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DEPARTMENT OF MINES

GEOLOGICAL SURVEY BULLETIN

No. 19

The Zinc-Lead Sulphide Deposits
of the Read-Rosebery District

Part I.—MOUNT READ GROUP

BY

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Issued under the authority of
The Honourable J. E. OGDEN, Minister for Mines



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PREFACE.

THIS volume is the first of a series of publications intended to give a complete description from all points of view of the zinc-lead sulphide deposits of the Read-Rosebery District, situated on the West Coast of Tasmania.

For geological examination this belt has been cut into two portions—a southern half and a northern half. The present volume deals with the former portion.

The publications dealing with this belt will be three in number:—

The Zinc-lead Sulphide Deposits of the Read-Rosebery District, Part I. (Mount Read Group).

The Zinc-lead Sulphide Deposits of the Read-Rosebery District, Part II. (Rosebery Group).

The Zinc-lead Sulphide Deposits of the Read-Rosebery District, Part III. (Metallurgy and General Review).

This volume is Part I. Parts II. and III. will follow in due course.

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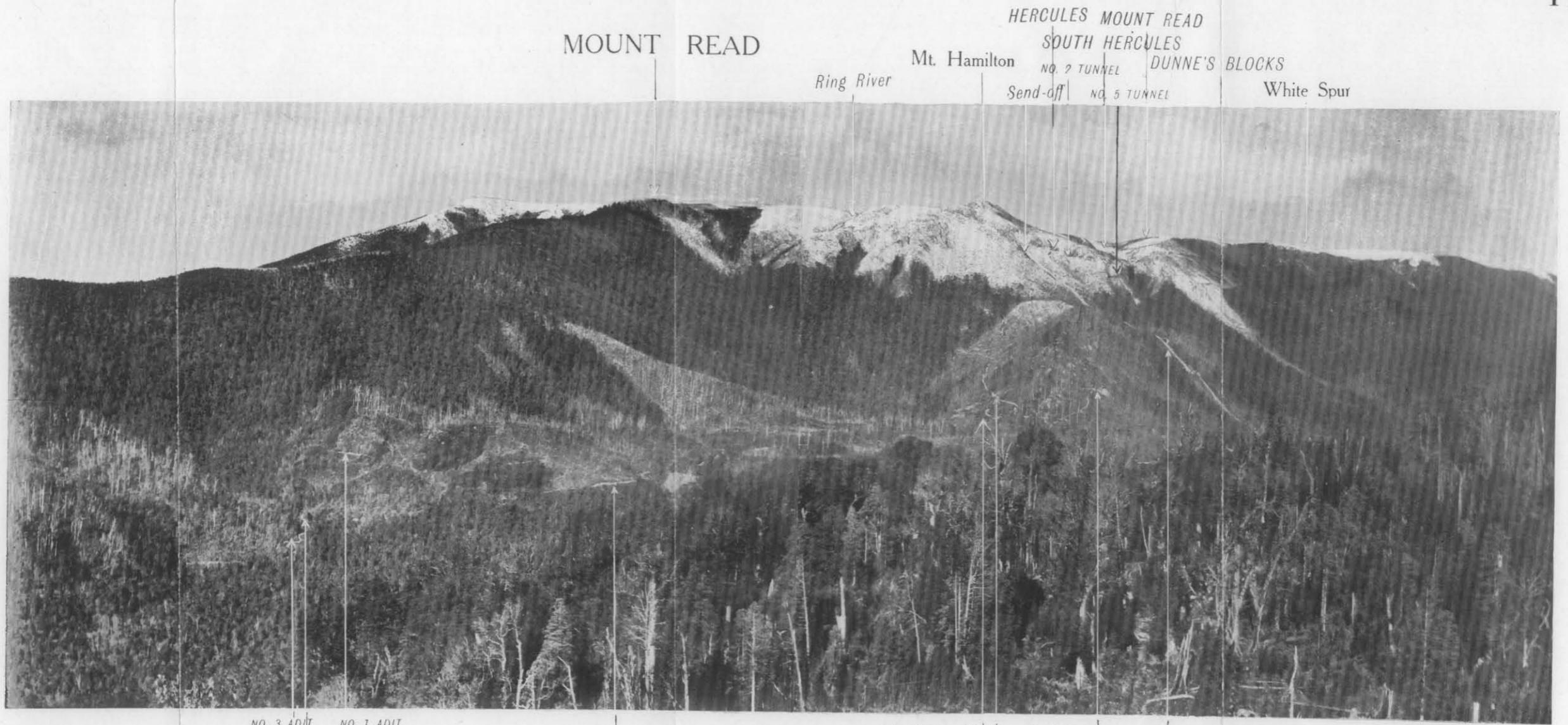
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At the end
of this report



MOUNT READ

HERCULES MOUNT READ

SOUTH HERCULES

Mt. Hamilton

DUNNE'S BLOCKS

Ring River

Send-off

NO. 5 TUNNEL

White Spur

NO. 3 ADIT NO. 1 ADIT

NO. 2 ADIT

Rosebery—Williamstown Road

Mt. Read—Williamstown Track Hercules Haulage

JUPITER

RING P. A.

BURNS' TUNNEL



GENERAL VIEW OF THE SOUTHERN HALF OF THE READ-ROSEBERY ZINC-LEAD SULPHIDE BELT.

TAKEN FROM COLEBROOK HILL, LOOKING SOUTH-EAST.

The Zinc-Lead Sulphide Deposits of the Read-Rosebery District.

Part I.

(MOUNT READ GROUP.)

I.—INTRODUCTION.

(1) GEOGRAPHICAL POSITION.

THE area dealt with in this bulletin is situated on the West Coast of Tasmania, and is approximately rectangular in shape, having as its centre the mountain mass known as Mt. Read. The dimensions of this rectangle are, roughly, 9 miles in an east-west, and 5 miles in a north-south, direction. The centre of population in the district is Williamsford, situated at the north-western foot of Mt. Read.

Mt. Read is situated to the east-north-east of Zeehan, being distant therefrom in a straight line about 10 miles. It is approximately 15 miles from the Lyell field, which lies to the south-south-east.

Access to the field is at present possible by two main routes. The first is by means of the Emu Bay Railway Company's line from the port of Burnie, which at present easily accommodates vessels of 4000 or 5000 tons, but is now being developed to take any vessel trading to the Commonwealth. Burnie is 71 miles by rail from Rosebery, whence Williamsford can be reached by means of a good macadamised road, 4 miles in length. The second route is from Zeehan, using the narrow gauge (2-foot) North-East Dundas Tramway to Williamsford. The distance along this line is 17 miles. Zeehan itself is connected with the port of Strahan by 28 miles of railway of the usual Government gauge. Strahan can accommodate vessels of about 1000 tons register, the maximum draught at the entrance to Macquarie Harbour being 13 feet.

(2) GENERAL.

The 45 square miles of country with which this bulletin deals constitute a portion of the extensive mineral belt of the West Coast of Tasmania. In this belt a great variety

of types of ore-deposits occur. In this particular portion there occur the following:—

1. The zinc-lead sulphide deposits.
2. Pyritic copper deposits.
3. Cupriferous magnetite and hematite deposits of the Red Hills.
4. Fahl-ore lodes.
5. Galena lodes.
6. Nickeliferous pyrrhotite deposits.
7. Tin deposits of North-East Dundas.

It was decided to make a special study of the first two types of ore-deposits, viz.:—The zinc-lead sulphide and pyritic copper deposits, leaving the investigation of the fahl-ore lodes, the galena lodes, and the nickeliferous pyrrhotite deposits for a subsequent journey. The tin deposits will be studied by another officer of the Survey in the near future. The magnetite and hematite deposits of the Red Hills were examined only sufficiently to show that they are in every way similar to those occurring in the Jukes-Darwin field, which the writer has described in detail in Geological Survey Bulletin No. 16, and to which the reader is referred for all information in this connection. They will receive no further mention in this bulletin, as no work has been done on them since 1900, when Mr. Twelvetrees reported on them.⁽¹⁾

The general geology, however, of the whole area has been studied in order to supply a fundamental basis for the investigation of the genesis of the zinc-lead sulphide ore-bodies, the systematic study of which was the special object aimed at.

These zinc-lead sulphide deposits have been proved by mine workings to occur at intervals over a total length of 7 miles. This stretch of country has been termed the "Zinc-lead Sulphide Belt," and extends from Mt. Read, on the south, to Mt Black, on the north. Exactly 3 out of the 7 miles of this belt are included in the area dealt with in this bulletin.

It was deemed to be too gigantic a task to undertake the investigation of the whole of this zinc-lead sulphide belt in one field journey. Accordingly, it was decided to first deal with the southern portion, extending from the Dunne's Blocks Mine, on the south, to the Jupiter, in the north, leaving the study of the northern portion, which

(1) See "Report on the Mineral Deposits of Zeehan and Neighbourhood," 1900.

will immediately succeed the completion of this bulletin. That journey will be conducted on exactly the same lines as the present one.

Immediately on the completion of the field work the writer submitted a preliminary statement of the results of the investigation, which has since been published as Report No. 3 of the Geological Survey, entitled "Preliminary Report on the Zinc-lead Sulphide Deposits of Mt. Read." In that report it was stated that the results had been greater than was at first anticipated, and those results were indicated in a brief but necessarily incomplete manner. It is the intention in this bulletin to state and explain the matters fully and completely, and to further elaborate the matters briefly mentioned in that preliminary statement. In addition, the general geology and physiography will be described, but these will only be very concisely dealt with, and will not occupy much space.

In short, therefore, this bulletin will contain as its speciality the description of the zinc-lead sulphide ore-bodies, their characteristics both in structure and composition, their origin and life-history. Following upon this will be discussed the behaviour of the ore-bodies throughout the 3 miles of the belt here considered; and, in addition, the influence of depth on the composition of the ore-bodies will be fully gone into. Succeeding the deductions as to the general behaviour of the ore-bodies will be given the details of a diamond-drilling scheme for the thorough exploitation of the zinc-lead sulphide deposits designed to finally establish the reliability of the predictions which will be clearly set forth, and which will be based on the deductions as to the mode of origin of the ore-bodies.

(3) ACKNOWLEDGMENTS.

In making an investigation of this character, a geologist depends for much statistical information on the mine managers and others resident on the field. The writer wishes here to acknowledge the assistance given in this way by most of those of whom such information was asked. That this cannot be applied to all of those with whom he came in contact, the writer much regrets, but as a protest against extreme secretiveness concerning facts the know-
of which would obviously be of benefit to the field, he must state that such information was in one case withheld. Apart from the general unwisdom of such action, the futility of it is exemplified by the fact that other success-

ful measures were employed of acquiring the desired information.

The writer wishes to especially acknowledge the information and general facilities freely given by Mr. C. H. Moxon, Mine Manager of the Hercules. In addition, acknowledgment of assistance of varying kinds must be made to the following:—Mr. Frank Rowley, Manager Metals Extraction Company, Rosebery; Mr. George Barker, Manager Tasmanian Copper Company; Mr. A. Worsley, of the Jupiter Mine; Mr. F. Dingle, Mine Foreman of the Hercules; Mr. J. Moyle; Hon. Stafford Bird, agent in Tasmania for the Mt. Read Mining Company; Mr. J. Will, the original discoverer of the Hercules Mine, who gave valuable information concerning the early history of the mine; and Mr. Luke Williams, who communicated the early history of the Mt. Read Mine.

The photograph of the southern half of the zinc-lead sulphide belt produced in this publication was taken by Mr. Frank Rowley, and the writer desires to record his appreciation of the assistance thus rendered.

II.—PREVIOUS LITERATURE.

The first mention of these deposits is contained in a report by A. Montgomery, then Government Geologist, entitled "A Report on the Progress of the Mineral Fields of the County of Montagu," and dated 11th April, 1893. In that report the discovery of sulphide deposits carrying iron, copper, zinc, and lead, beneath the gossan carrying gold at the Mt. Read Company's lease, is discussed. No work had been done on them at that time.

In his report entitled "Report on the Progress of the Mineral Fields in the Neighbourhood of Zeehan," dated 15th May, 1895, A. Montgomery describes the work done on the Mt. Read, Hercules, and Barlen Hercules Mines, and arrives at the conclusion that the ore-bodies are separate lenses of ore striking west of north and dipping to the east at a steep angle.

The next report dealing with this district is that by Harcourt Smith, B.A., Government Geologist. This is entitled "Report on the Mineral Fields in the Neighbourhood of Mt. Black, Ringville, Mt. Read, and Lake Dora," and is dated at the Government Geologist's Office, Launceston, 10th June, 1898. Therein are described the Mt. Read, Hercules, South Hercules, Barlen Hercules, North Hercules, Ring River, Ring Hercules, South Jupiter, Jupiter, and North Jupiter Mines. This observer also deduces that the ore-bodies are lenticular masses dipping to the eastwards in conformity with the fracture planes of the schists.

In 1900 Mr. W. H. Twelvetrees visited the field, and his report is dated 27th October, 1900, and is entitled "Report on the Mineral Deposits of Zeehan and Neighbourhood." He describes the Hercules, East Hercules, Mt. Read, and Dunne's Mt. Read Mines. His conclusions were that the ore-bodies consisted of lenses of sulphides placed *en echelon* in the fractures of the schists, and the opinion was further expressed that "the zinc-lead sulphide will generally be replaced at lower levels by copper ores," this deduction being based on the pyritic copper deposit cut in No. 5 tunnel on the Hercules, vertically below the zinc-lead deposits in the upper levels.

In 1902 Mr. G. A. Waller, then Assistant Government Geologist, examined the field, and his "Report of the Ore Deposits (other than those of

Tin) of North Dundas," deals, *inter alia*, with the zinc-lead sulphide and pyritic copper deposits. This was the latest official report on the field at the time of the undertaking of the present investigation. After discussing the genesis of the zinc-lead sulphides Mr. Waller arrives at the conclusion that they are the result of secondary enrichment of the pyritic copper deposits into which they will change as depth is gained. In the case of the Hercules the change from zinc-lead to copper he gives as taking place between Nos. 4 and 5 levels.

Numerous unofficial reports by men of repute have been written, of which that by Mr. G. H. Blakemore is the most recent and noteworthy. This report is dated 21st January, 1913, and, *inter alia*, contains the assertion that the zinc-lead sulphides are the result of secondary enrichment.

The previous investigators of the field have invariably accepted the fact that the schists consisted of beds or bands exactly conforming in dip and strike with the planes of schistosity. In addition to all these reports the zinc-lead deposits have been the subject of innumerable small articles dealing with their many aspects, and there has been much discussion concerning them in the papers and periodicals.

III.—PHYSIOGRAPHY.

(1) TOPOGRAPHY.

The area is essentially one of high relief, this being the result of the erosion of a period of denudation still in its youth. The mountain mass of Mt. Read rises to a height of 3660 feet above sea-level. From the summit of this mountain the country slopes steeply downwards in all directions. A spur runs westerly with a rather gradual slope towards a subsidiary peak known as Mt. Hamilton, on the western slope of which is the Hercules Mine.

The slope eastwards goes down to the saddle connecting Mt. Read with Mt. Murchison and the Red Hills. This saddle forms the watershed dividing the Henty drainage system from that of the Pieman.

Mt. Murchison rises steeply from this saddle and attains at its south-western extremity an elevation of 3770 feet.

Williamsford lies at the north-western foot of Mt. Read, and is approximately 1100 feet above sea-level.

No more need be said concerning the general topographical features, as the general geological map of the area (Plate III.) gives also the approximate topography. In addition, the photograph (Plate II.) of the portion of the area in which the zinc-lead sulphides occur, gives an accurate idea of the topographical features in that vicinity.

(2) THE RELATION OF TOPOGRAPHY TO MINING.

(a) Prospecting and Exploitation.

The facilities for prospecting and mining resulting from the topographical features vary in different parts of the field. Generally it may be stated that the higher portions of the zinc-lead sulphide belt offer far greater facilities than the portion at Williamsford and to the north thereof.

As regards the mining properties situated on the more elevated portion, it may be stated that the facilities are in most cases practically ideal for exploitation by means of adit driving. This is especially so in the case of the Hercules Mine. It will, in the writer's opinion, serve no useful purpose to take each property as a separate entity and discuss facilities on each which the topography affords for mining operations. As will be pointed out and fully emphasised in Part III. of this series of publications, the only procedure which would enable the field to be success-

fully worked is by an amalgamation of all interests. The ore-bearing belt must then be worked as a co-ordinated whole. If treated as such, the whole of the ore-bearing zone, extending from the Mt. Read Mine down to Williamsford (a total vertical range of 1500 feet), can be exploited by adit-levels under practically ideal conditions. The country extending northwards from Williamsford to the Jupiter is not so favourably situated, and although the upper portion of the ore-bearing zone in this portion of the belt can be penetrated by adits, the major part must ultimately be worked by shaft-sinking, after the exploration by diamond-drilling has been completed.

One important fact in regard to the relation of topography must be mentioned here. In the portion of the field where the biggest Beta fold plunges the ore-bearing horizon downwards, the surface likewise plunges downwards in the same direction. This topographical feature is not due to the direct effect of the geological structure, but is a coincidence. The result, however, is economically important, as the ore-bearing horizon is thus kept not very far beneath the surface.

(b) Transportation.

The extremely rugged nature of the country, combined with the denseness of the scrub, have greatly hindered the development of the field in the past. At present, however, it cannot be said that the rough topography is in any way hindering progress or is even likely to. The initial difficulties have all been overcome, and the position of the transportation problem is well known and can be successfully handled when occasion requires it.

The Hercules, Mt. Read, South Hercules, and Dunne's Block Mines are approximately 1700 feet above Williamsford. Transportation in connection with all these can be effected by means of the Hercules Self-acting Tramway, which, starting from the terminus of the North-East Dundas Tramway at Williamsford, rises a total height of 1642 feet in a length of 1 mile. If boring operations prove ore to exist between the Ring P.A. Mine and that already proved on the Hercules, as will be subsequently discussed, then it will be a question for the future to determine the location of the workings, but if they are so situated as to present difficulties in connection with the haulage, the erection of aerial ropeways will provide a simple solution. In fact, the whole of the country above Williamsford is particularly adapted for the erection and working of such ropeways.

There need be no hesitation, therefore, on the score of transportation difficulties when considering the scheme for the proper working of the field.

As regards the portion of the belt from the Ring P.A. to the Jupiter, there will be no difficulties presented in dealing with the question of transportation.

With very little trouble a railway could be constructed from Williamsford to pass along this belt and connect with Rosebery. Such a line has already been surveyed. The country, though somewhat broken, is by no means difficult for railway construction.

As indicated previously in this bulletin, Williamsford is connected with Zeehan by means of a light tramway, and Rosebery is connected by rail with the deep-water port of Burnie.

(3) RAINFALL AND WATER-SUPPLY.

Mt. Read is accepted as being the wettest inhabited spot in Tasmania. The average annual rainfall is, roughly, 144 inches, or 12 feet. The height of the recording station is 2867 feet above sea-level. The following tables will give the requisite information concerning the amount and distribution of this rainfall at Mt. Read:—

Table I.—Annual Rainfall in Inches.

Year.	Inches.	Year.	Inches.
1906	144·04	1910	112·91
1907	123·20	1911	130·09
1908	114·50	1912	147·71
1909	116·18	1913	150·60
Average for 8 years		...	129·90

Table II.—Annual Distribution of Rainfall in Inches.

Month.	Average over 6 Years.	Month.	Average over 6 Years.
	Inches.		Inches.
January	5·59	February	5·97
March	10·77	April	10·77
May	11·12	June	11·83
July	9·95	August	10·55
September	9·68	October	9·67
November	8·23	December	10·10

The rainfall at Williamsford is less than this, and in fact the precipitation varies in accordance with the height above sea-level. No data are available as to the rainfall at Williamsford.

The photograph shown as a frontispiece in this bulletin was taken immediately after a snowstorm. The actual fall at Mt. Read was several feet, but at Williamsford was not more than a few inches (3 or 4). This snow does not lie for any length of time, as the first succeeding north-westerly rain thaws the whole of it.

The high relief of the topography soon brings about a quick return of this rainfall to the sea. Such circulation is characteristic of the whole West Coast, so that in spite of the heavy annual rainfall a few weeks' fine weather results in a great diminution of the amount of water flowing in the streams. In all schemes for the utilisation of the heavy rainfall on the West Coast, therefore, the prime factor is storage capacity.

In regard to the supply of water for general purposes in mining and metallurgical operations, it may be accepted that there is more than sufficient available.

In connection with the consideration as to the generation of the power required for the large scale mining and metallurgical operations indicated subsequently in Part III. of this series of publications, it may be at once stated that only in one portion of the area examined is it possible to obtain the requisite amount of storage and fall. This is in the neighbourhood of Lake Rolleston, in the southern portion of the area which has been examined by Mr. Hartwell Conder, M.A., A.R.S.M., State Mining Engineer, with the object of determining its potentialities as a source of power.

IV.—GENERAL GEOLOGY.

(1) THE ROCK TYPES REPRESENTED ON THE FIELD AND THEIR MODE OF OCCURRENCE.

(a) *The Pre-Cambrian Quartzites.*

These are oldest rocks developed in the district. They occur to the east of the Anthony River, forming bare white hills. They consist mainly of white quartzites and quartz-mica schists, much crumpled and folded. Their general characteristics and structural features are similar to those of occurrences in other parts of the island described at some length in previous publications of the Geological Survey.⁽²⁾ For the purposes of this report there is no need to further describe them.

(b) *The Dundas Slates and Breccias.*

This series occupies the whole of the eastern portion of the area mapped. They consist of a succession of beds of various coloured slates (of which the purple variety is the predominant type), more massive sediments approaching quartzites, and an extensive development of altered pyroclastic deposits, of which the Dundas breccia is the most prominent. The series is, in fact, a continuation of that described by Mr. L. K. Ward in the North Dundas Tinfeld. The reader is referred to Geological Survey Bulletin No. 6 for a complete description of this series. Their structural features will be given under the heading of the "Read-Rosebery Schists," as the two series are conformable, and tectonic or structural relations, to be hereinafter described, are the same for both.

The boundary-line between them is not a hard and fast one, but it is sufficient to allow of the demarcation given in the accompanying geological map.

(c) *The Read-Rosebery Schists and Felsites.*

These are the most important rock types in this district, and will be described at some length, as certain of

⁽²⁾ Reports of Secretary for Lands and Surveys, 1907-8 and 1908-9. Geological Survey of Tasmania, Bulletin No. 3, p. 31 *et seq.*; No. 11, p. 13 *et seq.*; No. 13, p. 63; No. 14, p. 12; No. 15, p. 34 *et seq.*; and No. 18.

them are the repositories of the zinc-lead sulphide and pyritic copper deposits. The correct interpretation of their tectonic relations, their origin, and life-history is essential to the thorough understanding of the genesis of the ore-deposits. They occur continuously from Mt. Read to Mt. Black (Rosebery), and to indicate this extensive occurrence it is proposed to designate them by the appellation "Read-Rosebery." For convenience of presentment their description will be divided into two parts, the first of which will include a concise delineation of their general character, with just sufficient petrographic detail to enable a decision to be arrived at as to their mode of origin, while the second will consist of a somewhat more detailed presentment of the structural or tectonic features.

General Character.—In general there are two varieties of rock types in the group we are now considering. They are the hard, dense, and massive felsitic rocks, and the schists proper.

The felsites occur at the surface on the western slope of Mt. Hamilton, and continue eastwards, with repeated intercalation of chloritic schists, to the Red Hills. They outcrop at the surface south of the Mt. Read open-cuts, and thence are continuous with the variety occurring on the White Spur. They extend northwards from Mt. Hamilton to the northern boundary of the area examined. They are indicated in the geological map (Plate III.) accompanying this bulletin. The boundary-line separating them from the schists is indefinable, there being generally a gradual transition through chloritic schists to the argillaceous and other schists. They are hard, dense, flint-like rocks, generally reddish in colour, but often are discoloured green by the development of chlorite. They are similar in every way to the felsites on the Jukes-Darwin field, the bulletin on which gives full petrographic details. The particular occurrences in the Mt. Read district have been fully described by Messrs. W. H. Twelvetrees and W. F. Petterd in a paper read before the Royal Society of Tasmania, (3) and there is no need to recapitulate here. Suffice it to say, that after a study of their petrographic character and field relationships, the following conclusion is expressed:—

"The zone of felsites seems to mark the upturned edges of sheets of lava roughly parallel with the axis of the pre-

(3) See "Proceedings Royal Society, Tasmania," 1898-9: "The Felsites and Associated Rocks of Mt. Read and Vicinity."

sent West Coast Range. These lavas were probably geologically contemporaneous with the argillaceous sediments now converted into schists, and with them were folded, crumpled, and rolled out into the schistose, banded conditions in which we now find all the rocks of this belt of country."

This opinion is confirmed by Professor H. Rosenbusch, the eminent petrologist.

They further remark that some of these felsites are characterised by predominant soda felspars, and are therefore keratophyres.

In view of this it is only necessary now to add that the present investigation has completely confirmed this conception as to the derivation of these more or less schistose felsites from original lava flows.

The schists proper vary widely in character and composition. They may be briefly described as chloritic, argillaceous, calcareous, and quartzitic or siliceous. They range from rocks showing typical schistose structure to rocks possessing no fissile tendency whatever. As a matter of fact, the proportion which could be designated as truly schistose is small, and the greater portion should rather be called quasi-schists, or at best argillites. Some of the schistose appearance has been brought about by the effect of the ore-bearing solutions on the argillites, thus resulting in a purely local development of a talcose, or, more correctly, sericitic schist, although this latter character is developed in the original schists at certain localities.

The green chloritic schists vary in composition from a soft fissile rock containing a large percentage of chlorite to more or less fissile quartz-schists stained in patches with the chlorite. They occur for the most part in close relation to the felsites and keratophyres, either enclosed between the different beds of the latter, as at the East Hercules, Moxon P.A., &c., or to the west of them, separating them, in fact, from the argillaceous and calcareous schists. They also occur to the west of the calcite, argillaceous, and quartz schists, separating the Read-Rosebery schists from the Dundas slates and breccias; in this locality they are generally characterised by predominant quartz and subsidiary chlorite.

The most important members of the series, however, are the argillaceous, calcareous, and quartzitic schists. These vary widely in character and composition from a typical argillaceous rock through calcareous, or more correctly calcitic, schists, by increase in the lime contents, to practically pure limestone or calc schists. Similarly, there

is a gradation from the calcite schists by increase in the quartz contents to true quartz-schists with subsidiary calcite. The structure varies, in accordance with the composition of the rock, from highly fissile schists to massive, apparently homogeneous, rocks. The former structure is well exemplified by the portion of the series along the No. 4 Tram, Hercules, from the Send-off to the No. 2 Tunnel; the massive variety is well illustrated by the so-called "intrusion" forming the "lump" between Nos. 3 and 4 levels, Hercules, in the "E" ore-body.

Microscopic examination of the several varieties proves that they have all been subjected to an intense crushing and metamorphic action, as a result of which a reconstitution of the component constituents has been effected, rendering the original structure practically unrecognisable. What evidence is available, however, points to a derivation from sediments either argillaceous, siliceous, or calcareous in character, or pyroclastic accumulations.

There is one important feature, however, which points unerringly to their mode of origin. This is the occurrence of a distinct banded structure in certain of them which crosses the fissile cleavage at various angles. This can be well seen on the Hercules Company's lease near the old No. 1 workings and Dawson's open-cut. It is also observable on the South Hercules section and on the Mt. Read Company's lease. The same banding can be seen underground at innumerable points which will be fully indicated when discussing the structural features; it can even be seen in the massive rock forming the "lump" in the "E" ore-body, Hercules. The banding is also clearly observable in the Ring P.A. section, and in fact is observable, when searched for, over the whole field.

The banding is, in fact, the original sedimentary bedding, the successive layers of different colours still persisting in spite of the reconstitution of the rock components. It is noteworthy that the banding is mostly observed in those varieties which possess the least schistosity, the excessive crushing and readjustment having completely masked the original sedimentary structure in the more fissile schists.

The existence of such sedimentary bedding unerringly points to the conclusion that all these schists were originally laid down as sedimentary accumulations. The true sedimentation was accompanied by the submarine eruption of lava flows as well as the deposition of truly pyroclastic deposits. The sediments proper contained at a certain horizon much calcium carbonate. The metamorphism of the whole of these accumulations has resulted in the present

development of various schists, including among them the economically important calcite schists. During this metamorphism the reconstitution of the calcareous sediments consisted in a segregation of the various components into parallel bands coincident with the schist planes. In particular the lime contents have segregated into bands of almost pure calcite; the argillaceous components then forming bands relatively low in calcite but still decidedly calcareous. Thus is developed a schistose calcareous rock consisting of successive bands having varying lime contents. When the argillaceous material has been in marked excess in the original sediment, the lime contents have segregated in the form of blebs or rhombohedral crystals of calcite. This latter type can be seen in the No. 4 Tramway, Hercules.

The remnants of the sedimentary structures are all-important in the elucidation of the structural features of the series, and in the investigation of this question the banding described above is the most important character of this rock series.

Structural Features.—The most obvious structural feature is the fissile tendency along the planes of schistosity. This has been repeatedly described, and the strike and dip of these planes have always been regarded as identical with those of the bands of the different variety of schists.

The strike of the schist planes varies in different portions of the field. That which is generally characteristic of the field, however, is approximately 20 degrees west of north. Variations from this occur either to the east or west. For instance, at the Send-off on the Hercules the strike has swung round to 40 degrees west of north, while on the Mt. Read Company' lease, near the 2, 3, and 4 shafts, it is 20 degrees east of north. All measurements intermediate between these two extremes can be obtained. At the Jupiter Mine and neighbourhood the strike of the schist planes is exactly north-south.

The dip of the schist planes is invariably towards the east at angles varying from 45 to 70 degrees. The latter measurement indicates the prevailing dip in the neighbourhood of the Hercules-Mt. Read Mines. In the northern portion of the area the dip is flatter, but varies greatly, being almost horizontal in places, while at other parts it is nearly vertical.

In addition to these schist planes there occurs in the rocks of this series a complicated system of fractures and joints. The study of these is a difficult one, for it soon becomes

evident on examination that they have many distinct modes of origin. Thus throughout the field are to be observed planes of dislocation or fault planes, more than one set of joint planes, and, most important of all, the original bedding planes of the sediments. It is difficult to decide which of these is the mode of origin of any particular fracture, but certain criteria exist which make such a decision possible. Thus the universality of the schistosity renders it by no means difficult to decide that any fracture plane is of this category by observing its concordance with a large number of very closely spaced parallel cleavages.

It is more difficult to decide between a fault plane and a bedding plane, for it has frequently happened that movement has taken place along a bedding plane, thus making the fractures themselves identical in appearance in each case. The important and unquestionable criterion in this case, however, is the existence of the original sedimentary banding or stratification or lamination. If this is observed to be parallel to a fracture plane, then it may be accepted without any hesitation that the plane is a bedding plane. The absence of the stratification, however, does not prove the contrary, as the remnants of an original bedding plane often exist in schists which have had all signs of lamination removed or masked by the formation of the schistose structure. The only evidence that can be accepted is that of positive character; negative evidence is quite valueless. Concisely, therefore, the secret for the original bedding planes consists in endeavouring to find the stratification bands; when these are found, the bedding planes can be distinguished from the other fractures. This is the important factor in dealing with the structural characters of this rock series.

It may be stated at once that the true fault planes are quite subordinate in amount, and that the greater number of fractures in the various schists other than the schist planes are in reality original bedding planes, although formerly believed to have been planes of movement. Thus Mr. G. A. Waller, in his report on this region in 1902, mapped a number of slides, and states:—

“ Many of the slides are very flat, and nearly all of them dip towards the east or north-east. In many places there has been considerable movement of the country, as shown by the non-continuance of certain bands of schist on both sides of the slides.”

These so-called slides are, in fact, bedding planes, as is proved by the occurrence of stratification banding parallel

thereto, and it is thus easy to see why Mr. Waller observed the non-continuance of the same kind of schist on both sides of the fracture. The fact of the plane being merely the separation between two beds of different character makes this quite easy of explanation without necessitating the assumption of considerable movement.

