

GEOLOGICAL SURVEY
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WESTERN AUSTRALIA

1939.

WESTERN AUSTRALIA.

ANNUAL PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

FOR THE

YEAR 1938

PERTH :

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1939.

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Annual Progress Report of the Geological Survey of Western Australia for the Year ended 31st December, 1938.

The Under Secretary for Mines.

I have the honour to submit for the information of the Hon. the Minister for Mines my report on the operations of the Geological Survey for the year 1938.

STAFF.

Some changes of staff took place during the year. Mrs. G. Blatchford, B.A., Technical Assistant, resigned on the 8th of January. The position of Technical Assistant was abolished and Miss V. Russell was appointed as a senior typiste to carry out the clerical portions of the duties formerly performed by the Technical Assistant, the remaining duties of a technical nature being undertaken by the Government Geologist, Mr. Outtrim, and other members of the staff when not in the field.

Mr. F. G. Forman, Government Geologist, was awarded a Commonwealth Fund Service Fellowship tenable at Harvard University, Cambridge, Massachusetts, U.S.A., and left Western Australia on August 23rd to take up studies in the Department of Geology at Harvard University. I was appointed as Acting Government Geologist during his absence.

No other changes took place, and up to August the staff consisted of the Government Geologist, four field geologists, a senior typiste, a junior clerk and a messenger. Subsequent to August, the number of field geologists was reduced to three as a result of my appointment as acting Government Geologist.

FIELD WORK.

Re-Surveys of Goldfields.

Regional geological surveys of portions of the Yilgarn and Mt. Margaret Goldfields which were either commenced or were in progress during 1937 were continued during the year. One of the main objects of the re-surveys is an attempt to establish the relationship between broad geological structure and the location of main mining centres. Initial work on these lines was carried out in the southern portion of the Yilgarn Goldfield during 1935 and 1936 and was reasonably successful, and it is pleasing to be able to record some success for the work being undertaken in the Mt. Margaret Goldfield.

The economic significance of the results of this class of work lies in the use which can be made of the facts when ultimately established, in the search for new possibly auriferous areas which may be soil-covered and difficult to prospect.

In the course of this regional work all working mines and mineral deposits are examined with the

object of ultimately compiling information for publication in Bulletin form, while much appreciated geological help is afforded individual mine owners by the field officers during the course of their work.

Iron Ore Survey.

As a result of the embargo placed on the export of iron ore from Australia during the year a Commonwealth-wide stocktaking of the iron ore resources of Australia was proposed by the Commonwealth Government, the work to be undertaken by the various State Geological Survey Branches of the Mines Departments and paid for by the Commonwealth.

The work done in this State up to the end of November consisted of an extensive surface sampling campaign and a topographical and geological survey of the Koolyanobbing deposits situated about 30 miles N.N.E. of Southern Cross in the Yilgarn Goldfield. This investigation was commenced by Mr. H. A. Ellis, and subsequently handed over to Mr. R. A. Hobson.

Structural and genetic surveys of the other main known iron deposits of the State will be carried out during the coming year.

Proposed Field Work for 1939.

The re-surveys of the northern portion of the Yilgarn Goldfield and portion of the Mt. Margaret Goldfield are not yet completed, and the continuation of field work in these areas is contemplated.

As the iron ore survey is to be continued, Mr. Hobson will be placed in charge of the field work in connection with it, and additions to the field staff will be necessary to carry out the existing programme in the Mt. Margaret and Yilgarn Goldfields and also the iron ore survey.

Transport.

Two 15cwt. Dodge utility trucks are in use in the field, one being allotted to each field party. There are usually two geologists in each party working from the one camp, and the division of the work is such that it becomes necessary for the two geologists to be working in widely separated parts of the area being investigated. Experience of this arrangement of transport over the last three years has shown that a stage is reached in the work at a very early period when one geologist has to spend a considerable portion of his working time travelling to set down and pick up the other geologist. It is impossible to avoid this state of affairs when one vehicle has to serve

two geologists, and there is an urgent necessity both in the interests of safety and efficiency, for the provision of two additional utilities for use in the field.

Details of the field and office activities of the staff are as follow:—

F. G. Forman, Government Geologist.

In addition to administrative and routine duties, Mr. Forman attended, as a member, meetings of the Executive Committee of The North Australia Survey in Melbourne in January and July.

In April he visited the country in the vicinity of Cardabia Station north of Carnarvon to investigate and report on the possibilities of obtaining artesian water in that area, and in June he inspected the progress of field work in the northern portion of the Yilgarn Goldfield.

A considerable volume of work was also attended to by Mr. Forman during the latter part of the first half of the year in connection with the proposed iron ore survey of the State, and towards the end of June in company with Dr. Woolnough, Commonwealth Geological Adviser, he visited Koolan and Cockatoo Islands, Yampi Sound, to inspect iron deposits there.

On August 23rd Mr. Forman left the State en route to Harvard University, U.S.A., to take up geological studies there under the terms of a Commonwealth Fund Service Fellowship awarded to him during the year.

H. A. Ellis, Geologist.

From January 10th, on his return from annual leave, to March 22nd, Mr. Ellis was engaged on duties in connection with the preparation of material for last year's annual report, the proof reading of the typescript of Bulletin 97, the preparation of field plans and equipment for the survey of the northern portion of the Yilgarn Goldfield and inspection and report on Vulcan Tin Mines, Ltd., Greenbushes. During this period he accompanied the Government Geologist to Eradu on an inspection of coal deposits there, and also made an inspection and report on some copper deposits at Arrino.

From March 22nd to August 15th he was in the field in charge of the field party carrying out the regional geological survey of the northern portion of the Yilgarn Goldfield. From June 20th onward of this period he was in charge of the investigations being made into the Koolyanobbing iron deposits. On August 23rd Mr. Ellis took over the duties of Acting Government Geologist and in that capacity, in addition to administrative and routine duties, made visits to the field parties operating at Koolyanobbing and in the Mt. Margaret Goldfield.

An inspection and report for departmental purposes was made on Paget Gold Mines of Edjudina, Limited, towards the end of October. In November he prepared and delivered a broadcast talk on "How the Geologist can Aid Industry."

While in the Yilgarn Goldfield he visited Evans-ton's Find to report on the possibilities of obtaining domestic and battery water supplies at that centre.

R. A. Hobson, Geologist.

From January to the middle of April Mr. Hobson was engaged in preparing those portions of the annual report dealing with his 1937 field work, in making preparations for continuing the field work already

commenced late in 1937 in the Laverton district, and attending to various duties at Head Office during the absence of the Government Geologist.

From the middle of April to the middle of August he was in the Laverton district in charge of the field work being carried out there, and on the withdrawal of Mr. H. A. Ellis from the field to head office during August, Mr. Hobson was transferred to Koolyanobbing to take over the control of the geological and topographical survey of the iron ore deposits at that centre.

On the completion of the field work at Koolyanobbing at the end of November, Mr. Hobson returned to Perth where he was engaged up to December 19th in preparing various reports resulting from the year's field work.

Mr. Hobson commenced his annual leave late in December.

R. S. Matheson, Geologist.

From January to the middle of March Mr. Matheson was engaged in compiling reports on mines examined by him during the 1937 field season, in acquiring information necessary for the re-survey of the northern portion of the Yilgarn Goldfield and in carrying out miscellaneous office work.

From late in March to the middle of August he was in the field in the Yilgarn Goldfield carrying out geological surveys of mines and assisting in the regional geological mapping of the northern portion of the Yilgarn Goldfield.

From the middle of August to the end of September, Mr. Matheson was with the field party engaged in the re-survey of portion of the Mt. Margaret Goldfield, and in the course of his work there made a geological examination of the Erlistoun Gold Mine, Cox's Find.

From the beginning of October to mid-December, he was at head office engaged on various duties connected with the preparation for publication of Bulletins Nos. 97, 98 and 99. During this period he also compiled reports on mines which he examined during the 1938 field season as well as carrying out miscellaneous office work.

Mr. Matheson commenced his annual leave late in December.

K. R. Miles, Geologist.

From January to the latter part of March Mr. Miles was engaged at head office in a petrological examination of rocks collected from the Laverton district during the 1937 field season, the preparation of reports for the 1937 annual report, drafting work, the compilation of base maps, and the collection of other survey information in connection with the re-survey of portion of the Mt. Margaret Goldfield.

From March 22nd to the end of November he was continuously engaged in field work in the Mt. Margaret Goldfield. For a considerable portion of this period Mr. Miles was in charge of the field party as a result of the withdrawal of Mr. Hobson from the area to take over the iron survey field work.

During December Mr. Miles was at head office doing drafting work and preparing progress reports in connection with the year's field work.

Mr. Miles commenced his annual leave late in December.

PUBLICATIONS.

The only publication issued during the year was the Annual Progress Report of the Geological Survey for the year 1937.

The following Bulletin is in the hands of the Printer:—

Bulletin 97:

The Geology of the Yilgarn Goldfield South of the Great Eastern Railway, by H. A. Ellis, B.Sc., A.O.S.M., with an Appendix by Dorothy Carroll, Ph.D., D.I.C., on Sand-Plain Soils from the Yilgarn Goldfield.

The following Bulletins are prepared and are awaiting authority to print:—

Bulletin 98:

The Mining Groups of the Yilgarn Goldfield South of the Great Eastern Railway, Part I., From Southern Cross Southwards to Marvel Loch, by R. S. Matheson, B.Sc., and R. A. Hobson, B.Sc. (Hons.).

Bulletin 99:

The Mining Groups of the Yilgarn Goldfield South of the Great Eastern Railway, Part II., South of Marvel Loch, by R. A. Hobson, B.Sc. (Hons.), and R. S. Matheson, B.Sc.

