They are apparently only occasional bunches, and have no economic importance.

(21)—Section 6917m, 41 Acres.

This section is north of, and adjoining, section 7827, and occupies the summit of the Magnet Range, three-quarters of a mile north of the Magnet Mine. It is occupied mainly by the Dundas series, but Upper Mesozoic diabase is intrusive into these at the north-west corner, while they are overlain by Tertiary gravels at the north-east.

The ankerite lode at the north-east corner of section 7827, continues through this section. The trench along the lode near the corner extends a short distance into 6917, and the lode exposed consists of 30 inches of ankerite, with a little galena and blende. This dips west at 50°, and strikes north and south. Trenches driven across and along the lode have exposed it at various points for several chains to the north. It is characterised by the same features, but with an absence of galena and blende. The containing rocks are slates and breccias of the Dundas series, and the lode maintains the above strike and dip. A shallow shaft sunk to the west of the lode cut it at about 20 feet. It is stated that galena was exposed in the bottom of this shaft, but none is to be found on the dump, and the shaft being full of water, this could not be officially verified. To the north, the country is completely covered by surface soil, and nothing further can be seen.

The bulk of the lode is the ankerite, with which there was associated in the Magnet Mine only small amounts of galena. Thus the prospects here are not bright, but the conditions of deposition here may have changed slightly. If the report of galena in the bottom of the shaft be true, this portion of the lode could be easily prospected by an adit from the gully down the hill.

(22)—Section 6916m, 40 Acres.

This section is situated to the north of No. 6917 on the summit of the Magnet River. The western part is occupied by Upper Mesozoic diabase, and the remainder by the Dundas series, which are almost completely covered by Tertiary gravels and basalt. No minerals have been located on this section, but it would contain any northerly extension of the ankerite lode on No. 6917. No work is justified, however, unless the lode be proved of value on the other section where it has been opened up.

(23)—Detrital Gold and Tin Deposits.

Small quantities of gold and cassiterite have been obtained at a few localities along the flanks of the Magnet Range. The gold has been obtained in several of the small creeks, which flow into the Magnet Creek. In all of these streams water-worn pebbles and boulders occur. These could not have been formed by the action of the small creeks, and, moreover, the rock-types composing them are all strangers. The source of these pebbles and boulders has, therefore, to be explained, and it is undoubtedly the conglomerates and gravels forming the basal members of the Tertiary beds underlying the basalt capping of the Magnet Range. The gold is derived from these basal beds, and is present in the creeks as a result of the disintegration of these beds. The quantity of gold obtained has been very small, and amounts to only a few ounces obtained in Matthew's Creek by cradling. Small "colours" can be obtained at most places in these creeks by washing methods, but is not sufficient to render the operation profitable. It is also very probable that the amount of gold contained in the gravels (Tertiary), would not be sufficient to make the treatment of these beds an economic success.

About 35 years ago several sections were taken up for tin on the summit of the Magnet Range to the north-east of Magnet. Several adits are reported to have been driven in the Tertiary beds under the basalt, but cannot now be located. A series of bore-holes were also put down from the surface of the basalt to test the deposits. According to hearsay, good results were obtained, but this cannot be officially verified. It is probable, however, that tin would only be obtained in the basal gravels and conglomerates, and that it would not be present in sufficient quantity to render their exploitation profitable. Any further work in connection with detrital tin along the Magnet Range should be restricted to these basal gravels and conglomerates resting on the Dundas series.

VIII.—CONCLUSIONS.

The Waratah district must be regarded as one likely to contain valuable mineral deposits. It is composed largely of lower Palæozoic sedimentary rocks, which have been folded and faulted, and intruded on a large scale by Devonian igneous rocks. Extensive denudation during the time interval between the Devonian and probably Tertiary periods removed much of the overlying cover of sedimentary rocks, and exposed the Devonian igneous rocks. It is in such worn-down regions as these that the majority of the ore-deposits of the world are found.

The ore-deposits have been derived from solutions and vapours connected with the final phase of the Devonian granitic intrusions. This applies particularly to the silver-lead and tin deposits of the district. The osmiridium and possibly also the copper deposits are connected with the earlier basic and ultrabasic intrusions. Granite probably outcrops continuously from the Meredith Range to Wombat Hill, and it is in the country adjacent to this, as for example that covered by the present investigations, that mineral deposits have been formed.

Although the country has, generally, been fairly well prospected up to the present, and numerous lodes have been discovered, the results have, on the whole been disappointing as regards the silver-lead and copper deposits. Small quantities of ore have been obtained from most of these discoveries, but the large reserves of payable ore which go to make successful mines have not been proved to exist, and the returns from these mines have not been sufficient to compensate the outlay involved.

The Magnet Mine has proved to be the largest producer, and the only one to reach the dividend-paying stage. Work is still being carried on at this mine, and, with the present high prices for lead and silver, the immediate future of this mine should be a very successful one. There are considerable reserves of ore above the bottom level, while probable reserves of similar amount may be expected to be proved below this level.

Only two other mines are being worked at present. The Mt. Jasper Copper Mines, N.L., are testing the Mt. Wright lode, and producing small quantities of ore, but not sufficient to render operations payable.