The study of the stratification bands and the bedding planes throughout the whole field has resulted in the conclusive establishment of the fact that the rock series we are now considering has been thrown into a complex series of folds. This structural feature had not been previously observed in this field by any investigator, it having been presumed that the various schists constituted separate beds which coincided in both strike and dip with the planes of schistosity. Absolute proof that that assumption is wholly wrong is afforded by a study of the rock exposures in Dawson's open-cut on the Hercules Mine. An indication is thus given of the true structural features of these Read-Rosebery schists, for the separate beds can there be seen thrown into two series of folds, one set giving an undulation from west to east, while another series shows a similar undulation of the beds from south to north. The sediments composing the beds at this particular point are of such a character as to resist the development of the fissile schistose structure, and consequently show the folding in a very clear manner. Similar folding can be seen in the "A" open-cut on the Hercules, a little to the south of Dawson's. Another point where a complete fold can be seen is on the road about 2 chains south of the No. 3 Tunnel in the Jupiter Mine; the fold here is an anticline with an axis practically due north and south, but representatives of the other series cannot be observed at this point. Still another illustration of the folds is seen on the Mt. Read Tram at the point where it crosses Baker's Creek. The same structural feature can be observed in the Dundas slates, especially at the 16-mile peg on the North-East Dundas Tram, where both series of folds can be seen, together with the slaty cleavage which is quite independent of the original bedding planes.

The above are the only points at which the complete folds can be observed by direct observation. The mapping of the folds in the whole series throughout the field depends, therefore, on the location of those portions of them which are observable at innumerable points, and connecting and correlating them by logical deduction. As the true exposition of this structural feature is essential

to the laying of a proper foundation for the study of the ore-deposits, the details of the reasoning which has resulted in the correlation of the several folds indicated in the accompanying map of the zinc-lead sulphide belt (Plate V.) will be presented somewhat fully.

As mentioned above, there are two series of these folds. To avoid confusion it is proposed to designate that series which undulates from west to east with an axis bearing 16 degs. west of north, the Alpha series; the set of undulations rolling from south to north with axes 74 degs. east of north being correspondingly known as the Beta series.

The details of the Alpha series will be first presented, and those of the Beta series will be given separately. It has been found impossible to completely investigate the whole of the folds in the Dundas slates in the area mapped. Consequently the mapping of the folds will be confined to those which affect the Read-Rosebery schists, as these are the repositories of the zinc-lead sulphide ore-bodies. It is sufficient to say that these Dundas slates possess exactly the same structural features.

Passing from the contact between the Dundas slates and the Read-Rosebery schists in an easterly direction, the first indication of the Alpha folds that is observed is on the Mt. Read Company's lease at Williams' shaft. In this locality the stratification is dipping to the east, and continues to do so until at a point approximately 80 feet east thereof a change takes place to a westerly dip, which continues for about 40 feet. At this latter point the dip again changes to an easterly direction. This can be well seen in the Mt. Read No. 1 adit at about 150 feet from the entrance. The bedding planes are there seen rolling over towards the east, forming an arch. It is therefore perfectly clear that there is an anticlinal fold at this point, the axis being approximately the direction of the No. 1 adit. It is also quite obvious that there is a synclinal fold to the west of this, the axis being situated about 40 feet to the west of the axis of the anticline.

This is confirmed by a study of the first 250 feet of the South Hercules eastern adit, the "heads" or bedding planes there showing the easterly dip for 100 feet in from the portal where the synclinal trough occurs. There is then a westerly dip of the heads to the anticlinal arch, eastwards of which the bedding planes are again seen dipping to the east.

To the east of the No. 1 adit the stratification can be seen dipping to the east at rather a low angle. This can be

seen near the blacksmith's shop on the Mt. Read lease in the cutting at the entrance to No. 0 bench, where the angle is 26 degs. Just south of the South Hercules shaft the dip is at a slightly steeper angle. This same dip can be traced along the track leading from the Mt. Read Mine to the assay office on the Hercules lease, but cannot be observed further north than the southern side-line of the Hercules Consolidated lease, where the dip is 25 degs. The same dip from the anticlinal crest can be seen in the South Hercules eastern adit, both in the crosscut itself near the 250-foot point and in the drive southwards from that point where the bedding planes are seen rolling over in exactly the same manner as in the Mt. Read No. 1 adit. The dip easterly at this point is 25 degs.

This same easterly dip continues into the Hercules workings, having, however, become considerably steeper where it is penetrated and exposed in the westernmost portion of the 3A, 3, 4, 5, and 6 levels. It is in the workings of this mine that these folds can be most completely studied. The evidence presented in the several levels will be now given in some detail.

In the 3A level a succession of fractures, mostly filled with a brown or yellowish "pug" occur, dipping to the east at varying angles, which become markedly flatter as the E Main South Rise (13) is approached, at which point the stratification is horizontal. There is, therefore, a synclinal trough at this point.

In the No. 3 level main crosscut a bedding plane is seen about 30 feet east of the "A" ore-body, dipping to the east at about 60 degs.; another similar fracture, filled with pug, dips to the eastward at 45 degs. Still another bedding plane can be seen 15 feet east of McKnight's pass (33), dipping to the eastward at 62 degs.

The bedding planes are also seen dipping easterly in the "C" east crosscut at No. 3 level, where the settlement of the ground in that locality has caused the rock to open along these pre-existing fractures.

No definite bedding planes can be observed in Mooney's crosscut, but the stratification banding is quite apparent. East of the Main North Drive the banding is seen dipping eastwards until Woodard's rise (9) is approached, immediately west of which the banding becomes horizontal again, indicating a synclinal trough.

The evidence available in No. 4 level is greater than in either of the former. In both Nos. 2 and 4 tunnels the bedding planes are seen, generally filled with pug, striking

320 degs. to 340 degs., and dipping to the east at varying angles. This dip becomes flatter as the "E" ore-body is approached. Thus the dip near the portals of 2 and 4 tunnels is high (50 degs. to 75 degs.), while in the neighbourhood of the ore-bodies themselves it has decreased to 40 degs. and less. A well-defined bedding plane is seen in the Main Crosscut between "A" and "B" ore-bodies. It dips at an angle of 25 degs. to the east. This is a very pronounced fracture, and has been taken for a fault, but it is really nothing of the kind.

Similar bedding-planes are to be seen in the "D" West Crosscut, as also in No. 9 Crosscut. They here invariably dip towards the east.

In the No. 1 intermediate drive the banding is seen dipping to the east at a steep angle towards the southern portion of the "F" ore-body. In the southern stopes on that ore-body the same easterly dip of the bands can be seen at the 2nd and 3rd stopes on the footwall. This dip flattens as it approaches the centre of the 3rd stope area, where it has become horizontal, yet again showing the synclinal trough seen at the points mentioned above.

It is quite apparent, therefore, that there is a synclinal trough with an axis which is determined by the line joining the several points previously indicated. The direction of this line is approximately N. 16 degs. W.

It is now necessary to follow the ascending limb of that fold towards the east. In the South Hercules eastern adit the stratification banding and the bedding planes start to rise from the synclinal trough—that is, they assume a dip to the west at 320 feet from the eastern end of the adit. At a point 300 feet from the same end the stratification banding becomes horizontal and rolls over to assume an easterly dip. An anticlinal crest thus exists at 300 feet from the easterly end of the South Hercules eastern adit.

In a similar manner, we find the bedding planes and banding turning upwards from the synclinal trough in the Hercules workings. This can be seen to especial advantage in several localities. Thus in the 3A level at the "E" Main South rise (13), they can be seen rising from the synclinal trough at that point towards the anticlinal crest situated about 25 or 30 feet away to the east. The same thing can be seen very clearly in that portion of the "lump" which is at No. 3 level, and which can be entered from the 1st stope level 30 feet east of the Central Mullock rise (14). The "lump," which is part of the erroneously-named "intrusion" which here separates the footwall portion of

the "E" ore-body from the hanging-wall portion, has fallen away from this level for about 10 feet vertically. Standing in the cavity thus formed the banding or stratification can be seen on the western side dipping to the east, becoming flatter as the centre of the chamber is approached, to finally turn upwards and assume a westerly dip. The crest of the anticline cannot be seen at this point.

In Mooney's crosscut, No. 3 level, the same synclinal trough can be seen about 4 feet west of Woodard's rise (9), where the banding can be clearly seen. To observe the rise upwards from this trough it is necessary to examine the portion of the rise above the main floor level, where the bedding planes and stratification can be seen assuming a constantly increasing westerly dip as they pass from the western to the eastern side of the rise. The crest of the anticline is situated east of the rise.

At the No. 4 level the synclinal trough and the anticlinal crest we are now considering can be seen in the open southern stopes in the "F" ore-body approachable from Robinson's rise (4). At this point again both the stratification and bedding planes can be seen. The synclinal trough can be seen at a point 25 feet north and 25 feet west of Robinson's rise, while the anticlinal crest is situated 20 feet east of the synclinal trough. This is observable at the 3rd and 4th stope levels.

At the No. 5 level the synclinal trough can be seen a few feet east of the 620 feet south drive. A well-defined fracture or "head," filled with pug, starts at 15 feet west of the 550 feet north drive, appearing first in the roof. The dip measured along the crosscut is 16 degs. to the east. It also has a component of the true dip, which plunges it beneath the level on the north side of the crosscut at the 550 north drive, the dip in this direction being 24 degs. It can be followed along the 620 south drive for 30 feet. The dip gets flatter as it goes eastwards. This "head" is undoubtedly an original bedding plane which has served as a passage for ore-bearing solutions, and has thus become greatly accentuated by the effect of these solutions on the walls of an originally narrow parting between two beds. The actual position of the synclinal trough here is a few feet east of the 620 south drive. The "heads" in the country here indicate that eastwards of this point there is a gradual rise to the anticlinal crest, which is situated a few feet west of the winze at the 700-foot mark.

At the No. 6 level remnants of the bedding planes can be seen with the easterly dip, until at about 350 feet from

the end they assume an inclination to the west. Nothing definite occurs east of this, until at about 200 feet from the end the banding shows a dip to the east again. The synclinal trough is therefore about 350 feet from the end and the anticlinal crest between that point and 200 feet from the end.

The description of the Alpha folds has now proceeded as far as the location of the third anticlinal crest, counting from the most westerly one at Williams' shaft. For the reason that the mine workings have not penetrated very much further east than this point, the evidence for the fixation of the succeeding folds is correspondingly less. Quite enough evidence, however, is available to enable important conclusions to be arrived at. Thus in the South Hercules eastern adit, to the eastward of the lastmentioned anticlinal crest, there is a plunge of the strata downwards, to rise again to an anticlinal crest situated at 150 feet from the end, where the structure is very clearly depicted, both the bedding planes and stratification being present. From this apex there is a dip easterly, which becomes steeper towards the eastern end of the adit, where the stratification is dipping eastwards at an angle of 72 degs. In the No. 4 tunnel, Hercules, no structural feature in connection with the folds can be definitely observed, except in the extreme eastern end, where the stratification is seen to be dipping eastward at a very low angle. Correlating this with the occurrence mentioned above, the deduction results that the third Alpha anticlinal crest is situated in the No. 4 tunnel about 30 feet west of the end.

Similarly, the easterly dip from the third anticlinal crest is well seen in Mooney's crosscut, No. 3 level, Hercules. The rock types here show the stratification from about 20 feet east of Woodard's rise (9) to the eastern end of the crosscut.

In the 3A level, Hercules, the dip from the anticline can be seen along the crosscut from the so-called H.W. branch of the "E" ore-body continuously to the end, where the stratification is seen dipping to the eastward at an angle of 40 degs.

In the other crosscuts at the various levels in the Hercules nothing more than the downward plunge from the third anticline can be seen definitely enough to indicate the exact positions of the axes. Enough data have, however, been now presented to enable the several axes to be exactly located. They are shown in Plate V. Their exten-

sion towards the northern portion of the area is thus seen and it is, *inter alia*, observed that the axis of the anticline near Williams' shaft passes through Burn's tunnel a few feet west of the south drives therefrom. In these latter drives the bedding planes can be seen turning downwards to the east from a flat dip away from the anticlinal crest.

The same easterly dip from that anticline can be seen on the track from Williamsford to Mt. Read at a point where it crosses the Ring P.A. workings vertically above the No. 3 tunnel, where it can again be well seen. No data are obtainable at present as to the position of the folds to the eastward of this in this locality.

Coming now to the data available in the Jupiter Mine workings, we find that there is an anticlinal fold on the road 2 chains south of the No. 3 tunnel. The same fold can be seen in the No. 3 tunnel a few feet from the entrance, the westerly dip of the bedding planes on the western side of the axis giving place to an easterly dip about 40 feet in from the portal. The same anticlinal crest occurs on the road to the south and west of No. 2 tunnel. When these three points are plotted it is found that the direction of the axis is N. 2 degs. E., and it is therefore evident that the axes of the folds swing round at the Ring P.A. from N. 16 degs. W. to N. 2 degs. E.

Continuing the several axes from the Ring P.A. workings northwards in their new direction of N. 2 degs. E., we find that the anticline mentioned above as occurring near the portal of the Jupiter No. 3 tunnel corresponds with that along which the Mt. Read No. 1 adit was driven.

The immediately succeeding synclinal trough and anticlinal crest, which are seen in the Hercules, thus recur on the Jupiter section between the Nos. 2 and 3 tunnel workings and the No. 1 tunnel. So also must the next synclinal trough, for in the western end of the No. 1 tunnel the bedding planes are seen dipping west at an angle of 45 degrees. The next anticlinal crest is about 30 or 40 feet from the end of No. 1 tunnel. This exactly corresponds with the position resulting from the continuation of this axis from the Ring P.A. in a direction of N. 2 degs. E. There is no evidence as to the axes of the folds to the east of this.

This completes the information available in the portion of the Read-Rosebery schist belt included in this examination as to the Alpha folds. The study of the folds of the Beta series is essential before a correct idea can be formed of the precise undulations of any particular horizon in the

various sedimentary accumulations. They will now be described in a similar manner to the Alpha folds: in this case they will be followed progressively from south to north.

These Beta folds are rather obscure in the southern portion of this area, and here their successful location depends on the extent to which a certain restricted bed can be traced in the mine workings of the Mt. Read Company. It will be remembered that the No. 1 adit of that mine was driven along the axis of an anticlinal Alpha fold. If, therefore, a particular bed passes successively overhead and underfoot in the drive, and if we already realise the existence of these Beta folds, the conclusion must certainly follow that there is here a succession of the Beta folds. Thus it is quite evident that a Beta anticline exists to the south of the end of the adit, from which a northerly dip occurs to a synclinal trough situated at about 850 feet from the entrance. There is then a southerly dip to an anticlinal crest situated at 700 feet from the portal. From this anticlinal crest there is a dip to the northwards which constitutes the southern portion of a synclinal trough of relatively great extent, as it continues northwards with a few minor undulations, of which that seen at the bridge where the Mt. Read Tram crosses Baker's Creek is an example, to the synclinal axis which is located about 200 feet south of the South Hercules eastern adit. This northerly dip can be seen near the entrance to the Mt. Read No. 1 adit, at the entrance to No. 0 bench, and near the South Hercules shaft. These two latter localities have been indicated previously in connection with the investigation of the Alpha folds, but it must be pointed out and fully realised at this stage that the actual dip measured at any point in this rock series is the result of the combined effect of two components. It is a mathematical law that any particular direction of dip can be resolved into two components at right angles to one another, and it is clearly possible to obtain a considerable number of such pairs of dip components. In the rock series which we are now discussing it is essential, before attempting such a calculation, that the structural features throughout the field be considered and studied as a whole, and a conclusion arrived at as to the general relationships between the several folds observed. Thus we have investigated primarily the Alpha folds, and find that the axes strike N. 16 degs. W. as far as the Ring P. A. If, therefore, we resolve any observed dip at a particular point into a component in

the direction of N. 16 degs. W. or S. 16 degs. E., then the corresponding component at right angles thereto in a direction of N. 74 degs. E. or S. 74 degs. W. will give the dip actually due to the Beta folds.

Thus the stratification a few feet south of the South Hercules shaft dips at about 25 degs. in a direction of N. 20 degs. E. On resolving, this gives a dip of 20 degs. in a N. 16 degs. W. direction, and one of 14 degs. to N. 74 degs. E. The latter is the component which has been considered in connection with the Alpha folds, while the former is that which is due to the effect of the Beta folds. In the neighbourhood of the South Hercules shaft, therefore, there is a dip of 20 degs. to N. 16 degs. W. down towards a Beta synclinal trough.

Similarly, both the bedding planes and stratification seen in the South Hercules eastern adit, as well as the stratification to be seen on the surface on the northern boundary of this lease, show a true dip of about the same amount in a direction of S. 70 degs. E., which can be resolved into an Alpha dip of 14 degs. to N. 74 degs. E., and a Beta dip of 20 degs. to S. 16 degs. E. Thus there is a rise towards this point from the synclinal trough which is continued to the No. 4 tunnel, Hercules, in the eastern end of which the stratification can be seen, having a true dip of about 15 degs. to S. 70 degs. E. It is therefore apparent that the rise from the syncline towards the next anticline continues to the No. 4 tunnel, and the decrease in the amount of dip at that point shows that the anticlinal crest is not far north of the tunnel. Where it is next seen in the Hercules workings, northwards of the No. 4 tunnel, the stratification has a true dip in a direction of N. 20 degs. E. This continues northwards in these workings. Thus in the 3A level there is a Beta dip of 33 degs. to N. 16 degs. W. The angle varies in different portions of the workings, but continues in the same direction until, in the southern slopes of the "F" ore-body, the Beta dip is at about 30 degs. to S. 16 degs. E.

It is quite apparent, therefore, that there is a Beta anticlinal axis a few feet north of No. 4 tunnel, and a corresponding synclinal axis at approximately the No. 8 bore. The direction of these axes is N. 74 degs. E.

The next succeeding Beta anticline is seen in Dawson's open-cut, from which a plunge northwards down a synclinal fold occurs. This Beta syncline is of great size, as the axis is situated not far south of the Ring P.A. workings. The vertical distance between the anticlinal crest and

the synclinal trough is, approximately, 1550 feet. The rise northwards to the next anticline can be seen in the Ring P. A. workings as well as on the track to Mt. Read, where it crosses vertically above the No. 2 tunnel. The position of the axis of this anticline is indeterminable at present, as there are absolutely no data available between here and the Jupiter Mine workings. It must be accepted, however, that the Beta folds do continue northwards, and subsequent exploratory work will undoubtedly disclose the data necessary for their location. It seems, however, that they will be of the same general extent as those on the Mt. Read, South Hercules, and Hercules Mines, since one definite horizon of the original sediments occurs in both the Ring P. A. and Jupiter Mines at approximately the same height above sea-level.

The details of both series of folds have now been presented, and it has thus become evident that the actual effect of their co-existence is to produce a succession of domes and basins in this rock series. For practical purposes, however, the plotting of the main axes is the method of presenting them that will give the more definite information and provide more certain grounds on which to base exploratory work.

(d) The West Coast Range Conglomerate.

This now well-known rock type has been fully described in many of the publications of the Geological Survey, to which the reader is referred for information. Its occurrence in this field is restricted to the easternmost portion excepting one or two small boulders observed near the Mt. Read open-cuts and the huge glacial erratics at Williamsford.

The boundaries of the outcrops in the eastern portion of the field are indicated in the general geological map herewith (Plate III.). It is confined to Mts. Murchison and Tyndall, including also portion of the foothills of these. Its occurrence at the surface has been determined by the combined effect of denudation and block-faulting.

There is no need to describe the rock type, as it is altogether similar to the other occurrences on the West Coast. It is sufficient here to say that the conclusion arrived at and fully discussed in the Jukes-Darwin Bulletin is completely confirmed by the observations made in this field. In short, those conclusions were that the conglomerate is

younger than the felsite, schists, &c., and was laid down horizontally on their upturned edges. The present complicated relations of conglomerate and felsite are wholly the result of complex folding and faulting.

Thus in this field we observe that the structure of the conglomerate series on Mt. Tyndall is that of a huge anticline rising from the piedmont plain at its western foot to plunge eastwards into the Anthony Valley. This anticline can be seen to special advantage from Mt. Read. On Mt. Julia, which is really a northern outlier to the Tyndall Range, considerable crumpling has taken place, the conglomerate beds being folded into closely-compressed synclines and anticlines. The general structure, however, is still that of a large anticlinal fold, the crumpling being due to subsidiary folding.

Along the surveyed pipe-line from the Anthony Dam, the conglomerates are clearly seen resting on the felsites, porphyries, &c.

On the Goose they strike west of north and dip at about 80 degs. to the eastwards. East of the Goose the surface is wholly felsite, chloritic schist, &c., until the ridge on the eastern side of the Red Hills is reached. Here the conglomerates again lie on top of the felsites, striking at this point also a little west of north, and dipping at a flat angle of about 10 degs. to 20 degs. to the eastwards. This generally flat dip characterises the series as a whole in this locality, as also on the south-west end of Mt. Murchison. To the east of this ridge felsite recurs. This is due to the effect of a fault striking a little west of north. The upthrow has been on the eastern side, consequently the felsite appears at a higher level on the east than on the west side of the Red Hills conglomerate ridge. A parallel fault occurs to the east of the first, and the effect is similar.

Both of the abovementioned faults are of the nature of pivotal faults, for the upthrow on the northern end is much greater than that further south. In this way the conglomerate capping Mt. Murchison has been thrust up to that height, the underlying felsite, &c., accompanying it; the whole, in fact, forming a large uplifted mass.

During this field journey the writer only had the opportunity of examining the south-western third of the Murchison mountain mass. The remainder will be studied in connection with the investigation of the Rosebery district. The full details of the geological structure of this conglomerate series will be given in the bulletin on that field.

(e) *The Permo-Carboniferous Conglomerate.*

About 5 chains south of the shaft on Dunne's Blocks the Mt. Read-Zeehan track crosses over a patch of conglomerate. The matrix of this conglomerate is bluish-grey in colour, and the boulders consist of more or less rounded fragments up to 1 foot in diameter, of many porphyroids, West Coast Range Conglomerate, and fossiliferous Silurian sandstone. The width, as shown on the track, is 300 feet, but the extension north and south is undeterminable, as it is covered by thick scrub.

From its general appearance, taken in conjunction with the occurrence of fragments of undoubted Silurian rocks, the writer has concluded that this conglomerate is of Permo-Carboniferous age. It apparently represents the remnants of a once extensive deposit at this level (3200 feet above sea-level), and is the geological analogue of the Permo-Carboniferous strata known to exist on Mt. Sedgwick to the south-east, and Eldon Bluff, almost due east.

The important point to notice in connection with this occurrence is that it rests unconformably directly on the Read-Rosebery schists.

(f) *The Glacial Deposits.*

These deposits are confined to the less elevated portion of the region, and consist of typical glacial till and erratics. There are four separate occurrences in the area under discussion. The first occurs at Williamsford, and continues in a northerly direction from that point to ultimately unite beyond the northern boundary of the area with the northern continuation of the second occurrence, which is situated in the valley of the Koonya and Stitt Rivers, the southernmost point extending towards the Moxon Saddle, which connects Mts. Read and Murchison, and forms the watershed here between the Pieman and Henty drainage systems. The third deposit is that which occupies the Anthony Valley on the eastern side of Mt. Tyndall. The fourth occurs on the southern foot of Mt. Read in the Henty Valley, and along the western foot of Mt. Tyndall.

All four occurrences possess the same general characteristics. They have undoubtedly been deposited by the agency of glaciers, and each occurrence represents the work of a separate glacier. The same applies here as in the Jukes-Darwin field, in the bulletin on which the writer has described the nature of these glaciers. The conclusion

is there arrived at that they were "mountain glaciers," and in no sense "continental." From the disposition of the deposits in this field the conclusion is clear that there were four main glaciers in this field. The first headed from approximately the head of Baker's Creek, near where the Hercules and Mt. Read Mines now are. This glacier flowed northwards down to Williamsford, past which it continued, and ultimately reached the Pieman Valley. The second glacier had its head at what is now the head of the Stitt-Koonya Gorge, and, travelling west of north, junctioned with the former glacier.

The third glacier was really composite in character, but headed from the vicinity of Lake Rolleston and Walford Peak, and travelled northwards down the Anthony Valley, meeting subsidiary ice-sheets from the western side. The enormous glacial cirque on the eastern side of Tyndall points to the head of one of these feeders of the combined glacier.

The fourth ice-sheet started from the present head of the Henty River to the west of the Goose.

The boulders and erratics of these glacial deposits consist of West Coast conglomerate and porphyroids, but the former undoubtedly predominate. Some of these conglomerate boulders are of enormous size, several at Williamsford being over 15 feet high, but some in the Anthony Valley far exceed that size.

(2) THE GENERAL SEQUENCE OF EVENTS LEADING TO THE PRESENT GEOLOGICAL STRUCTURE.

(a) *The Pre-Cambrian Sedimentation.*

The geological history of the region began with the laying down of the sediments on the floor of a Pre-Cambrian sea. The nature of this floor is unknown, as it has not yet been observed in Tasmania. The sediments in this area consisted of various sandstones.

(b) *The First Period of Metamorphism.*

At the close of this period of sedimentation there ensued a period of diastrophism, during which the Pre-Cambrian sandstones were converted into quartzites and assumed their present crumpled and folded condition.

(c) *The Extrusion of the Porphyroid Felsites and the Accompanying Sedimentation.*

After that period of diastrophism an important and extensive period of sedimentation and vulcanism ensued, during which the rocks now grouped as the porphyroids were erupted, and the accompanying sediments laid down. The exact position of this period in the geological record is undetermined, but it certainly preceded the Silurian, and has been referred to tentatively as Pre-Silurian. The result of the alternate sedimentation and extravasation of lavas and tuffs was the accumulation of a complicated succession of truly sedimentary rocks, lavas, and fragmental volcanic rocks. Some of these deposits were subsequently penetrated by dykes of igneous material in its passage upwards to the surface of the accumulations already formed. Many of these lavas were probably submarine, and the tuffs and breccias also were most probably laid down on the sea-floor. It has been up to the present undetermined whether the Dundas slates and breccias are older or younger than the Read-Rosebery schists, and whether the latter are older or younger than the felsites and chloritic schists of the Red Hills. From the evidence gathered during this survey as to the structural relations of these rock series, the writer is of the opinion that the Dundas slates and breccias are the oldest, the Read-Rosebery schists being younger than them, while the felsites and chloritic schists are the youngest of all.

One fact must be specially noted in connection with the progress of this combined igneous and sedimentary activity, and that is, that at two horizons at least in the whole series *i.e.*, both in the Dundas slates and in the Read-Rosebery schists, there occurred a cessation of the igneous activity, or the sea-floor sank sufficiently to allow of an accumulation of calcareous deposits of varying purity; the purity, in fact, varying from practically pure calcium carbonate to argillaceous sediment with only a trace of calcareous matter.

(d) *The Second Period of Metamorphism.*

The close of the period of formation of the porphyroid lava flows and accompanying sedimentation was characterised by the occurrence of a period of diastrophism, during which the whole of the accumulations were subjected to intense pressure and crushing. This resulted in the

development of a complex series of folds, and at the same time brought about the present schistose structure.

(e) The Formation of the West Coast Range Conglomerate.

After a period of denudation the land surface formed by the metamorphosed porphyroids and sediments sank to sea-level, and the West Coast Range conglomerate was laid down on the truncated edges of the folded strata as a purely littoral deposit. The exact position on the geological scale to which this period must be assigned is not quite clearly established. It is certainly higher in the scale than the porphyroid period previously described, being separated from it by a period of great diastrophism, but its exact relation with the Silurian strata is uncertain. In other parts of Tasmania we know that the Silurian limestones and sandstones overlie the conglomerate conformably (⁴). Its geological age is tentatively given as Pre-Silurian, but it is quite possible that its true position may be at the base of the Silurian.⁽⁵⁾

(f) The Period of Ore-deposition.

The age of the zinc-lead sulphide deposits is discussed in a later portion of this bulletin, and the conclusion is arrived at that they are genetically associated with the Devonian granite irruption.

Subsequently, therefore, to the laying down of the conglomerate series, and probably the whole of the Silurian strata above them, there followed in Devonian times a period of renewed igneous activity and concomitant diastrophism. Thus the faulting and folding which is now seen in the conglomerate series was effected, and the final stage in the cooling of the granite magma was the injection of the ore-bearing solutions into the Read-Rosebery schists and felsites. The derivation of a valuable ore-deposit from these solutions depended on their meeting a congenial rock mass. In this way we get relatively poor ore-bodies in the chloritic and argillaceous schists, while the interaction of the solutions and the congenial metamorphosed calcareous beds has resulted in the formation of massive bodies of zinc-lead sulphides.

(⁴) See Geological Survey of Tasmania, Bulletin No. 16, pp. 58-64.

(⁵) See Geological Survey of Tasmania, Bulletin No. 16, p. 60.

(g) *The Events Subsequent to the Formation of the Ore-bodies.*

After the deposition of the ores was complete there ensued a prolonged period of denudation during which the level of the land surface, which this area then consisted of, was greatly lowered, and an unknown, but certainly large, portion of the West Coast Range conglomerate and Silurian strata was removed. Apparently the amount thus eroded varied from place to place, as we find the next succeeding sedimentary deposit lying directly on the schists, while portion of the conglomerate still remains in other parts of the field.

The next geological event of importance was the sinking of this land surface beneath the sea and the deposition of the Permo-Carboniferous conglomerate on that sea-bottom, together with probably other sediments of the same age. Succeeding this sedimentation was the intrusion of the diabase at the close of the Mesozoic era. This diabase cannot be seen within the limits of the area examined, but is known to occur on the summit of Mt. Dundas at an elevation greater than that of Mt. Read. As this rock is intrusive it must have been intruded beneath some sedimentary strata.

We have no data in this field of any further geological events until we consider the glacial action which undoubtedly occurred in quite recent times. We must assume that after the intrusion of the diabase the area became a land surface, which it has remained up to the present, having in the intervening time been subjected to several cycles of erosion. The effect of these and the glaciation has been to remove the whole of the overlying rocks from above the Read-Rosebery schists on Mt. Read itself, while in the eastern portion of the field the erosion has only been sufficient to remove portion thereof.

It is, however, impossible to say how much of this conglomerate remained on what is now Mt. Read after the denudation succeeding the Devonian granitic irruption but preceding the Permo-Carboniferous sedimentation. Some must have remained, as the huge boulders in the recent glacial accumulations at the north-western foot of the mountain testify. Undoubtedly, also, the conglomerate was completely removed in places, as is proved by the Permo-Carboniferous beds resting directly on the schists. The combined effect, however, of these two widely separated periods of denudation has been to completely remove

the whole of the conglomerate from the summit of Mt. Read.

The present configuration is due to a prolonged cycle of denudation, which is still in its youth, and the effects of this erosion have been exaggerated in places and modified greatly by the effect of the glacial action. The glacial cirques still remain, but one at least is almost unrecognisable. This is the cirque which was situated in the upper portion of Baker's Creek, near the Hercules No. 5 tunnel. The erosion which has succeeded the melting of the glacier has masked the evidences of glaciation here because of the rapidity with which the soft schists have yielded, when compared with the resistance offered by the West Coast range conglomerate, which forms the prominent cirque on the eastern side of Mt. Tyndall.

The cycle of denudation, of which the glacial epoch was an incident, still continues, and has already cut deeply into the glacial accumulations; the aggregate effect, however, being still a long way from the base-levelling which will be the ultimate end of the cycle.

V.—ECONOMIC GEOLOGY.

(1)—GENERAL REMARKS.

To systematically study the economic aspects of the geology of these deposits it is essential to first deal with their mineralogical composition, and then to study their structural features and tectonic relationships, after which the discussion as to the genesis or mode of origin can be confidently entered upon. Having decided the mode of origin, a reliable deduction can be drawn concerning the effect of depth on the value and size of the ore-deposits.