The information contained in these Bulletins is of the greatest value when it can be made available to the mining community as soon as possible after it is compiled, and it is to be hoped that all three Bulletins will be published during the coming year.

SERVICE TO THE GENERAL PUBLIC.

During the course of a year many hundreds of inquiries, both personal and written, for information on geological matters, are attended to by the Government Geologist and other members of the staff who happen to be in the office at the time. Petrological determinations are made on specimens submitted, and information is freely given to intending prospectors. It is satisfactory to be able to record that these services are much appreciated by those receiving them.

It should also be placed on record that mine-owners, leaseholders, and prospectors generally show an appreciation of the advice and general help offered them by the field officers in the course of their mine examinations and general field work in the areas in which they are operating.

Not infrequently, the field officers are able to offer to those new to the arts of prospecting and mining of small ore deposits, suggestions which save them much useless work, and in the course of the examination of numerous mines it becomes obvious how much this service is needed.

Keenness in field work, engendered by a desire to satisfactorily solve the many problems of geological structure met with in the course of their field investigations, has been manifested by the field officers during the year, and under the somewhat arduous conditions attached to camp life in the Eastern Goldfields, it is not easy to maintain this state of efficiency. I desire to record my appreciation of the quality of the work done by the field officers and also to state that the office staff have given good service.

Mr. I. F. Outtrim, junior clerk, who has had some training in geology, has attended to many inquiries

of a technical nature since the office has been without the services of a trained technical assistant.

The reports which follow place on record the results of the work done by the various members of the staff, except that carried out for purely Departmental purposes.

H. A. ELLIS,

Acting Government Geologist.

30th December, 1938.

ARTESIAN AND SUB-ARTESIAN WATER POSSIBILITIES ON CARDABIA STATION, NORTH-WEST DIVISION.

(By F. G. Forman, B.Sc., Government Geologist.)

Cardabia Station is situated about 125 miles north of Carnarvon adjacent to the coast. The homestead is situated close to the Indian Ocean about one mile from the landing near Point Maud.

Except for a coastal strip about six miles wide which is occupied by sandhills of Sub-Recent and Recent origin, the whole of Cardabia Station is underlain by rocks of Cretaceous age. Over the greater part of the area occupied by the Cretaceous rocks the geological succession and structure is clearly revealed by frequent outcrops, but the sandhills in the coastal zone effectively mask the underlying bed-rock, which is presumably a westward extension of the outcropping Cretaceous rocks to the east and make it impossible to elucidate the structure of the coastal strip by surface examination.

A study of the Cretaceous outcrops and the logs of the various bores which have been put down from time to time reveals the following generalised succession:—

TOP.	THICKNESS.
Red clays or shales and limestone ...	105 feet in No. 5 bore.
Yellow calcareous clays with limestone bands and hard white polyzoal limestones with bands of yellow clay. (The red beds mentioned above may be a local variation of these beds. See logs of Nos. 2, 7 and 33 bores.)	About 200 feet as measured in the section between Nos. 10 and 33 bores.
Green glauconite clay, sandy clay or sandstones with Ammonites and coprolites. (Absent in No. 10 bore where this bed is reported as replaced by light coloured clay with limestone rubble.) Bores 8 and 9 in the same vicinity have, however, cut the green clays, in their normal position	10 feet as measured in bores Nos. 8 and 9. Also seen outcropping at House's mound east of No. 18 bore.
Light coloured clays and marls or light grey shales carrying <i>Inoceramus</i> . Reported in some bore logs as fawn coloured clays carrying <i>Inoceramus</i>	100 feet in No. 10 bore. 140 feet in bores on eastern side of Cardabia Range near Winning Station Boundary.
Blue puggy shales	150 feet thick in bores on east side of Cardabia Range. Increasing in thickness westwards to 800 feet in the Government bore.
Mainly black shales with a Belemnite zone near the top and sand or sandstone at base	1,000 feet and increasing in thickness westwards.

A detailed study of the various outcrops would enable the Cretaceous rocks to be divided up into a greater number of stages with distinct lithological characters and fossil contents, but the subdivision given above is sufficient for the purpose of discussing the water problems of the area and it is considered that further subdivision in a report of this nature would be an unnecessary complication.

The Cretaceous rocks everywhere exhibit low dips and on the eastern side of Cardabia Station they have been thrown into a broad anticlinal fold. The axis of this fold strikes in a N.N.E.-S.S.W. direction and passes close to the site of No. 2 deep bore. The denuded western limb of the anticline is well exposed in the long line of hills known as the Cardabia Range, and in the vicinity of Remarkable Hill a very complete section of the strata from near the base of the *Inoceramus* beds to and including the greater part of the polyzoal limestone beds can be seen. The rocks of the eastern limb of the fold form a belt of high country made up of a series of disconnected low hills close to the eastern boundary of Cardabia Station. The outcrops on the eastern limb are discontinuous and scattered but are sufficiently frequent with the help of information available from bore logs in this locality to indicate that the geological section is broadly identical with that exposed in the Cardabia Range. The central or axial portion of the fold has been deeply eroded, so that, in the bed of Cardabia Creek the blue and black shales of the lower part of the Cretaceous Series are extensively exposed and elsewhere are met with at very shallow depths in bore holes and wells.

To the west of the Cardabia Range, the rocks continue to dip to the westward wherever they are exposed to view. Unfortunately, the sandhill country, which occupies the whole of the coastal strip, masks from view the structure of the underlying rocks on the western portion of the property, and it is, therefore, impossible to say definitely how the rocks behave in the coastal area. Cross sections drawn between bores which have been put down on the western side of the Cardabia Range indicate, however, that the dip of the rocks does not increase beyond that observed in the Cardabia Range. It is possible that the rocks may continue to the westward with a uniform dip so that the depth to any particular horizon will steadily increase towards the west in the coastal strip. The dip may flatten out and the strata eventually become horizontal, in which case the depth to any particular horizon will remain uniform as the coast is approached. There may be a reversal of dip of which there is some evidence in at least one place (the vicinity of Nos. 2, 3 and 4 bores). In this case the depth to a particular horizon would decrease towards the west. What the actual conditions are can only be determined by putting down several trial bores in the coastal section, after the sinking of which, fairly accurate predictions of the depth to a particular bed could be made.

From a study of the logs of the bores which have already been put down it appears that the principal shallow water bearing horizons lie in the clays and marls which constitute the *Inoceramus* zone. Poor supplies of good quality water have been met with in this zone in Bores Nos. 8 and 9 and Nos. 22 and 23. These supplies were found near the top of the zone. Good supplies of good quality water have been met with lower in the same zone, in Bores Nos. 5, 6 and 7.

The water obtained in Bores Nos. 14 and 17 on the eastern limb of the Cardabia anticline also comes from the *Inoceramus* zone, but the succession in the locality is abnormal as a band of glauconitic green-sand which carries the water occurs near the base of the *Inoceramus* zone.