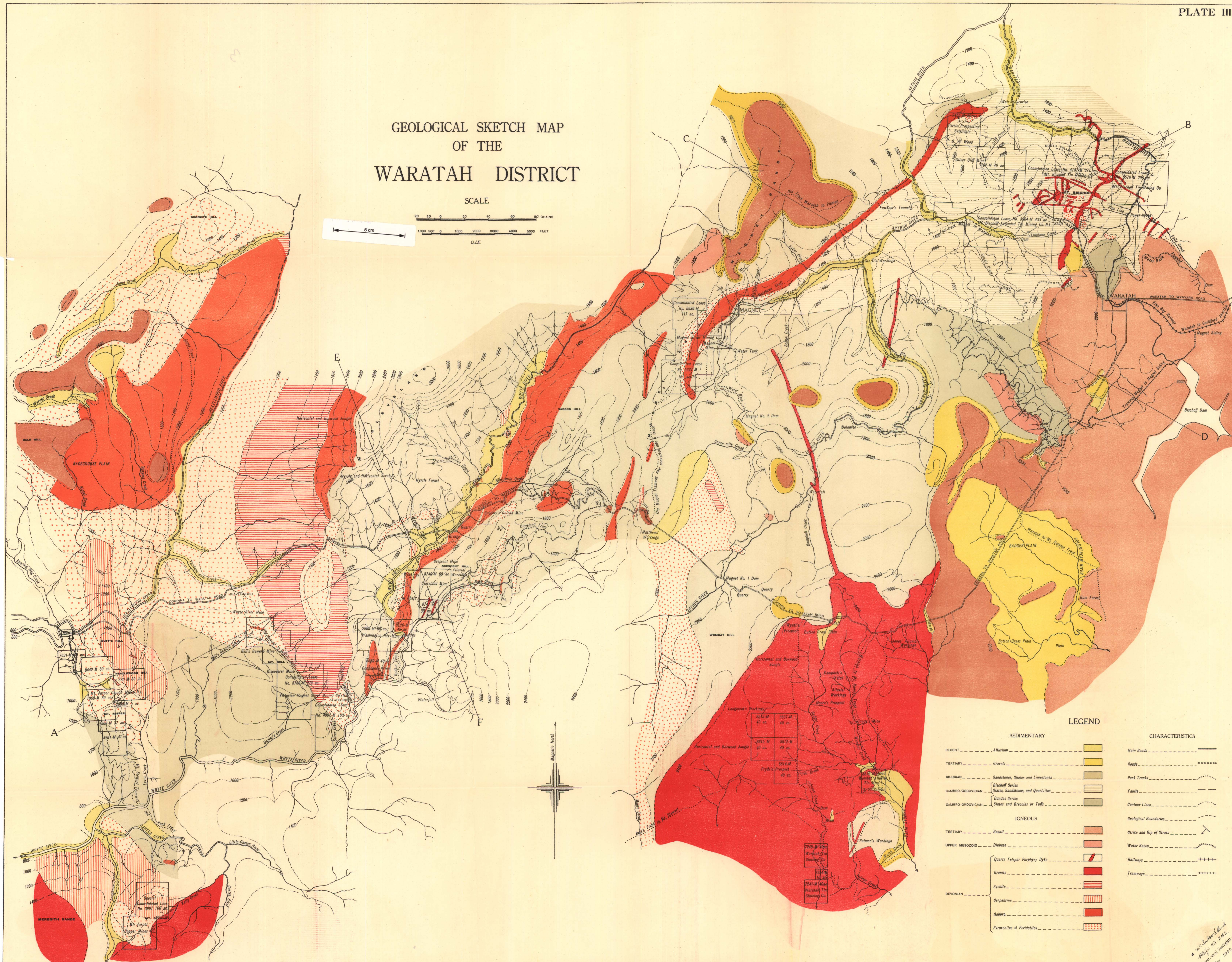
Prospecting work is still being carried out at the Godkin Mines by the (Victorian) Magnet S.M. Company, but without any success.

Although the results have been disappointing, the search for further deposits should not be discontinued. Many parts of the district are covered with thick undergrowth and jungle, so that efficient prospecting has not been possible. The basic and ultrabasic Devonian rocks appear to have been especially liable to attack by the mineralising solutions, and it is in these rocks that most of the deposits have been formed. It is recommended, therefore, that attention should be paid to these rocks in future prospecting. The areas occupied by these rocks are shown on the Geological Sketch Map, and it is in these areas that prospecting is recommended.

P. B. NYE, Government Geologist,

30th November, 1922

PLATE III



A. McIntosh Reid
P. B. Nye, M.Sc., B.M.E.
Government Geologists
May 1923

PLATE VI.