This will be the system adopted in this chapter, and the descriptive matter and discussions will be presented as concisely as possible. It must be remembered that this series of bulletins on the Read-Rosebery zinc-lead sulphide deposits has been written with the object of presenting to the mining and investing public a clear and concise description of its resources and possibilities. Consequently, abstruse discussions have been eliminated, but as bald dogmatic statements are of no value in themselves, the reasons which justify such statements are concisely indicated. To save much lengthy descriptive and explanatory matter, free use has been made of illustrations, and the reader will find constant references to the many plates accompanying this bulletin to assist him in understanding the details of the structure of the ore-bodies. If the following descriptive matter is read in conjunction with a study of these plates it is hoped that a clear understanding of the behaviour and general structure of the ore-bodies will be obtained by the average reader.

(2)—PRIMARY ORE-DEPOSITS.

A.—MINERALOGY OF THE ORE-DEPOSITS.

(a) *The Replacement Ore-bodies.*

The minerals known to be present in this class of ore-deposit in the Mt. Read field are as follows, in approximately the order of their relative proportions:—

Metallic Minerals.—Sphalerite or zinc-blende, galena, pyrite, chalcopyrite, tetrahedrite or fahl-ore, pyrargyrite or ruby silver; silver and gold are

always present, being chemically associated with certain of the other mineral constituents.

Non-metallic Minerals.—Barite, calcite, quartz, rhodocrosite, siderite, fluorspar, sericite, and chlorite.

These may be taken as the relative proportions of the minerals throughout the deposits as a whole, but of course from point to point in the ore-bodies there are great variations in the relative amounts present. Thus in one part of the ore-body zinc-blende may predominate, while in another part of the same ore-body galena may be the most plentiful mineral; and in still a third portion both of these minerals may decrease in amount with a predominance of pyrite. In addition it is found that not only does the same apparently distinct ore-body vary in mineralogical composition from point to point, but it as a whole may differ in average composition from that of a neighbouring ore-body.

The outstanding feature, however, is the fact that the three minerals, blende, galena, and pyrite, are the most plentiful; and particularly that the two former (blende and galena) exceed the amount of pyrite present, the remaining minerals enumerated above being quite subordinate in amount.

The following analyses will give an accurate idea of the general composition of the zinc-lead sulphide ore:—

Particulars of Ore.	Au ozs.	Ag ozs.	Pb %	Zn %	Cu %	Fe %	S %	Mn %	Ca O %	Al ₂ O ₃ %	Si O ₂ %
High-grade Zinc Ore, Mt. Read Mine ...	0·13	12·7	13·8	43·2	0·15	10·17	29·5	0·42	—	3·06	(insol.)
From "B" Ore-body, Hercules	0·50	33·1	6·8	38·3	0·48	13·7	32·6	0·4	—	6·5	(insol.)
No. 2 Bore, Hercules	0·07	40·7	16·8	32·5	0·3	6·5	26·6	0·5	3·5	3·5	5·2
Ditto	0·06	16·0	4·5	10·9	0·3	22·4	31·3	0·8	7·3	3·3	9·0
Ditto	0·10	3·9	5·5	34·1	0·1	7·2	20·3	14·4	1·5	1·1	1·9
Ditto	0·12	13·2	11·0	35·3	0·2	13·7	34·2	0·4	trace	1·2	1·7
Average Sample, No. 7 Bore, Hercules .	0·105	5·3	4·0	23·6	0·33	14·05	24·6	0·6	1·35	26·9	(insol.)
Average Sample, No. 8 Bore, Hercules	0·138	5·9	7·2	28·8	0·38	10·42	25·9	0·53	0·35	21·0	(insol.)

The outstanding feature is the remarkably low proportion of gangue, which in the average ore throughout the field averages about 10 per cent.

Zinc-blende is always more or less perfectly crystallised. At only two points in this field have complete crystals of zinc-blende been observed in the replacement deposits. These are at the Jupiter Mine, where some excellently developed crystals have been obtained, and at Sligo's tunnel on the Ring P.A. Mine, where the crystals are smaller, but very well developed. Generally, however, this mineral only shows a partial development of crystal facets, although in no case did the writer observe any blende which did not show a crystalline structure. The size of these crystalline particles varies from that of subhedral grains only visible under the microscope to coarse aggregates of incomplete crystals measuring up to 1 inch or more in diameter.

The colour of the zinc-blende also varies within wide limits. Every gradation is observable, from a very light amber, or even grey, through deep amber and red, to black. The most common varieties, however, are those possessing the various shades of amber.

Galena occurs in its common habit of aggregates of cubes. It is always crystalline, and the particles vary in size from microscopic crystals to crystalline aggregates of appreciable size.

Pyrite varies in character to a considerable extent throughout the ore-deposits. In that portion of the "A" ore-body in the Hercules which is characterised by predominant copper contents pyrite occurs well crystallised, perfect cubes being quite common. In the ordinary zinc-lead sulphide ore-bodies the pyrite is almost invariably massive in character, and in places in the ore-bodies consists of a dense homogeneous mass, finely granular in texture, closely resembling the cupriferous pyrite of the Mt. Lyell Mine. Throughout the whole of the ore-bodies pyrite is present in various-sized bunches of incomplete crystals.

Chalcopyrite occurs constantly in the zinc-lead ore-bodies as splashes and stringers. In places, however, it becomes the characteristic and predominant component of the ore-body. Thus the southern end of the "A" ore-body in the Hercules Mine is essentially a copper deposit, the pyrite and chalcopyrite being intimately associated, while the zinc-blende is quite subordinate in amount, and the galena has almost completely disappeared. Similarly, the copper

deposits worked in the Ring P.A. and Jupiter No. 1 tunnel consist of chalcopyrite and pyrite, with practically no zinc. Particularly at the Jupiter the chalcopyrite is very pure, but even in this case it is regularly massive in character, no crystalline structure being observable.

Tetrahedrite or fahl-ore is far less plentiful than the three former minerals, but is certainly persistent throughout the ore-bodies in this field. It has the usual steel-grey colour, and is generally massive, but bunches of crystals do certainly occur. It occurs as blebs and specks associated with the other sulphides, but often occurs pure and solid in seams up to 1 inch in thickness, particularly in small veins in the walls of the ore-body. At other points it occurs as bunches admixed with the other sulphides. Mr. W. F. Petterd, in his "Catalogue of the Minerals of Tasmania," reports the following analysis of a picked sample taken from the Hercules Mine:—⁽⁶⁾

Variety—FREIBERGITE.

	per cent.	
Ag.....	9.82	= 3201.32 oz. per ton
Au.....	0.0019	= 13 dwt. per ton
Cu.....	29.76	
As.....	2.69	
Fe.....	4.56	
S	27.21	
	<hr/>	
	94.7319	

Balance = Insoluble matter

There are apparently many different varieties of this mineral species occurring throughout this field, some of which are quite low in silver in spite of the fact that their general physical properties resemble those of the silver-rich varieties. Thus, in the "F" ore-body in the Hercules a steel-grey mineral occurs in places to a quite considerable extent, but the silver contents of these portions is not specially high, although the presence of a very similar mineral in other parts of the same ore-body considerably raises the silver assay.

Tetrahedrite is present generally in the ore-bodies, and cannot be said to occur in one portion more than another.

Pyrrargyrite or *Ruby-silver* is not of very abundant occurrence in this field, but in two special localities it is

⁽⁶⁾ "Minerals of Tasmania," page 181.

developed to a noticeable extent. The most important of these is in what is known as the Ruby-Silver ore-body in the Hercules Mine. The mineral there occurs in a typical calcite schist as a metasomatic replacement associated with abundant barite, together with small quantities of pyrite, zinc-blende, and galena. The pyrargyrite is steel-grey to ruby-red in colour, the latter being the most usual. Clusters of imperfect rhombohedral crystals can be seen, but for the most part the mineral occurs in massive aggregates in which a few indeterminate facets are visible. The only other locality where this mineral has been observed in any quantity is the "F" ore-body in the Hercules, where it occurs in specks and splashes associated with the other sulphides in a typical zinc-lead sulphide mass. Ruby-silver has also been observed at different points to a small extent, as for instance the extreme eastern end of No. 4 tunnel, Hercules; but only the two above mentioned have been a source of silver ore on a working scale.

Barite is quite a common constituent of the zinc-lead ore-bodies, and may be regarded as a mineral typical of this type of ore-deposit. It occurs as splashes and irregularly-shaped masses up to 1 foot in diameter within the sulphide ore-body. These masses consist of platy crystals of pure white barite.

Quartz is quite common, but is generally less noticeable than the barite. It occurs in patches in a similar manner to the barite, and is generally massive and uncrystallised.

Calcite occurs in veins in the vicinity of the ore-body in appreciable amount, but the occurrence of this mineral within the sulphide ore-bodies is restricted to occasional patches of dull white calcite up to half an inch in length. These patches are irregular in shape, and are apparently quite distinct from the calcite occurring in the veins in the neighbourhood of the ore-bodies.

Fluorspar has not been observed in the sulphide bodies themselves, but seems to be confined to seams in the country-rock. It will be more fully dealt with under "Fissure Fillings"; the same applies to *Rhodochrosite*.

Pyrrhotite has not been observed in association with these deposits.

Having now described the general characteristics of the several mineral species as they occur in the ore-deposits of

this area, we can pass on to a consideration of the mode of aggregation or inter-relationship of the minerals within the ore-bodies.

The most obvious characteristic of the zinc-lead sulphide ore-bodies is the pronounced and persistent banded structure, the bands dipping at about 70° to the eastwards. This banded appearance is, in fact, due to the occurrence of alternating bands of varying composition. Thus, one band may be characterised by predominant zinc-blende, and the neighbouring band may contain an excess of galena, while the next succeeding band may be mainly pyritic in character. This division of the ore-bodies into nearly vertical bands of varying mineralogical composition characterises the whole of the zinc-lead sulphide deposits of this field. The bands vary in width, in some places as many as twelve alternations occurring in a width of 4 inches, while at other localities one band may be 2 feet or more thick, being quite homogeneous for this thickness.

Although this banded appearance is due to the preponderance of a certain mineral, it by no means follows that that mineral is present to the exclusion of the other mineral constituents. In no case did the writer observe a band of pure mineral persisting for any apparent length. Thus, a band which on a casual inspection seems to consist almost wholly of zinc-blende, on close examination will be found to contain a greater or less amount of galena. This galena is intimately intercrystallised with the blende, the intergrowth of the crystals and the decided predominance of the zinc-blende almost obliterating the galena. In the same way, a band apparently consisting of galena only is seen on close examination to contain zinc-blende, there being in this case also a very intimate intergrowth of the two minerals. The bands of pyrite or chalcopyrite also contain much blende.

A further characteristic is the variation in the texture of the bands. In some places the amber or red zinc-blende and galena are quite coarsely crystalline, although intergrown; while at other places in the ore-bodies the ore consists of a homogeneous dense granular mass, steel-grey in colour, in which no galena is visible, and through which larger blebs of amber-coloured zinc are scattered. In the former ore an assay such as the following typical result is such as would be reasonably expected:—

Au	Ag	Pb	Zn
ozs.	ozs.	%	%
·138	7·3	6·3	39·0

The assay of the second variety, however, although apparently a pure zinc ore, shows an appreciable lead content, as shown in the following typical analysis:—

As	Ag	Pb	Zn
ozs.	ozs.	%	%
·3	5·5	2·6	48·2

No free galena is observable, as such, even under a strong glass, and the same applies to samples showing even a higher lead content than 2·6 per cent. In one polished section, however, examined by the writer under the microscope of a specimen which showed no apparent galena to the naked eye, it was seen that that mineral was present in small amount, dispersed between the grains of zinc-blende, and apparently enwrapping them. The absence of any visible galena, however, in this class of very dense homogeneous ore has led to the belief that the lead present was in the form of a chemical compound of lead sulphide and zinc sulphide, to which the name huascalite has been given. This question is now being investigated, and it is hoped that sufficient conclusive evidence will be available in order to allow of a definite pronouncement thereon in Part III. of this series of bulletins dealing with the zinc-lead sulphide belt.

As stated above, the pyrite occasionally occurs in seams of dense fine-grained texture. This pyrite is seldom, if ever, quite free from zinc. A characteristic occurrence is that of the dense pyrite, veined with narrow seams of amber blende coarsely crystalline, and apparently quite free from galena. These veins are orientated parallel to the general banding, but are not necessarily continuous for any length. The pyrite itself may end abruptly against a band of fine-grained zinc-lead ore, or there may be a narrow band of coarse-grained amber zinc-blende interlaminated in places between them.

The occurrence of quartz is interesting. It seems to occur in those parts of the ore-bodies which are becoming lower in grade. Thus, in the Hercules, the amount of quartz in the true replacement deposits is greatest at the southern end of both the "B" and "E" ore-bodies at both the 3 and 4 levels. The quartz is seen to occur in masses, say, up to 2 feet in diameter. It is always non-crystalline, and is massive and milky. An almost invariable accompaniment is well-crystallised galena and zinc-blende in separate crystalline aggregates. It is an important fact that none of this quartz is observable within those

parts of the ore-bodies which consist of practically solid sulphide; it is only when the ore-body is changing in character to partially-replaced schist that they make their appearance.

It is also an important fact that in no case has there been observed the occurrence of seams, say, of galena, dispersed otherwise than parallel to the general banding. If a band of purer mineral is seen it is always disposed with a dip of 70° , corresponding to that of its neighbours.

In places in the ore-bodies the banding is not very marked, but in these cases the ore consists of a more or less uniform admixture of zinc-blende, galena, and pyrite, there being no special development of any one mineral above its general average to produce the banding.

One marked variation from the ordinary banded structure is noticeable. This occurs especially on the Hercules Mine at the mouth of the "C" South Surface drive. At this point the zinc-blende occurs in blebs consisting of pure zinc-blende, dark-amber in colour. These blebs are roughly rhombohedral, with rounded edges, to ellipsoidal in shape, and are set in a groundmass of pyrite carrying both zinc-blende and galena in small amount. It will be remembered that in the chapter on "General Geology" there were described the calcite schists, which are argillaceous schists carrying rhombohedral and ellipsoidal crystals of calcite. The ore-deposit we are now considering is, in fact, the result of the metasomatic replacement of a rock of this character, the zinc having completely replaced the calcite blebs. The significance of this will be discussed later on in this bulletin.⁽⁷⁾ There occurs a variant from this type in the "E" open-cut at the entrance of the Main North drive No. 3 level, Hercules, which, in addition to the blebs of zinc-blende, carries blebs of galena. Here, again, however, the galena, although pure at the centre of the bleb, becomes intimately intergrown with blende at the periphery. In this special case the pronounced rhombohedral or ellipsoidal shape of the blebs is absent, the structure being more of the character of a nearly solid sulphide aggregate of irregularly-shaped patches of galena or zinc-blende.

The pyritic copper deposits at the Hercules Mine are simply a variant from the general type of zinc-lead sulphide deposit already described, the outstanding feature being the marked increase in the amount of pyrite and chalcopyrite relative to the zinc-blende and the galena.

(7) See below, p. 62 *et seq*

The latter mineral is only present in exceedingly small amounts. The pyrite and chalcopyrite, with quite subordinate zinc-blende, occur as seams parallel to the planes of schistosity in a black schist. The relative amounts of sulphide and schist in the ore-body vary within wide limits. Generally zinc is not very noticeable, but occasionally it forms seams an inch or more in thickness, and this is similar in every way to its occurrence in the zinc-lead sulphide deposits.

The silver and gold contents of the ores in different parts of the field vary within wide limits. The exact mode of occurrence of these metals in the ore is at present unknown, and no research has been undertaken to ascertain the mineral or minerals with which either metal is associated. G. A. Waller, in his report on this field in 1902, states (p. 22), *inter alia*, that the gold appears to be present in the zinc-lead sulphide in the metallic state. He also states that the silver is present in the fahl-ore.

Certainly, the fahl-ore raises the silver contents, but it is impossible for that mineral to be responsible for the silver contents of the ore-bodies as a whole. Similarly, it is extremely doubtful whether the gold in the zinc-lead sulphide is wholly in the metallic state.

If the assays from all over the field be examined with the object of discovering whether there is any fixed ratio between, say, the lead and gold values, or zinc and gold, it is found that there is no dependence between these factors whatever. Similarly, in regard to the ratio between the lead, or zinc and silver contents, there is no indication of anything approaching a regular variation.

High gold or silver assay may accompany either a high-lead content or a high-zinc value. The following assays will illustrate these variations:—

Origin of Sample.	Au oz.	Ag oz.	Pb % _o	Zn % _o
"A" Ore-body open-cut 3A level Hercules	0.44	27.3	2.4	43.1
"B" Ore-body 4 level, Hercules	0.12	7.7	9.2	42.7
"C" " 4 " "	0.17	9.6	12.8	40.9
"D" " 3 " "	0.35	21.1	14.7	34.4
"D" " 4 " "	0.55	6.0	22.5	34.4
"D" " 4 " "	0.88	33.0	14.0	35.0
"D" " 4 " "	1.87	17.0	15.0	34.7
"B" " Grant's Rise "	0.142	9.3	1.7	53.2
"B" " " " "	0.3	5.5	2.6	47.2
"E" " 4 level, " "	0.146	6.4	5.4	45.0
No. 8 Bore, at 160' below 4 level, Hercules	0.504	5.0	1.2	55.0
No. 8 Bore, 170' below 4 level, Hercules	0.140	19.1	18.6	44.0
No. 8 Bore, 186' below 4 level, Hercules	0.095	6.4	7.2	46.6
Mt. Read Mine, Shaft	0.162	9.0	7.0	38.4
Mt. Read Mine, Main Adit	0.130	10.1	8.7	31.1
" " " "	0.210	27.2	12.9	32.4

The assay figures given in the above table are from the companies' assay plans, and do not include any ore which showed visible fahl-ore or ruby-silver. Of course, when either of these minerals is present, the silver assay will be high, as illustrated by the following assays of bulk samples:—

Origin of Sample.	Au oz.	Ag oz.	Pb % _o	Zn % _o
Ruby Silver Ore-body 3A level, Hercules .....	.257	34.5	4.6	16.9
Ditto .....	.249	23.8	6.2	25.1
Ditto .....	.26	77.9	5.4	17.4
"F" Ore-body, Hercules .....	.282	70.8	6.8	14.0

The influence of the fahl-ore and ruby-silver on the silver content can be readily seen from these results, but in the preceding table, in which the presence of either of these minerals is not observable, we are at a loss to understand the exact mode of occurrence of the precious metals. As will be seen in a subsequent portion of this bulletin, the increase in depth bears no fixed ratio to any of the metal contents of the ore-bodies, so that the apparent erratic distribution of the precious metals is not due to the influence of that factor.

Finally, therefore, it must be stated that a definite statement on this question of the mode of occurrence of the gold and silver values, although important metallurgically, must be postponed until the necessary investigations are complete.

(b) *Fissure Fillings.*

This type of deposit is of relative insignificance compared with the replacement deposits, both in size and economic importance, and is only described because of its bearing on the important question of genesis.

The minerals present in this class of ore-deposit are as follow:—

Metallic Minerals.—Zinc-blende, galena, pyrite, chalcopryite, and fahl-ore.

Non-metallic Minerals.—Quartz, rhodochrosite, calcite, chlorite, and fluorspar.

All of these minerals are more or less perfectly crystallised. The structure is that which is generally characteristic of a fissure-filling, although crustification is not marked. Drusy cavities occur, and these are lined with well-formed crystals.

The most marked characteristic of these veins is the occurrence of all of the constituent minerals in separate crystalline aggregates. There is little, if any, intergrowth. Thus pure zinc-blende up to 6 inches thick may be obtained, and, similarly, galena. The latter is always well crystallised, and the blende, although always showing crystalline structure, only occasionally shows anything approaching a perfect development of crystal facets. The colour of the blende is always bright amber in these veins.

The fluorspar is green or purple, and has its usual habit.

The fahl-ore is often crystalline, but the writer could observe no well-formed crystals, although these have been reported.

The rhodochrosite is in colour a delicate pink, and has two habits. One is that of complete rhombohedra, and the other is a variety showing marked botryoidal structure.

The quartz often shows crystals lining cavities.

Hand specimens may be obtained showing in one sample all of these minerals. The minerals zinc-blende, galena, fahl-ore, and fluorspar can often be seen intimately associated, although occurring as separate crystal aggregates, which are to some extent intergrown at their edges.

B.—THE GEOLOGY OF THE ORE-DEPOSITS.

(a) *Distribution.*

The geographical distribution of these ore-deposits is indicated in Plate V., which shows the position of the mine workings throughout the portion of the zinc-lead sulphide belt dealt with in this bulletin. It will be seen that they occur in a comparatively narrow belt of country running 16° west of north from Dunne's Blocks to the Ring P.A., and from this latter section running practically due north. The zinc-lead sulphide deposits are confined wholly and solely to this belt.

As regards the relation of the ore-deposits to the several lithological groups it may be stated that they are wholly confined to the Read-Rosebery schists. As a matter of fact their relationship to these schists can be indicated more precisely by stating that they are confined to one particular horizon of these schists. This horizon is approximately 200 feet thick, and is situated at about the central portion of the Read-Rosebery schist group. This is the horizon which is characterised by the presence of calcite schists. An important point to note is the constant association of the zinc-lead sulphide deposits with these calcite schists, while the pyritic copper deposits invariably occur in the "black schists." Thus, in the "A" ore-body in the Hercules, at both the No. 3 and No. 4 levels, where at its southern end it changes in character from a zinc-lead deposit to a pyritic copper one, the transition is accompanied by the appearance of the "black schist" to the exclusion of the calcite schists.

As indicated clearly in a previous portion of this bulletin, these Read-Rosebery schists represent a folded and metamorphosed series of mixed sediments and pyroclastic accumulations. Consequently, any special horizon, if

traced along either the strike or the dip, will be found to undulate through two series of folds, which, as shown previously, now characterise the whole rock series. It therefore follows, if the ore-deposits are confined to one limited horizon of the schists, that they themselves must follow the same undulations. This is actually the case, as will now be fully described under the heading "Structural Features."

(b) *Structural Features.*

As pointed out in describing the mineralogical composition of the zinc-lead sulphide ore-bodies, the most apparent structural feature is the decided banded appearance. This banding is parallel to the planes of schistosity in the schists, and dips to the eastwards at, roughly, 70°.

Such is the general internal structure of a zinc-lead sulphide ore-body, but we must now consider the behaviour of the ore-body as a whole. On examining any portion of an ore-body which can be seen across its whole width, we find with few exceptions that there is a clean hanging-wall and footwall. We see this in the "A," "B," "C," "D," and the footwall portion of the "E" ore-bodies in the Hercules, and also in the zinc-lead ore-body at the Jupiter.

The walls are in these portions of the ore-bodies parallel to the banding in the ore, and therefore to the planes of schistosity in the schists of the hanging-wall and foot-wall.

In the Mt. Read Mine the walls have not been penetrated sufficiently to show this characteristic.

Usually the solid sulphide ends abruptly on either wall, there being no gradual increase in the amount of barren schist. Sometimes the solid ore rests directly against the barren schist-wall, but more often there is a seam of soft pug or selvage up to 1 inch in thickness between the ore and the wall. In certain parts of the ore-bodies this selvage is very pronounced, as, for example, in Spillane's branch of the "E" ore-body, near Spillane's Rise. The selvage is here on both walls, and the sulphide ends abruptly against it, as a general rule; but in places there occur slices of barren schist interlaminated between the solid ore and the selvage. This is illustrated in Plate IX. (Fig. 3). Exactly the same thing can be seen in the "D" ore-body at No. 3 level. The illustration referred to does not represent either of these two occurrences accurately,

but is only designed to illustrate the general type of structure.

This selvage contains some sericite, and occasionally it is replaced by a very thin film of scaly sericite. This is the only occurrence of sericite observed in connection with these ore-deposits.

Occasionally there is a gradual merging into the foot-wall or hanging-wall schist by a decrease in the amount of sulphides present. This can be seen in the footwall of the "E" ore-body at No. 3 level. This, however, is not a characteristic structural feature of the ore-bodies, the clean walls being the usual characteristic.

If an ore-body showing clean walls, such as, for example, the "D" ore-body at the No. 3 level, Hercules, be followed along its strike, the walls will ultimately be found to converge and meet at a point, the ore correspondingly petering right out. This characteristic is shown in Plate IX. (Figs. 2 and 3). There is no gradual diminution of the proportion of sulphides, but the solid ore runs right out to a point. The walls in this type both deviate from their average direction towards each other.

Another type of ending is that which can be seen at the northern end of the "C" ore-body at No. 4 level, and also at the northern end of the "A" ore-body at both the No. 3 and No. 4 levels, Hercules. In this case the clean footwall retains its strike, while the hanging-wall suddenly swings round towards it, and ultimately meets it, thus forming a blunt but rounded end to the ore-body. This can be seen in Plate XIV., which shows the outlines of the ore-bodies at the No. 4 level. That of the "C" ore-body is most marked, and can be seen in the unfilled stopes at its northern end at that level. A variant of this type is seen in the Jupiter Mine, where at the southern end of the ore-body at the No. 2 adit level the footwall suddenly swings round to the hanging-wall, thus again developing the blunt end.

Again, an ore-body when traced along its strike may be found to split up into several portions, each with clean walls, and consisting of solid sulphide, and separated from each other by barren schist. This can be well seen in the "E" ore-body near the footwall at No. 3 level, where, in addition to the two main branches known as Spillane's and Hickey's there are several minor bifurcations. This structure is illustrated in Plate IX. (Fig. 3).

Similarly, when traced in the direction of the dip the ore-body is sometimes split up into two or more portions

by the appearance of barren schist which separates them. Thus, in the Hercules Mine the "B" ore-body at the No. 3 level is split at its northern end into two portions, which have united at the No. 4 level. Similarly, two ore-bodies which appear to be quite distinct deposits at one level may junction either above or below it. Thus the "A" and "C" ore-bodies junction at about the fourth stope above No. 3 level, and the "E" and "B" ore-bodies also join at the third stope above No. 4 level. In the same way the "C" and "D" ore-bodies are quite distinct at the No. 3 level, but at the No. 4 level they have united to form one ore-body.

Returning now to the manner in which the ore-bodies end, by the convergence of their walls and the continuance of the solid sulphide to the end point, there are two general types of structures to indicate. The first of these is illustrated in Plate IX. (Fig. 2). In this case there surrounds the ore-body itself what is termed in the diagram "a low-grade disseminated deposit." This consists of argillaceous or quartzite schists carrying a small amount of mineral distributed as metasomatic replacements along the planes of schistosity. It must be here remarked that it is not possible to find any specimen of schist within the neighbourhood of the ore-bearing horizon, which does not carry some mineral. Often such mineralisation consists merely of pyrite, but at other places both zinc-blende and galena may be present. By the term "low-grade disseminated deposit" is meant such mineralised schist carrying higher lead and zinc values than is found in the schists generally. A typical assay of such a deposit would be:—

Au	Ag	Pb	Zn
oz.	oz.	%	%
0.18	1.0	0.2	2.6

An example of the type is the "D" ore-body at No. 4 level at its northern end, the disseminated deposits being seen in the northern portion of the "D" north drive and in the eastern end of the "D" west crosscut.

The second typical structure taking the place of the ore-body beyond its sudden ending is that illustrated in Plate IX. (Fig. 3). It will be seen that there are three grades of ore indicated in this type, viz.—(1) high-grade ore; (2) low-grade ore; (3) disseminated deposits. The structure is really that of schists replaced along the planes of schistosity by varying amounts of sulphides. Thus, immediately beyond the end of the solid sulphide ore-

body there may be only a very small amount of mineralisation, but when following along the direction of the strike it may merge into a deposit of that type of ore previously described as carrying blebs of zinc-blende in a pyritic groundmass. The number of blebs of zinc may become large enough to constitute a good grade ore. In fact, the amount of zinc and lead sulphide may be so largely increased in patches as to develop lenses of high-grade ore. This typical structure is exemplified at the northern end of the "C" ore-body at No. 4 level, Hercules; the ore at the entrance to the "C" south surface drive is of this character. The following assays from this locality will indicate the general value of these deposits:—

	Au	Ag	Pb	Zn
	oz	oz.	%	%
Disseminated deposit ...	·005	0·5	0·3	6·6
Low-grade ore	trace	0·4	0·5	22·6
High-grade ore	·185	15·0	8·5	19·4

It must be pointed out at this stage of the description of the structural features that up to the present we have only considered that portion of the ore-bearing zone as far east as the footwall portion of the "E" ore-body in the Hercules. The conclusion which would naturally result from a consideration of this portion of the ore-bodies is that they will continue downwards with the general dip of the planes of schistosity, and there is nothing in what we have so far described in this chapter to indicate otherwise. This was the state of affairs after the Hercules Company had driven the No. 4 tunnel and located the "A" and "B" ore-bodies at that level. The No. 5 tunnel was then driven at a depth of 145 feet with the object of intersecting the "A" ore-body. This was not accomplished at the point expected, but at some distance to the eastwards, a pyritic copper formation some 150 feet wide was penetrated. Subsequently No. 6 tunnel was driven to ascertain whether this copper deposit continued down to that depth (200 feet below No. 5 tunnel), with the then surprising result that no ore-body of any kind was penetrated.

Acting on the same assumption, the Mt. Read Company drove a tunnel (the western, or No. 2, adit), with the similar object of penetrating the zinc-lead sulphide ore-body 300 feet below the No. 1 or main adit. The result in this case also was that no ore-body whatsoever was disclosed at that level.

These results upset the preconceived ideas concerning these ore-bodies, and the conclusion was drawn by certain observers that the zinc-lead deposits of the upper levels changed in depth to pyritic copper deposits, to ultimately disappear as greater depth was attained. Subsequent exploratory work in the Hercules Mine, however, proved that this was not an actual fact, and it was established that at one point the zinc-lead sulphide ore-body continued with undiminished value 87 feet below No. 5 level. Although this fact was established, certain other anomalous results were obtained, and the exact structural features of the ore-bodies which could explain all these difficulties could not be ascertained. The writer's investigations have cleared up these difficulties, and the structural features are now quite clear, and the exposition of these will be now proceeded with.

Taking cognisance now of those ore-bodies in the Hercules Mine, which lie to the eastwards of the footwall of the "E" ore-body, it will be most instructive to first study the ore-body known as "F." This was first worked at the surface as the No. 1 ore-body, and an incline shaft was sunk on it down to No. 4 level. Down to that level it was rich, but not very wide. At the No. 4 level, however, it widened considerably, and at its widest point in that level measured 45 feet. This portion has been stoped both north and south of the shaft (at the southern end to the fourth stope). The larger portion of the ore-body is thus seen to continue upwards from the No. 4 level, but to be separated from the ore-body, on which the incline shaft was sunk by barren schist. This latter portion was thus designated as the "footwall branch of the 'F' ore-body." The southern stopes of the "F" ore-body (*i.e.*, those accessible from Robinson's Rise) have been left unfilled, and at the second and third stopes the hanging-wall of the footwall branch can be seen coming down with an easterly dip to flatten at the second stope and turn upwards, thus assuming a westerly dip. This wall continues with this dip to the roof of the south stopes, where immediately above Robinson's Rise it can be seen rolling over like an arch, to again assume an easterly dip. In other words, the clean wall of the ore-body is folded into a syncline and an anticline in this locality. As a matter of fact, the synclinal fold of the wall corresponds exactly with the synclinal folding in the stratification bands seen in the schist at this point separating this "footwall branch" from the remainder of the "F" ore-body.

Returning now to the discussion under the heading "General Geology," of the folds which constitute the most important structural feature of the schists, the reader will find that the syncline and anticline formed by the wall of the "F" ore-body correspond exactly with the syncline and anticline established in connection with the schists.

The "F" ore-body, therefore, is folded in conformity with the folding of the schists. The question immediately arises, "Is this peculiar to the 'F' ore-body? Is this folding characteristic of the ore-bodies as a whole throughout the field?"

The writer is able to give a definite answer to this question without hesitation, as he has definitely established the following facts:—

The ore-bodies are folded, the folds conforming with those which are structural features of the Read-Rosebery schists. Both the Alpha series and Beta series of folds affect the ore-bodies.

We will now use this fact in explaining those structural features yet undescribed, and all those anomalous results which had previously been inexplicable. The reader is referred at this stage (in addition to Plate IX., which he has already been studying) to Plates XII., XIII., XIV., XV., XVI., XVII., which must be examined in connection with this descriptive matter to make it completely intelligible.