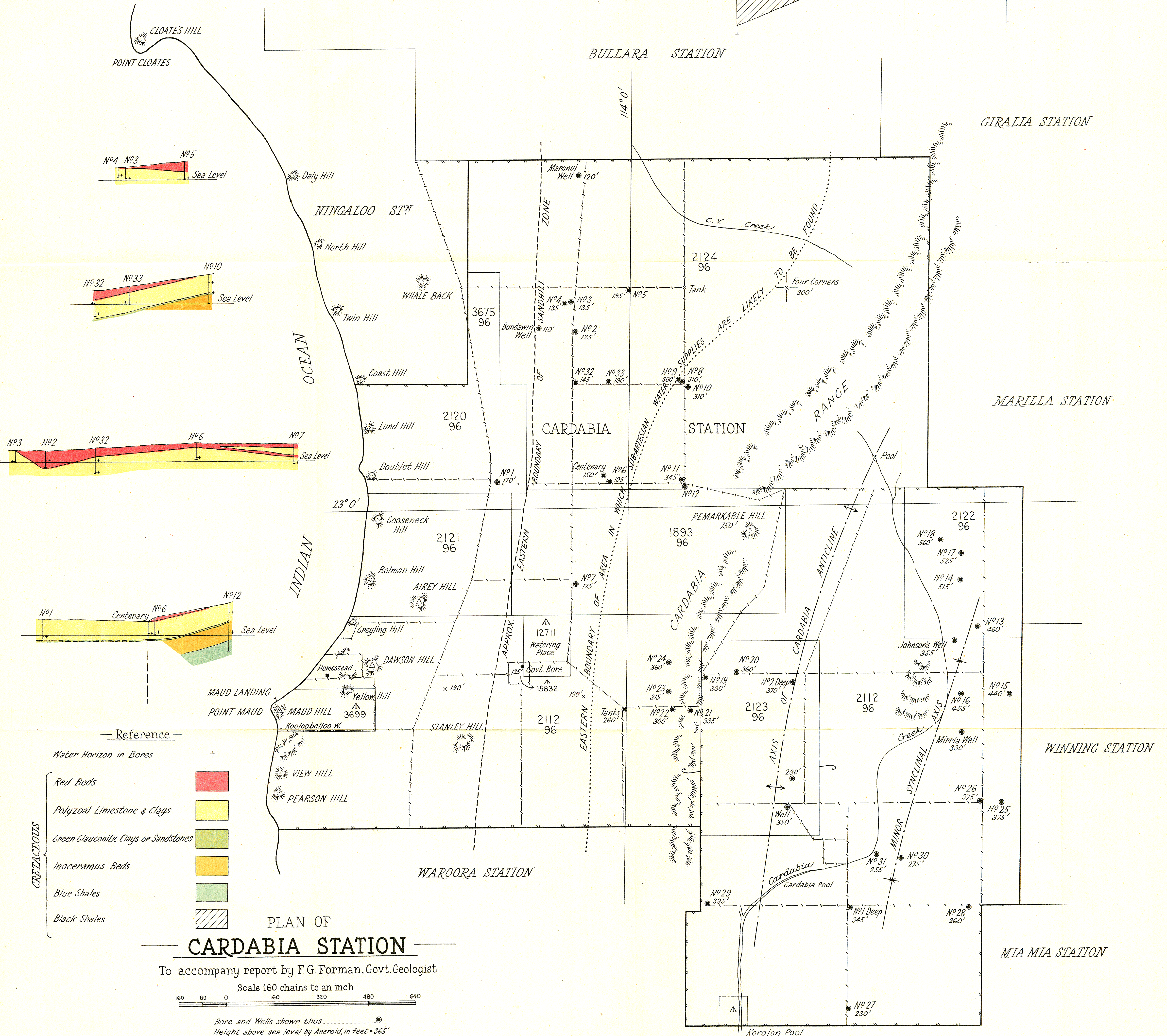
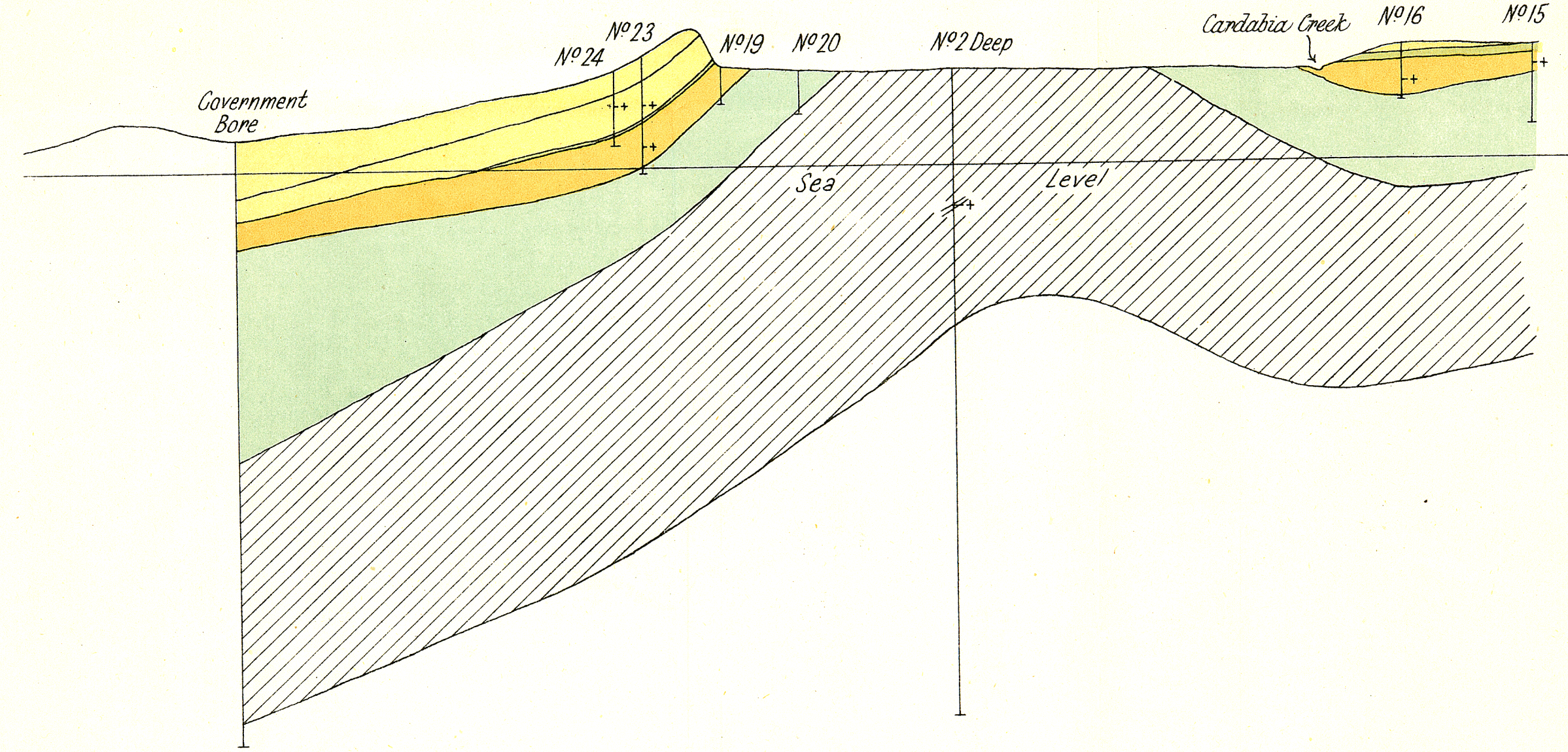
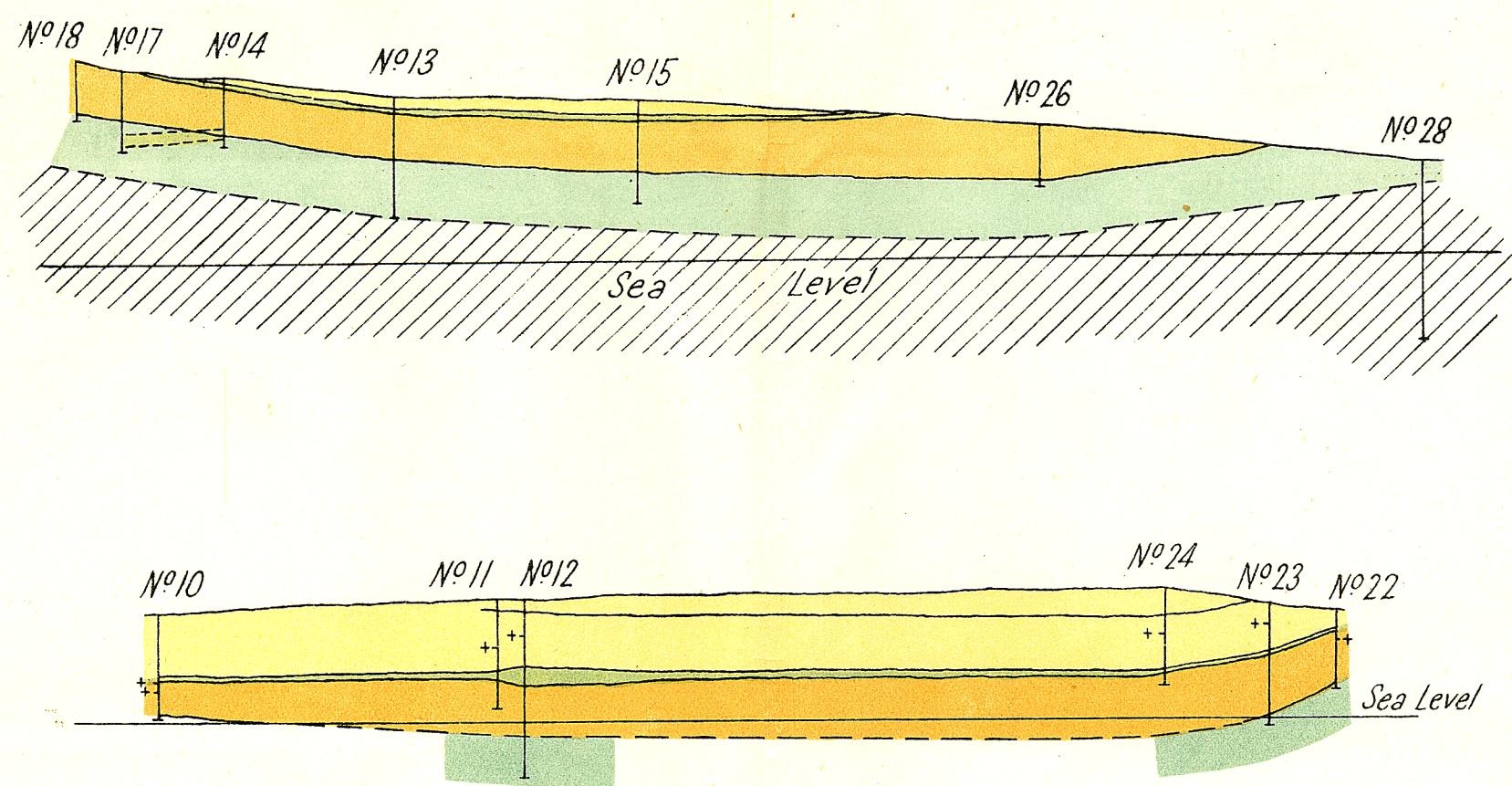
A sandy zone at the base of the blue and black shales of the lower part of the Cretaceous Series constitutes an important artesian water horizon. It is in fact, the most important artesian water horizon throughout the North-west Artesian Basin and has been tapped in scores of artesian and sub-artesian wells throughout the pastoral country north of Hamelin Pool. The flow from the Government Bore, that which was originally struck in the Centenary Bore and which has since failed, and the sub-artesian supplies obtained in the Cardabia No. 1 and No. 2 deep bores all come from the deep artesian zone at the base of the Cretaceous Series. The depth of this horizon is over 1,000 feet everywhere on Cardabia Station, its closest approach to the surface being along the axis of the Cardabia anticline where it has been tapped by the Nos. 1 and 2 deep bores at a depth of a little over 1,000 feet. At both these sites only sub-artesian supplies have been obtained, as the surface of the ground at the bores is well above the rest level of the artesian supply. The depth to the artesian water horizon in the Government Bore and the Centenary Bore is respectively 2,275 feet and 2,374 feet. This marked increase in depth as compared with the Nos. 1 and 2 deep bores is due partly to the thickening towards the west of the lower part of the Cretaceous Series, but principally to the westerly dip of the beds on the western limb of the Cardabia anticline.