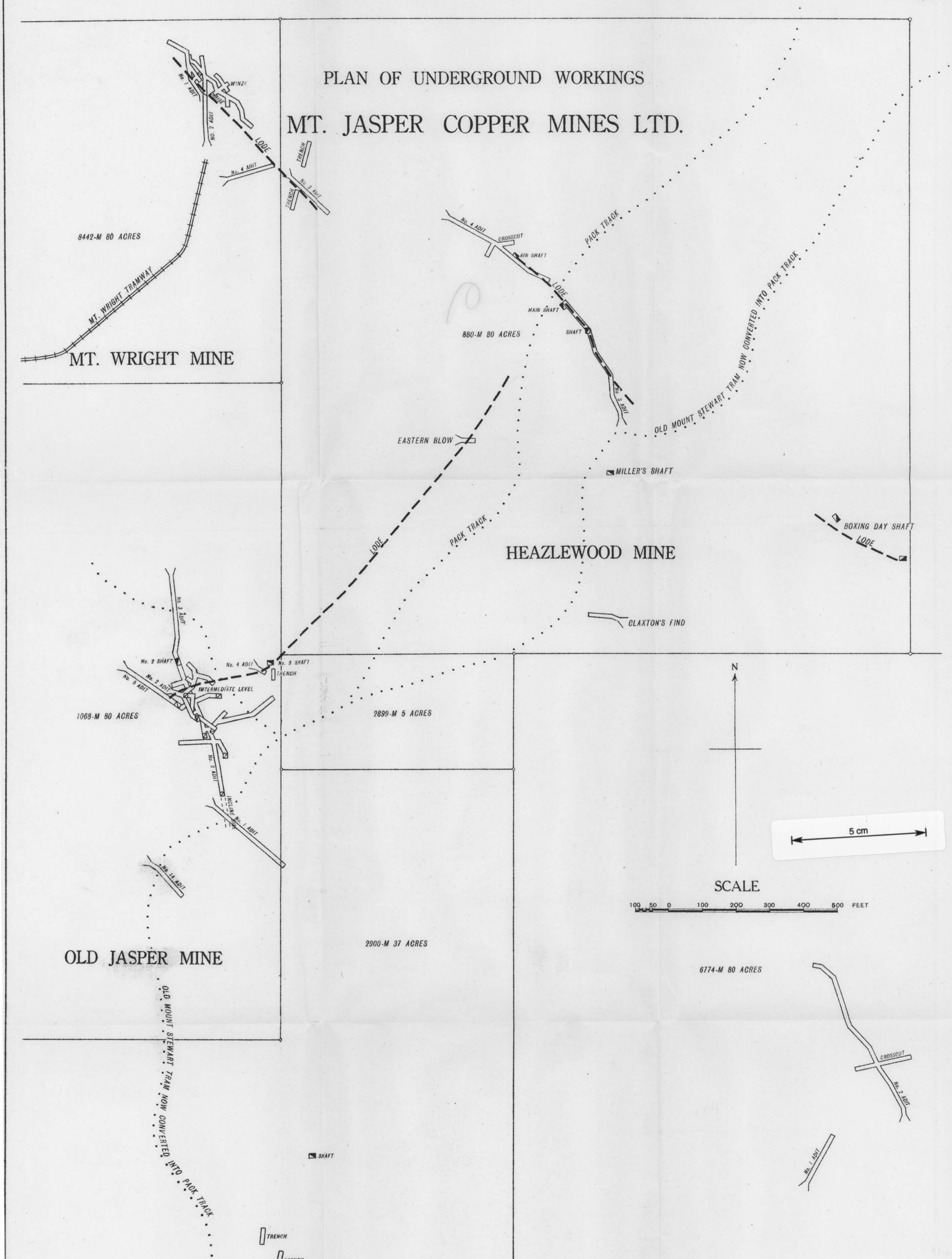


Photo Algraphed by John Vail, Government Printer Hobart Tasmania.

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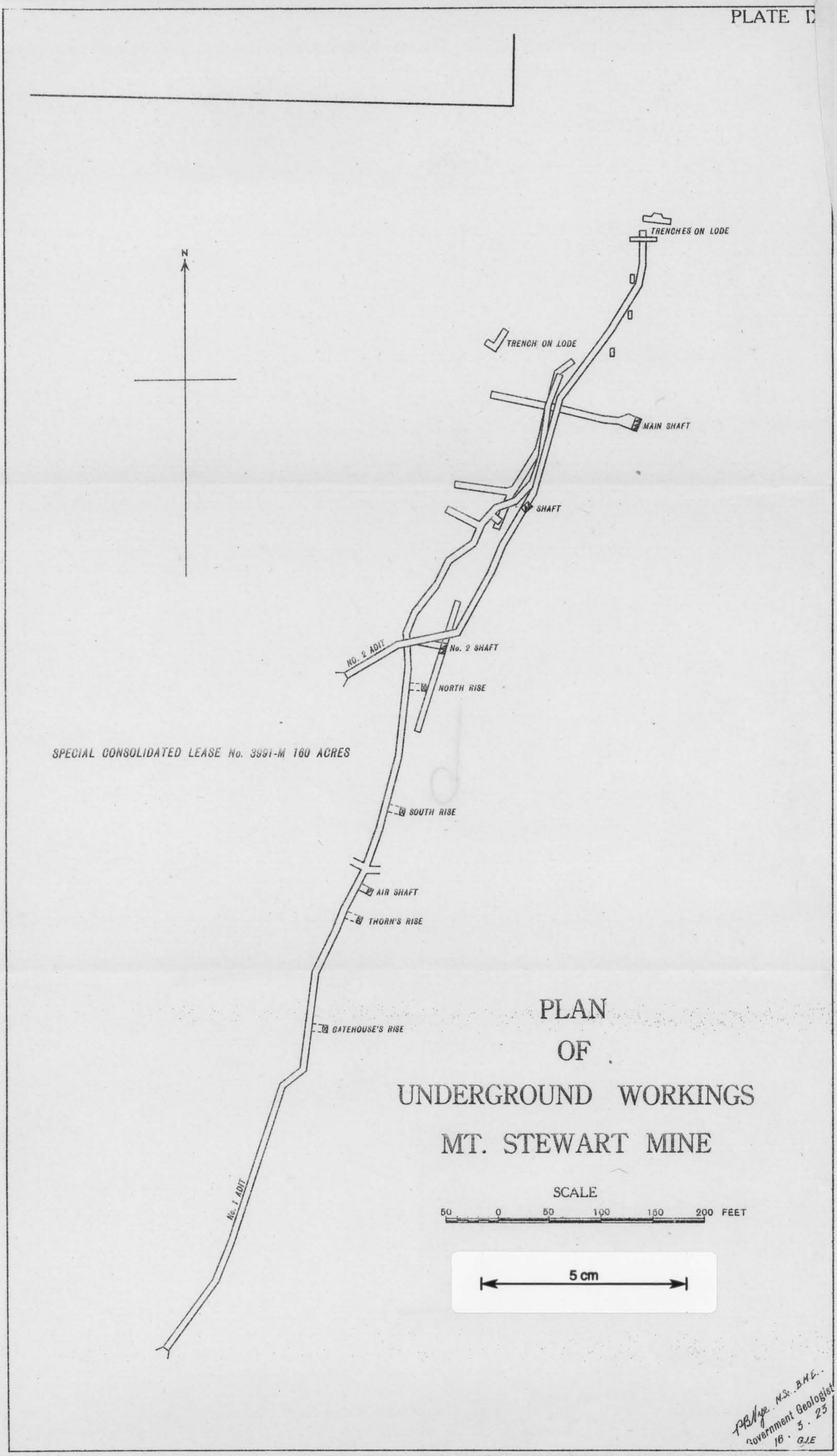