At the No. 3 level, Hercules, in the neighbourhood of the Central Mullock Rise, the "E" ore-body is divided into two portions—the footwall and hanging-wall portions—being separated by what has been erroneously termed "intrusive schist." Vertically below this at No. 4 level at the No. 2 crosscut, the "E" ore-body is continuous from footwall to hanging-wall (see Plate XIV.). A few feet north of No. 2 crosscut, however, the schist which separates the footwall from the hanging-wall portions comes down to the main floor level, thus dividing the body of ore known as the "E" ore-body into two portions in exactly the same way as at No. 3 level. On examining the hanging-wall of the footwall branch as it approaches the No. 4 level, it is seen to flatten, and, becoming horizontal where the separating schist reaches the main floor-level, to turn upwards when traced eastwards and assume a westerly dip. This can be well seen in the stopes near McKenzie's Pass, where the ore has fallen away at the third stope from the perfectly flat hanging-wall. The hanging-wall, therefore, here forms

a synclinal fold, and, in fact, this syncline again coincides with the position determined for such a fold in the schists as previously pointed out.⁽⁸⁾ This can be seen in Plate XV., where the syncline is plainly visible. When traced upwards this hanging-wall with the westerly dip cannot be observed to roll over, as was the case in the "F" ore-body. In fact, this hanging-wall portion of the "E" ore-body in places has a westerly dip as a whole, or has an almost vertical footwall. This can be seen in Plates XV., XVI., XVII. It is necessary to account for this departure from the simple arching of the continuous hanging-wall, which would occur if a continuous ore-body were folded.

The explanation is quite simple, as can be seen by reference to Plate IX. (Figs. 6A and 6B). In Fig. 6A is shown at its lower portion a bed of limestone. This bed is continuous on the left of the sketch from top to bottom. On the right, however, is seen the overlapping of argillaceous deposits, thinning out towards C. Above this the limestone thins out to nothing at the point B. This quite common sedimentary structure would result from the raising of the sea-floor, on which limestone or highly calcareous sediments were being deposited with the consequent invasion of other sediments in the form of clays or mud, as far as C. This was followed by a sinking of the sea-floor, which allowed the resumption of the deposition of calcareous sediments to the point B. There next followed a decided rising of the sea-floor, which was responsible for the complete covering of the limestone bed by other sediments.

We have now accounted for the existence of the wedge-shaped bed of limestone, A, B, C.⁽⁹⁾ Fig. 6A shows the position of the two axes at which folding will take place, such folding being caused by the pressure in the direction indicated by the arrow. Fig. 6B shows the structure after the folding has taken place. The wedge A, B, C has been thrown vertically upwards, and the axes of the anticlinal fold placed just to the right of the point C. The continuation of the limestone bed will be found in the folded part of the bed to the right of C. This very accurately reproduces the structure

⁽⁸⁾ See above, p. 20.

⁽⁹⁾ It has been necessary here to anticipate the conclusion arrived at in investigating the genesis of the ore deposits, viz., that the zinc-lead sulphide deposits are metasomatic replacements of a limestone bed rendered schistose by the pressure which caused the folding.

which characterises the hanging-wall portion of the "E" ore-body in the Hercules Mine above the No. 4 level. The upturned wedge can be seen in Plates XV., XVI., XVII., which are actual sections drawn to scale.

It must be pointed out at this stage that the banding in the ore is constant in strike and dip, no matter how the walls are placed. This can be seen in Fig. 1., Plate IX., which shows the banding in the ore in white lines, while the planes of schistosity in the schist are shown as black lines.⁽¹⁰⁾ They are seen to be independent of the walls of the ore-body, although in places coinciding with their direction. In this illustration also can be seen the mode of occurrence of the fissure fillings. They occur in two typical ways. The first is that of fillings in original bedding-planes, which have been forced open at the synclines and anticlines; similar, in fact, to the saddle reefs of Bendigo. This type can be well seen in the syncline in the "F" ore-body in the southern stopes near Robinson's Rise. The second type is that of a filling in fractures which have been opened, sometimes near the walls of the ore-bodies, but sometimes at appreciable distances therefrom. A typical example of this latter type is seen at the footwall of the "E" ore-body at the main cross-cut, No. 4 level, Hercules. This vein carries wonderfully pure blende, galena, and chalcopyrite. The vein carrying blende, galena, and fahl-ore near the eastern end of the western or No. 2 adit, Mt. Read Mine, is an example of such a vein removed from the immediate vicinity of the ore-bodies.

It is clear, therefore, that the hanging-wall portion of the "E" ore-body represents a particular modification of the folded structure. The easterly dip from the anticlinal axis can be seen at the eastern end of No. 2 cross-cut, No. 4 level, and at several other points, as indicated under "General Geology." But one occurrence is worthy of mention: this is in the 5B level, east of Cox's Rise. There occurs here a well-defined "head" in the country dipping along the crosscut to the eastward at about 32°. There is solid ore on the bottom of this "fracture," and mineralised schist above. This has been erroneously termed a fault, but is in reality an original bedding-plane dipping eastwards from the anticlinal axis down to the next syncline (see Plates XV., XVI., and XVII.).

⁽¹⁰⁾ This diagram, in the same way as Figs. 2, 3, 4 and 5 in Plate IX. does not represent an actual occurrence at a particular locality, but is designed to illustrate the general type of occurrences throughout the field.

Another slight modification in this structure occurs in the inverted wedge-shaped portion of the "E" ore-body itself at the second and third stope levels above No. 3 level, just east of the Central Mullock Rise. This is represented in Fig. 4, Plate IX., which is a horizontal section at the third stope. The solid ore runs out to a point at A, while a seam of ore between clean walls runs from B, narrowing down to as far as penetrated to about 1 foot in thickness. A nearly vertical fault occurs here, with just a slight dip eastwards, striking 320° , filled with soft pug. The mass of schist known as the "Lump" fell away from this fracture, having been undermined in the stopping of the ore at the trough of the syncline above the No. 4 level. It is possible to enter the cavity thus formed and examine the fault-plane. Such examination results in the discovery that the movement took place in the direction of the arrow in the diagram, with a slight upward tendency, as indicated by the direction of the fault striæ on the polished fault-plane. It will be observed that the hanging-wall of the ore-body is really a continuation of the direction of the fault-plane, and, in fact, the movement took place also along this plane. Originally, therefore, the points A and B were coincident before the faulting took place, the distance AB now being approximately the amount of "throw." If we imagine the points A and B coincident, the ore would then be narrowed down, going northwards, and would represent simply the apex of the wedge. This is actually what has taken place, the fault, however, being a "pre-lode," one which caused a fault in the limestone bed, which was subsequently replaced by ore.

Similar investigations result in the complete correlation of the folds in the ore-body with those described and plotted in the Read-Rosebery schists. Plate V. is a general plan of the portion of the Read-Rosebery zinc-lead sulphide belt with which this bulletin deals, and shows the relative position of the mine workings, as well as the ore-bodies, in approximate outline. It also shows the positions of the axes of both series of folds. These are the axes which affect both the schists and the ore-bodies, and their economic importance lies in the invaluable help they are in explaining the behaviour of the ore-bodies. This plan must be studied in connection with Plates VII., VI., and VIII., which are, respectively, vertical sections in the direction of the Beta axes at the Hercules and Mt. Read Mines, and a vertical section along the Alpha synclinal trough AB.

The ore-bearing horizon is represented in black. Those portions penetrated by mine workings represent actual ore, while the parts unexplored by such workings may or may not consist of ore, but remain to be investigated by diamond-drilling or otherwise.

The reader is first referred to Plate VI., which shows the ore penetrated in Williams' and Nos. 2, 3, and 4 shafts, dipping downwards to the synclinal axis situated to the west of the main adit. The folds in the ore-body are those necessitated by the positions of the Alpha axes already fixed.⁽¹⁾

Referring now to Plate VII., it will be seen that the portion of the ore-bearing horizon corresponding with that penetrated by the Mt. Read Company's workings has, in its northern extension at the Hercules lease, been removed by denudation. It will also be observed that, whereas the portion immediately to the east thereof at the Hercules is shown by the mine workings to be split up into several portions, yet the corresponding portion of the ore-bearing horizon to the east of the Mt. Read Company's workings is shown as continuous. This is only conjecture, and has to be investigated, and it may quite possibly be found to be split. The important point, however, is the position of the ore-bearing horizon; whether it is split or continuous remains for future exploratory work to prove. The undulations of the ore-bearing horizon are accurately represented as far to the east as the easternmost Alpha axis plotted. Beyond that axis the undulations are purely conjectural. The reader is at this stage referred to Plate IV., which is a vertical cross-section of the Mt. Read field as a whole. The ore-bearing horizon is there shown in black, and the undulations of the Alpha series, excepting those corresponding to Plates XV., XVI., and XVII., are purely hypothetical, but represent the general structure.

If now Plate VIII. be examined, the effect of the Beta folds on the ore-bearing horizon in the different portions of the field can be seen. This section is taken on a synclinal axis, and consequently the ore-body occupies a lower position than if the line of section were the anticlinal axis lying to the west. A study of this section, however, along with that in Plate VI., will enable a mental picture to be formed of the certainly complicated series of undulations affecting the ore-body.

(1) See above, p. 18-21.

A comparison of Plates VI. and VII. will result in the observation that the ore-bodies (as contrasted with the ore-bearing horizon) did not at any time since their formation reach so far westwards at the Hercules as at the Mt. Read Mine. This is in agreement with the observation made previously ⁽¹²⁾ that any one ore-body is not necessarily continuous, either in the direction of strike or dip. That portion of the ore-body exposed in Williams' shaft is the most westerly occurrence known on the field. This westerly extension becomes less going northwards, but may vary from point to point.

Taking this fact into consideration, and referring to Plates VI., VII., VIII., XIII., XIV., XV., XVI., and XVII., it is easy to explain the apparently anomalous results of exploratory work throughout the field.

Plates VI. and VII. explain why the Mt. Read western adit did not penetrate the ore-body. Incidentally it is quite clear why Dunne's western tunnel did not disclose the zinc-lead sulphides.

Plate VIII. shows the relation of the South Hercules eastern adit to the ore-bearing horizon, and it is quite clear why this adit missed the ore-bodies. It was, in fact, driven over the top of the horizon which carries them.

The extension of the replaceable beds westward of the western limit in the South Hercules section begins at the No. 4 tunnel, Hercules. Here the South ore-body was cut.

The reason why the other ore-bodies in the Hercules were not penetrated by this tunnel is quite apparent by examining Plate VIII. in conjunction with Plate XIV.

The reason why neither No. 5 nor No. 6 tunnels penetrated zinc-lead sulphide ore-bodies is seen in Plates VII. and VIII.

It is seen in Plate VII. that the No. 5 tunnel penetrated a pyritic copper deposit, shown in that section as the downward continuation of the "A" ore-body. This will be further discussed in dealing with the genesis of the ore-deposits.⁽¹³⁾

The missing of the ore-bodies by No. 2 tunnel, Hercules, is explained by reference to Plates VIII. and XIV. It will be noted in Plate XIV. that the "F" ore-body approaches very closely to No. 2 tunnel at Robinson's Rise. It will be remembered that this portion of the ore-body is an Alpha anticlinal fold. Plate VIII. shows the Beta syncline plunging the ore-body below No. 2

⁽¹²⁾ See above, p. 48.

⁽¹³⁾ See below, pp. 64, 65.

tunnel. As pointed out previously, this latter section is taken along the Alpha synclinal trough. Although therefore the section shows the ore-body some considerable depth below No. 2 tunnel, the arch of the anticline just passes under that level, rising above it northwards towards the Beta anticlinal crest.

Plate VIII. also shows why the Barlen tunnels did not penetrate ore.

Examining Plate V. in conjunction with Plate VI., it is seen that the zinc-lead sulphide occurring in the Ring P.A. is situated on the limb of the fold corresponding to that disclosed in Nos. 2, 3, and 4 shafts on the Mt. Read Mine. Thus is explained the location of the ore below the Ring P.A. workings in Plate VIII. In the same way, it is apparent that the zinc-lead sulphide ore-body worked at the Jupiter corresponds with the "A," "B," "C," "D," and footwall portion of the "E" ore-bodies at the Hercules. The portion corresponding with the remainder of the Hercules "E" ore-body is thus to the east and below the Jupiter No. 3 adit, as shown in Plate VIII.

Special attention must now be drawn to the results obtained by diamond-drilling on the Hercules. In the light of the explanations given up to this point, together with the details given in Plates XV., XVI., and XVII., the results of these bores can be clearly understood. These results, in fact, afford additional conclusive proof of the correctness of the writer's deductions as to the structural features of the ore-bodies. The positions of these bores are shown in the general plan and cross-section of the Hercules Mine (Plates X. and XI.). The negative results of bores Nos. 1, 3, and 6 need no further explanation than that given above.

No. 2 bore put down from No. 4 level in the direction of No. 2 crosscut at an angle of 50° passed out of solid ore at 97 feet, and from that point only showed mineralised schist. Plate XV. is a vertical section along the line of this bore, and is self-explanatory.

It is easy now to see why No. 5 bore did not penetrate zinc-lead sulphides, for it passed beneath the synclinal trough. Neither did it show the pyritic copper deposits, because that horizon has dipped down below No. 5 level on its way to the Beta synclinal axis situated to the north (see Plate VIII.).

No. 7 bore was put down vertically, and continued in zinc-lead sulphide ore for 127 feet. A cross-section at this bore is not given among those in this bulletin, being,

in the writer's opinion, unnecessary, as it practically reproduces that at No. 2 bore, with, however, the important exception that the trough of the Alpha syncline is lower, this being shown by the depth of the footwall indicated by No. 7 bore, and, in fact, agreeing with the dip down the Beta syncline towards No. 8 bore.

Plate XVI. is a vertical section along No. 8 bore, which was put down at an angle of 70° from the horizontal. It passed through solid ore up to 113 feet, between which point and the 155 feet point low-grade ore of an average assay for the distance of—

Au	Ag	Pb	Zn
oz.	oz.	%	%
·049	2·4	1·8	11·9

was met with. From 155 feet onwards solid zinc-lead sulphide was penetrated, and still continued when boring ceased at 87 feet vertically below No. 5 level. It will be noticed in this section that the "C" ore-body is shown as petering out below the bottom of the "C" winze, which proved it to be narrowing rapidly. The particular portion of the ore-bearing horizon corresponding to the "C" ore-body is shown by dotted lines, continued to No. 8 bore, where ore again makes its appearance in an ore-body petering out upwards. This is the ore-body penetrated by No. 8 bore, after passing through the low-grade disseminated deposit.

No. 8 bore is located practically at the Beta synclinal axis, towards which the whole ore-bearing beds have been dipping from No. 2 bore, or rather from the Beta anticlinal axis situated to the north of No. 4 tunnel. The ore-bearing horizon, therefore, begins to rise from the No. 8 bore northwards to the Beta anticlinal axis situated at Dawson's Rise. At the No. 4 bore it has risen sufficiently to bring the break between the two ore-bodies penetrated by No. 8 bore up to the No. 5 level. No. 4 bore, therefore, which was driven horizontally, passed through mineralised schists for the whole distance, excepting at 105 feet, where it cut the extreme uppermost tip of the lower ore-body, proved by No. 8 bore. It passed just beneath the synclinal trough of the continuation of the ore-body penetrated by the first part of No. 8 bore.

Plates XV., XVI., and XVII. also incidentally explain why the 550 and 700 feet north drive at No. 5 level did not cut the zinc-lead sulphide ore-bodies.

It will thus be seen that the whole of the observed facts are in accordance with the conception of the folded

structure of the ore-bodies along the two series of axes at right-angles to each other. In view of this, and also from the fact that the folding of the ore-bodies can in places be actually seen, there is no doubt whatever that such is the true and all-important structural feature of the ore-bodies.

Now, if a dome (*i.e.*, a mass affected by two series of folds with axes at right-angles) be cut by a horizontal plane, the result is a circular section. If the two anticlines do not possess the same dip, such a horizontal section will be lens-shaped. Thus we see the explanation of the lens-shaped outline of the ore-bodies at the different levels in the mine workings.

The greatest length of any such lenses disclosed up to the present is that of the "A" ore-body in the Hercules, which is 295 feet in length at the No. 4 level, with an average width of about 20 feet. The maximum width shown up to the present is that of the "E" ore-body, which is approximately 100 feet wide at its widest portion. The reader is here referred to Plates XII., XIII., and XIV. for details as to the outlines of the ore-bodies at the Hercules, and to Plate XVIII. for the Mt. Read Mine.

One interesting and important point to note here is the fact that it has been noted at several points in the Hercules Mine that when high values were located at a particular point these pitched northwards. This was seen in Cox's Rise and at other points in the "E" ore-body, and can now be seen at the eastern end of the No. 2 cross-cut, No. 4 level, Hercules, at the extreme hanging-wall of the "E" ore-body, where seams of ore dip north-easterly at a low angle; *i.e.*, they dip easterly, and have a northerly pitch. The explanation of this will be given later.⁽¹⁴⁾

The zinc-lead sulphide ore is split up into blocks by a series of fractures, one set of which is parallel to the banding in the ore. The other set has a flat dip (round about 25°) to the north, *i.e.*, in the direction of the northerly pitch of the ore-bodies in portion of the Hercules.

(3) SECONDARY ORE-DEPOSITS.

There is only one class of deposits to be described under this head. This is the gossan, which in places constitutes the portions of the ore-bodies near the surface. The

⁽¹⁴⁾ See below, p. 65.

gossan has been produced by the effect of atmospheric waters acting on the zinc-lead sulphide deposits.

The mineralogical constitution is as follows:—

Metallic Minerals.—Limonite, pyrolusite, cerussite, smithsonite, and native silver and gold.

Non-Metallic Minerals.—Quartz, barite, and calcite.

The most plentiful constituent is, of course, limonite; the remaining mineral components being subordinate in amount, although in places relatively abundant. Cerussite has its usual habit, and some beautiful clusters of crystals have been obtained. The general association of the minerals is that which is generally characteristic of iron gossans. There is no need to further elaborate this question.

Quartz is insignificant in amount, except locally, where quartz veins and masses originally present in the sulphide ore-body now stand out prominently in the gossanous material.

The amount of the four metals present in the gossan is illustrated by the following typical assays:—

Particulars.	Au. oz.	Ag. oz.	Pb %	Zn %
12,000 tons shipped to Dapto	0·55	21·6	8·04	—
3300 tons sent to Zeehan ...	0·36	25·6	16·20	—
From "A" ore-body	0·60	26·1	5·0	—
Ditto	0·49	16·3	11·0	—
From No. 1 workings	2·50	236·1	—	—
From "E" ore-body, north drive, 3 level	0·387	35·6	4·4	10·9
From "F" lode, 3rd stope level	0·3	20·3	3·1	5·2

The general structural features are shown in Plate IX. (Fig. 5), which shows the manner in which the surface waters have travelled down both the footwall and hanging-wall, and thence penetrated the interior of the ore-body. Isolated masses of undecomposed sulphide remain suspended in the gossan.

The special structural feature of these gossan masses is the occurrence of cavities either within the oxidised portion of the ore-body or in the sulphide immediately

adjacent thereto. Such a cavity is that known as the "Vugh," in the "C" ore-body, above No. 3 level. This was of considerable size, occupying, in fact, the greater portion of the ore-body in this locality. It is not at present visible, as it has been the location of a collapse of ground of considerable dimensions. Other small vughs have been observed at different spots, and, in fact, are quite characteristic of the oxidised portion of the ore-bodies. There is nothing unusual in these occurrences, as such cavities are quite a characteristic feature of zinc-lead replacement deposits in limestone.

One point must be here noted: it is not by any means an invariable rule that this gossan forms the uppermost portion of the ore-bodies, for it happens in a great number of cases that the zinc-lead sulphides occur absolutely unaltered right up to surface.

(4) THE GENESIS OF THE ORE-DEPOSITS.

The discussion of the genetic association of ore-deposits with igneous intrusions has been fully entered into by the writer in the bulletin on the Jukes-Darwin field⁽¹⁵⁾, and the conclusion there arrived at is that the ore-deposits of Tasmania are genetically associated with one or other of two granitic irruptions widely separated as to age. One of these—the porphyroid granite—is Pre-Silurian in age, while the other is the more common granite of Devonian age. In certain cases it is still undecided as to which granitic intrusion the ore-deposits are to be genetically assigned, but in other cases there is no doubt whatever.

In the Mt. Read mining field, however, there is not much room for doubt. In close proximity to the zinc-lead sulphide belt (within 3 miles, in fact) there occurs the tinfield of North Dundas, the ore-deposits of which have been conclusively established to be genetically associated with the Devonian granitic intrusions which occur throughout that field.⁽¹⁶⁾ In the country intervening between the nearest known tin deposit and the zinc-lead sulphide belt there occur a series of lode-formations containing some of the minerals characteristic of the tin-ore deposits, such as pyrrhotite, arsenopyrite, &c., and which are characterised by the presence of galena, tetrahedrite, or fahl-ore, and some zinc-blende. These deposits recur

⁽¹⁵⁾ Geological Survey, Tasmania, Bulletin No. 16, pp. 86-106.

⁽¹⁶⁾ Described by L. K. Ward, in Geol. Sur. of Tas., Bulletin No. 6.

constantly to within a few chains of the zinc-lead sulphide deposits, which themselves contain the same minerals—zinc-blende, galena, and fahl-ore—and, in addition, the mineral fluorite, which is characteristic of the tin ore deposits.

There is every reason, therefore, to regard the ore-bearing solutions as having been derived from the same igneous source as those responsible for the tin deposits; in fact, these solutions and the granitic rocks of the tin-fields of North Dundas and Parson's Hood have both been derived by differentiation from a large injected mass of igneous material, which contained at the time of its irruption the component parts of both. *The ore-bearing solutions from such a source were ascending solutions.*

Having now decided the original source of the solutions containing the mineral components, the next step is to see by what means such solutions could have reached the positions in which the ore-bodies for which they are responsible are now found. It is simply necessary, therefore, to revert to the portion of the chapter on "General Geology," which describes the Read-Rosebery schists as having been derived from original sediments and pyroclastic accumulations, which have been folded, and rendered schistose. In particular, the calcareous beds have been converted into schistose calcareous rocks, with the banding parallel to, and continuous with, the planes of schistosity in the surrounding schists.⁽¹⁷⁾ The reader is now referred to Plate IX. (Fig. 1), which shows the general structure of the folded calcareous beds (black) and the planes of schistosity. It is quite clear from this diagram that the planes of schistosity being such a continuous feature have in all probability played the part of the main "feeders" of the ore-bearing solutions. It is quite plain, also, that the bedding-planes, too, have provided important channels for the passage of the ore-bearing solutions. It is also quite conceivable that the solutions travelling up the schist-planes met a bed in which these planes were less pronounced, and so were forced to move along the bedding-planes. In fact, in general, it may be stated that an original bedding-plane will provide a freer passage for solutions, once they have reached it, than any plane of schistosity. Thus we can understand why such a great number of the original bedding-planes are filled with "pug," which simply is the result of the alteration effected by such solutions on the rockwalls.

⁽¹⁷⁾ This is described on p. 11 *et seq.*

We have, therefore, the solutions rising upwards along the schist-planes being concentrated into the channels along the old bedding-planes. If, now, they arrive at the two bedding-planes separating a schistose calcareous bed from its neighbours, they will interact on walls of argillaceous schist producing the "selvage" or "pug" seam, which now separates the ore from the clean wall (see Plate IX., Fig. 3). From these bedding-plane channels the solutions escape to the interior of the calcareous bed *via* the schist-planes, and thus thoroughly permeate it. Immediately the solutions come into contact with the calcareous material a series of chemical reactions take place, resulting in the deposition of its contents in the form of definite mineral species. The unreplaced splices of schist between the solid ore and the selvage, as shown in Plate IX. (Fig. 3), are thus the result of the solutions, which circulated around them, not being able to chemically react with them to enable such a mineral species to crystallise.

We will now shortly examine the nature of these reactions. In the first place, it must be noted that it has been established⁽¹⁸⁾ that zinc-lead deposits in general are derived from solutions at intermediate depths at a moderate temperature of from 150° C. to 300° C., and relatively high pressure. Such solutions are acid in character, and immediately they come in contact with calcium carbonate the acid is neutralised. Immediately the solution becomes neutral the zinc begins to crystallise as zinc-sulphide or zinc-blende, for, with the decrease in pressure, the sulphide and zinc radicals cannot remain together in solution under neutral or alkaline conditions. This deposition taking place at innumerable points is, in fact, a metasomatic replacement of the calcareous schists, the neutralisation and crystallisation taking place molecule by molecule, in this case by a liquid and solid in contact.

Consequent upon the decrease in pressure and by interaction with the calcium carbonate, the lead crystallises as galena. This agrees with the deduction which results from the examination of the relation of the zinc-blende to the galena, that the former mineral was often the first to crystallise, although the crystallisation was mostly simultaneous.

It is thus seen that the character of the ore-deposit will depend on the composition of the replaced material, and

(18) The reader is referred for information on this point to "Mineral Deposits," by Waldemar Lindgren (McGraw Hill Book Co., 1913), p. 188, and p. 513 *et seq.*

therefore the origin of the banded structure of the ore-body is quite clear, since, as previously pointed out, the calcareous bed has been converted into a schist consisting of bands of varying composition.⁽¹⁹⁾ It is now also apparent why the values in the ore-bodies show a tendency at times to pitch northwards. This has been observed only where the ore-body is dipping northwards towards a synclinal axis, as in the Hercules Mine, as far north as the No. 8 bore. The variations in the original sedimentary deposit would thus dip northwards, and the northerly pitch of the values in these ore-bodies is the direct result of this. Thus, there are two directions of variation in values—one due to the banding of metamorphic origin; the other due to original variations in the sediments, which were too pronounced to be obliterated by the readjustment accompanying metamorphism.

The constant association of the "black schist" with the pyritic copper deposits unerringly points to the fact that the character of these deposits has been determined by the selective action of this variety of schist on the ore-bearing solutions. The exact chemical reactions by which this is brought about are obscure, and need further investigation, but it is certainly a striking fact that this variety of schist wherever it occurs on the West Coast is characterised by the presence of copper. As stated previously, the southern portion of the "A" ore-body at both the Nos. 3 and 4 levels consists of predominant copper constituents in that schist. At the 5B level this "A" ore-body is seen to be split up into two portions—a copper deposit in the black schist, and a zinc-lead deposit which is narrowing rapidly. Plate XV. shows this change, and also the complete disappearance of the zinc-lead portion some depth below 5B level. The copper portion, however, continues downwards to No. 5 level.

The ore-bodies, therefore, are metasomatic replacements of the schists, the varying character of the ores being the result of the varying character of the schists which have been replaced. There is really no doubt that the ore-bodies are metasomatic replacements, but to satisfy the captious critic, the following criteria are enumerated:—

- (1) The presence of complete crystals in the country-rock.
- (2) Complete absence of crustification.
- (3) The preservation of the banded schist structure.
- (4) The presence of unsupported masses of schist or "horses" in the ore-bodies.

⁽¹⁹⁾ See above, p. 15.

- (5) The filling of cavities by quartz and well-crystallised galena and blende within the ore-bodies. These cavities have been caused by the replacement of the original rock by minerals of less molecular volume, such as galena and blende.

Reference to Plate IX. (Fig. 1) will clearly show how the fissure-fillings have originated from the filling of cavities at the bedding-planes and other points by the ore-bearing solutions. In these fissures, such solutions have been under conditions which allowed of the free and uninterrupted crystallisation of the several mineral species, thus differing in a marked manner from the simultaneous crystallisation at innumerable points in the replacement deposits.

(5) THE PERSISTENCY OF THE ZINC-LEAD SULPHIDE ORE-BODIES.

It has been definitely stated by several investigators that the zinc-lead sulphides were the result of the secondary enrichment of pyritic copper deposits carrying small proportions of zinc and lead. This assumption was the direct outcome of the conclusion that the ore-bodies coincided wholly with the strike and dip of the schist-planes, a conclusion proved in the preceding pages to have been erroneous. A glance at Plates XV. and VII. will show why on the above assumption it was deduced that at the No. 5 level the zinc-lead sulphides gave place to copper deposits. There is no need to further explain why this is quite erroneous, after what has been fully explained up to this point.

In fact, there is no evidence whatever to indicate a secondary origin of the zinc-lead sulphides; the evidence is all in the other direction. The greatest depth of gossan at any point is 50 feet from the surface, which is insignificant compared with the total depth at which the zinc-lead sulphides have been found, although, of course, a considerable depth of such gossan may have been removed by denudation. Even in the latter case the folded structure of the ore-bodies militates against the amount of such gossan so removed being sufficient to account for the great depth of zinc-lead sulphides.

Again, if the zinc-lead sulphides are the result of secondary enrichment, we should expect the three metals, silver, lead, and zinc, to show in their vertical distribution the well-established order of their precipitation from a solution. This order is as follows:—(1) Silver, (2) lead, (3) zinc.

The following table shows the assays of bulk parcels of ore from various levels in the Hercules Mine:—

No. of level.	Height above Datum in feet.	" A " Ore-body.				" B " Ore-body.				" D " Ore-body.				" E " Ore-body.							
		Au oz.	Ag oz.	Pb %	Zn %	Au oz.	Ag oz.	Pb %	Zn %	Au oz.	Ag oz.	Pb %	Zn %	Au oz.	Ag oz.	Pb %	Zn %				
3 A	330	·44	27·3	2·4	43·1	...	...	...	...	...	...	...	...	·139	8·8	8·7	32·5
3	280	·180	10·3	10·3	31·2	·174	22·4	7·9	28·2	·209	13·9	11·1	35·7	·165	10·8	10·4	34·1				
4	230	·202	10·8	9·2	33·6	·136	8·5	9·4	34·0	·55	14·9	17·2	34·2	·143	8·7	8·9	36·5				
5 B	180	·189	9·8	8·9	39·6	Average of 10 feet of 2, 7 and 8 bores at this level												·109	6·6	5·0	32·6
5 A	130	Average of 10 feet of 7 and 8 bores at this level												·319	15·5	10·6	39·9				
5	87	Average for 43 feet below No. 5 level in 8 bore												·183	10·8	9·3	43·5				
		Average of last 44 feet (vertical), proved by 8 bore												·157	9·0	11·5	29·1				

This table is based on the assay figures of the Hercules Company of the ore as stoped in the various workings from 1907 to 1913 inclusive. They therefore represent a fair range of the values.

It will thus be seen that none of the metallic components show any marked decrease or increase as depth is gained.

It is significant that it is possible to obtain bulk samples having identically the same assay from the surface, and at a point 330 feet vertically below:—

	Au. oz.	Ag oz.	Pb %	Zn %
Ore from "A" ore-body in Gillespie's open cut, 3A level	440	27·3	2·4	43·1
Ore from No. 8 bore, near its end	840	20·8	15·0	45·6

Such a state of things could not possibly exist if the zinc-lead sulphides were the result of secondary enrichment.

The change in values encountered down Cox's Rise has been referred to in support of the assertion of secondary enrichment from pyritic copper deposits. Here are the figures given in descending order from No. 4 to 5B level (46 feet):—

Depth in Feet below 4 Level.	Au oz.	Ag oz.	Pb %	Zn %	Cu %
0 - 10	·148	8·2	9·8	39·0	0·3
10 - 20	·167	6·6	8·8	38·2	0·4
20 - 30	·115	6·0	7·6	37·6	1·2
30 - 40	·122	4·0	3·3	31·3	2·2
40 - 45	·155	3·3	2·7	24·6	2·3

These figures certainly show a decrease in the lead and zinc contents, with increase in depth, and a corresponding increase in the copper contents. It must be remembered, however, that the ore-body is pitching northwards at Cox's Rise, so that in descending vertically at that point the poor southern end of the ore-body is approached in depth. This will explain the decrease in values. The increase in copper contents is quite a coincidence, as rela-

tively high copper assays can be obtained from different parts of the mine, as for example, at the "E" north quarry at No. 3 level, where copper becomes quite appreciable in amount. As a matter of fact, the continuance of the high-grade zinc-lead sulphides below No. 5B level, proved by Nos. 2, 7, and 8 bores, demonstrates the unreliability of the deduction drawn from the values down Cox's Rise.