Artesian water could be obtained by sinking bores to the base of the Cretaceous Series anywhere along the coastal strip, as the surface elevations over the whole of the western section of Cardabia Station is below the rest level of the water in the artesian horizon. It would, however, be necessary to sink to greater and greater depths as the coast is approached, owing to the thickening of the strata and the westerly dips.

The sub-artesian horizons of the *Inoceramus* zone lie at comparatively shallow depths throughout the central and western portion of Cardabia. They are almost everywhere at a depth of less than 500 feet below the surface and it seems likely that they will be found at much the same depths throughout the coastal strip. As explained earlier, however, this will depend on the structural behaviour of the rocks and no definite information can be given until several exploratory test bores have been put down.

A number of bores which have already been sunk, mainly those along the western slope of the Cardabia Range and those close to the eastern boundary of Cardabia Station have either failed entirely to strike water, or obtained only seepages of good water or moderate supplies of water unsuitable for stock. In all cases, the failure is due to the bores being located too close to the outcrop of the water-bearing beds in the Cardabia Range or to the outcrop of the same beds in the eastern limb of the Cardabia anticline.

A line has been drawn on the accompanying map showing what I consider to be the eastern boundary of the area from which useful supplies of water can confidently be expected. The whole of the country



PLAN OF CARDABIA STATION

To accompany report by F.G. Forman, Govt. Geologist

Scale 160 chains to an inch

Bore and Wells shown thus ●

Height above sea level by Aneroid, in feet = 365'

Vertical Scale: 500 feet = 1 inch

east of this line is not worth the expense of boring owing to the water-bearing beds being too close to the outcrop and consequently carrying only small supplies of good water or moderate supplies of bad water. On the eastern side of the line the volume of water circulating in the beds is insufficient to flush out any salt which was an original constituent of the sediments making up the Cretaceous Series.

An examination of the map will show that No. 10 Bore which yields a good supply of good water lies on the eastern side of the boundary line. The most likely explanation of the finding of good water in this bore is that it was sunk close to the bed of a fairly large creek which runs to the westward from the Cardabia Range and consequently the water-bearing horizon which has been tapped in No. 10 Bore has been well fed by soakage from the creek bed at its outcrop somewhere to the east.

No doubt a number of successful bores could be obtained on the eastern side of the line and close to it by choosing favourable sites for sinking a bore close to a creek bed which cuts throughout the water-bearing horizons at their outcrop to the eastward.

It would, however, be a very uncertain matter and it is not considered advisable to go to the expense of putting down bores on the eastern side of the line indicated.

The selected site for a bore at the Four Corners east of No. 5 Bore is also on the eastern side of the boundary line. There is, therefore, doubt as to whether suitable water would be met with at this site. In this case, I have considered that the sinking of a bore is justified because of the peculiar suitability of the site for watering four paddocks from the one point. It cannot be said that the site is particularly favourable but there is some chance of obtaining useful supplies. If the Four Corners site fails to obtain good water, the next best alternative is to sink a bore about $2\frac{1}{2}$ miles north, close to the bed of C.Y. Creek, where water will probably be obtained owing to the water-bearing beds probably being well supplied at their outcrop in the upper reaches of the creek. The second alternative would be a bore put down about $2\frac{1}{2}$ miles west of the Four Corners which lies westward of the line marking the boundary of good sub-artesian supplies.

Any site to the south of the Government bore should strike good supplies of water, and this remark applies equally to the whole of the coastal strip. It might be objected that shallow sub-artesian water was not reported in the log of the Government Artesian Bore, but it seems probable that the drillers who had as a definite objective the artesian horizon at the base of the Cretaceous Series, did not bother to mention any shallow water horizon lying within three or four hundred feet of the surface.

On the meagre evidence available it seems probable that the depth to the main sub-artesian horizons in the *Inoceramus* zone should be met with in bores throughout the coastal country on Cardabia Station at depths of probably less than 500 feet. (In all cases of exploratory boring the work should not be abandoned until it is certain that the blue shales underlying the *Inoceramus* zone have been penetrated, as until this occurs there is always a possibility of cutting a useful water-bearing bed.)

A study of the bores already put down indicates that the water horizons cut do not always lie in the same position in the *Inoceramus* zone. Sometimes

the water occurs near the top of this zone, sometimes near the bottom. A probable explanation of this fact is that the water-bearing beds are lenticular and do not extend uniformly over the whole area. For this reason no statement has been made as to the depth of water-bearing beds below the top of the *Inoceramus* zone. The safest rule to follow would appear to be to bore for the *Inoceramus* zone which is usually easily identified by the numerous shell fragments which are scattered throughout, and to continue boring until the main body of the underlying blue shales is penetrated before abandoning a bore-site as hopeless. Until the blue shales are penetrated, there is always a chance of cutting a useful water-bearing bed.

REPORT ON THE VULCAN TIN MINE, GREENBUSHES.

(By H. A. Ellis, B.Sc., A.O.S.M., Geologist.)

Introduction.

The Vulcan Tine Mine is situated in the north-eastern corner of Mineral Claim No. 4, known as the "New Caledonian" Lease, situated on a flatly undulating spur between Bunbury and Westralian Gullies on the south side of the main Greenbushes-Bridgetown road, some two miles south-east by south from Greenbushes Townsite.

The mine is operated by a Perth company known as Vulcan Tin Mines, Limited, mining operations being carried out by the hydraulic sluicing of a weathered, kaolinised tin-oxide and tourmaline-impregnated zone of granitised schist and associated pegmatite dykes. The maximum dimensions of the working cut are approximately 260 feet in length, 195 feet in width and 35 feet in depth. The disintegrated tin-bearing material is elevated from the bottom of the open-cut as a pulp by a gravel pump and passed through sluice boxes in which the tin-oxide concentrate is recovered by the normal sluice-box process.

Since the commencement of production by the present company on February 4th, 1937, approximately 41 tons of tin concentrates, of an average metallic tin content of nearly 57 per cent. valued at £5,707 10s., have been won up to the end of January, 1938. The approximate volume of the ore treated for this return is 16,900 cubic yards, giving an average value of 5.39 lbs. of concentrates, containing 57 per cent. of metallic tin per cubic yard. Operations are at present (January, 1938) suspended owing to a shortage of water, and the necessity for additional equipment to enable sluicing to be carried out under a higher nozzle pressure than is at present in use.

The limits of the tin bearing formation at present being worked are known definitely at one point only, namely, in a tunnel driven through the eastern wall of the open cut in a north-easterly direction.

As a result of an inspection of the mine workings and leases made by the writer during the period January 18th-26th, 1938, it was found that the only practical means of determining the extent of the payable tin-bearing formation was by a series of boreholes sunk with a percussion drilling plant in which the shoe of the casing can be kept in advance of the face of the drilling bit.

Topography and Geology.

The area in which the company's holdings are situated is one of gentle slopes of general low relief, and

falls within the the 760 to 920 feet contours of the contoured geological map of Greenbushes contained in G.S.W.A. Bulletin 32. It forms part of the headwaters of a southerly trending drainage system of the Blackwood River. The narrow alluviated valleys of Bunbury and Westralian Gullies cross the leases in a general south-easterly and easterly direction respectively, and, with the exception of these valleys, the entire area is thickly timbered with jarrah and red-gum forest, and is covered with ferruginous laterite of varying thickness, which completely obscures the underlying rock.

There are no natural outcrops of bed-rock which can be definitely recognised, and a conception of the nature of this rock can only be gained from places such as the open cut of the main workings, and the dumps of shallow shafts.

In the dump of the old main shaft, situated in the south-western portion of Mineral Claim No. 3 near the main road, some pieces of fresh looking quartz-hornblende schist and tourmaline-bearing pegmatite may be seen, while further to the north-west along a line of old shallow surface workings extending in this direction, pieces of soft, weathered, purple phyllite and weathered mica-schist occur in the dumps.

The rock exposed in the open cut at the main mine workings on Mineral Claim No. 4 is a highly felspathic, decomposed, quartz mica schist showing marked schistosity, striking N. 30° W., and dipping W. 30° S., at an average dip of 35°. This rock grades imperceptibly, in parts of the open cut, into what appears to be a massive kaolin formation, with or without granular quartz. The whole rock mass is liberally impregnated with black tourmaline, ranging in size from irregular patches, some 6 inches across, down to specks so small as to be only just recognisable. It is in this combined schistose and massive kaolinised rock that black tin-oxide occurs in payable quantities, irregularly disseminated throughout the mass.

A tunnel driven in a north-easterly direction through the eastern wall of the tin-bearing formation passed through a red clayey formation devoid of quartz and mica. This material represents the weathered portion of a rock type, the nature of which cannot be determined on present available evidence.

On the old Cornwall leases, a short distance S.E. of Greenbushes Townsite, in pieces of diamond-drill bore-core lying near the old workings, fresh amphibolite schist similar to the greenstone schists of the eastern goldfields may be seen in contact with fresh albite-pegmatite dykes.

Several exposures in road cuttings and old dredge holes, within a radius of six miles of the area under discussion, consist of hornblende schist, biotite schist, fine grained biotite granite and migmatites.