PLAN OF UNDERGROUND WORKINGS MT. STEWART MINE

SCALE

P.B. Nye. M.Sc., B.M.E.
Government Geologist
16 · 3 · 23
G.J.E

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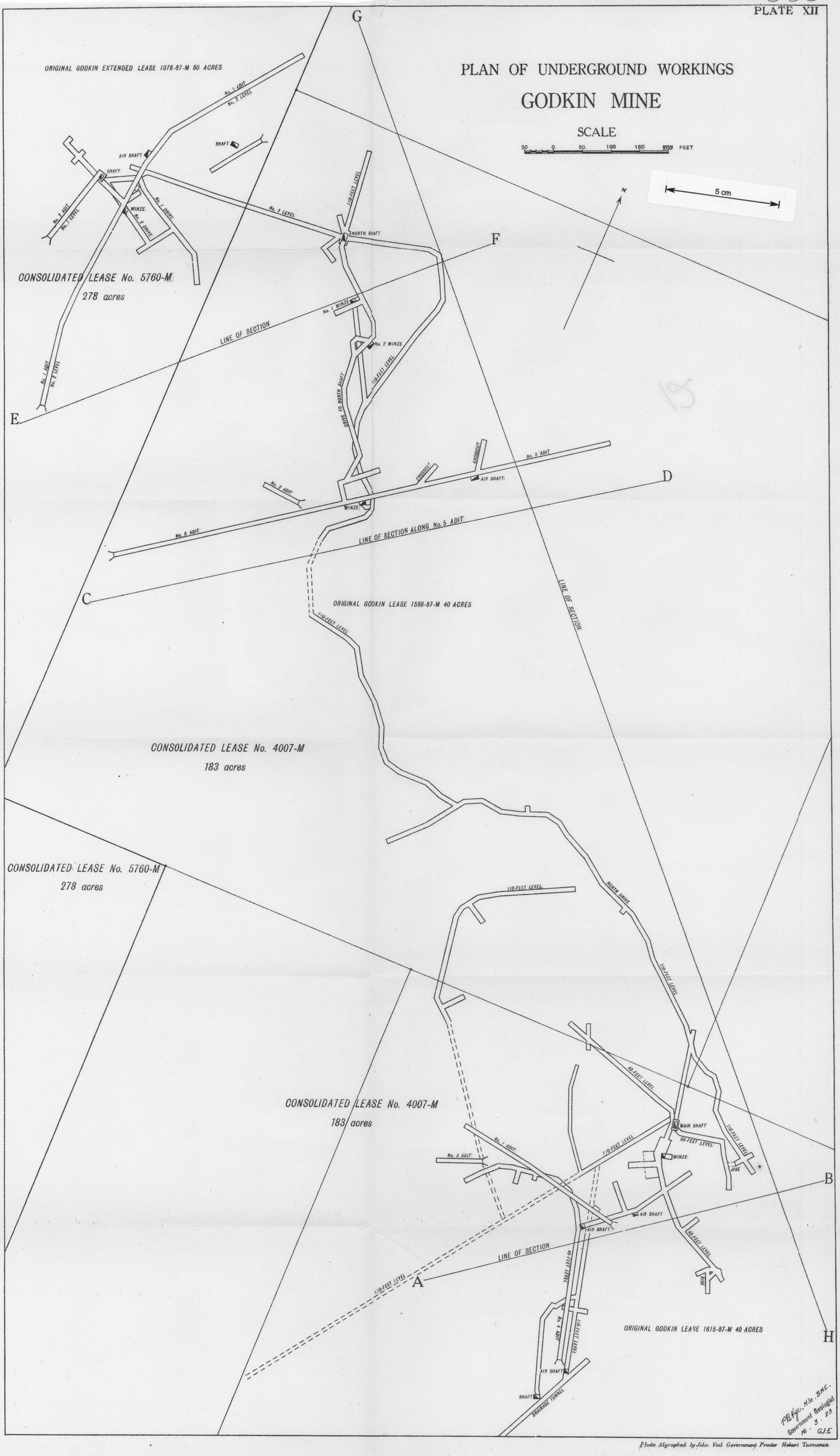
PLATE XII



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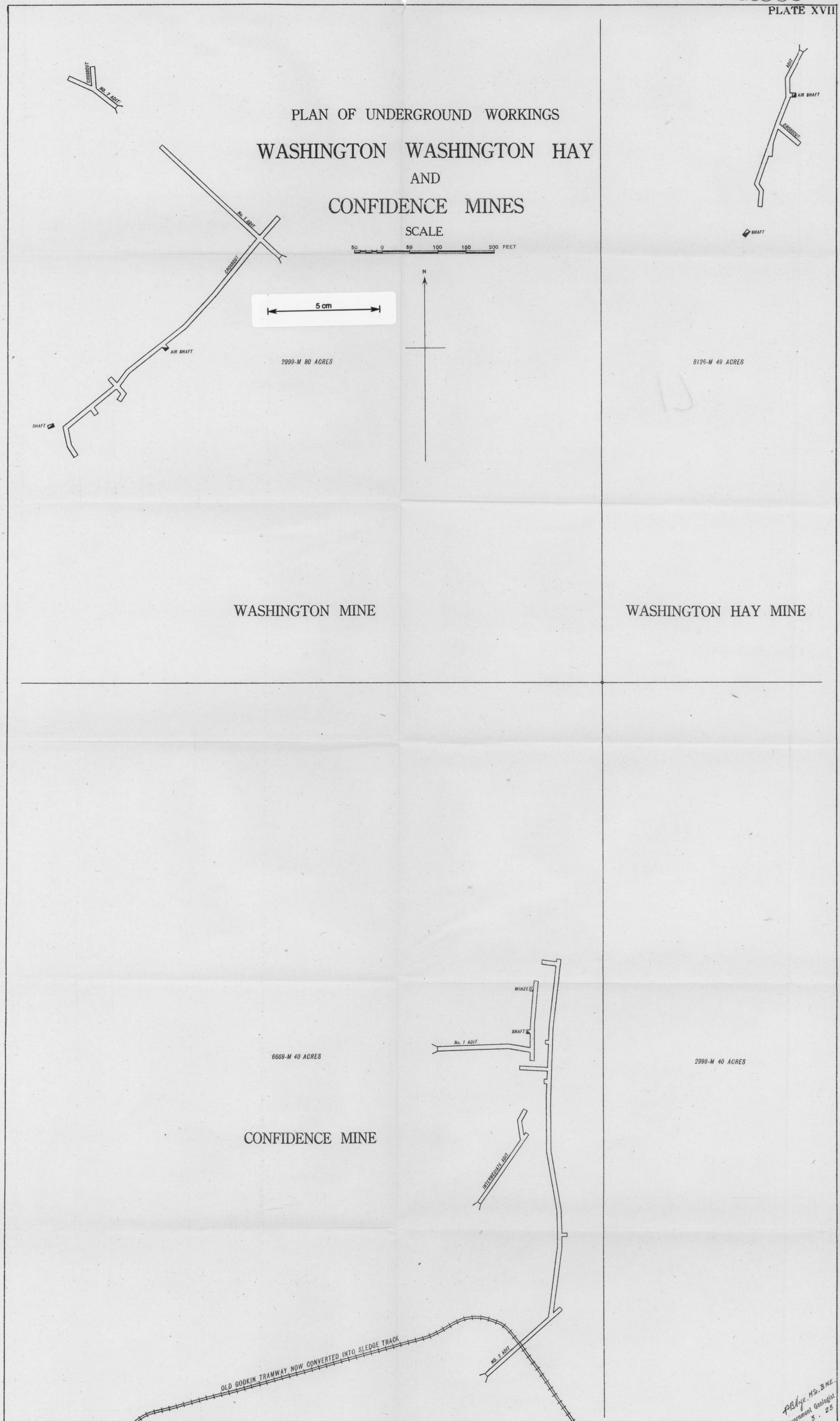