The falsity of the deduction drawn from the values in Cox's Rise is illustrated by the following copper values shown in No. 8 bore:—

Distance down Bore, in Feet.	Au oz.	Ag oz.	Pb %	Zn %	Cu %
7	·065	5·0	1·0	24·0	0·15
19	·126	7·5	6·2	26·0	0·30
42	·144	13·9	8·2	33·0	0·20
62	·150	8·6	5·2	18·0	0·10
81	·124	8·3	7·2	34·0	0·30
100	·118	6·0	7·8	32·6	0·20
156	·178	8·1	7·5	40·0	0·25
203	·148	11·0	10·7	34·4	0·10
220	·093	4·9	14·0	29·2	0·15
231	·088	6·2	6·9	14·5	trace
235	·840	20·8	15·0	45·6	1·10
239	·610	17·2	23·0	37·0	0·80
245	·106	15·7	15·0	39·2	0·90

It is quite a striking fact also that most of the stopes in the Hercules Mine are remarkably dry. If descending waters were responsible for the formation of the zinc-lead sulphides, why are they not present now, as it must be admitted that there is quite sufficient rainfall to continue the circulation, which, it is contended, must have existed to produce the secondary enrichment?

The minerals tetrahedrite and pyrargyrite are generally regarded as of secondary origin, but the occurrences in this field are undoubtedly primary, as is clearly shown by the intimate association of the former mineral with fluorite, which is certainly primary.

The assertion, therefore, that the zinc-lead sulphide deposits changed in depth to pyritic copper deposits has been disproved.

The zinc-lead sulphides may thus be regarded as being now in the same form, and in exactly the same state, as they were originally deposited by ascending solutions.

It has been established that the formation of the zinc-lead sulphide deposits depends on the existence of limestone beds. These are confined to one narrow horizon of about 200 feet thick in the Read-Rosebery schists, and this horizon must be followed throughout the undulations, which affect the whole of these schists. Thus, the horizon ultimately reaches sea-level. Whether the zinc-lead sulphides will persist to this depth depends on two factors:

(1) The distance from the magmatic hearth from which the mineralising solutions originated. The vertical range from the highest occurrence of the zinc-lead sulphides to sea-level is 2900 feet. The range given by Lindgren for the general class of deposits to which these belong is 5000 feet. It is quite justifiable to presume, therefore, that the ore-bearing solutions were effective to sea-level and below. This is rendered all the more probable when one remembers that the tin deposits (which belong to the zone intervening between this and the granitic reservoir) are horizontally distant about $2\frac{1}{2}$ miles, or 13,000 feet. As a matter of fact, at the Tasmanian Copper Mining Company's property at Rosebery, the zinc-lead sulphides have been proved by boring practically down to sea-level, and they are known at all elevations between this and 2900 feet.

(2) Being assured of the presence of the mineralising solutions, the other essential is the presence of the replaceable calcareous beds. When we take cognisance of the fact that these zinc-lead sulphides are known to occur at intervals for a length of 7 miles and a known width (*i.e.*, the distance between the lines drawn through the most westerly and easterly observed occurrences, parallel to the Alpha axes) of 1 mile, confidence is certainly engendered that the proportion of calcareous beds is large. These are known not to be necessarily continuous, but they probably recur at very frequent intervals. The zinc-lead sulphides may, therefore be expected to occur at any portion of this undulating ore-bearing horizon.

Taking all these facts into consideration, therefore, it may be stated that the zinc-lead sulphides may be confidently expected to be more or less continuous to sea-level, and below.

VI.—THE DIAMOND-DRILLING SCHEME.

To definitely establish what portions of this ore-bearing horizon actually carry zinc-lead sulphide deposits a scheme of exploratory work of considerable magnitude is essential. It is the intention in this chapter to briefly indicate the lines on which such exploration should be carried out. In a matter of this kind, however, it must be realised that any outlined scheme must be subjected to modifications rendered necessary as the result of knowledge gained during its progress.

It must be understood, therefore, that although the following scheme of exploration is complete in itself, and is based on the deductions made in this investigation as to the genesis and structural features of the ore-deposits, yet, to obtain the best results, the whole work must be in charge of a man thoroughly conversant with all the details of the general and economic geology of the field, who can thus adjust the details of the work according as developments necessitate it. It may not be advisable to put all the bores down that are indicated, and the direction of the boring operations must be guided by his judgment in this connection.

To systematise the scheme it is proposed to number the bores successively from south to north. They are to be numbered 1A, 2A, 3A, &c., to avoid confusion with the existing Hercules bores, which are numbered 1, 2, 3, &c.

There has been no attempt in deciding on this scheme to systematically explore any particular property. The deposits have been regarded as a whole, and artificial boundaries have been ignored.

When these explorations have been completed, the necessary data will be available on which to base the laying out of works designed to extract the ore from the deposits as a whole.

The general rule may be adopted of locating the bores at the crests of the anticlinal folds, as the ore-bearing horizon is nearer the surface at these points. This rule has been followed in fixing the bore-sites indicated on Plate V., which will now be briefly discussed.

Bores Nos. 1A to 6A are designed to test the ore-bearing horizon eastwards of the occurrence of ore at Dunn's No. 1 shaft. They will have to be from 700 to 800 feet in depth. They are vertical bores.

Bores Nos. 7A to 14A will serve to test the ore-bearing horizon east of the Mt. Read Company's ore-body; they are all vertical. Nos. 7A and 8A ought to penetrate the ore-bearing horizon at about 500 feet, while Nos. 10A and 11A will need to be slightly deeper. No. 9A should cut the horizon within 100 feet. No. 13A will probably cut the ore-body between 120 and 140 feet; No. 12A at about 450; and No. 14A in the neighbourhood of 500 feet. Bore 16A should penetrate the ore-bearing horizon at about 100 feet; bore 15A at about 700 feet; and 17A at 850 feet.

It is a matter of convenience for working which will decide whether bores 18A and 19A will be put down from the South Hercules eastern adit or from the surface about 100 feet above. These two bores should penetrate the ore-bearing beds at approximately 900 feet from the surface.

Bore No. 20A, in all probability, need not be deeper than 100 feet.

No. 21A must be located in the No. 4 tunnel, Hercules, and should be vertical. This should give results at from 50 to 100 feet. The results from this bore will decide the exact angle at which 22A should be directed to the eastwards. Probably 45 degrees will be sufficient; it should penetrate the continuation of any ore proved in 21A at from 150 to 200 feet.

Bore 23A is intended to be put down from the surface, and should reach the ore-bearing horizon between 150 and 200 feet.

No. 24A is placed at the entrance to the "F" north drive from the No. 2 tunnel. It should be bored at an angle of 70 degrees. It should enter ore in a few feet.

Bore 25A is a vertical one. It should give results at from 50 to 60 feet.

No. 26A is a vertical bore located in Barlen's No. 3 adit. It should enter the ore-bearing horizon between 50 and 100 feet; 27A is also in Barlen's No. 3 tunnel, and should enter the ore-bearing zone at a somewhat greater depth.

Nos. 28A and 29A are horizontal or slightly inclined, and are intended to locate the ore-bearing horizon on its downward plunge to the Ring P.A. If no ore is encountered up to 1000 feet, then the fault shown in Plate VIII. probably exists.

Bores Nos. 32A to 50A are all vertical, but, owing to the fact that it has not been possible to plot the Beta folds in this part of the field, no indication can be given as to the probable depths of such bores. It will be advisable, therefore, to put these bores down consecutively from 32A

northwards to 50A, so that estimates of the probable depth of the next succeeding bore can be made.

No. 51A should penetrate the ore-bearing horizon between 350 and 400 feet vertically; 52A at from 250 to 300 feet; while 53A ought to prove ore within 50 feet, this bore being put down from the No. 3 adit level.

It is impossible to give any idea of the requisite depths of bores 54A to 57A, as here again we do not know the position of the Beta axes. They should be put down consecutively from south to north.

[The following text is extremely faint and largely illegible, appearing to be bleed-through from the reverse side of the page. It contains several paragraphs of text, including names like 'Mr. Head' and 'T. H. Moore', and mentions of 'the company' and 'the mine'. It is not transcribed here due to its illegibility.]

VII.—HISTORY OF MINING ON THE FIELD.

Access to this field was first effected in 1877 by Mr. T. B. Moore, who cut the first track from Zeehan into this district, which incidentally passed over the summit of Mt. Read. He named that mountain after Mr. R. C. Read, of "Redlands," Plenty, near New Norfolk.

Early in 1891 the outcrop of the Mt. Read Mining Company's ore-body was discovered, and an 80-acre section was pegged on the 17th March of that year by A. E. Conliffe, for Messrs. Cowburn and West. This was the first section pegged on this field.

In June, 1891, Woolans and Rooke found alluvial gold in the Ring River, and the terraces up Baker's and Tippeary Creeks were then worked for gold. Following these creeks to their source in the endeavour to locate the origin of the alluvial gold, George Johnston and Charlie Allen discovered a considerable deposit of detrital gold at the outcrop of the ore-body on the section pegged by Conliffe. They worked this deposit until Allen sold out to Goldie, who built the Mt. Read Hotel. A two-head battery was subsequently erected, and the gossan was treated for its gold contents.

Subsequent to the pegging of the 80-acres section a company was formed to open up the ore-deposit, and was termed the *Mt. Reid* Mining Company. This was due to the fact that in the absence of a chart showing Mt. Read with the name given it by T. B. Moore, the Scotchmen concerned in the flotation of the company assumed that *Reid* must be the correct spelling. This spelling has been persisted in, in connection with this mine, up to a few years ago, when, on the registration of the present company owning that property, it was given its correct name, viz., Mt. Read.

Some time after its formation this company became aware that Johnstone and Goldie were treating the gossan for its gold contents, and legal proceedings were instituted, which ultimately resulted in the compulsion of the latter to cease operations about the year 1901.

Immediately following the discovery of free gold on the Mt. Read lease by Johnston and Allen, the neighbouring country was pegged in 10-acre sections, including that portion now included in the Hercules consolidated lease. One of these, an 8-acre block, was pegged by H. Evenden in the name of Mr. Percy Hart. Mr. J. Moyle informed the

writer that Evenden showed him a small vein of low-grade zinc-lead sulphide he had located on the surface of this section at this time, but it was deemed unpayable, and received no further notice.

In December, 1894, Mr. J. Will discovered an outcrop of gossan about 1 inch wide near the present No. 1 tunnel, Hercules. This was on the 8-acre section indicated above as charted in the name of Percy Hart. Mr. J. Will was at that time prospecting on behalf of the Mole Creek Prospecting Association, who, however, decided not to spend any money on this discovery. A few speculators in Launceston, however, decided to go and examine the occurrence. That visit resulted in Mr. Will being instructed to open up the seam. The first shot put in disclosed 2 feet of gossan, assaying 60 per cent. lead, 22 ozs. gold, and 365 ozs. silver per ton. Immediately proceeding to Launceston, Mr. Will became aware that all the neighbouring sections, excepting that held by Barlen, had become vacant owing to non-payment of rent. These sections were all secured by the syndicate, and a small amount of capital being subscribed, work proceeded on the gossan outcrop. Several parcels of exceptionally rich gossan were then got out. Beneath the gossan was found high-grade zinc-lead sulphide, assaying 2 ozs. gold and 68 ozs. silver per ton, several parcels of which were packed over the track to Dundas.

The incline shaft sunk on this ore-body reached No. 4 level, and then the No. 2 tunnel was driven, without, however, cutting the ore-body as expected. At this time Gillespie found a gossan outcrop at what is now Gillespie's open-cut. This was the "A" ore-body, and No. 3 tunnel was driven to cut it 50 feet below.

J. R. Booth was in charge of the work on the Hercules at this time, and Mr. G. P. Sinclair had succeeded Mr. A. B. Kitchener in directing the operations on the Mt. Read Mine, which had been taken over by an English company. At this time also work was started on the surrounding sections as far north as the Jupiter, and a veritable boom set in.

Subsequent work on the Hercules disclosed further ore-bodies such as the "A," "B," "C," and No. 4 tunnel was driven, while the Mt. Read ore-body was being exploited by open-cut workings and shallow shafts.

Mr. G. P. Sinclair was succeeded at the Mt. Read Mine by Mr. Luke Williams in 1898, while Mr. J. R. Booth retained the management of the Hercules until the com-

pletion of the No. 5 tunnel, when Mr. S. W. Thow was commissioned to report on the property, under the impression that the pyritic copper deposit encountered in that tunnel indicated the transition of the mine into a copper proposition. Subsequently Thow took charge in October, 1900.

In the meantime the Ring P.A. was opened up, and was ultimately purchased by the Tasmanian Copper Company of Rosebery in 1906, and stoping of copper ore continued up to 1907. Work at the Jupiter and North Jupiter was discontinued about the year 1896, owing to the discovery of only insignificant copper deposits.

The Barlen tunnels and the South Hercules eastern adit had also been driven at this time, with disappointing results.

The first output of ore on a large scale from the field was in 1900, when the Hercules Haulage had been completed and connected to the North-East Dundas tramway, which was completed at about the end of 1899. In that year the Hercules Company started sending out lead and zinc ore, and the Mt. Read Company also raised sulphide ore. The latter company continued sending out sulphide until 1901, when the last parcel from that mine was sent away. Having spent a considerable sum of money in surveying and clearing a haulage line from the North-East Dundas tramway terminus to its mine, the company ceased active operations, and Mr. Luke Williams retired from the management, which has since been held by Mr. J. Moyle.

Thow started the driving of the No. 6 tunnel, and proceeded to tear out the gossan and the high-grade sulphide, which was sold under different tariffs to many buyers, including the Tasmanian Smelting Company at Zeehan.

The output of ore from the Hercules continued until in 1905 the metal market became so low that an effort was made to reduce the miners' wages. This resulted in a strike which lasted from February, 1905, to December, 1906.

In 1905 Mr. H. Worsley discovered zinc-lead sulphides on the old North Jupiter lease, and acquired the present consolidated lease. Work on this section has continued more or less intermittently up to the present time.

Operations were renewed at the Hercules Mine in December, 1906, under the present manager, Mr. C. H. Moxon. Contracts for the supply of lead ore were entered into with the Tasmanian Smelting Company, and the zinc ore was

sold to several German firms. These contracts continued, with several interruptions due to strikes, &c., at the smelters, until the 25th August, 1909, when the Zeehan Smelters shut down for the reason that they had been run at a loss.

During this period the Mt. Read western adit had been driven with very disappointing results, and since that date no important work has been done on that mine. During the same period also boring operations on several sections in the vicinity of the Hercules were carried out by the Tasmanian Smelting Company and the Tri-metallic Syndicate (now the Tasmanian Metals Extraction Co.) with negative results.

An important event in the history of the Hercules Mine was the finding of the " E " ore-body in 1908.

The output of zinc ore alone was continued at the Hercules until, as the result of the recommendations of the Select Committee appointed by Parliament, the Zeehan Smelters resumed operations in July, 1911. The delivery of sulphide ore to the smelters continued until October, 1913, when the Zeehan Smelters finally ceased operations. Since that date there has been no output from the Hercules Mine, and only a handful of men were retained to carry out diamond-drilling operations.

This final closing of the Zeehan Smelters was the result of the failure to float in London a new company designed to merge the interests of the Tasmanian Smelting Company, the Hercules Gold and Silver Mining Company, and the Primrose Company into one organisation. This was expected to eventuate in 1913, but failed to do so.

A complete change in the directorship of the Hercules Company was effected in the year 1913.

In the year 1913 also zinc-lead sulphide was disclosed on the Ring P.A. section in a trench near the Mt. Read-Williamsford track. Subsequent work undertaken by Mr. A. D. Sligo showed that an important body of zinc-lead sulphide existed at this point, where it had previously not been suspected.

Between October, 1913, and March, 1914, the results of diamond-drilling disclosed zinc-lead sulphide at considerable depths below No. 4 level on the Hercules.

Continued attempts to bring about an amalgamation of interests were being made up to the time of the outbreak of the European war, but were unsuccessful.

At present the whole of the mines in this field are absolutely idle.

VIII.—THE MINING PROPERTIES.

(1)—THE HERCULES GOLD AND SILVER MINING COMPANY.

This mine consists of one consolidated lease, 3808-m, 146 acres in area.

The history of the mine has been described in a previous chapter, from which it will be seen that it has had rather an eventful career, its troubles having culminated in the present idleness. The exact causes of this will be specially dealt with in the third of the series of bulletins dealing with the zinc-lead sulphide belt.

The total capital subscribed up to the present date is £39,050, and dividends to the amount of £36,323 9s. 3d. have been paid.

There is no necessity to describe the mine workings in detail, as they are shown in plan in Plate X., and as a vertical projection in Plate XI. These two plates will give all the necessary information. The following are total lengths of all workings:—

	Feet.
Drives (now open)	6732
Crosscuts	6434
Rises and winzes	2912
Bore-holes	1180
Total	17,258

The present lease also includes the section originally held by the East Hercules Company, Barlen's section, and the North Hercules section.

The workings have demonstrated the existence of the following ore-bodies:—"A," "B," "C," "D," "E," "F," South, Ruby-silver, Baryta, and Antimonial. These are all shown in Plates XII., XIII., and XIV., which are plans of the Nos. 3A, 3, and 4 levels. The outlines of the ore-bodies as at present demonstrated are shown in these plans, and it is unnecessary to go into further descriptions in this connection, as all essential details have been given in the chapter on "Economic Geology." In addition Plates XV., XVI., and XVII. give full details in vertical sections.

The following details as to area and cubical capacity of the stopes on the various ore-bodies will give additional information as to the size and extent of the ore-bodies.

These figures are those given by Mr. C. H. Moxon, and only refer to work done under his management since the beginning of 1907:—

Ore-body.	Level.	No. of Stope.	Length in Feet.	Width in Feet.	Area Sq. Feet.	Cub. Cap. Cub. Feet.
" B "	3	Main	77	20	1540	11,550
"	"	1st	68	21	1428	10,710
"	"	2nd	48	19	912	6840
" E "	"	Main	170	47	7990	59,925
"	"	1st	99½	58	5771	43,282
"	"	2nd	73	48	3504	26,280
"	"	3rd	41	22½	922½	6919
" A "	4	3rd	36	18	650	4860
"	"	4th	41	15½	635½	4796
"	"	5th	36	17	612	4590
" B "	"	Main	153	35	5355	40,162
" E "	"	Main	276	56	15,456	115,920
"	"	1st	255	62	15,810	118,575
"	"	2nd	252	50	12,600	94,500
"	"	3rd	229	48	10,992	82,440
"	"	4th	219	40	8750	65,525
"	"	5th	210	36	7560	56,700
"	"	6th	153	37	5661	42,457
" F "	4	2nd	59	28	16,152	12,390
"	"	3rd	59	26	1534	11,505
"	"	4th	67	16½	1105½	8291
"	"	5th	30	14½	435	3262
"	"	6th	17	6	102	765

The following table shows the total output up to date from the various ore-bodies in this mine:—

Ore-body.	3 Level & above.		Bet. 3 & 4 Levels.		Total.
	Gossan.	Zn-Pb Sulphide.	Gossan.	Zn-Pb Sulphide.	
" A "	5843	1646	39	5457	12,985
" B " .....	...	4352	...	17,693	22,045
" C "	4247	2560	2270	15,729	24,796
" D " .....	...	1560	...	10,319	11,879
" E "	1828	16,884	...	66,903	85,615
" F "	153	1415	67	17,029	18,664
South	429	2639	...	2971	6039
Grand Total.	...	...	...	...	182,023

Such being the past achievements of this mine, it is now necessary to examine its prospects for the future.

We will first deal with the amount of ore available above No. 4 level. Examining Plates XII., XIII., and XIV., which show the outlines of the ore-bodies in conjunction with Plates XV., XVI., and XVII., which are vertical sections, we notice the following points:—

- (1) The proportion of the walls shown as assumed is small when compared with the length actually visible, or proved, and may in fact be regarded as practically correct. We can therefore accept the length and average width as correct.
- (2) The details of outline up to 3A level are very complete, but are less so at that level. In fact, no outlines above 3A level are available, and must be assumed, with, however, so great a probability for certain distances as to amount to certainty, as seen by comparing the figures given in the table below with Plate XII.
- (3) The greatest amount of assumption as to the outlines of the ore-bodies is in the case of the southern end of the "C" ore-body at No. 4 level. The presence of this portion of the "C" ore-body at this level only becomes apparent on placing the plan showing the outlines at 3 level over the 4 level. The portion assumed at 4 level is placed below the proved portion of "C" in the level 50 feet above. This portion of 4 level is virgin ground, and is destined to provide a considerable tonnage of ore. In fact, at Polan's Pass at the second stope solid sulphide can be seen continuing strongly in this direction.

The following table shows the average dimensions of the various ore-bodies between the several levels and the tons of ore they originally contained, reckoning 10 cubic feet to the ton of sulphide in "A," "B," "C," and "D" ore-bodies; and 9 cubic feet per ton for the "E" ore-

body; and 14 cubic feet per ton in the case of the gossan in "C" ore-body above 3 level:—

Ore-body.	Above 3A Level.		Bet. 3A & 3 Levels.		Bet. 3 & 4 Levels.	
	Average Area. Sq. feet.	Amount in Tons.	Average Area. Sq. feet.	Amount in Tons.	Average Area. Sq. feet.	Amount in Tons.
"A" ...	...	...	3312	16,250	3562	17,810
"B" ...	180	360	1702	8500	4722	23,610
"C" ...	...	...	4800	17,143	9000	45,000
"D" ...	...	...	515	2575	2200	11,000
"E" ...	450	1000	9000	50,000	21,000	116,666

Deducting now the amount already stoped from these various ore-bodies, the following table can be compiled:—

Ore-body.	Above 3 Level.			Between 3 & 4 Levels.			Total. Tons.
	Original Contents.	Stoped.	Remaining.	Original Contents.	Stoped.	Remaining.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
"A" ...	16,250	7489	8761	17,810	5496	17,314	26,075
"B" ...	8860	4352	4508	23,610	17,693	6927	11,435
"C" ...	17,143	6807	10,336	45,000	17,999	27,001	37,337
"D" ...	2575	1560	1015	11,000	10,319	681	1696
"E" ...	51,000	18,712	32,288	116,666	66,903	49,763	82,051
Total...	...	...	...	...	...	...	158,594

Making allowances for vughs, poor patches, &c., the total ore reserves above No. 4 level may be stated in round numbers as 150,000 tons. This may be regarded as ore blocked on three sides.

No ore is allowed by the writer in the "F" ore-body above 4 level, as practically all this has been stoped.

Coming now to the calculation of ore-reserves below 4 level, we find that there are less data available than in

the upper levels, and all estimates of ore in the ore-bodies "A," "B," "C," "D," and "F" must be classed as probable ore. The following table gives the details of the estimate of "probable ore" in "A," "B," "C," "D," and "F" ore-bodies below 4 level based on Plates XV. and XVI.:—

Ore-body.	Length.	Average Width.	Depth.	Amount. Tons.
"A"	250	11	70	21,500
"C"	300	20	100	66,666
"B" & "D"	350	30	110	128,332
"F"	250	20	100	44,000
Total Tonnage...	...	...	...	260,498

We now come to the consideration of the ore opened up by Nos. 2, 7, and 8 bores in the "E" ore-body. Taking the results of bores Nos. 2 and 7 and that portion of No. 8 up to the 120-foot point, and also taking cognisance of the ore proved below No. 4 level by Cox's rise (46 feet), we get a series of triangular blocks containing in all 123,000 tons. This may be regarded as ore blocked on three sides.

Although the No. 8 bore re-entered high-grade sulphide at 156 feet and continued to the end, yet, as will be realised from Plate XVI., no estimate of "blocked ore" can be based thereon. An estimate of probable ore can, however, be attempted.

The following table gives the calculation of the "probable ore" in the "E" ore-body east of No. 8 bore:—

	Length.	Width.	Depth.	Amount.
Upper Rectangular block in Plate XVI.....	200	50	70	77,777
Lower Triangular block in Plate XVI.....	100	60	30	20,000
Total Tonnage .....	...	...	...	97,777

From the general behaviour of the ore-bodies as to length of shoots, the writer feels perfectly justified in

adding another rhomboidal block to the east of the last-named, as follows:—

	Length.	Width.	Depth.	Amount.
Rhomboidal block on next fold...	100	50	60	33,333

As regards the copper ore penetrated at the 5B and 5 levels and the 6c winze, no estimate of blocked ore is possible. The following estimate of "probable ore" may, however, be made (see Plate XV.):—

	Length.	Width.	Length along Dip.	Amount.
Copper Ore.....	50	15	300	22,500

This may be regarded as having the following approximate composition:—

Au	Ag	Pb	Zn	Cu
oz.	oz.	o/0	o/0	o/0
·012	0·68	0·53	5·0	1·5

Summing up, therefore, the ore reserves on the Hercules Mine are as follows:—

	Above 4 Level. Tons.	Below 4 Level. Tons.	Total. Tons.
Zinc-lead Sulphide—			
Blocked Ore	150,000	123,000	273,000
Probable Ore .....	...	391,000	391,000
Total.....	...	...	664,000
Copper Ore			
Probable Ore .....	...	22,000	22,000
Grand Total ...	...	...	686,000

As regards the assay value of this ore, the writer is quite justified in stating that it will equal that of the total output of the mine up to date. This opinion is based on the assay figures throughout the mine, placed at his disposal by the manager, some of which have been given in this bulletin. Those given are in no way "picked" assays. The writer's own observations from end to end of the mine perfectly justify him in stating that all ore estimated is distinctly good grade. As regards the ore below No. 4 level, the values up Cox's Rise have already been given,

and the following figures relating to Nos. 7 and 8 bores show the values in that portion of the ore-bodies:—

No. 7 bore averaged for the whole 124 feet in the ore-body:—

Au oz.	Ag oz.	Pb %	Zn %	Cu %
105	5.3	4.0	23.6	0.33

No. 8 bore averaged, while in the ore-bodies, *i.e.*, for 218 feet of its length:—

Au oz.	Ag oz.	Pb %	Zn %	Cu %
153	6.5	8.1	31.6	0.35

These latter figures may be taken as indicative of the value of the 123,000 tons of "blocked ore" below No. 4 level.

This estimate of ore is destined to be greatly exceeded as further development work proceeds in the mine. The directions in which such exploratory work should be located are as follows:—

- (1) The exploitation of the southern end of the "C" ore-body at No. 4 level.
- (2) The exploitation of the ground between the main crosscut and No. 4 tunnel at No. 4 level. This block of ground contains the southern continuation of the "E" ore-body with its Beta fold, and should disclose a large body of ore. A glance at Plate VIII. will show this.
- (3) The testing of the corresponding ground south of the No. 3 tunnel.
- (4) The examination of the ground south of the 3a crosscut at the "E" ore-body.

These works should, in the writer's opinion, disclose ore which will greatly add to the amount available above No. 4 level. This, of course, is in addition to that which may be proved below 4 level by the drilling scheme outlined in Chapter VI.

There is one special point to draw attention to in regard to the ore estimated above 4 level. Some portion of this

is in ground which has been affected by serious subsidences and falls, as the result of slipshod mining methods adopted in the past.

These falls are situated as under:—

- (1) In the "A" ore-body, from above the 3 level down to 4 level, extending for about 60 feet northwards from the No. 4 main crosscut.
- (2) In the "C" ore-body, from the surface down to 4 level, extending from Devine's rise northwards to Duncombe's rise.
- (3) In the "B" ore-body at 3 level, and also at 4 level.
- (4) At the northern end of the "D" ore-body at 4 level.
- (5) In the "E" ore-body, at the "lump" which came away from about the third stope above 3 level, near the central mullock rise, and crushed down to the 4 level.
- (6) In the "F" ore-body in the south stopes.

This will make the mining of the ore at these points more difficult and costly, but cannot be regarded as having rendered it unavailable.

It may be remarked at this stage that the mining of these ore-bodies will always require great care owing to the effect of the old bedding-planes now providing "heads," from which sudden falls take place. This is particularly likely to happen at the synclines and anticlines. Knowing this characteristic, however, the necessary precautions can be taken. The absolute necessity of studying the structural features as work progresses is thus rendered apparent.

(2)—MOUNT READ MINING COMPANY LIMITED.

This mining property consists of Consolidated Lease 5413-M, having an area of 104 acres.

As fully detailed in the chapter on the history of the field, this was the first mine discovered and worked in the district. The main portion of the workings were driven prior to 1900, with the exception of the No. 2 or western adit, which was started in 1903, and completed in 1907. As previously pointed out, this tunnel, being 300 feet below the main adit, did not penetrate ore, as it passed beneath the ore-bearing horizon.

Plate XVIII. shows the details of the mine workings and the probable outlines of the ore-bodies.

The present company, which has absorbed the interests of all previous companies, has a total subscribed capital of £142,000. Of this amount £115,945 16s. 1d. has been spent on "purchase of property," while £20,874 has been spent in conducting the affairs of the company. No dividends have been paid.

The writer has been unable to exactly determine the total amount spent by the three different companies which have operated the mine, but £100,000 may be taken as approximately representing the amount.

The total output has been 8059 tons, valued approximately at £8000.

When we come to attempt to estimate the amount of ore in the mine, we find that it is impossible to estimate more than a very small quantity of "blocked ore," owing to the remarkable absence of development work. This, in spite of the large sum expended on the property, is surprising. Particularly it is inexplicable to the writer why, since 1907, the work at the main adit level was concentrated on the driving of crosscuts east and west from the southern end of the adit rather than systematically cross-cutting the ore-body. A glance at the plan of the mine will show this clearly.

The dimensions in the following estimate are based, for the horizontal dimensions, on the length exposed by the main adit and the width shown by the one solitary crosscut at that level. The vertical depth is based on two winzes sunk from the main adit level—the east winze in ore for 35 feet, and the west winze in ore for 39 feet.

Ore-body.	Length.	Width.	Depth.	Amount.
Large Lens.....	400	50	50	100,000
Small Lens.....	120	20	50	12,000
Stacked at surface	...	...	...	12,000
Total .....	...	...	...	124,000 tons

No account is taken in this estimate of the ore shown in stopes Nos. 2, 3, and 4 and Williams' shaft. The particulars of this ore are shown in the following table:—

Name of Shaft.	Length of Ore.	Depth of Ore.	Assay Value.			
			Au oz.	Ag oz.	Pb %	Zn %
No. 2	8	4	0·5	29·0	7·4	...
No. 3	8	20	0·6	15·0	6·0	10·0
No. 4	8	20	0·25	5·4	6·8	12·0
Williams'	50	50	0·02	7·0	8·0	32·0

As regards the assay value of this ore, there are not full details available, but from the company's assay plans showing the values along the main adit, in the crosscut, and down the winzes, the following figures may be given as generally indicative of the value:—

Particulars.	Au oz.	Ag oz.	Pb %	Zn %
Probable Ore	0·1	9·0	7·0	22·0
Ore stacked at surface	0·1	7·0	2·0	10·0

It must be noted that the ore in the northern portion of the ore-body at the main adit-level is of higher grade than the remaining portion, as illustrated by the following average assay of the ore showing in the main adit in the northern 150 feet of the ore-body:—

Au oz.	Ag oz.	Pb %	Zn %
0·15	14·0	10·7	36·3

The work to be first undertaken in this mine is that of systematically crosscutting and rising on the two lenses of ore to ascertain their exact size and value.

This work is quite apart from that outlined in the diamond-drilling scheme which is designed to investigate the eastern extension of the ore-body. If these bores suc-

ceed in locating ore east of the present workings, then the western adit will come in very handy as providing a convenient means of exploiting them.

(3)—SOUTH HERCULES MINE.

This property is situated between the Hercules and Mount Read Mines. It was originally owned by the South Hercules Mining Company, No Liability, now defunct. It consists of a lease 19 acres in area, now charted in the names of Corrigan & Maddox as Consolidated Lease 6632-M. The amount spent on this property is in the neighbourhood of £5000.

The workings are shown in Plate V. The eastern adit showed no ore-body, excepting a few small makes of pyrites and disseminations of fahl-ore of no commercial value. In the western adit a small seam of ore carrying galena, zinc-blende, and pyrites was cut, which was up to 3 feet wide, but petered out when followed to the south. This is the ore-bearing horizon which is dipping eastwards beneath Baker's Creek. The seam is unpayable.