The general line of the known tin-bearing lode formations passes through the workings on M.C. 4 in a general direction of N. 30° W. up Bunbury Gully, through the old Cornwall workings and on to the old "White Lode" area, south of the Greenbushes railway station. Along this line rich alluvial ground has been worked in the past, and it is also from this locality that most of the lode-tin has been mined. From information supplied by old miners on the field, most of the lode formations dipped to the west.

Considering all the available evidence outlined above, it would appear that the underlying rocks of the Greenbushes Tinfield consist of metamorphic crystalline rocks of both a basic and acid composition, comprising a belt of unknown width, with a general north-north-westerly trend and a westerly dip. This belt has been intruded by one or more granite magmas, and has undergone granitisation marginally, and in zones within itself, resulting in the formation of replacement gneisses and schists and migmatites.

The main workings on M.C. 4 are considered to be in a zone or belt of replacement gneiss and schist of unknown width, the economic importance of which is due to an accompanying introduction of tin-oxide into the schistose rock with associated tin-oxide and tourmaline-bearing pegmatite masses. As previously mentioned, this zone has a known length of some three miles in a general N.N.W. direction.

The evidence at present available tends to support the conception that the open-cut on M.C. 4 is situated near the southern end of this zone, and that the country to the south of Westralian Gully contains only narrow zones not yet shown to carry workable concentrations of tin-oxide.

The several shallow shafts on the old "Ironad" leases south of Westralian Gully are considerably to the west of the general strike of the main zone, and, although they show the presence of tin and tourmaline bearing pegmatites in the dumps, the small extent of the old workings suggests that deposits similar in nature to that at the open cut do not exist in this direction, or that, if they do, their presence has not yet been revealed by surface prospecting.

It would be possible for the strike of the main zone to swing round in the direction of these old workings; in fact, such a swing in strike would be in keeping with the shape of several small north-pitching dragfolds seen in exposures in localities some distance away from the present open cut, as these small folds indicated that some of the schistose rocks of the tinfield formed part of the western limb of a north-pitching anticline.

It would, however, be mere presumption on the meagre evidence available in the field to consider that the tin-bearing zone being worked in the open cut on M.C. 4 had a southerly continuation on the south side of Westralian Gully. The question of the northerly continuation of the formation and conditions associated with tin-oxide deposition can be taken as proved, since either tin-oxide or tantalite have been mined at intervals from M.C. 4 to just south of the Greenbushes railway station along the line of the formation. The manner of distribution of the tin-oxide throughout this belt is not accurately known, but present indications are that certain parts of it contain rich irregular concentrations as well as finely disseminated cassiterite scattered through a considerable bulk of rock. In all occurrences so far known, the matrix of the tin-bearing material consists either of albite pegmatite (the "Cornwall" leases) or a massive or schistose mixture of kaolin, mica, and quartz with abundant tourmaline.

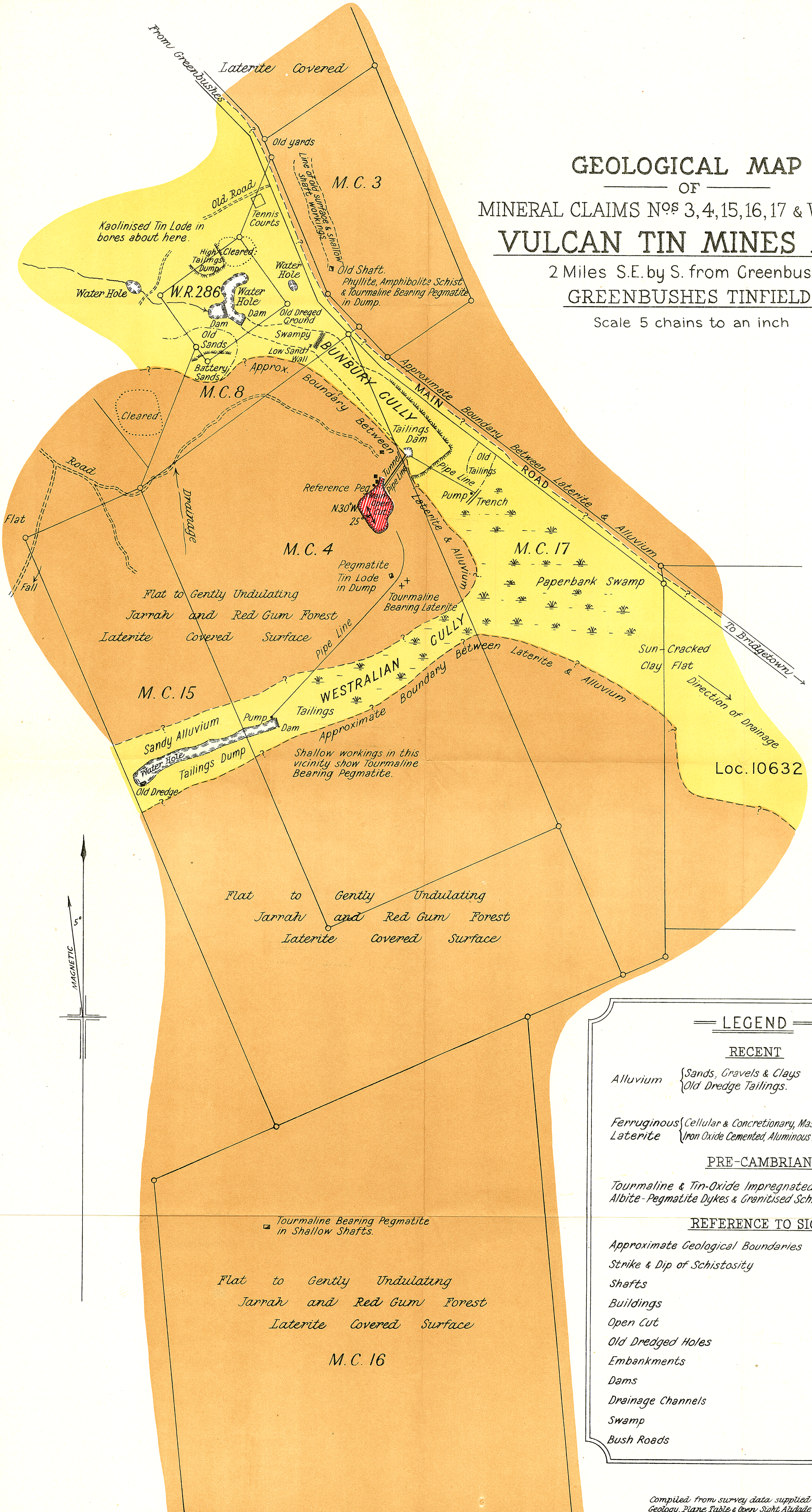
The old workings on M.C. 3 (known as the "Lost and Found" lease) suggest that the bulk of the tin oxide was obtained in the past from alluvial deposits associated with the laterite, and from narrow decomposed pegmatite dykes, forming a stock-work in

GEOLOGICAL MAP OF MINERAL CLAIMS Nos 3, 4, 15, 16, 17 & W.R. 286 VULCAN TIN MINES LTD.

2 Miles S.E. by S. from Greenbushes

GREENBUSHES TINFIELD

Scale 5 chains to an inch



LEGEND

RECENT

Alluvium { Sands, Gravels & Clays
Old Dredge Tailings.

Ferruginous { Cellular & Concretionary, Massive
Laterite { Iron Oxide Cemented, Aluminous in places

PRE-CAMBRIAN

Tourmaline & Tin-Oxide Impregnated
Albite-Pegmatite Dykes & Granitised Schists.

REFERENCE TO SIGNS

Approximate Geological Boundaries
Strike & Dip of Schistosity
Shafts
Buildings
Open Cut
Old Dredged Holes
Embankments
Dams
Drainage Channels
Swamp
Bush Roads

phyllites and amphibolite schist. There is no indication in these old workings of the existence of a wide mineralised and granitised zone similar to that exposed in the open cut on M.C. No. 4, and the deposits of M.C. No. 3 can be best regarded as forming a band of narrow pegmatite dykes parallel in strike to the main belt to the west.

The several shallow shafts on the other claims indicate the existence there of tin and tourmaline-bearing pegmatite dykes, but the amount of work done on them gives no clue as to the extent of these deposits. There is ample scope for surface prospecting in the vicinity of these old workings, and in the portions of the leases situated away from the known workings the presence of tourmaline in the ferruginous laterite can be considered a favourable indication of the possible presence of tin-oxide.

The Main Workings.

The main workings of Vulcan Tin Mines, Ltd., are situated in the north-eastern portion of M.C. No. 4 on a flatly undulating laterite and forest-covered spur between Bunbury and Westralian Gullies, on the south side of the Greenbushes-Bridgetown road, some two miles south-east by south from Greenbushes Townsite.

Black tin-oxide is being obtained from a soft, highly decomposed, schistose and massive kaolinised rock of granitic composition, mined in an open cut by hydraulic sluicing methods, the disintegrated rock being elevated from the open cut as a pulp by gravel pump and passed over sluice boxes in which the tin-oxide is recovered.

The site of the present open cut and the surface immediately surrounding it was the scene of alluvial and lode mining carried out spasmodically since about the year 1899. The alluvial mining consisted of the collection of tin-bearing alluvial material shed from the soft kaolinised lode material and covering laterite, and its subsequent treatment by washing. The lode mining consisted of small open cuts and shallow shafts sunk in rich concentrations of tin-oxide and the subsequent treatment of the puggy lode material in various classes of treatment plant, none of which appears to have been able to successfully treat the difficult lode material. A combination of Huntington mills, cone classifiers and Wilfley tables was noted in one old plant, and the equipment used by the owner of the lease who was operating it immediately prior to the present owners consisted of a 6-foot Chilean mill and sluice box.