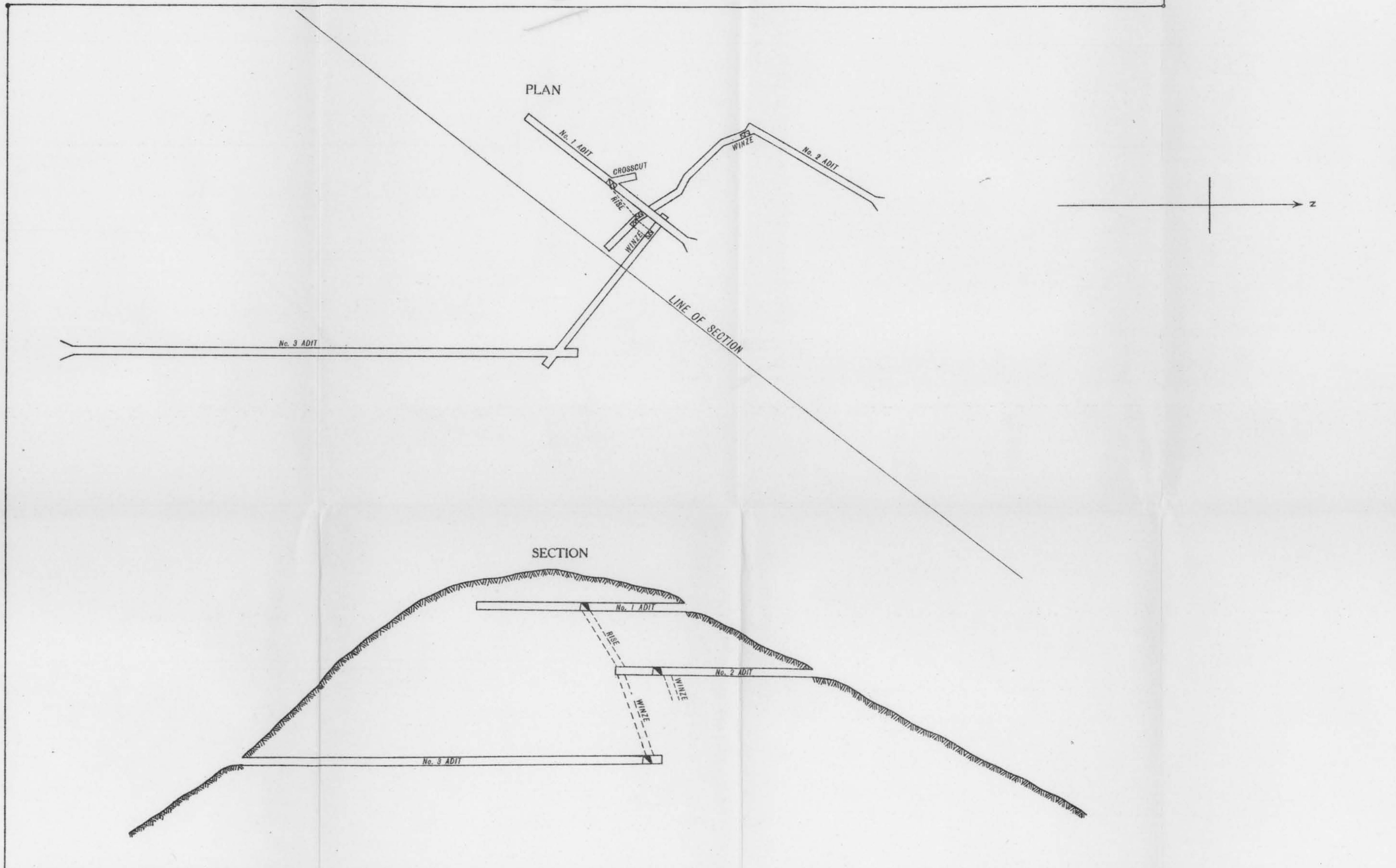
Photo Algraphed by John Vail Government Printer Hobart Tasmania.

PLATE XIX.