The shaft was sunk just inside the northern boundary on a seam of solid zinc-lead sulphide. Total depth of shaft, 52 feet; bottom still in ore; average width of ore-body, 6 feet. A drive north from the bottom of shaft was put in for 16 feet; ore in face, 8 feet wide.

The total output from this shaft was 270 tons, which represents the total amount derived from the property. This is average-grade sulphide.

The reason why the eastern adit did not penetrate the ore-bodies has been previously explained.⁽²⁰⁾ The diamond-drilling scheme will show whether the ore-bearing horizon carries ore below this adit-level. It is the writer's opinion that if the ore be followed downwards below the shaft it will open out into a large body of ore.

(4)—DUNNE'S BLOCKS.

This property is situated to the south of the Mount Read Mine. It is at present charted in the name of A. J. Douglas. Section number is 6897-M, and the area is 63 acres.

The workings are shown in Plate V.

²⁰ See above, p. 57.

Low-grade ore was found in the No. 1 shaft, this portion of the ore-bearing horizon corresponding to that located in Williams' shaft on the Mount Read Mine. It is only a few feet wide, and is distinctly low-grade. The adit was driven 280 feet below, with the object of cutting the downward continuation. As will be seen from the plan, this adit is not yet below the shaft, and as the ore-bearing horizon dips rather flatly from this anticline, the eastern and downward extension lies a long way to the east of the present end of the adit.

Investigation of this ore-bearing horizon should be made by means of the diamond-drilling scheme outlined previously.

(5)—RING P.A. MINE.

The workings of this mine are now included in the 80-acre Section 5672-m, charted in the name of J. H. S. Munro. It is, roughly, 1300 feet below the Hercules Mine.

The mine workings are shown in Plate XIX.

The writer is unable to give exact figures as to the total expenditure on this property. It was sold to the Tasmanian Copper Company about the year 1901, who stoped the copper ore down to No. 2 adit level.

The total output has been 2340 tons, valued at £6000. The total amount spent by the Tasmanian Copper Company was £7339.

Since the present owner has had possession about £250 has been spent in work at Sligo's tunnel, which was driven in 1913. This disclosed the existence of zinc-lead sulphide, which had not previously been known on the property.

The copper occurred in the No. 1 and No. 2 adit workings up to the surface, from which a shaft was sunk to the former level. The length of the shoot of copper ore in No. 1 adit was 180 feet; that in No. 2 adit was only 90 feet. The thickness varied from 18 inches to 4 or 5 feet. The character of the ore is that of the chalcopryite, either in pure masses or disseminations in the schist. The composition averaged approximately as follows:—

Au oz.	Ag oz.	Pb %	Zn %	Cu %
Trace	2.70	nil	trace	4.4

The copper ore worked at the end of Burns' tunnel is on the same body of ore.

The zinc-lead sulphide in the trench is almost 1 foot in width. In Sligo's tunnel it varies from 1 to 3 feet in width, and is 60 feet in length. This latter shoot is really continued into the south drive off No. 1 adit as a low-grade disseminated deposit of zinc-lead and iron sulphides. The ore in Sligo's tunnel is good-grade zinc-lead sulphide.

It has been accepted by those in charge of the work at this point that the ore in Sligo's tunnel was the downward continuation of that seen in the trench 70 feet above and 35 feet west. This, in the writer's opinion, is impossible, and he would advise the extension of Sligo's tunnel to cut the downward continuation of the ore shown in the trench.

Advantage should also be taken of the opportunity afforded by No. 2 adit of crosscutting therefrom eastwards, to cut the downward continuation of the zinc-lead sulphide. This should be cut in from 130 to 200 feet of driving.

As regards the eastern continuation of the ore-bearing horizon, the diamond-drilling scheme again will give the necessary information.

(6)—JUPITER MINE.

This mine consists of Consolidated Lease 5849-m, 124 acres, charted in the name of Thomas Puckey. It originally consisted of two leases—the Jupiter and North Jupiter—but on the discovery of zinc-lead sulphides in No. 2 adit in 1905 the present consolidated lease was acquired. It is situated at the northern end of the area dealt with in this bulletin, and is a few hundred feet lower than the Ring P.A.

The old Jupiter Company drove No. 1 adit and disclosed only copper ore, of which 22 tons were extracted during its subsequent lease by the Hercules Company.

The total amount spent on the property is, roughly, £7000.

Subsequent to the discovery of zinc-lead sulphide, No. 3 adit was driven. The total length of the shoot of sulphide at No. 2 adit level is 57 feet, while at the No. 3 level it is 156 feet. The width varies from 2 feet up to 20 feet, sudden bulges being the characteristic. It has been stoped right to the surface—a total vertical range of 100 feet.

The Tasmanian Smelting Company, Zeehan, held it under lease from the present owners for some time, and the following total output was obtained:—

Zinc-lead Sulphide—				
Lead Ore	...	...	...	6400 tons
Zinc Ore	...	...	...	600 "

The zinc ore averaged 42 per cent. zinc. No figures are available as regards the lead ore, but it was certainly good-grade ore.

There still exists some ore above No. 3 adit, but this is small in amount. The ore is going strongly underfoot, and a lower adit driven from the valley 50 feet below No. 3 adit should encounter ore in reasonable distance.

The ore in the folds of the ore-bearing horizon further east will be disclosed by the diamond-drilling scheme.

At present an intermediate tunnel is now being driven 80 feet below No. 1 adit, with the object of cutting the copper deposits showing therein at that depth. It will probably be found that the seams are wider at this depth than in the upper adit.

(7)—J. H. S. MUNRO'S SECTIONS.

The sections, in addition to the Ring P.A. Mine, charted in this name are 6405-M, 6741-M, 5671-M, and 6807-M.

Section 6405-M contains proposed bores Nos. 1A and 2A.

Section 5671-M contains six existing bores, four of which were put down by the Tri-Metallic Syndicate and two by the Tasmanian Smelting Company. The two latter were vertical, and were blanks. The total depth is unknown to the writer, but did not exceed 300 feet. It is clear, therefore, that they had no chance of penetrating the ore-bearing horizon in that depth, as they were altogether too far east. The other four bores were driven towards the west at an angle of 65°. This was absolute waste of time, as they did not exceed 150 feet in depth in any case. They were almost parallel to the surface. This section contains proposed bores 28A and 29A.

Section 6807-M contains proposed bores 44A to 47A.

Section 6741-M, lying to the east of the Hercules lease, and being situated beyond the area of plotted axes, must remain untested until the present diamond-drilling scheme has been completed. It must be remembered that the ore-

bearing horizon gets deeper as it goes eastwards, so that the ore, if it is present, will be considerably below the surface in this section.

(8)—WILLIAM REDMAN'S SECTIONS.

There are two sections in this name, 6824-M and 6825-M.

Section 6824-M contains proposed bores 33A to 41A.

Section 6825-M is similar to Section 6741 in that it lies outside the range of the axes which are at present plotted, and must therefore remain untested until further details are available on which to base the location of the bores.

(9)—A. D. SLIGO'S SECTION.

This section is numbered 6389-M, and is east of and adjoining the Mount Read lease.

There are two existing bores on this section just inside the western boundary. These are both vertical, and the deepest is down 140 feet. It is quite apparent that these bores at that depth had no chance of cutting the ore-bearing zone. It is hard to understand why they were put down at all.

Proposed bores 4A, 5A, and 7A are on this section.

(10)—C. H. FERGUSON'S SECTIONS.

These are 6861-M, 6862-M, and 6864-M, but they all lie eastward of the area suggested for boring, although, as is also the case in all sections occupying a similar position, the ore-bearing horizon exists at some uncertain depth below the surface. As stated before, however, it is desirable to postpone boring on these sections until the suggested bores have given further information.

(11)—A. BABINGTON'S SECTION.

This section has an area of 77 acres, and is numbered 6037-M. It is situated to the north-east of the Hercules lease. There was a bore put down by the Tasmanian Smelting Company on this property on the bank of the Ring River. The angle of the bore was 30°, and the direction due west. This bore did not penetrate ore.

This section, again, is too far east to be of present direct importance, but undoubtedly ultimately this section will contain many points which will be convenient for diamond-drilling designed to test the ore-bearing horizon eastwards of the Alpha axes already plotted.

IX.—CONCLUSION.

(1)—SUMMARY OF THE RESULTS OF THE PRESENT INVESTIGATION.

The results of this investigation of the field have been far greater than was anticipated, and are destined to have a far-reaching effect on the history of mining in this area. It has been a constant belief of many people that this district had a large amount of ore still unexposed, far greater than that already mined. The writer's deductions as to the structural features and mode of origin of the ore-bodies have served to put into concrete form what was previously an uncertain dream of many optimists.

The net results of the investigation will now be enumerated:—

- (1) It has been established that the Read-Rosebery schists are either sedimentary or pyroclastic in origin.
- (2) It has further been shown that the original bedding-planes do not necessarily coincide with the planes of schistosity. Incidental to this it has been proved that a large number of fractures previously regarded as faults are simply the original bedding-planes.
- (3) Following upon these two discoveries, proof has been obtained that the schists are these old rocks folded and metamorphosed. It has been shown that there are two series of folds, which make the structural features very complicated.
- (4) It has also been established that the old sedimentary series contained calcareous beds at one particular horizon.
- (5) The conclusion has been arrived at that the zinc-lead sulphide deposits have been formed by the metasomatic replacement of these metamorphosed calcareous beds by ascending solutions, and also that the pyritic copper deposits were formed by the metasomatic replacement of the black schist.
- (6) It has been shown that the ore-bodies conform to the folds of the whole schist series which existed before the arrival of the ore-bearing solutions. These folds have been mapped for a consider-

able area, and thus the trend of the ore-bearing horizon determined.

- (7) The statement that the zinc-lead sulphides were the result of secondary enrichment has been disproved.
- (8) All anomalous results obtained in exploratory work have been thus explained.
- (9) It has thus been rendered possible to formulate a definite scheme of diamond-drilling to search for the zinc-lead sulphide deposits in places where they have not yet been found.
- (10) In addition, it has been deduced that the zinc-lead sulphide deposits may be expected to persist to sea-level and below.
- (11) It has been found possible also to give the first description of the structural features of the porphyroid system ever attempted.
- (12) It has been proved that the Dundas slates and breccias are older than either the Read-Rosebery schists or the felsites and chloritic schists.

(2)—THE MINERAL RESOURCES OF THE REGION.

The total amount and value of the output of this portion of the Read-Rosebery zinc-lead sulphide belt have been:—

Mine.	Zinc-lead Sulphide. Tons.	Gossan. Tons.	Copper Ore. Tons.	Total. Tons.	Value. £
Hercules	165,704	15,376	346	181,426	264,316
Mt. Read	8059		...	8059	8000
Ring P.A. ....	...	...	2340	2340	6000
Jupiter	7000	...	22	7022	7500
Total .....	...	...	...	198,847	285,816

The total output has therefore been 198,847 tons, of a value of £285,816.

The total amount expended on this portion of the zinc-lead sulphide belt has been approximately £400,000.

The total dividends have been approximately £36,400.

The following is a summary of the figures given in the preceding pages of the amount of ore available at the present time:—

Mine.	Blocked Ore. Tons.	Probable Ore. Tons.	Total. Tons.
Hercules	273,000	413,000	686,000
Mt. Read .....	...	124,000	124,000
Grand Total.....	273,000	537,000	810,000

This estimated ore is of good grade, and may be accepted as agreeing in average composition with that of the amount already extracted.

In addition to this there are large quantities incapable at present of accurate estimation of lower-grade ore of approximately the following composition:—

Au	Ag	Pb	Zn
oz.	oz.	%	%
·05	2·5	1·8	10·5

These are certainly destined to be a source of ore in the future history of the field.

It is the writer's opinion that exploratory work on the lines indicated in this bulletin will result in the proving of an amount of ore compared with which the above estimate will be quite insignificant.

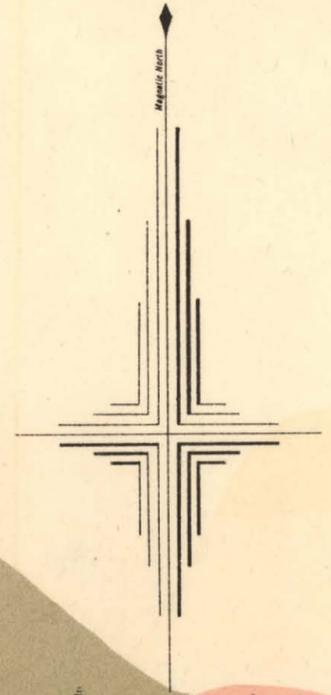
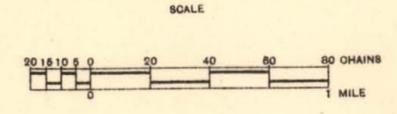
LOFTUS HILLS, M.Sc.,

Assistant Government Geologist.

Launceston, 30th November, 1914.

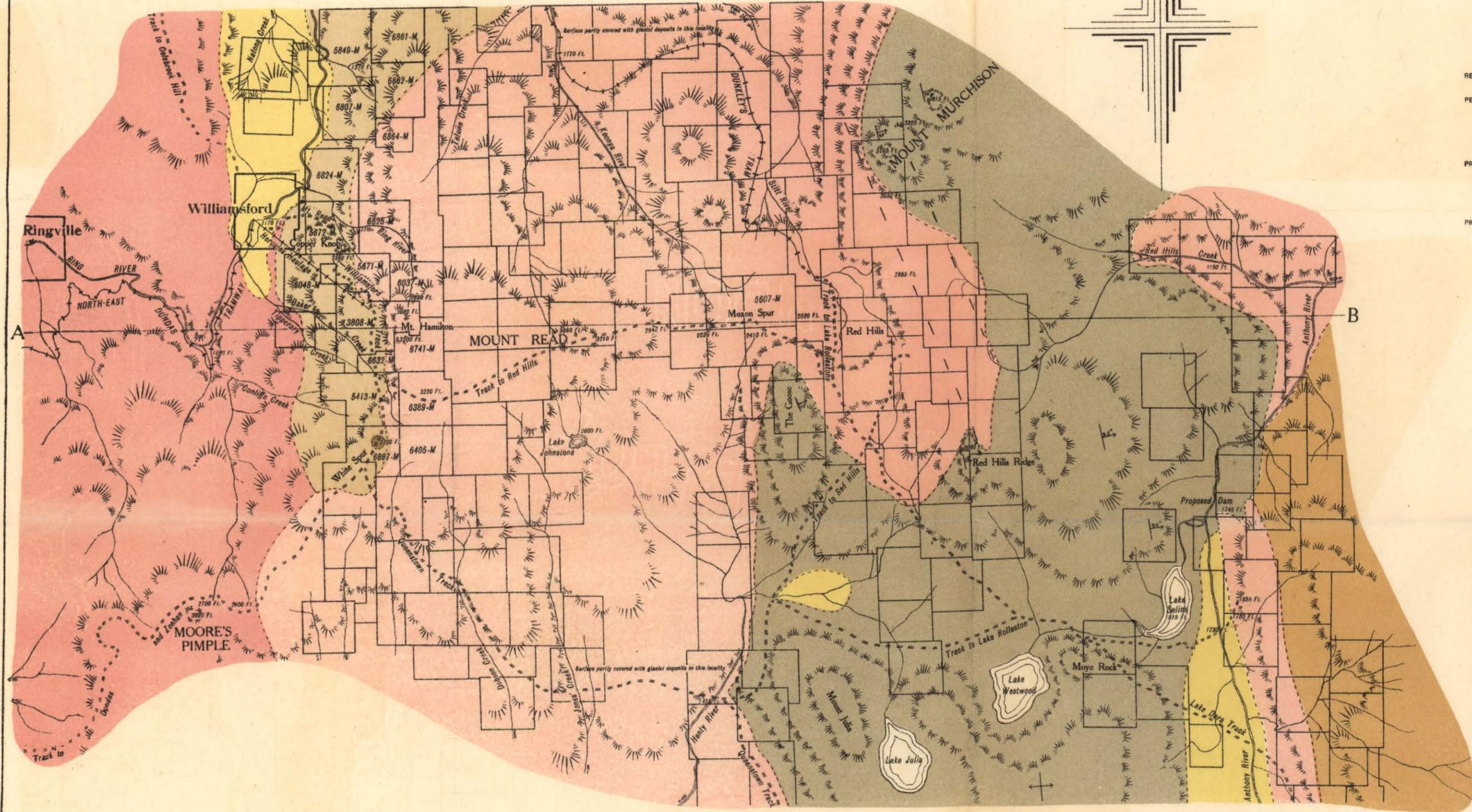
SKETCH GEOLOGICAL MAP OF THE MOUNT READ MINING FIELD

5 cm



Legend

- RECENT --- Moraine Deposits --- [Yellow Box]
- PERMO-CARBONIFEROUS --- Glacial Conglomerate --- [Dark Brown Box]
- West Coast Range Conglomerate --- [Light Brown Box]
- PRE-SILURIAN --- Felsites and Chloritic Schists --- [Pink Box]
- Red-Rosebery Schists --- [Light Green Box]
- Dundas Slates and Breccias --- [Red Box]
- PRE-CAMBRIAN --- Quartzite and Quartz Schists --- [Dark Green Box]
- Geological Boundaries --- [Dashed Line]
- Strike and Dip of Strata --- [Arrow]
- Faults --- [Zigzag Line]
- Rosbery-Williamsford Road --- [Wavy Line]
- Pack Tracks --- [Dotted Line]



KEY TO NUMBERS OF MINERAL SECTIONS

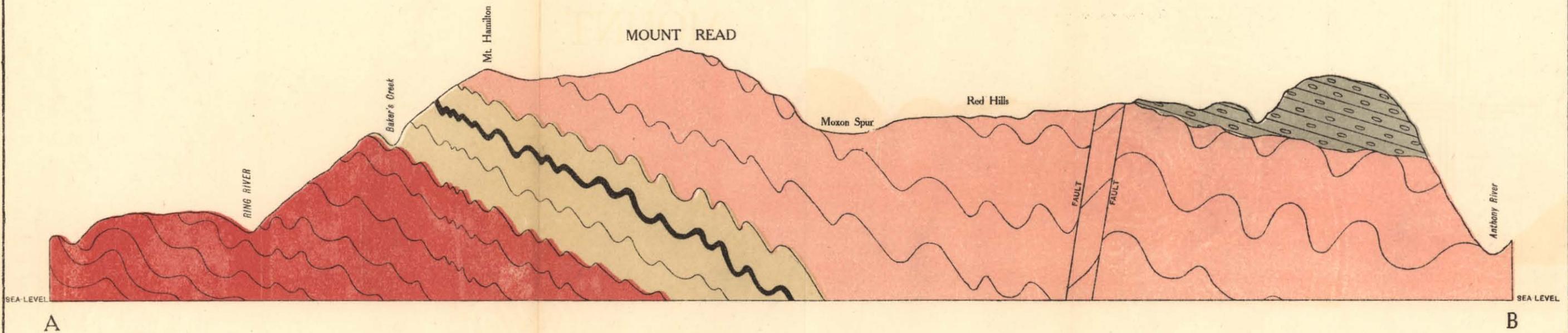
Number of Section	Acres	Lessee
3808-M	146	Hercules Gold & Silver Mining Co., N.L.
5473-M	102	Mount Read Mg. Co. Ltd.
6632-M	19	J. Corrigan & A. Maddox
5849-M	124	Thomas Puckey
5672-M	80	
5871-M	81	
6741-M	64	J. H. S. Munro
6406-M	75	
6807-M	80	
6824-M	80	William Redman
6825-M	80	
6380-M	79	A. D. Sligo
6897-M	63	A. J. Douglas
6037-M	77	A. Babington
6861-M	80	
6862-M	78	C. H. Ferguson
6864-M	38	
6048-M	77	F. Burns
5607-M	40	G. Dunkley

Lopus Hills M.S.

Assistant Government Geologist
30 Nov 1914

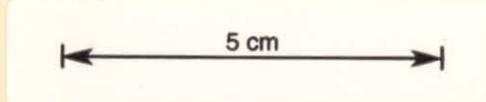
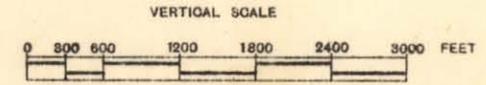
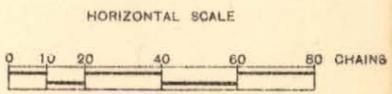
Photo Aligned by John Hall Government Printer, Edward Freeman

SKETCH GEOLOGICAL SECTION ACROSS THE MOUNT READ MINING FIELD ON THE LINE AB.



Legend

- West Coast Range Conglomerate —
- Felsites and Chloritic Schists —
- Read-Rosebery Schists —
- Dundas Slates and Breccias —
- Ore-bearing Horizon —



Logan Shill M.Sc.
Assistant Government Geologist
30 Nov 1914

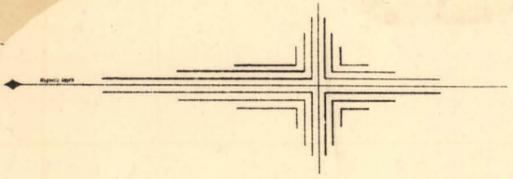
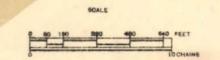
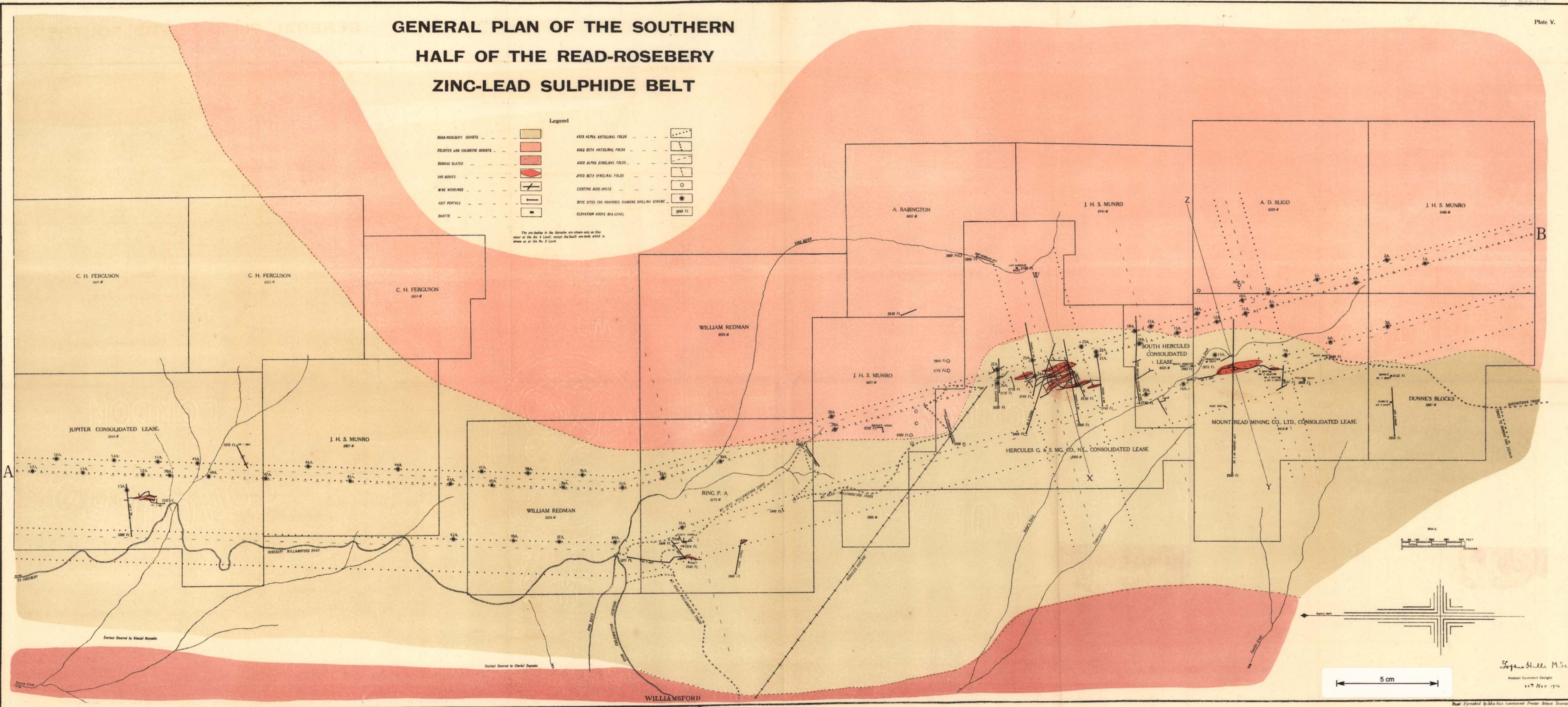
Photo Aligned by John Vass Government Printer Hobart Tasmania.

GENERAL PLAN OF THE SOUTHERN HALF OF THE READ-ROSEBERY ZINC-LEAD SULPHIDE BELT

Legend

READ-ROSEBERY SCHISTS		AXES ALPHA ANTICLINAL FOLDS	
FELDITES AND CHLORITIC SCHISTS		AXES BETA ANTICLINAL FOLDS	
DUNDAS SLATES		AXES ALPHA SYNCLINAL FOLDS	
ORE-BODIES		AXES BETA SYNCLINAL FOLDS	
MINE WORKINGS		EXISTING BORE-HOLES	
ADIT PORTALS		BORE SITES FOR PROPOSED DIAMOND DRILLING SCHEME	
SHAFTS		ELEVATION ABOVE SEA-LEVEL	

The ore-bodies in the Hercules are shown only as they occur at the No. 4 Level, except the South ore-body which is shown as at the No. 3 Level.



5 cm

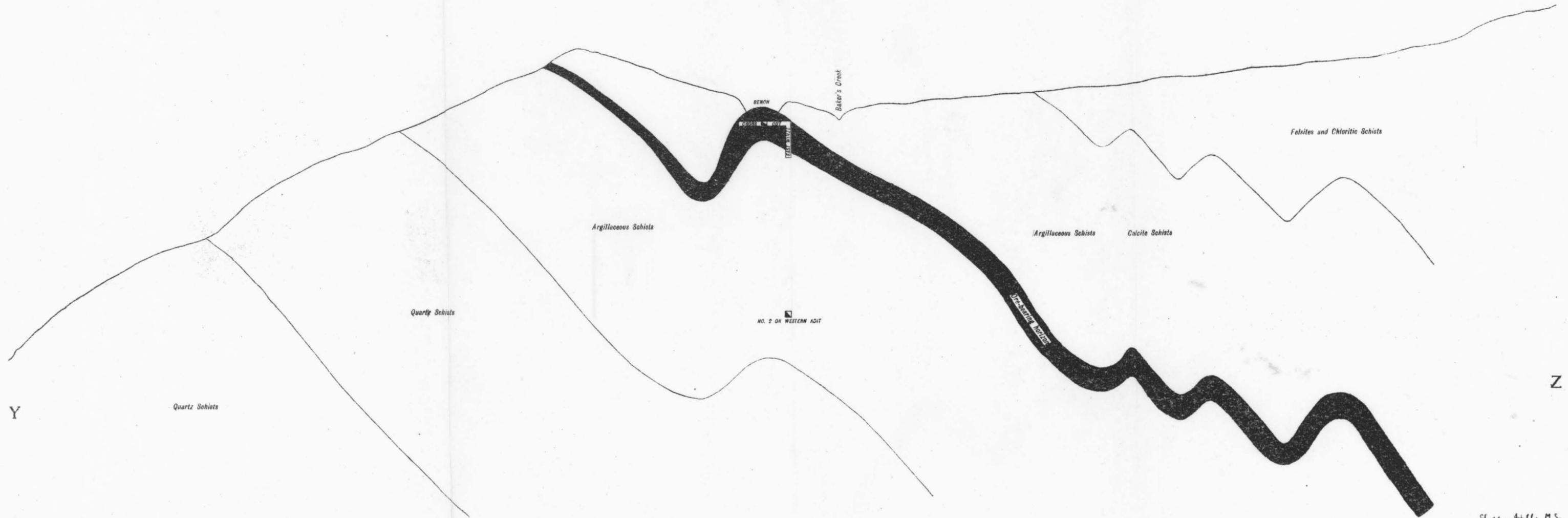
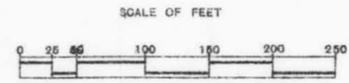
Geopon Hills M.S.C.
Assistant Geomorphologist
557 Nov. 1914

Drawn by J. H. S. Munro, Geomorphologist, and J. H. S. Munro, Geomorphologist.