The main treatment difficulty lies in the very high content of kaolin in suspension in the pulp, necessitating the use of large quantities of water in the sluice boxes to effect efficient saving of the fine tin-oxide.

The open cut has a maximum length of 260 feet, is 195 feet wide and 35 feet deep in its deepest part. The sides of the cut show a thickness of from two to four feet of ferruginous laterite capping a weathered kaolinitic formation, which shows both a massive and schistose structure in various parts. The general strike of the schistosity is N. 30° W. and the average dip 35° W. 30° S., with a tendency for the dip to steepen as the western side of the cut is approached. The weathered schistose exposures consist essentially of kaolin, quartz and muscovite mica, with a liberal impregnation of tourmaline frequently arranged parallel to the schistosity. They also carry

black tin-oxide scattered through them in a very fine state of division. In all probability this weathered schistose material represents a replacement schist formed by a process of granitisation of a pre-existing rock type whose original nature cannot be determined. Grading almost imperceptibly into the schistose material are masses of almost pure kaolin carrying more or less tin-oxide and tourmaline, either with or without small lenses or irregular patches of massive, jointed quartz or granular quartz. Muscovite mica in plates up to 2 inches square occurs unevenly through the whole formation, while occasional crystals of beryl, about 1 inch across, were seen.

The manner of occurrence of the patches of granular quartz in the more or less massive kaolin, and the presence of thin quartz veins cutting the planes of schistosity of the schistose rock, is very similar to that seen in granitised zones bordering greenstone belts in the Eastern Goldfields, and points to the occurrence of this process in the rocks exposed in the open-cut.

The eastern wall of the formation is met in a tunnel driven N.E. from the bottom of the open-cut, and consists of an iron-oxide stained clay without noticeable quartz, mica, tourmaline or tin-oxide. The other limits of the formation are not known, although definite evidence is available that it extends for at least 160 feet north, 160 feet west and 500 feet south of the present north, west and south limits of the open-cut, and that it is tin-bearing in these localities.

Dish samples taken and washed by the writer from a number of points in the walls and floor of the open-cut all showed traces of tin-oxide, together with ilmenite. The tin-oxide appears to be disseminated throughout the entire kaolinised formation in a fairly fine state of division, pieces as big as a wheat grain being occasionally seen. Much of the first grade concentrate consists of pieces of tin-oxide of smaller dimensions than this, while the second grade has some very fine tin-oxide, almost a powder, in it.

Crystals of cassiterite up to $\frac{3}{4}$ inch across are reported as having been found in the workings, but recognisable crystals are rare in the heavily tourmalinised kaolinitic formation which constitutes the lode.

Irregular masses of black tourmaline and some partially formed crystals of the same mineral up to six inches across occur, and the formation is liberally impregnated with irregularly shaped masses of tourmaline of smaller dimensions, the finest of which are in the nature of a fine powder.

Local concentrations of tin-oxide in the form of irregularly shaped shoots of comparatively small dimensions are reported to have been worked in the area now occupied by the open-cut by previous leaseholders. No doubt similar rich shoots have been encountered in the course of hydraulic sluicing operations by the present owners, and other shoots can be reasonably presumed to exist in the formation under the floor and behind the walls of the present workings.

No information is available as to the depth to which the weathered kaolinised material extends below the bottom of the present workings, and, since the depth of the oxidised zone determines the limits of the present method of working the mine, this in-

formation is important and must be secured if any large scale mining operations are contemplated. With the information at present available a useful estimate of this depth cannot be made; it will be found more practicable to gain this information from bore holes.

Production.

Mines Department records show that between 1899 and 1934 some of the ground now held as M.C. 4 produced approximately 69 tons of tin-concentrates. It is impossible to determine whether or not this production came from an area now occupied by the open-cut, but it is almost certain that a large portion of it was actually produced from rich shoots of tin-oxide found in the formation now being worked by Vulcan Tin Mines, Ltd.

A more definite production figure is that of the recent owner, H. Paterson, who, according to Messrs. Lindsay and McKay, tin buyers of Greenbushes, produced about 9½ tons of concentrates, of about 60 per cent. metallic tin content, during the period July, 1935, to June, 1936, from ore taken from the open-cut now being worked.

In these production figures no yardage or tonnage is given, and the grade of the ore cannot, therefore, be ascertained. A complete record of the production by Vulcan Tin Mines, Ltd., was made available by the company, and the following is an analysis of the figures:—

Date commenced production	4th February, 1937.
(Production figures to end of January, 1938.)	
Total tonnage of First Grade Concentrate	35 tons 13 cwt. 1 qr. 25 lbs.
Total tonnage of Second Grade Concentrate	4 tons 19 cwt. 3 qr. 16 lbs.
Total Production	40 tons 13 cwt. 1 qr. 13 lbs.
Average Assay Value of Total Concentrate Production	57.04% metallic tin.
Average Assay Value of First Grade Concentrate	59.65% metallic tin.
Average Assay Value of Second Grade Concentrate	38.46% metallic tin.
Market Value of Production	£5,707 10s.

In order to arrive at some approximate estimate of the quantity of material treated for this return, a quantity survey of the open-cut was made by the writer, whereby the total cubic content was obtained. This amounted to approximately 24,900 cubic yards. From a sketch plan and longitudinal section of the open-cut, as it was prior to the commencement of operations by Vulcan Tin Mines, Ltd., an approximate cubic content of 8,000 cubic yards was obtained from the very meagre information available on the plan. This estimate has had to be made on insufficient information, and must be regarded as roughly approximate only.

It would appear then that a volume of approximately 16,900 cubic yards of lode material has been treated by Vulcan Tin Mines, Ltd., for a return of 40 tons 13 cwt. 1 qr. 13 lbs. of tin-oxide concentrate, containing 57.04 per cent. of metallic tin. This is equivalent to a recovery of 5.39 lbs. of tin concentrate per cubic yard of material treated.

The difficulty of treatment brought about by the high suspended kaolin content in the pulp in the sluice boxes makes it almost certain that some appreciable quantity of concentrate has found its way into the tailings dumps. These have not been sampled, and consequently an estimate of the total weight of

tin concentrate per cubic yard and the percentage recovery figures of the treatment process cannot be determined.

Nevertheless, the value of 5.39 lbs. of recovered concentrates per cubic yard is a very satisfactory one, and prospects are favourable for the existence of large quantities of similar grade lode material beyond the present limits of the open-cut workings.

Future Development.

The manner of occurrence and the physical nature of the tin-bearing lode material makes possible the application of mining methods usually employed in working alluvial deposits, and from a practical point of view the deposit must be regarded as if it were an alluvial deposit.

In hydraulic sluicing or dredging processes it is necessary to be able to treat large volumes, and the treatment plant and water supply at present available is not capable of doing this. Before considering the enlargement of the plant and the provision of a better water supply it is essential to establish the existence of adequate ore reserves, and this can only be done in the present case by a thorough boring campaign.

The limits of the workable ground are determined by the depth of the material amenable to the present treatment processes and by the length and width of the mineralised zone. The occurrence of tin-oxide in lode or reef formation is notoriously irregular, and in the present case this fact will materially influence the setting out of bore sites.

At present, the limits of the payable tin-bearing material being worked in the open-cut are known in one point only, and it is not possible to form even the remotest estimate of its extent. To secure this information it is suggested that a series of suitably located cased bore-holes be drilled with a percussion drilling plant capable of keeping the shoe of the casing in advance of the drilling bit, and also capable of withdrawing the case on the completion of the hole.

In view of the fact that the tin-oxide may occur in any portion of the hole and that the whole of the material must be treated to recover it, it may not be necessary to record the concentrate from less than 15 feet sections of the borings. It will be necessary to carry the bores down to the limit of the lode material which is sufficiently soft to enable it to be mined by the methods at present in use.