PLAN AND SECTION OF UNDERGROUND WORKINGS
WHYTE RIVER SILVER MINE

SCALE

50 0 50 100 150 200 FEET



P.B. Nye, M.Sc., B.M.E.
Government Geologist.
16.3.23
GJE

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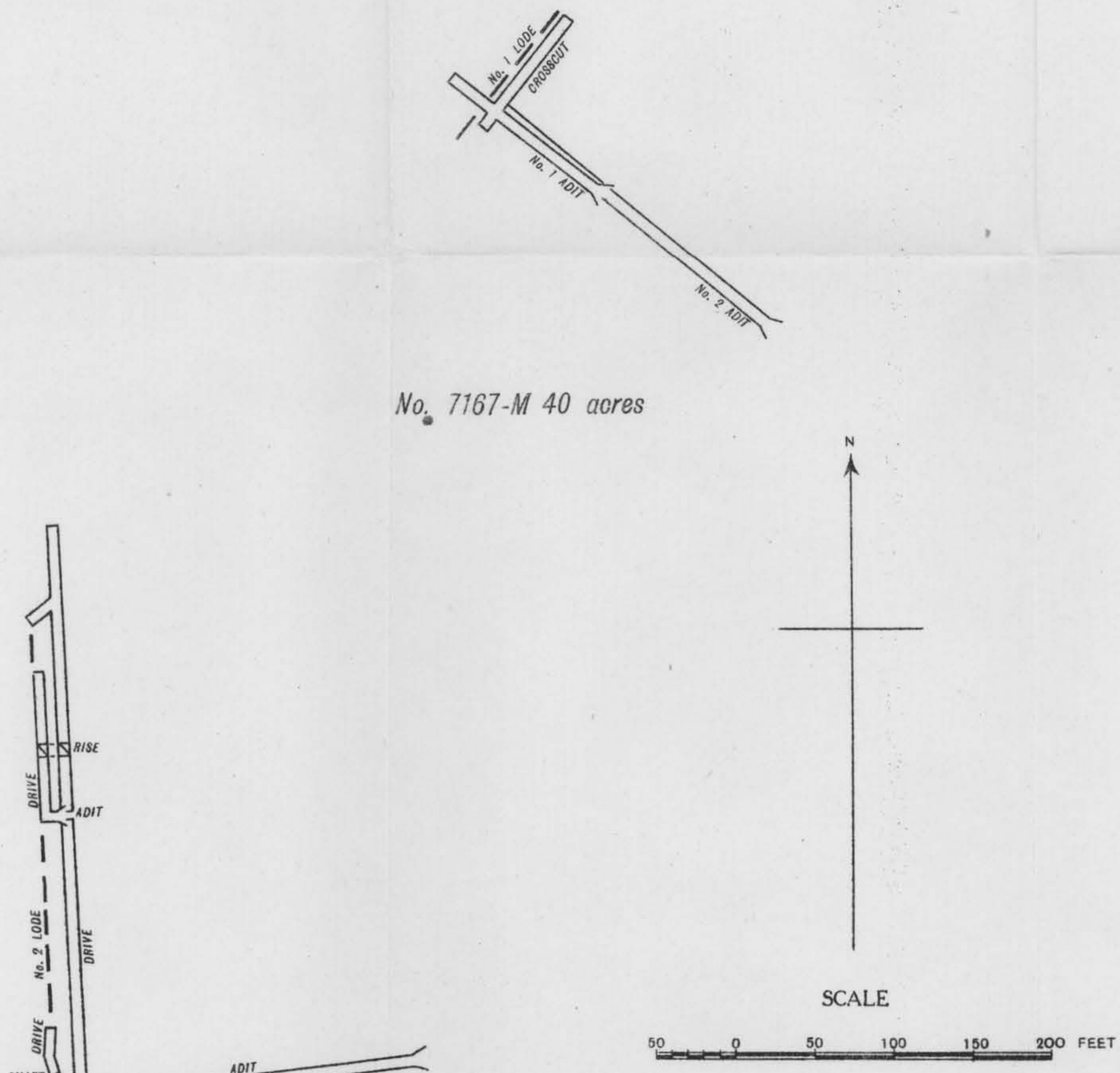
PLATE XX

PLAN
OF
UNDERGROUND WORKINGS
SILVER CLIFF MINE



R.B.Nye. M.Sc. B.M.E.
Government Geologist
16 · 3 · 25
GJE

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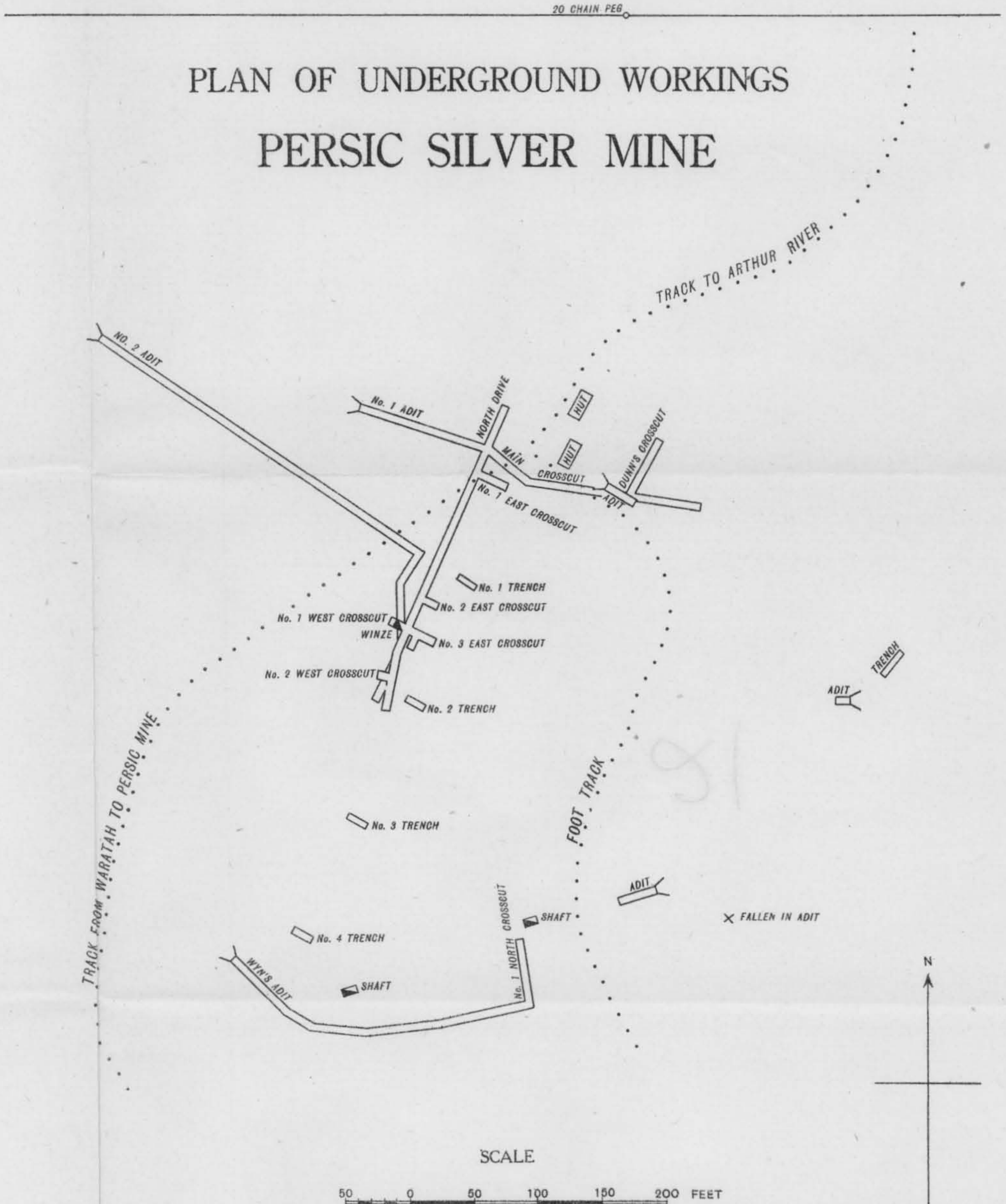
PLATE XXI