5 cm

SKETCH GEOLOGICAL SECTION ON THE AXIS OF THE BETA FOLDS

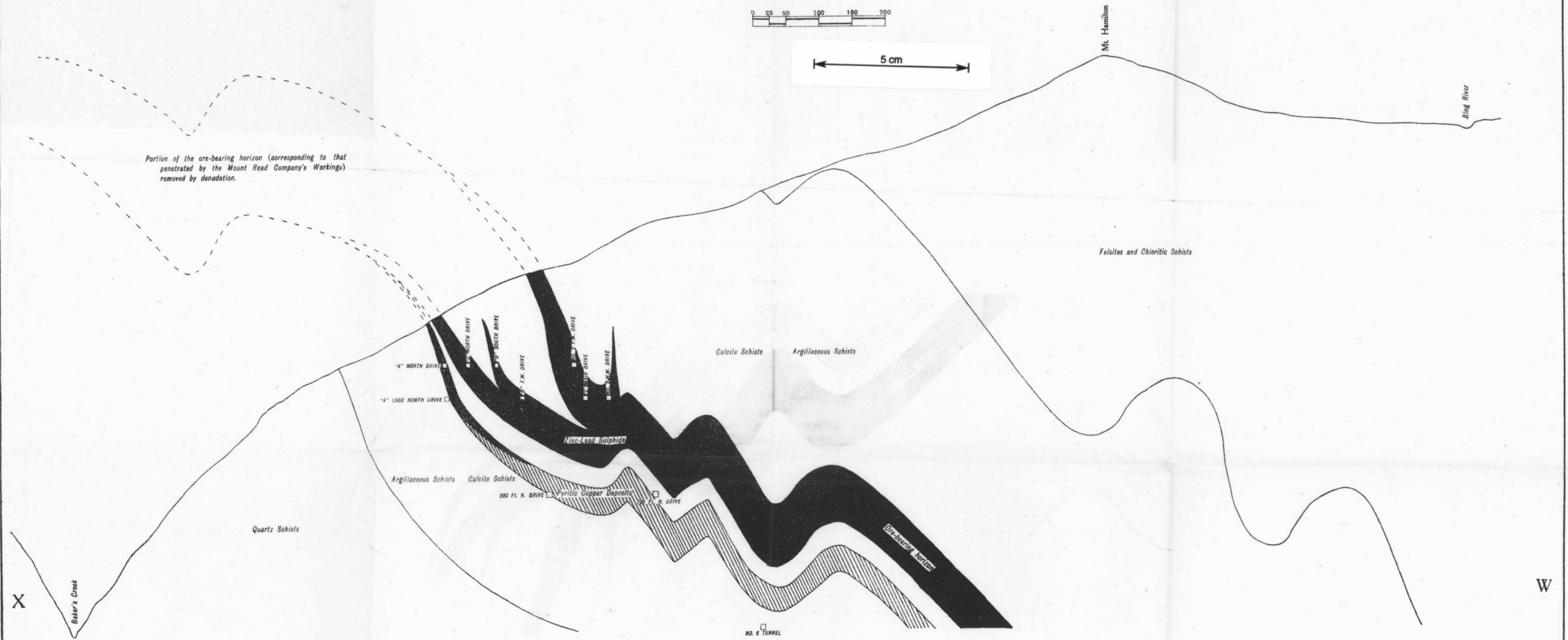
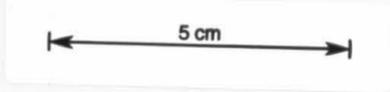
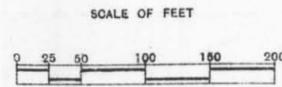
VERTICAL SECTION ON THE LINE YZ MOUNT READ MINE



Stephen Hills M.Sc.
 Assistant Government Geologist
 20th Nov 1914

SKETCH GEOLOGICAL SECTION ON THE AXIS OF THE BETA FOLDS

VERTICAL SECTION ON THE LINE XW HERCULES MINE

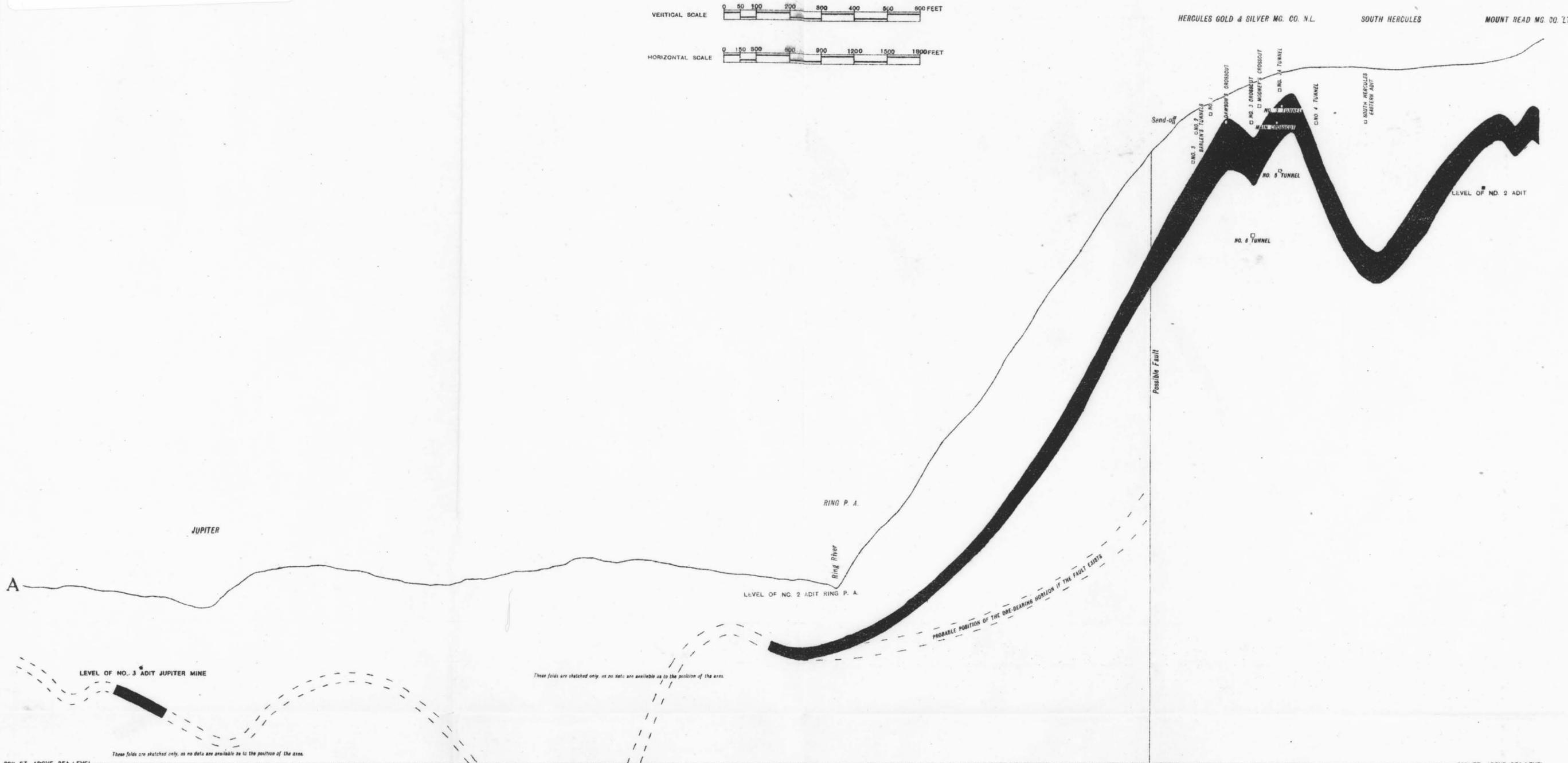
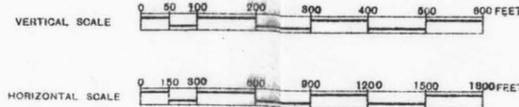


Goffus Hills M.Sc.
 Assistant Government Geologist
 20th Nov. 1914

SKETCH GEOLOGICAL SECTION ON THE AXIS OF THE ALPHA FOLDS

VERTICAL SECTION ON THE SYNCLINAL AXIS A B

5 cm



900 FT. ABOVE SEA-LEVEL

John Hills M.Sc.
Assistant Government Geologist
22nd Nov. 1924

Photo Aligned by John Vail Government Printer Hobart Tasmania

PI 833
MIV staff

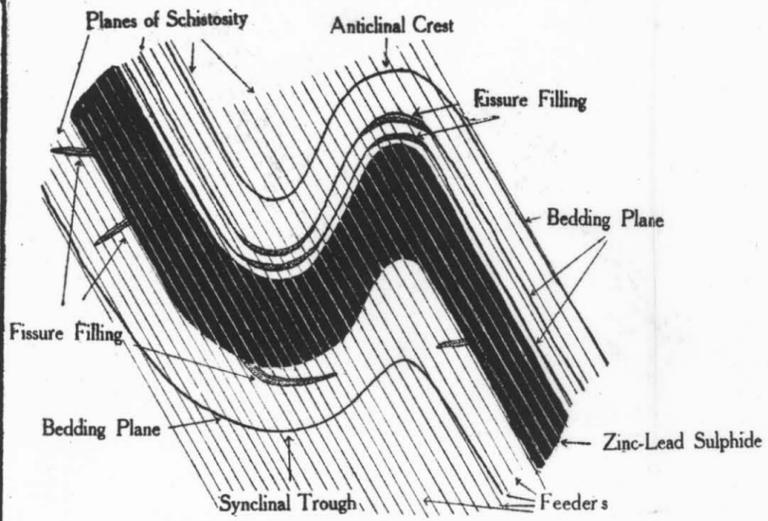


FIG. 1

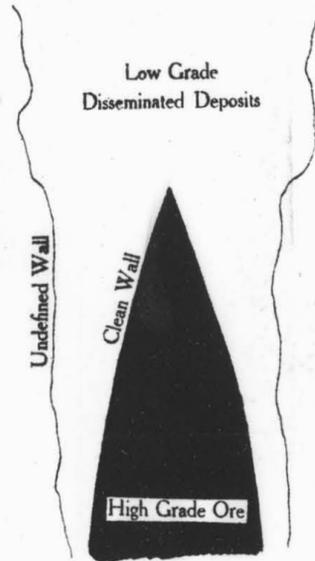


FIG. 2

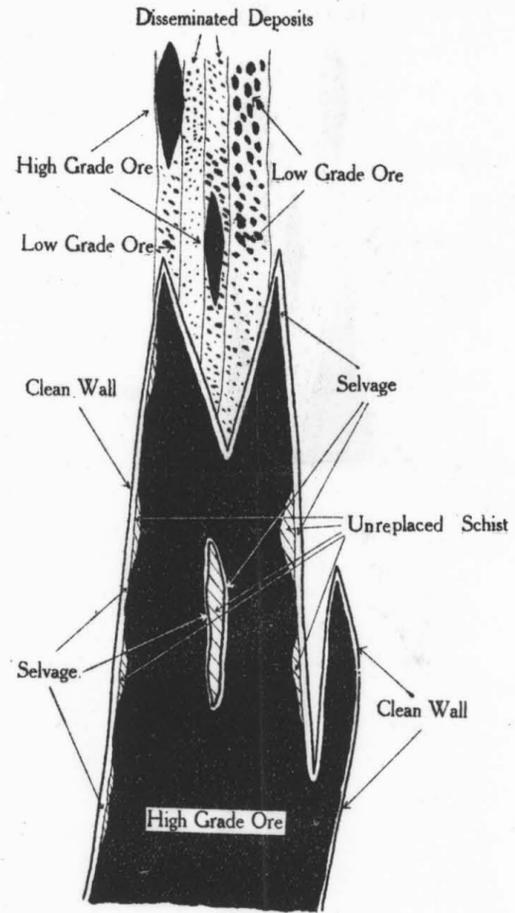


FIG. 3

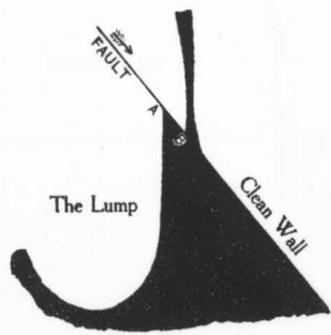


FIG. 4

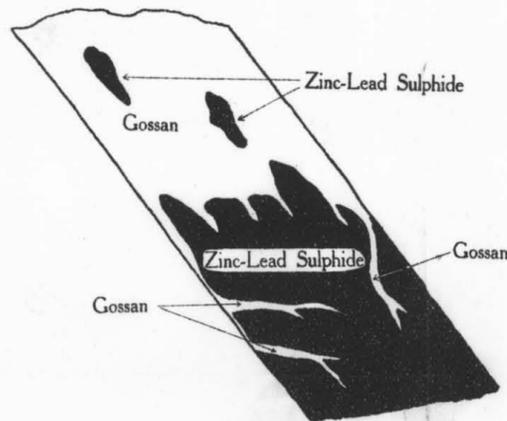


FIG. 5

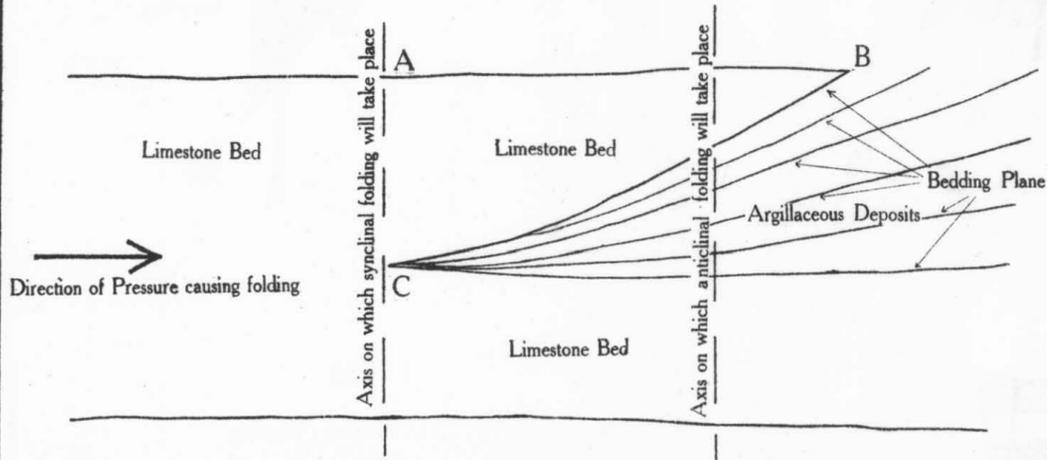


FIG. 6A

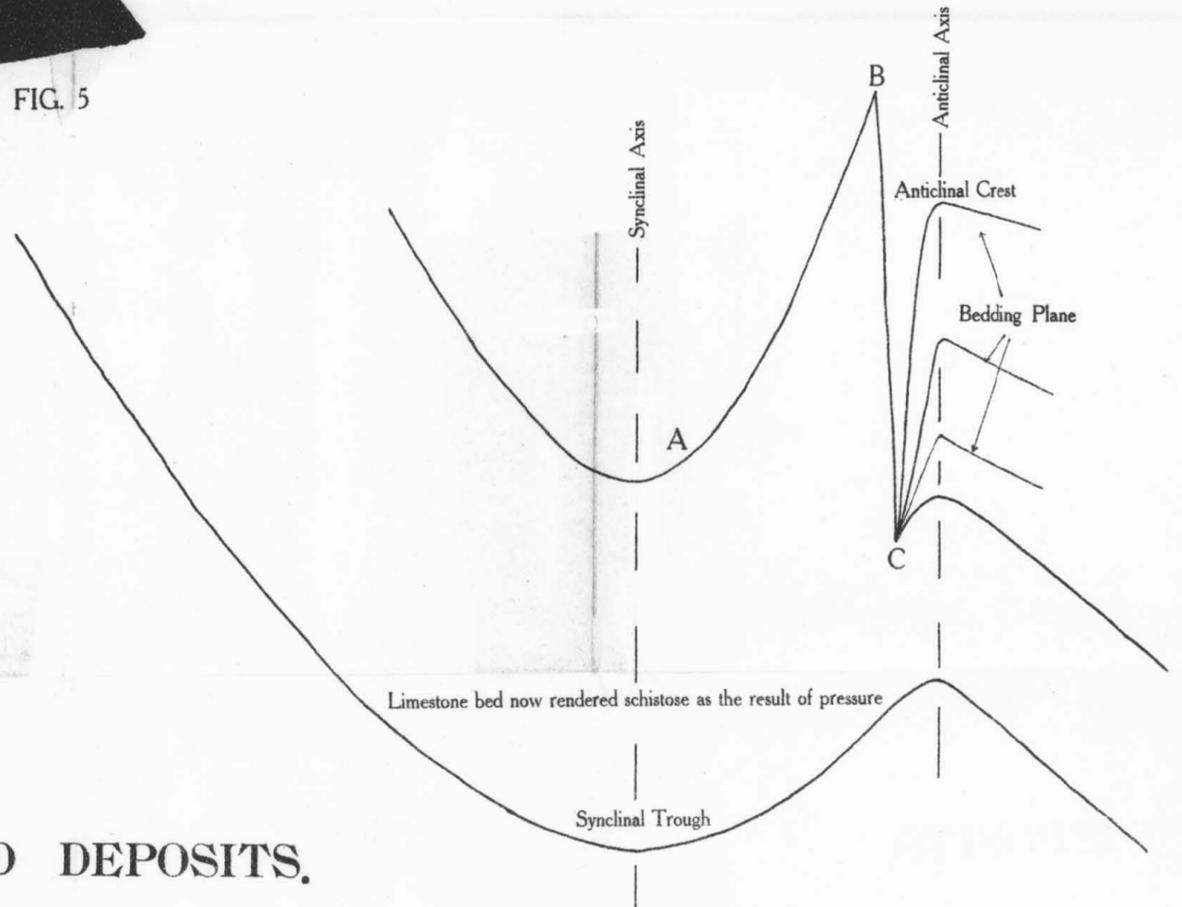


FIG. 6B

DIAGRAMMATIC SECTIONS OF ZINC-LEAD DEPOSITS.

SHOWING STRUCTURAL FEATURES.

5 cm

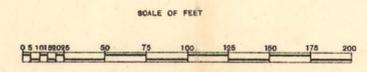
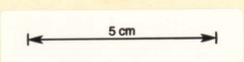
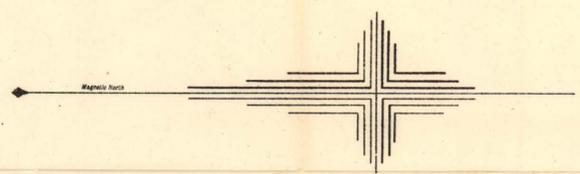
Loftus Hills M.Sc.
Assistant Government Geologist
30 Nov 1914

GENERAL PLAN OF THE HERCULES MINE.



Legend

No. 3A Level	--- (dashed line)	Red square
No. 3 Level	--- (dashed line)	Light red square
No. 4 Level	--- (dashed line)	Yellow square
No. 5 Level	--- (dashed line)	Light yellow square
No. 6B Level	--- (dashed line)	Orange square
No. 6 Level	--- (dashed line)	Light orange square
Shafts	○ (circle)	Circle with dot
Height above Sea-Level	□ (square)	Square with number

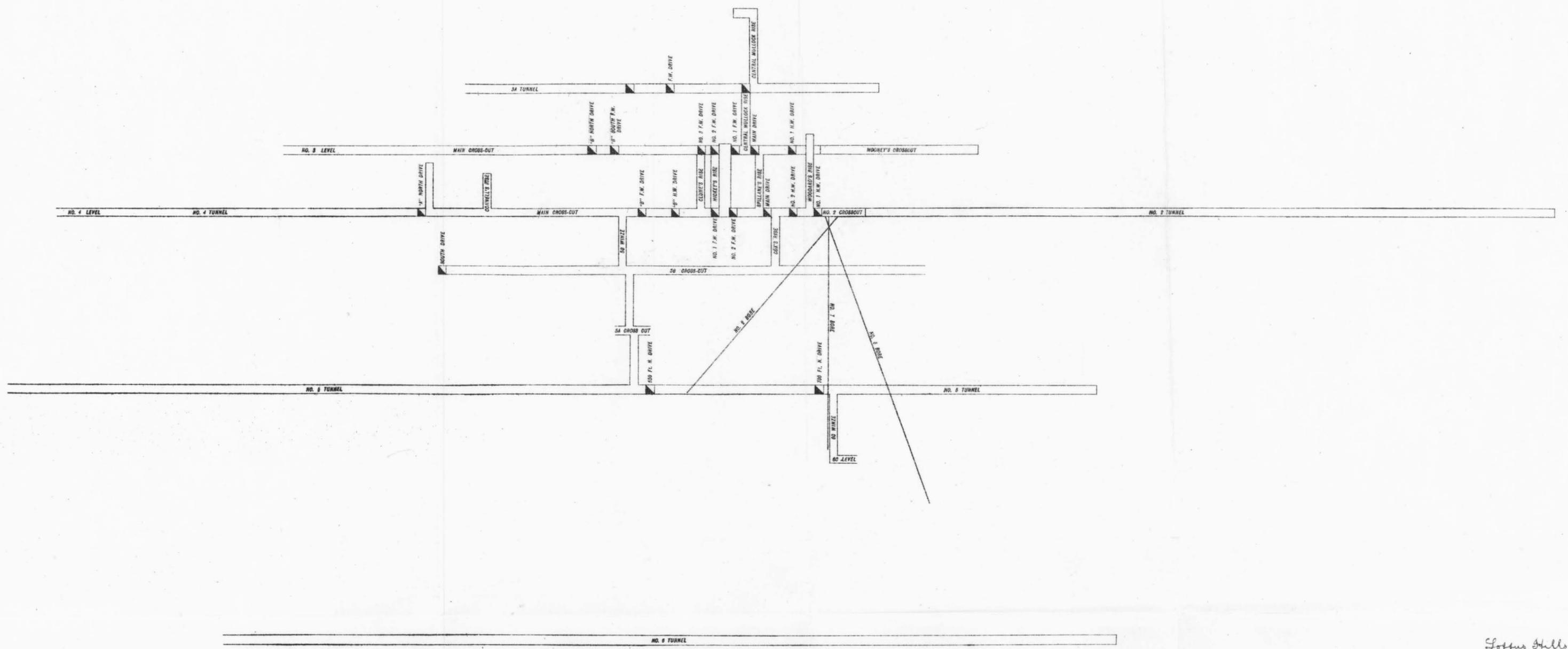
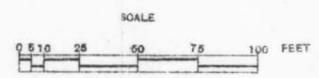
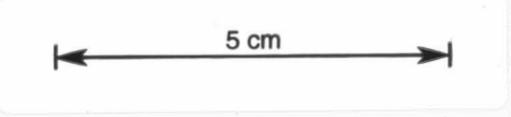


Joseph S. Hille M.S.
 Assistant Government Geologist
 30th Nov 1914

Plan: Aligned by Mrs. Hall, Geom., and Prof. E. B. Reynolds.

1830
Plots XI

VERTICAL SECTION ON THE LINE MN HERCULES MINE.



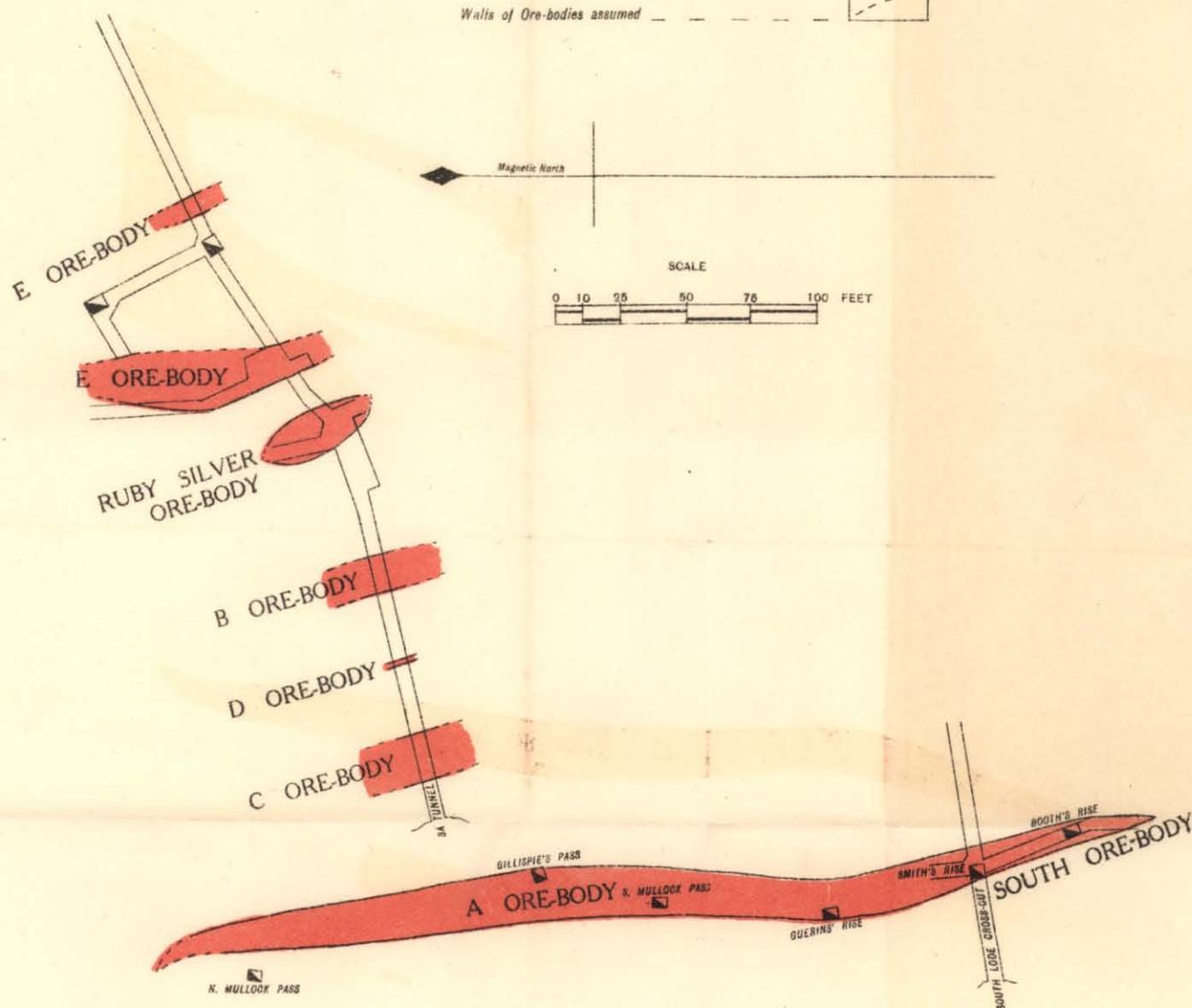
Sopue Hills M.Sc.
Assistant Government Geologist
30th Nov 1914

PLAN SHOWING THE OUTLINES OF THE ORE-BODIES NO. 3 A LEVEL HERCULES

5 cm

Legend

Ore-bodies	-----	
Walls of Ore-bodies actually visible	-----	
Walls of Ore-bodies assumed	-----	



Lofius Hills M.Sc.

Assistant Government Geologist

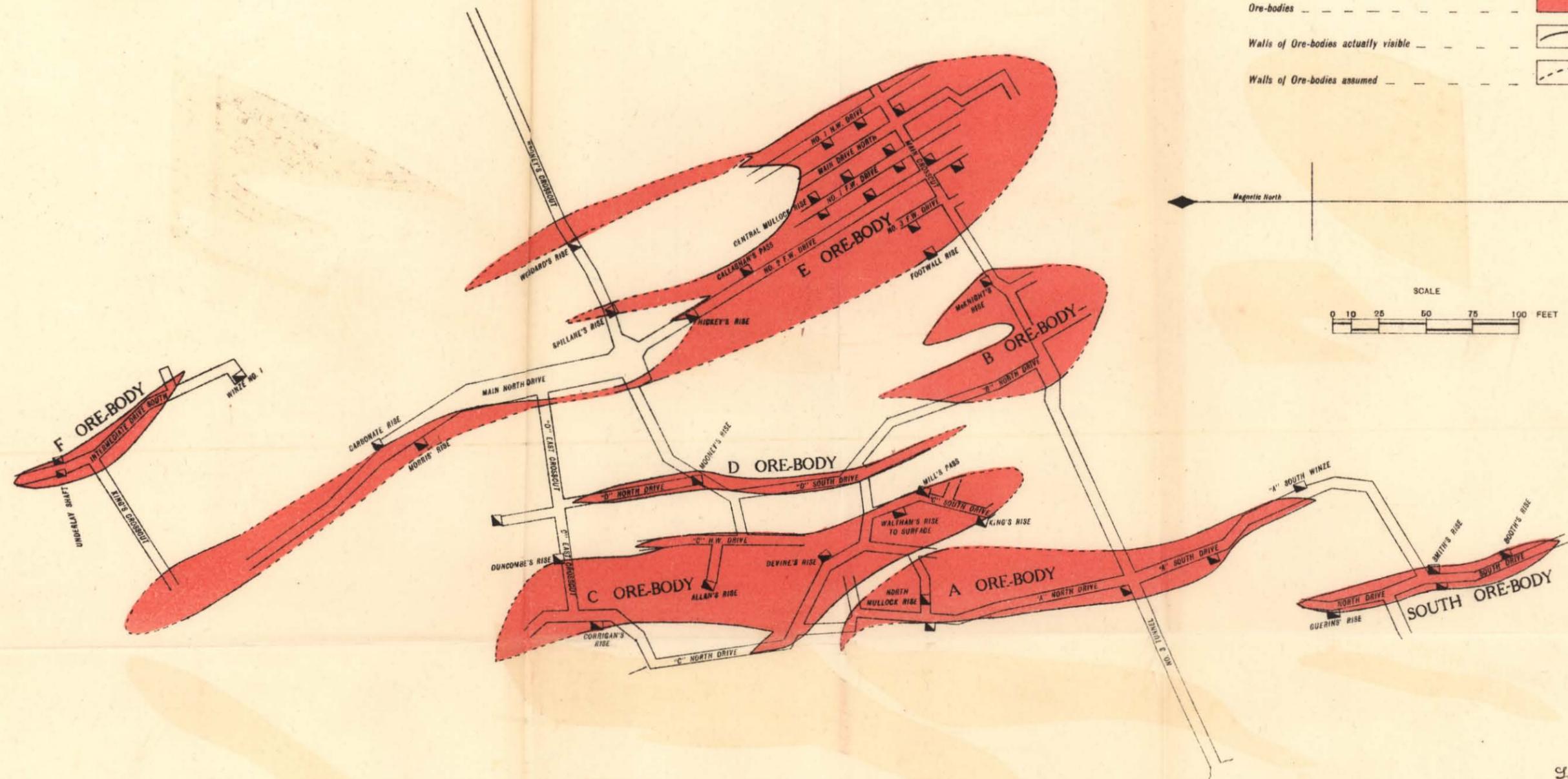
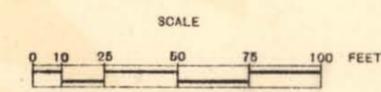
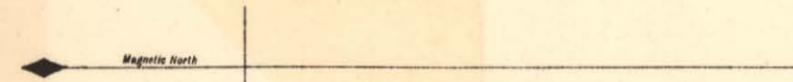
20th November 1914.

PLAN SHOWING THE OUTLINES OF THE ORE-BODIES MAIN FLOOR NO. 3 LEVEL HERCULES

5 cm

Legend

- Ore-bodies ————
- Walls of Ore-bodies actually visible ————
- Walls of Ore-bodies assumed ————



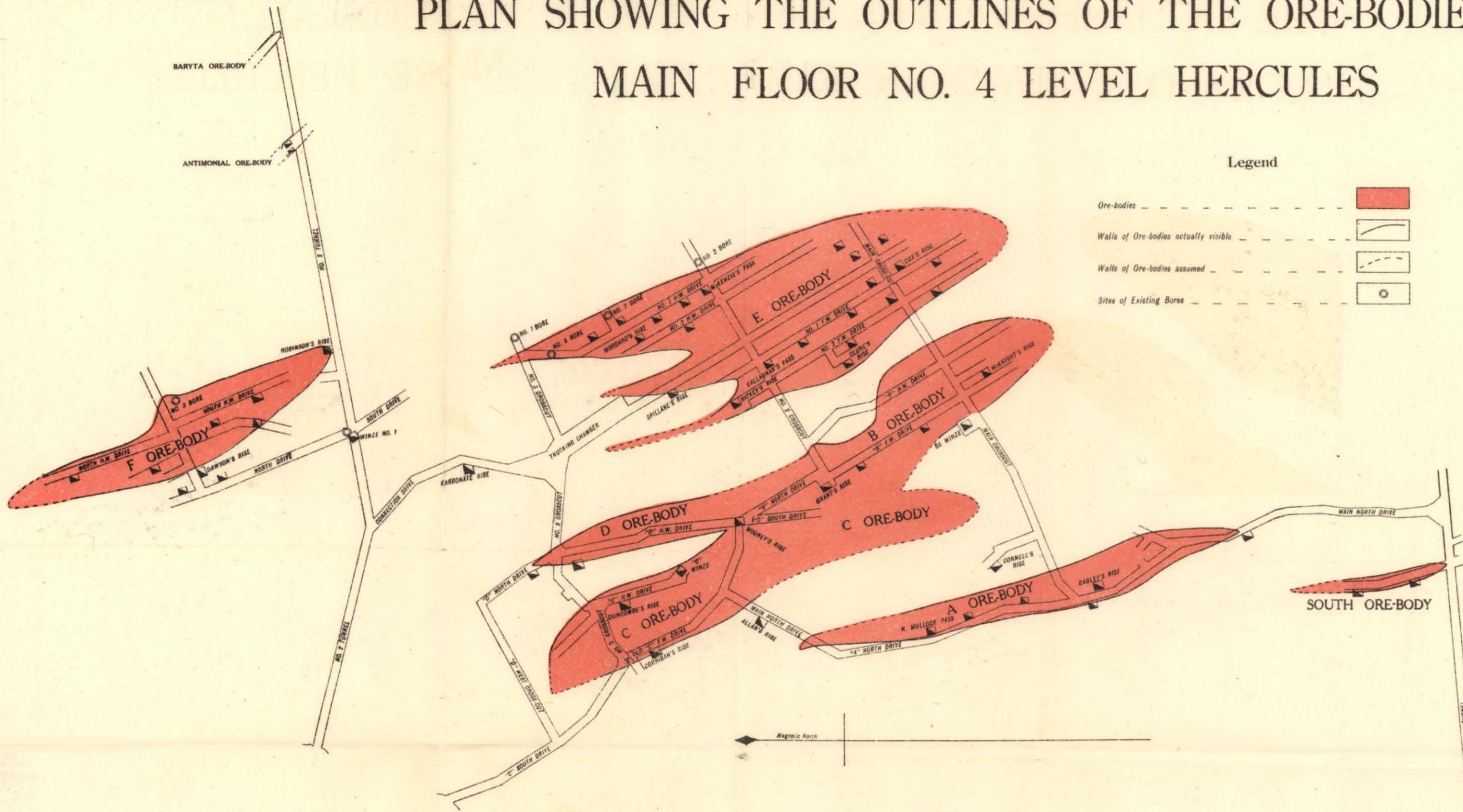
Yofano Shille M.Sc.
Assistant Government Geologist
30th Nov. 1914

Photo Aligned by John Vail Government Printer Hobart Tasmania.