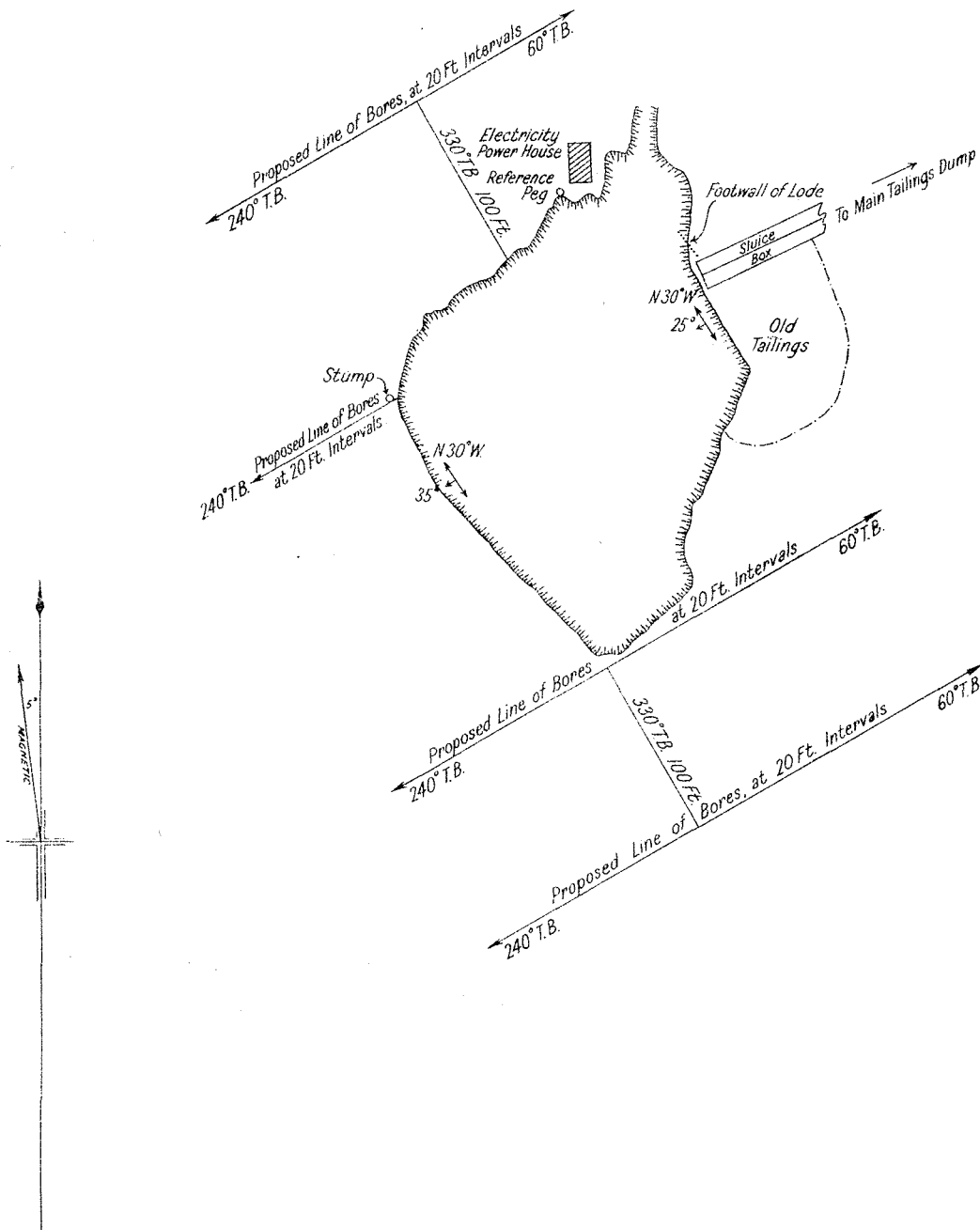
The concentrates from the 15-foot sections should be carefully saved and individually weighed, after which they could be bulked and submitted for assay for metallic tin. All computations should be made on a metallic tin content, because the concentrates cannot be obtained absolutely free from ilmenite or possibly tantalite and columbite. By this means a value in terms of metallic tin will be obtained for a section of the lode, the volume of which is represented by the product of the area of the cutting end of the casing-shoe (using the external diameter of the shoe if this has a bevelled edge) and the depth of the hole.

The boring campaign should be carried out under the supervision of a geologist, who would be in the position to locate bores additional to the lines set out below, using the information obtained from these bores.

PLAN OF
OPEN CUT-MINERAL CLAIM N^o 4
VULCAN TIN MINES LTD.

2 Miles S.E. by S. from Greenbushes
Showing Proposed Line of Bore Sites
GREENBUSHES TINFIELD

Scale 200 feet to an inch



Starting from the known tin-bearing deposit of the open-cut, and utilising the general direction of strike of the schistose lode material, the initial bores could be advantageously placed as follows:—

(a) The first line to be drilled at about 20-foot intervals in a direction of 240° true bearing from the most westerly part of the open-cut.

(b) The second line could be started in the same direction from a point situated about 100 feet on a bearing of 330° true bearing from the centre of the north-western bank of the open-cut. By drilling at 20 feet intervals in both directions (240° and 60° true bearing, respectively) the width of the tin-bearing formation will be established here.

According to the results obtained from these two lines of holes the distance between the lines of holes themselves can be adjusted to meet the circumstances when extending the campaign further to the north.

(c) Using the most southerly point of the open cut as a starting point two preliminary lines of holes at 20-foot intervals along lines 100 feet apart should be drilled across the southerly continuation of the formation in the same direction as for the northern lines.

In drilling these holes it will be best to determine the lateral limits of the formation by working outwards first to the east and then to the west from a centre line. The lines of these proposed bore sites are shown on the attached plan.

No boring difficulties are anticipated, and the footage drilled per shift should be high in this class of country. It will be essential for the boring contractor to keep an adequate supply of water on the bore site, and to provide a sluice box with sides sufficiently high to prevent the splashing over of the sludge as it is tipped from the sludge-pump into the box. This sludge will have a high content of suspended kaolin in it, and a reasonably large vessel should be provided at the end of the sluice box to take the outflow from the box and provide an opportunity for fine tin-oxide to settle below the lip of the overflow.

It is obvious that with no knowledge of the probable limits of the tin-bearing formation, a useful estimate of the number of holes required to prove a large volume of material cannot be made. The prospects of the present workings certainly warrant the provision of at least £1,000 for boring purposes, but until several lines of holes are drilled, no estimate of the probable amount of ground this expenditure would prove can be made.

Water Supply.

The present water supply drawn from old dredged channels, now forming water holes in Bunbury and Westralian Gullies, and from a trench in Bunbury Gully below the tailings dam, is inadequate for the present treatment plant in the summer months. During the winter months ample water is available from these sources.

An immediate improvement in these supplies could be made by ring-barking the jarrah and red-gum forest on the catchments of these two gullies, and additional supplies could be obtained from a group

of wells sunk at the junction of Westralian and Bunbury Gullies.

If the deposit is shown by boring to be extensive, then a water supply adequate for the requirements of a larger plant is necessary, and this could probably be best obtained by constructing a dam across Westralian Gully.

CONCLUSIONS.

(1) Mining operations carried out in the open cut on M.C. 4 show that tin-bearing lode material of a minimum average value of 5.39 lbs. of tin concentrate per cubic yard has been won from approximately 17,000 cubic yards of material treated by Vulcan Tin Mines, Limited, between February, 1937 and January, 1938.

(2) Records of production from an area which can be reasonably presumed to have included the present site of the open cut indicate that approximately 78 tons of tin concentrate was obtained from the formation prior to the commencement of operations by Vulcan Tin Mines, Limited.

(3) The sides and bottom of the present workings carry tin-oxide finely disseminated through the lode material, and hand bores reveal the presence of the tin-bearing formation at distances of up to 140 feet north, west and south of the present limits of the workings. There is no information at present available as to the limits of the tin-bearing zone.

(4) The manner of occurrence of the tin-oxide in the formation and the favourable geological structure, together with the proved occurrence of tin-bearing material, at intervals, for approximately three miles to the north-northwest, suggest the distinct possibility of the existence of an extensive tin-bearing formation on M.C. 4, both to the north and south of the present workings.

(5) Tin-bearing reefs and lodes, unlike gold deposits, are not subjected to surface enrichment by chemical processes, and the occurrence of further rich shoots of tin-oxide may be anticipated in the unoxidised rock below the downward limits of the weathered material at present being worked.

(6) A prospecting boring campaign is necessary to prove the extent of the deposit, and the results obtained from mining operations to date amply justify the expenditure of at least £1,000 on this work.

(7) The various known occurrences of tin-bearing pegmatites exposed in shallow workings on the other mineral claims of the company's holdings require further prospecting before an estimate of their value can be formed. On present indications, they do not appear to have the possibilities of the deposit at present being worked on M.C. 4.

Plans.

The following plans accompany this report:—

- (1) Geological Map of Mineral Claims Nos. . . 4, 8, 15, 16 and 17, and W.R. 286. Scale 5 chains = 1 inch.
- (2) Plan of open-cut, Mineral Claim No. 4, showing lines of proposed boresites. Scale 100 feet = 1 inch.

Photographs.

A series of photographs of the open-cut and rock formations exposed therein has been added to the Departmental collection.

PROGRESS REPORT ON THE GEOLOGICAL
SURVEY OF THE YILGARN GOLDFIELD
(NORTH OF THE GREAT EASTERN RAIL-
WAY).

(By H. A. Ellis, B.Sc., A.O.S.M.)

Field work on this area was commenced late last year and was continued this year from March 22nd to the middle of June when an interruption was caused by the concentration of work on the Koolyanobbing Iron Ore deposits.

Mr. R. S. Matheson was in the field with the writer and undertook the detailed investigations of the mining groups as well as assisting in the regional mapping when opportunity afforded.

The regional mapping was carried out by the writer, and up to the middle of June, the external boundaries of the Greenstone Series, as well as the boundaries of some of the more distinct lithological types forming part of this Series, were delineated as far north as a line passing through the Sisters Trigonometrical Station (H.K. 7) and the Radio Mine, about five miles north of Bullfinch townsite. A considerable area of granitic and gneissic country lying to the east and west of the greenstone belt extending between Southern Cross and Colreavy was traversed, and in the Koolyanobbing district Mr. Matheson carried out a plane-table triangulation survey of about 150 square miles of country in which only a very small amount of survey data was available on existing plans.

The following mining groups were examined by Mr. Matheson and his reports appear elsewhere in the Annual Report:—

The Hope's Hill Group,

The Pilot Group,

The Copperhead Syndicate (Bullfinch Group),

The Koolyanobbing Group.

Several geological features of importance in the interpretation of the major geological structure have been recognised and mapped, and it is now possible to indicate the approximate position of the axis of the major anticlinal cross-fold comparable in order of magnitude with the major synclinal crossfold occurring between Nevoria and Burbidge in the southern portion of the goldfield.

The regional pitch of the structure southward from Southern Cross is steep to the south-east, and between Southern Cross and a point situated a short distance north of Corinthian there is a length of about twelve miles of country in which changes of pitch from north-west to south-east occur, and in which are situated, in addition to many small gold occurrences, the Hope's Hill, Pilot, and Corinthian mining groups.

North of Corinthian the regional pitch is to the north-west, with minor reversals of pitch. This regional pitch to the north-west is maintained at least as far north as the Sisters Trigonometrical Station, the northern limit of the detailed regional mapping so far carried out.