PLAN OF UNDERGROUND WORKINGS

PERSIC SILVER MINE



P. B. Nye. M.Sc. B.M.E.
Government Geologist
16 . 3 . 23
G.J.E

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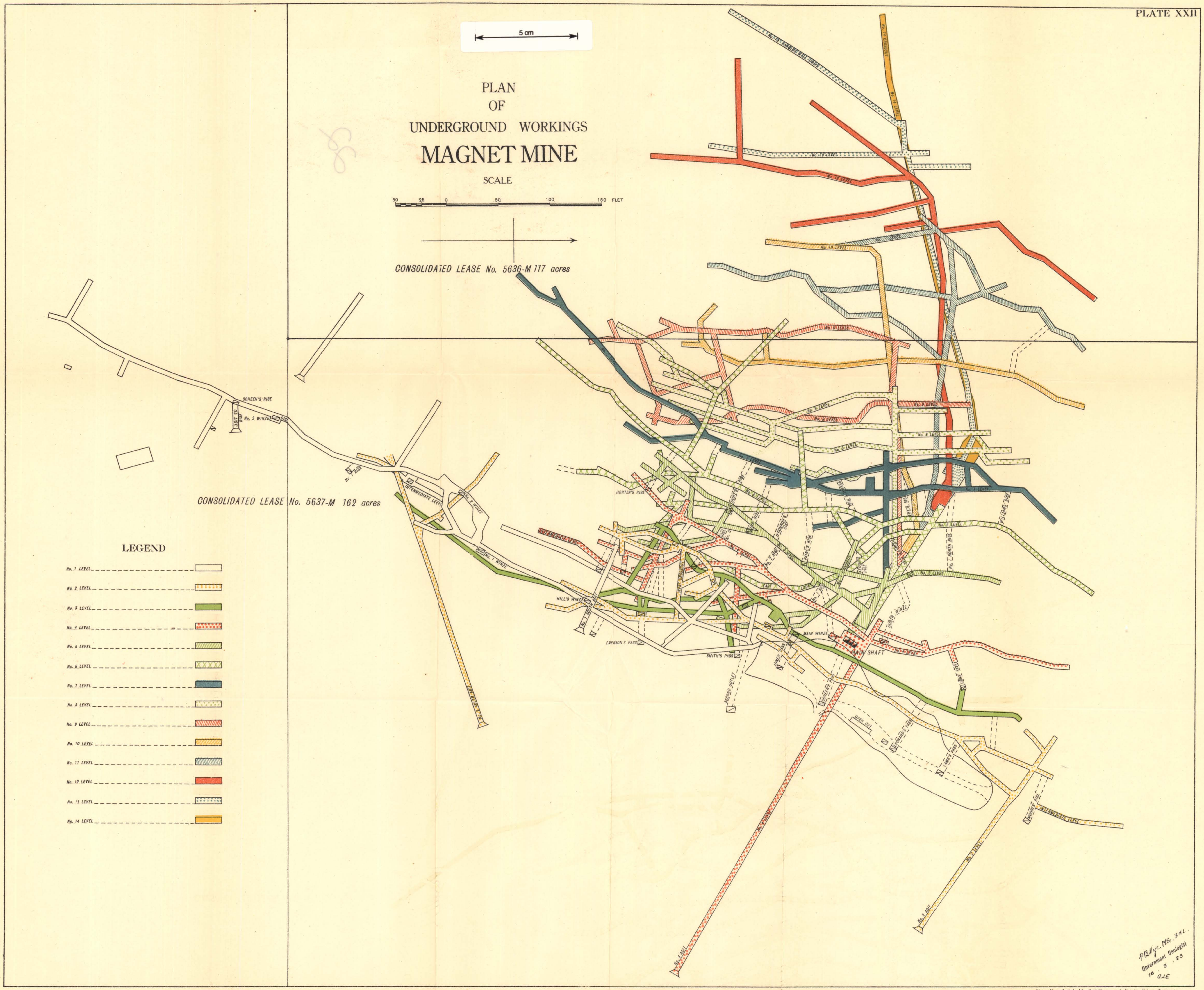


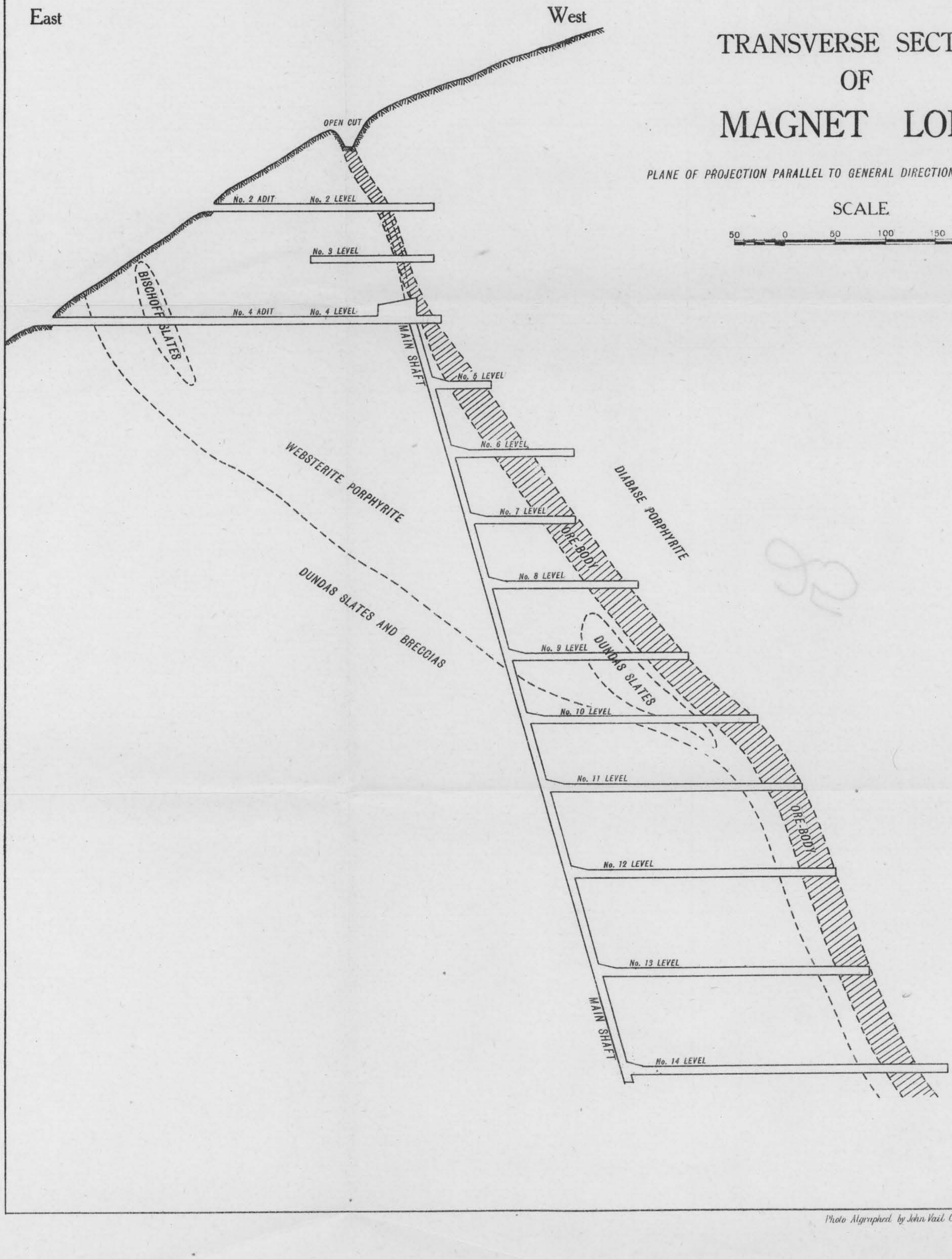
Photo Algraphed by John Vail Government Printer Hobart Tasmania.