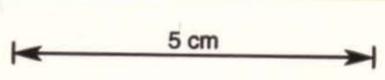
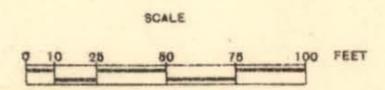
PLAN SHOWING THE OUTLINES OF THE ORE-BODIES MAIN FLOOR NO. 4 LEVEL HERCULES

Legend

- Ore-bodies
- Walls of Ore-bodies actually visible
- Walls of Ore-bodies assumed
- Sites of Existing Bores



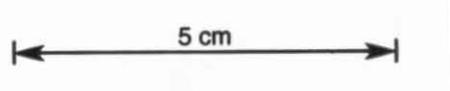
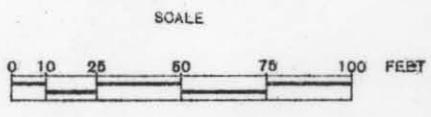
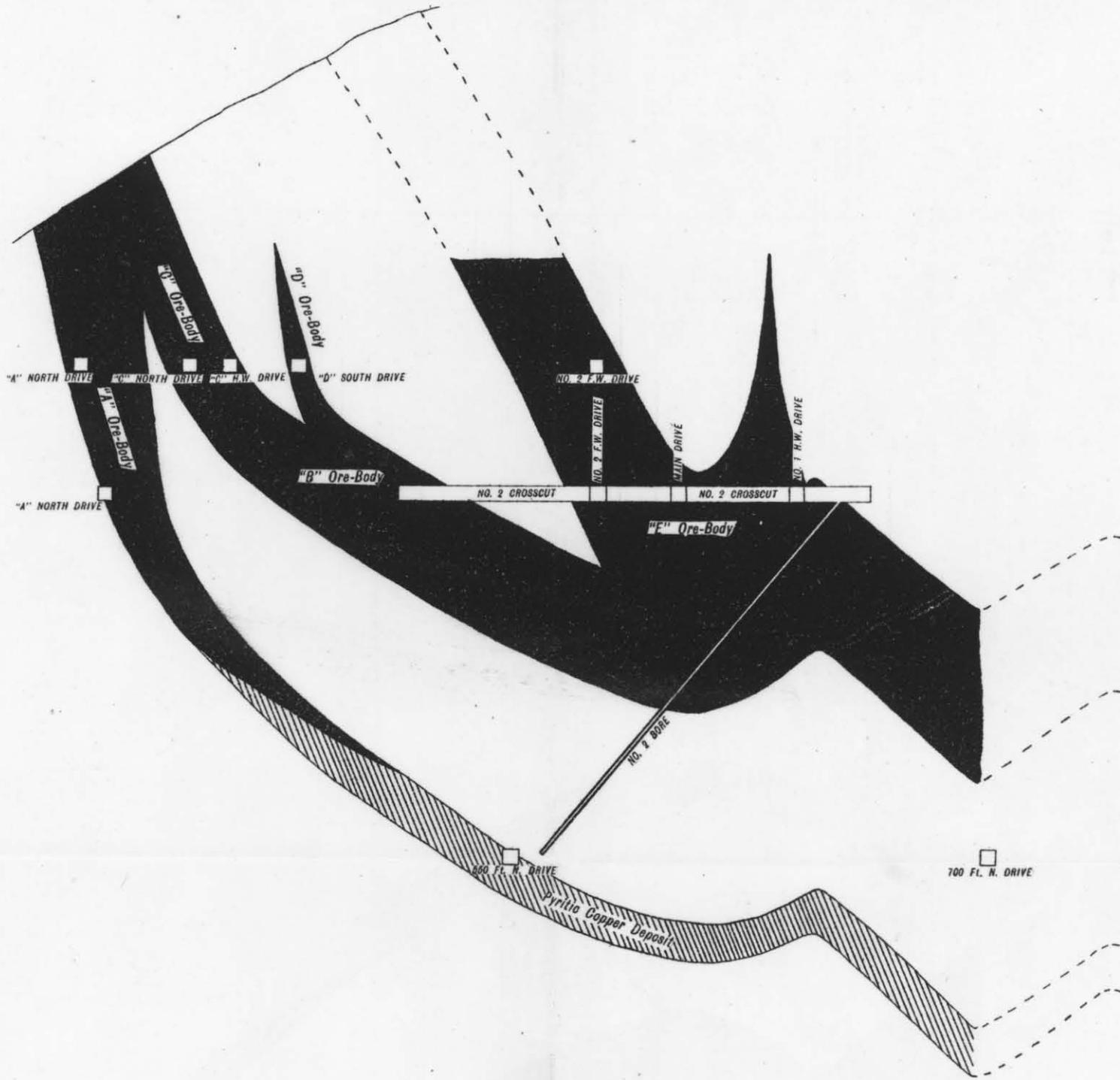
Magnetic North



Loftus Hills M.S.
 30° N. 1914

Photo Aligned by John Vail Government Printer, Robert Tassman

VERTICAL SECTION ALONG THE NO. 2 BORE HERCULES



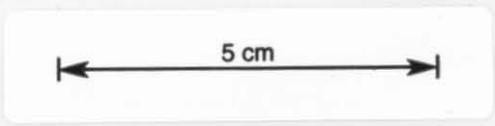
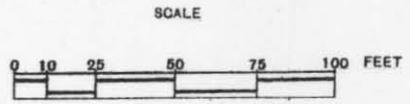
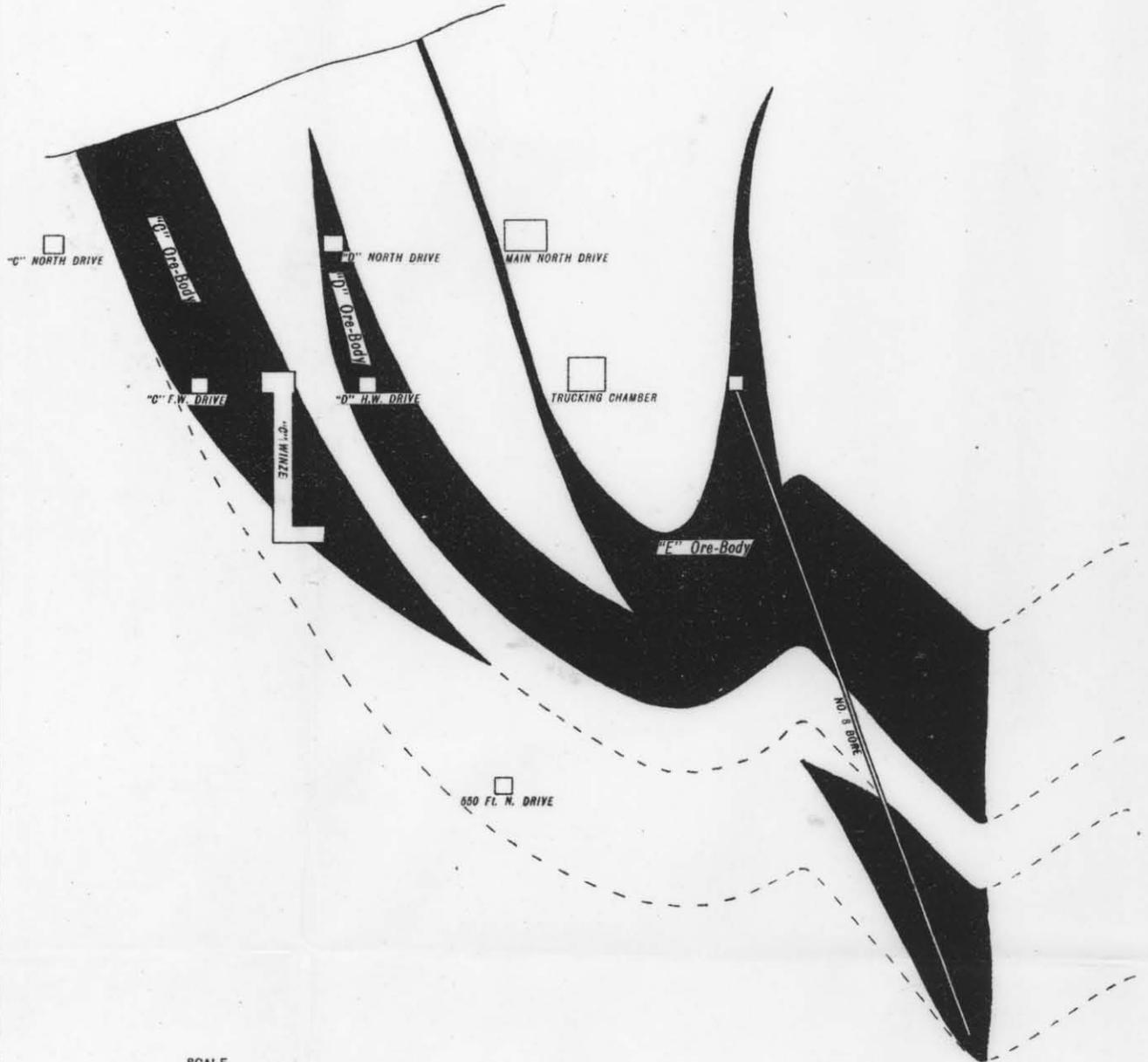
NO. 6 TUNNEL

Gopius Hills M.Sc.
Assistant Government Geologist
30th Nov 1914

Photo Algraphed by John Vail Government Printer Hobart Tasmania.

11820
Plates 20 and 21

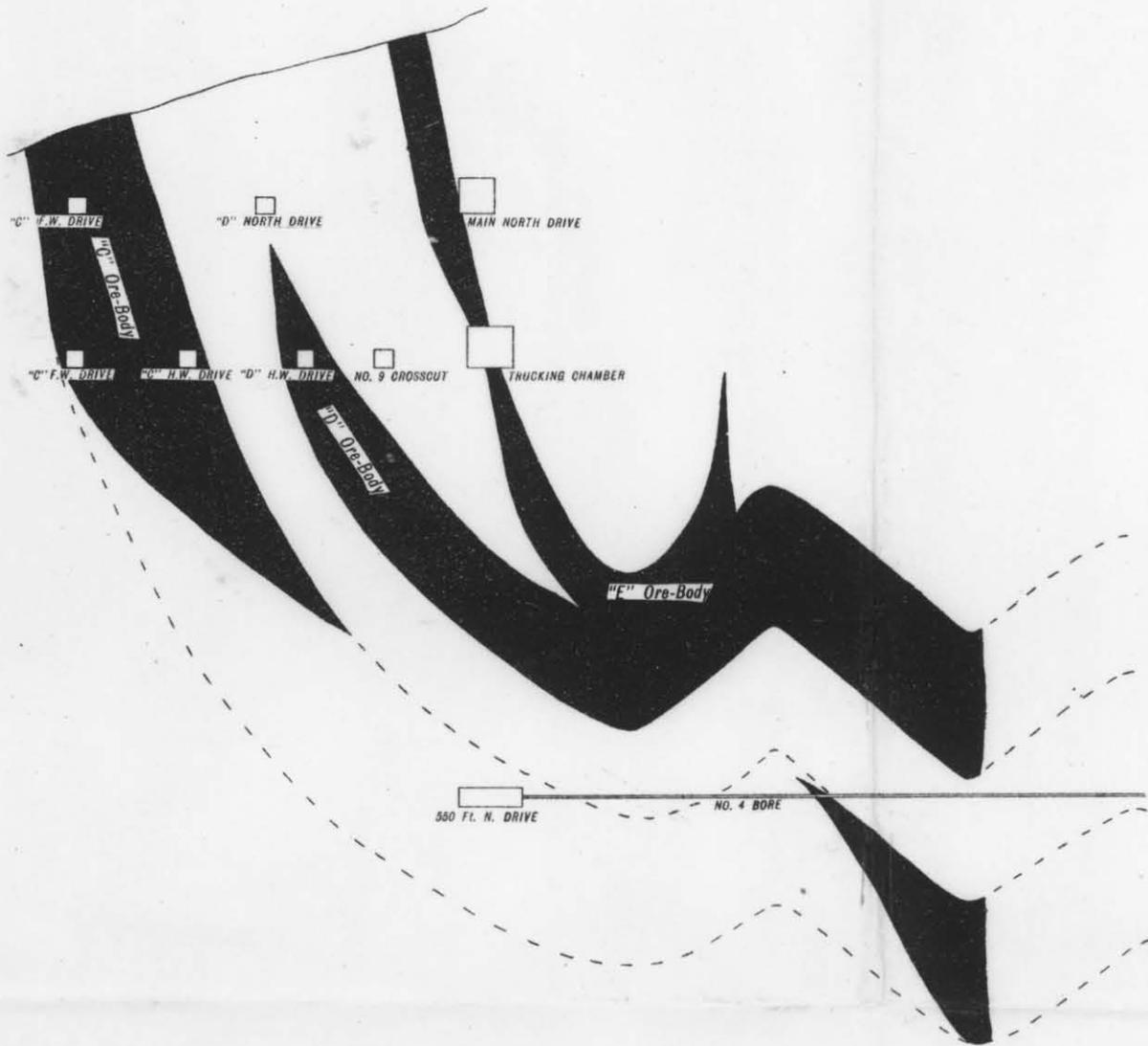
VERTICAL SECTION ALONG THE NO. 8 BORE HERCULES



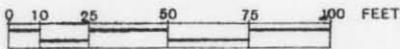
NO. 6 TUNNEL

Lopus Hills M. Sc.
Assistant Government Geologist
30th Nov. 1914

VERTICAL SECTION ALONG THE NO. 4 BORE HERCULES



SCALE

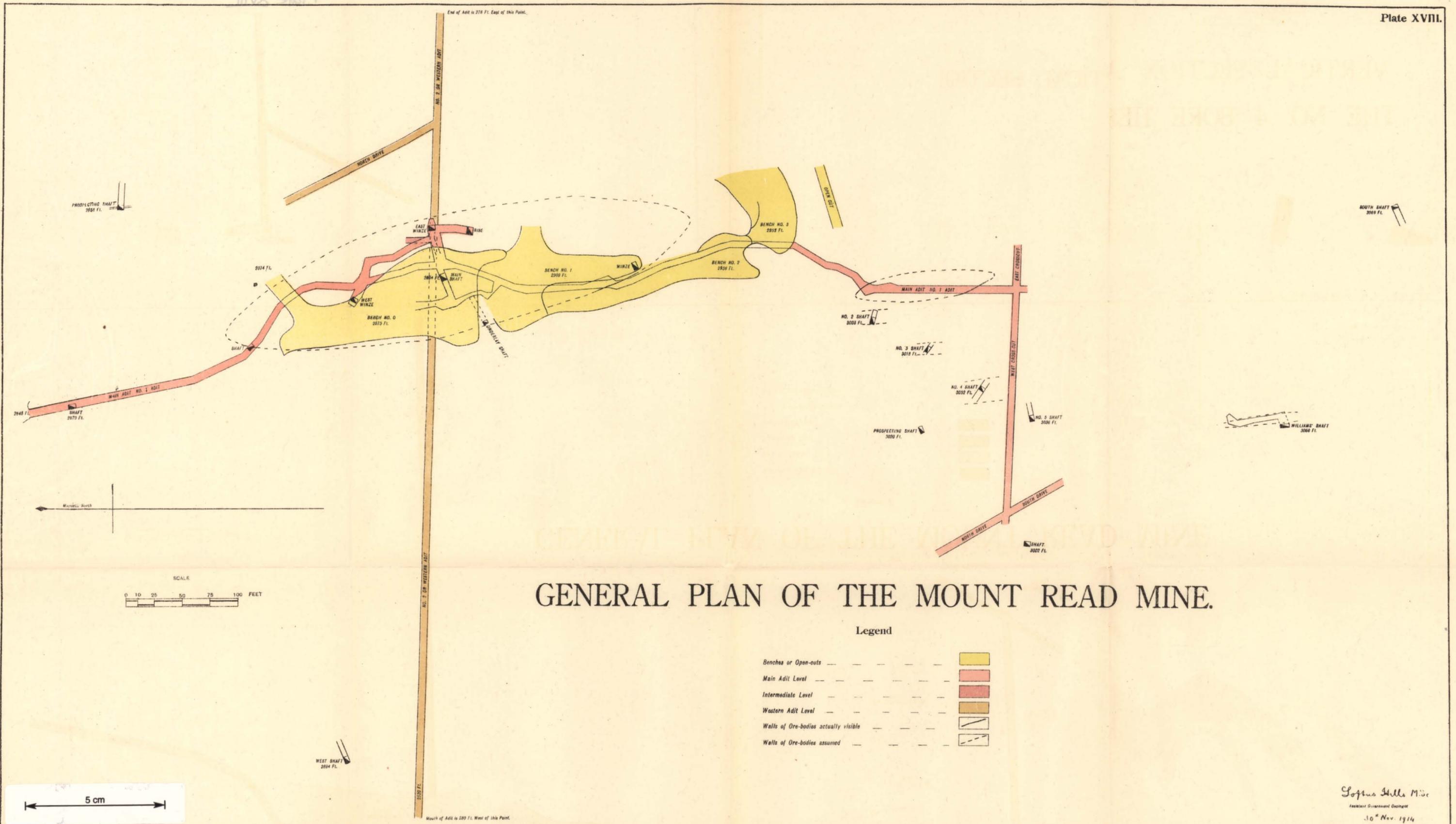


□
NO. 6 TUNNEL

Loftus Hills M.Sc.

Assistant Government Geologist

30th Nov 1914



GENERAL PLAN OF THE MOUNT READ MINE.

Legend

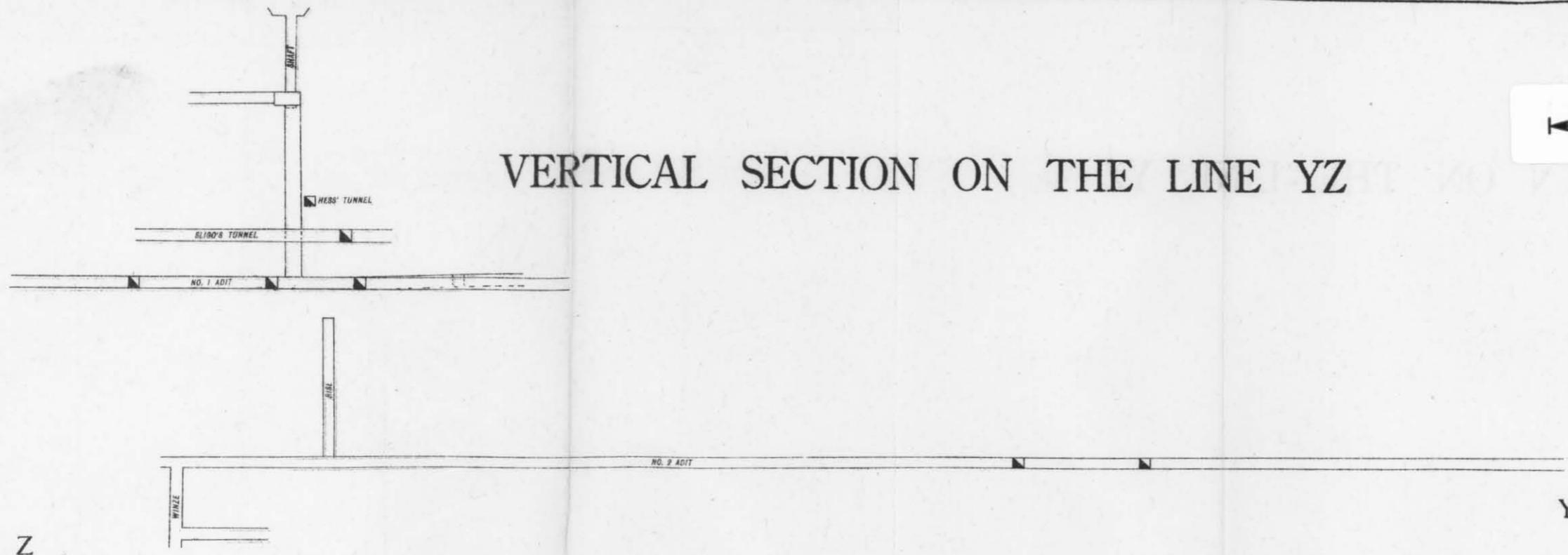
Bench or Open-outs	— — — — —	
Main Adit Level	— — — — —	
Intermediate Level	— — — — —	
Western Adit Level	— — — — —	
Walls of Ore-bodies actually visible	— — — — —	
Walls of Ore-bodies assumed	— — — — —	

Joseph Hills M. & C.
 Assistant Government Geologist
 30th Nov. 1914

Photo Aligned by John Hill Government Printer Robert Tasmania

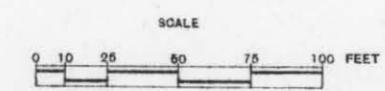
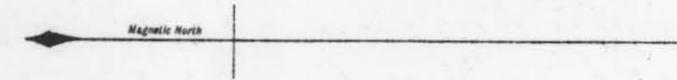
5 cm

VERTICAL SECTION ON THE LINE YZ

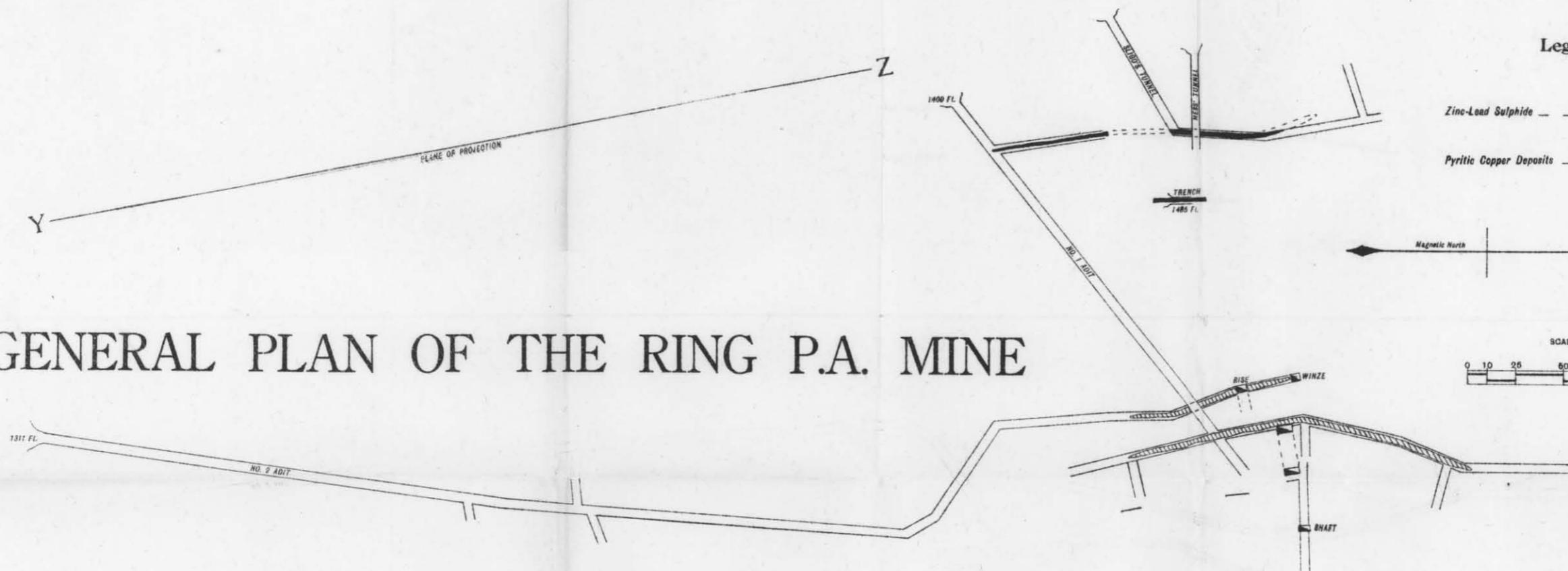


Legend

- Zinc-Lead Sulphide
- Pyritic Copper Deposits



GENERAL PLAN OF THE RING P.A. MINE



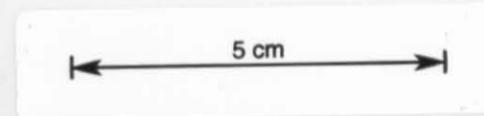
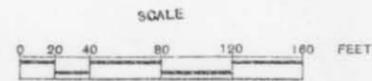
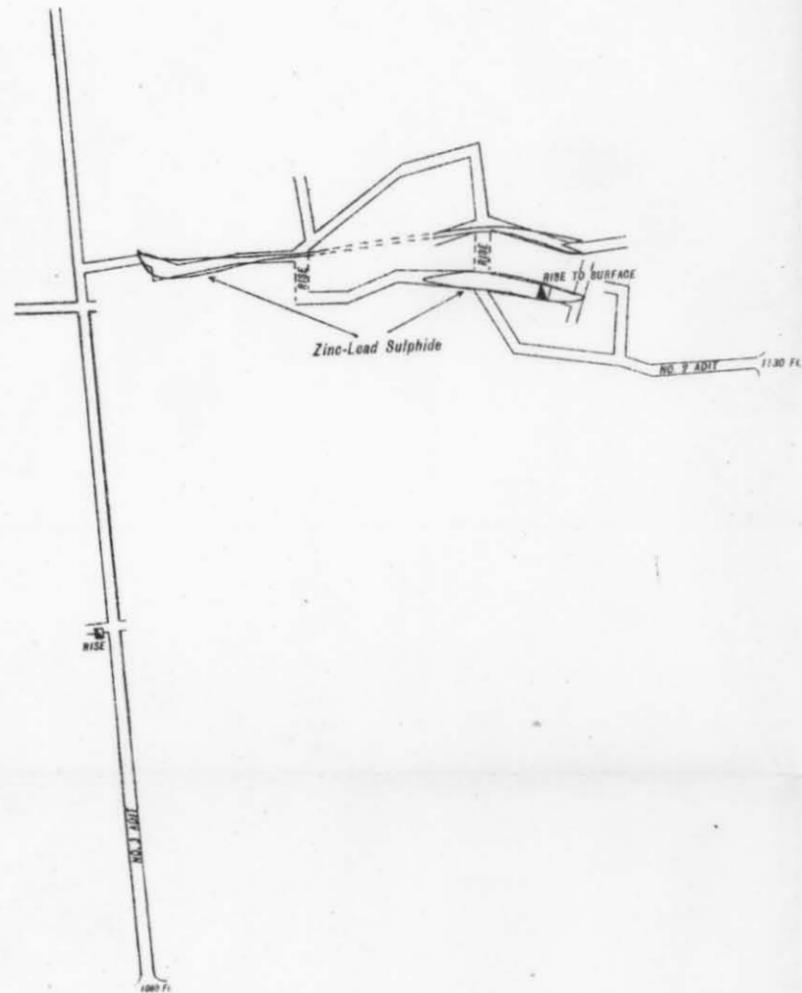
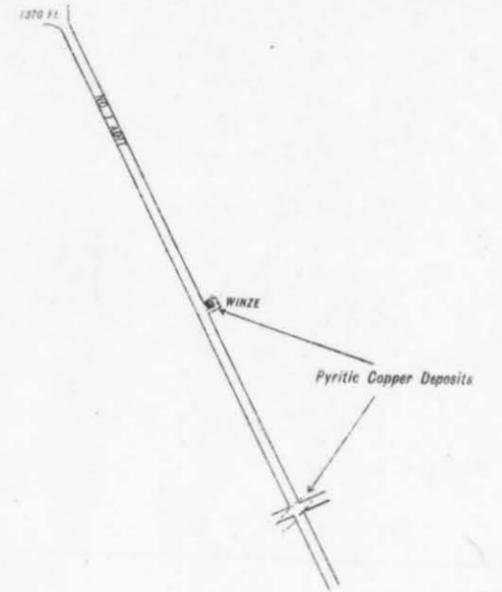
Loffus Hills M.Sc.
 Assistant Government Geologist
 30th Nov 1914

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Plate XX

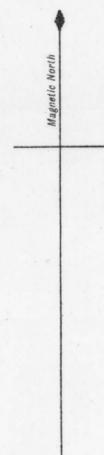
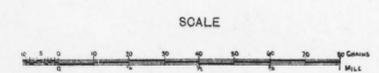
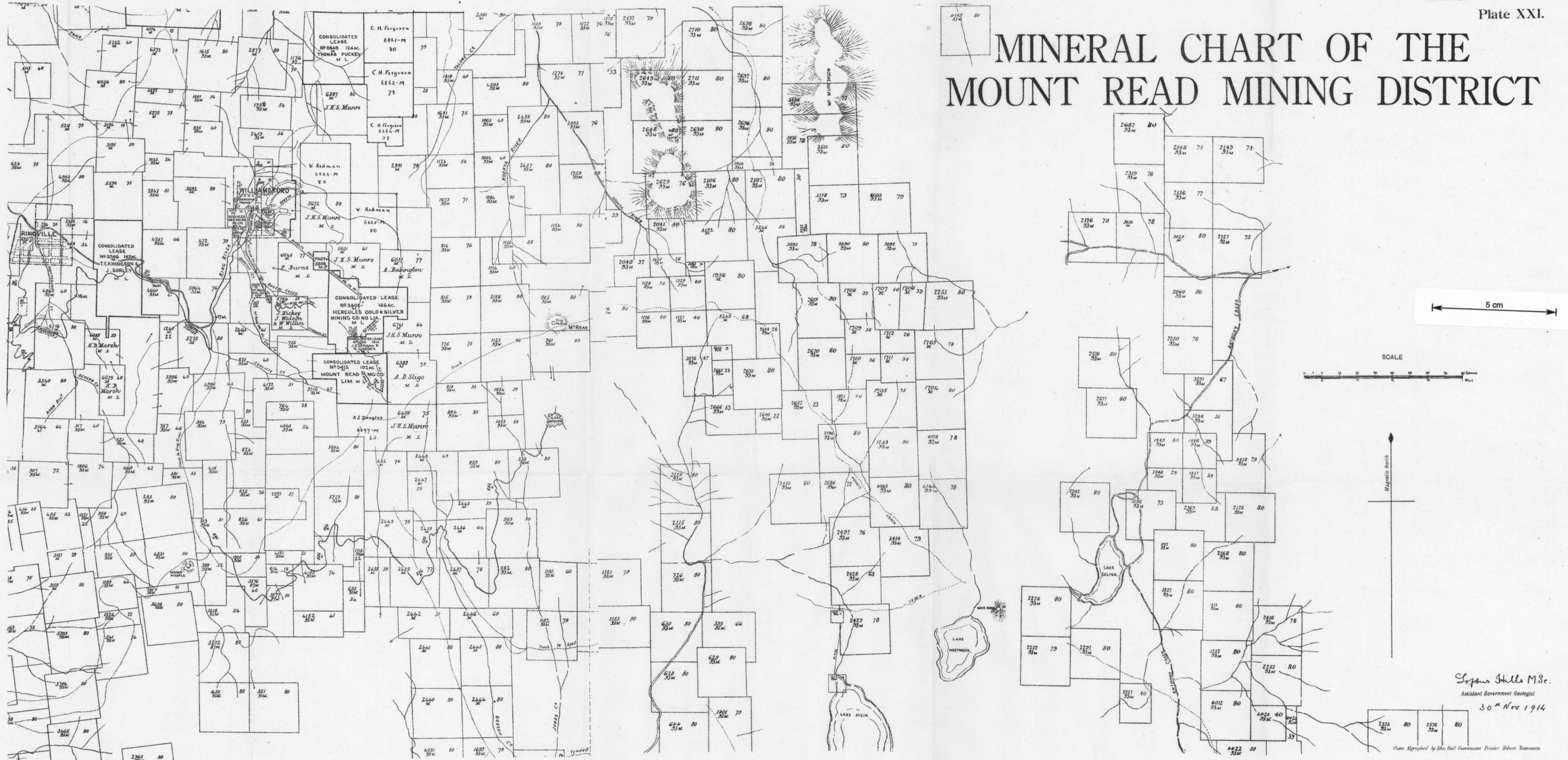
Plate XX.

GENERAL PLAN OF THE JUPITER MINE.



G. J. Hills M.Sc.
 Assistant Government Geologist
 30th Nov 1914

MINERAL CHART OF THE MOUNT READ MINING DISTRICT



Sopars Hills M.Sc.
 Assistant Government Geologist
 30th Nov 1914

Plate Mapgraphed by John Hall Government Printer, Hobart, Tasmania.