TRANSVERSE SECTION OF MAGNET LODE

PLANE OF PROJECTION PARALLEL TO GENERAL DIRECTION OF MAIN CROSSCUTS

SCALE

50 0 50 100 150 200 FEET



W.H. Twelvetrees?

R.B. Nye. M.Sc. B.M.E.
Government Geologist
3 . 16
16 G.I.E

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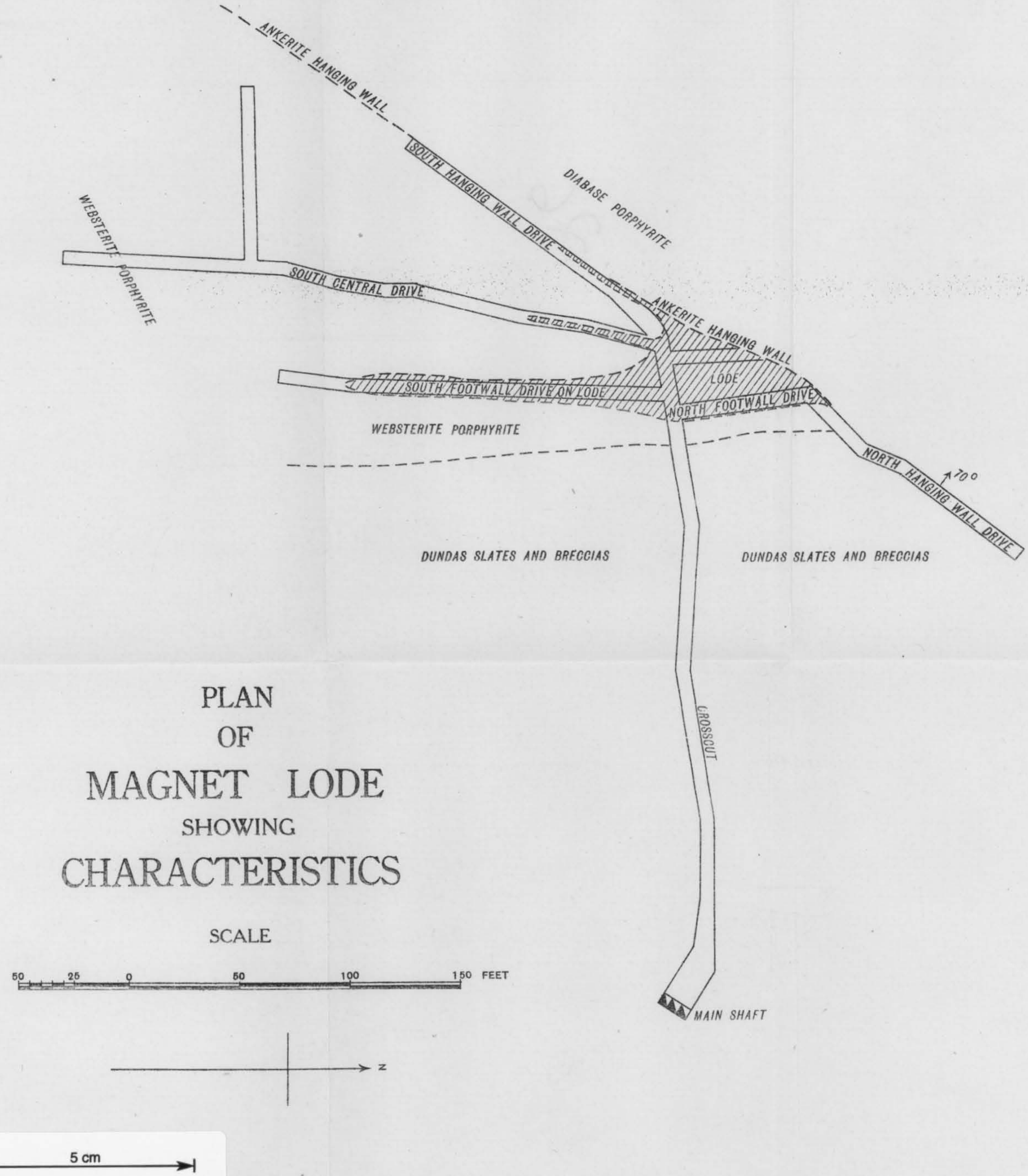

PLAN OF MAGNET LODE SHOWING CHARACTERISTICS

SCALE

5 cm

P. B. Nye. M.Sc. B.M.E.
Government Geologist
16 · 3 · 16
O.J.E

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