The axis of a major anticlinal crossfold must, therefore, pass through the Greenstone Series somewhere between Southern Cross and a little north of Corinthian.

On the other side of the structure, namely, the jaspilite horizon in the Greenstone Series as exposed at Koolyanobbing which is traceable with breaks, from Bullfinch south-eastward through Southern Cross, Marvel Loch, Nevoria and then in a northerly

direction through Palmer's Find, Yellowdine Lake and north-westward from Koolyanobbing, there is evidence which points to a spot about eight to ten miles south-east of Trig. Station M.Y. 1 as being the locality of a change in regional strike associated with the existence of a cross-fold. On the western shores of Lake Barlee in this vicinity the jaspilite horizon can be seen extending southward to Yellowdine Lake with a regional strike approximating to the north. To the northward the jaspilites assume a regional strike of nearly north-west, and for a considerable length of this north-westerly striking portion of the jaspilites the regional pitch is to the north-west, and the major drag-folds indicate that the beds are forming the eastern limb of a northerly pitching antiline.

The axis of the major anticlinal crossfold can be reasonably presumed to pass through the major structure in a north-easterly direction from a point somewhere between Southern Cross and Corinthian to a point about eight to ten miles south-east of Trig Station M.Y. 1 at Koolyanobbing.

This anticlinal crossfold, together with the synclinal crossfold at Nevoria, has caused the gradual convergence of the jaspilite horizon in a southerly direction and the convergence of the structure lines in a general northerly direction demanded by this interpretation of the major structure, can be seen to be taking place northward from the line of the axis of the anticlinal crossfold.

A synclinal crossfold is surely being approached as we proceed in a general northerly direction from Bullfinch, but field work has not yet been undertaken in this direction.

A band of metamorphosed erosion sediments and fine grained basic tuffs in which quartzites, phylites, pebble conglomerates, and garnetiferous amphibolite schist are prominent, has been traced north-westwards to Bullfinch townsite from the northern shore of Lake Koorkoordinate immediately west of the point where the Southern Cross-Hope's Hill road crosses the lake. At present, this Series of rocks of predominantly sedimentary origin is thought to be a stage in the Greenstone Series, as no evidence of repetition of the beds by folding has so far been found. If they represented a portion of the White-stone Series which had been preserved as an infolded synclinal remnant, repetition of the beds in a direction at right angles to the strike should be able to be detected. A careful search for this feature was made without success, and it certainly seems at present that these beds form part of a unilateral structure at least as far north as Corinthian.

Anthophyllite schist and talc associated with a coarse-grained amphibolite showing a pegmatoid development occur as parallel bands on the western side of the metamorphosed sedimentary band and are traceable for many miles north-westward from the shore of Lake Koorkoordinate.

The formation of replacement gneisses and micaeous schists as a result of metasomatic replacement of the marginal areas of the Greenstone Series by granitic material is well shown in the exposures near the eastern boundary of the Greenstone Series between Hope's Hill and Corinthian. Unfortunately, the rocks are too deeply weathered to provide a suite of typical specimens for petrological and chemical investigation, but the field evidence supporting the conception of granitisation is very strong in this locality.

PROGRESS REPORT ON THE GEOLOGY OF AN AREA IN THE VICINITY OF LAVER- TON AND MORGANS—MT. MARGARET GOLDFIELD.

(R. A. Hobson, B.Sc. (Hons.).)

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INTRODUCTION.

During 1917 and 1918 regional geological mapping was undertaken by Clarke in the Leonora-Duketon district, and the maps published on a scale of 4 miles to an inch.¹ Prior to this, and mostly before 1908, various mining centres had been examined by members of the Geological Survey Staff. In late 1937, the writer, with Messrs. Matheson and Miles, commenced field work in the vicinity of Beria. The object was to carry out geological work of a similar nature to that then only recently completed in the Yilgarn Goldfield. It was intended to cover a smaller area than that broadly mapped by Clarke, and to include more detailed work in the vicinity of active mining centres. Particular emphasis was to be given to the structural aspect of the work, as it had already been found² that there was a relationship between geological structure and gold deposition.

FIELD WORK.

Field work was commenced by Mr. R. S. Matheson on 4th October, 1937, at the Lancefield Gold Mine. On 28th October he was joined by Mr. K. R. Miles. During the 1937 field season, these two officers completed the examination of the Lancefield Gold Mine, the country in its immediate vicinity,³ and commenced the mapping of the jaspilites in the vicinity of Laverton and Beria. After Mr. Matheson's departure on 25th November this latter work was continued by Mr. Miles. The writer joined the field party on 2nd November, and field work was continued until 17th December. In addition to making a broad examination of the country the writer reported upon the King of Creation Gold Mine.⁴

Field work was resumed by Mr. Miles on 26th March, 1938, and he continued with the mapping of the jaspilites in the vicinity of Laverton and to S.W. He was joined by the writer on 21st April. On 4th August the writer was withdrawn to take over work at Koolyanobbing in connection with the

iron survey, and Mr. Miles continued with both the jaspilite mapping and the broader geological mapping. During the period 18th August to 29th October, Mr. Matheson was also in the district, and in addition to mapping the jaspilites to the S.E. of Laverton, also made an examination of the Erlistoun Gold Mine at Cox's Find.

As a result of the work outlined in the previous two paragraphs 2,000 square miles of country have been mapped on a scale of one mile to an inch. It is worthy of record that this includes the accurate mapping of all jaspilite outcrops. The Lancefield Group (including the Lancefield Gold Mine), the Gladiator Group⁵ (including the Gladiator Gold Mine), the King of Creation Gold Mine and the Erlistoun Gold Mine⁶ have been examined, and appropriate maps and plans prepared.

During the 1938 field season the work was severely handicapped by the lack of adequate transport—only one utility being provided. Had an additional utility truck been provided, appreciably more country would have been mapped.

MAPS AND PLANS.

The broad scheme of work followed during the course of the Yilgarn Survey⁷ has been used. Broad geological mapping has been done on a scale of one mile to an inch, and recorded on Lands Department lithos. numbers 137, 138, 139, 144, 145, 146 and 172. During the course of the field work it was found that the one mile to an inch lithos. contained too much irrelevant detail to be suitable for base maps, and accordingly base maps, showing only survey information, were prepared from these lithos. Jaspilite mapping has been done for the most part using a plane table and telescopic alidade, and intersection and resection methods on a scale of 20 chains or 40 chains to an inch.

GENERAL GEOLOGY.

The principal rocks of economic importance are those of the Greenstone Complex. This consists of a highly folded series of basic lavas, tuffs, agglomerates, epidiorites, coarse-grained greenstones (probably intrusive), with fairly frequent thin bands of erosion sediments. Of the erosion sediments the most useful for structural purposes are the jaspilites, which form conspicuous outcrops, and which are continuous along their strike for many miles. The Greenstone Complex is invaded by a Granitic Series, consisting of granite, gneiss and acid dykes of various types, including the auriferous quartz veins. This is, in turn, intruded by dolerite dykes, which are, however, not of very frequent occurrence. Overlying all these unconformably, are rocks of much more recent origin—glacial erratics, siliceous and ferruginous laterite, soil and alluvium. As elsewhere in the Western Australian Goldfields soil and alluvium extend over large areas, and effectively cover much geological detail. During the course of the geological mapping soil covered areas, in which the underlying rocks could not be reasonably inferred from the soil, are mapped as soil.

¹ Clarke, E. de C. The field geology and broader mining features of the Leonora-Duketon district, Western Australia, Geological Survey Bulletin No. 84, 1925.

² Ellis, H. A. Progress report on the geology and mines of the Yilgarn Goldfield, south of the Great Eastern Railway, Annual Progress Report of the Geological Survey for the year 1936, p. 31. Also—The geology of the Yilgarn Goldfield, south of the Great Eastern Railway, Geological Survey Bulletin 97 (in press).

³ Matheson, R. S., Lancefield Gold Mine, Mt. Margaret Goldfield; Miles, K. R., Lancefield Group—Report on "Beria Main Lode," G.M.L. 2216T, Mt. Margaret Goldfield, Annual Progress Report of the Geological Survey for the year 1937, pp. 14 and 20.

⁴ Hobson, R. A., King of Creation Gold Mine, Mt. Margaret Goldfield, Annual Progress Report of the Geological Survey for the year 1937, p. 12.

⁵ P. 27.

⁶ P. 24.

⁷ Ellis, H. A., Progress report on the geology and mines of the Yilgarn Goldfield, Annual Progress Report of the Geological Survey for the year 1935, p. 19.

So far no sedimentary series, corresponding to the Whitestone Series of the Yilgarn Goldfield, has been found. It was thought that an outcrop of chistolithic rock, occurring 2½ miles S.E. of the late Child Harold Gold Mine, might be portion of such a series. This outcrop forms a low hill, approximately one mile by half a mile, and is completely surrounded by alluvium. Geological mapping has not yet been continued southward from here, so that it is not known if there are any further outcrops of this rock. It occurs in a broad synclinal fold, and would therefore be in a stratigraphic position similar to the Whitestone Series. Mapping to the S.W. of Morgans in an area where there is another large synclinal fold, has not revealed any extent of sedimentary rocks. The small outcrop referred to above is therefore, for the present, best regarded as merely another sedimentary band in the Greenstone Complex.

The following is put forward as a tentative rock classification, subject to expansion and alteration as the work proceeds:

RECENT.

Soil, alluvium, siliceous and ferruginous laterite.

AGE UNKNOWN.

Glacial erratics.

PRE-CAMBRIAN.

Dolerite dykes.

Granitic Series: granite, gneiss, pegmatite and aplite dykes, porphyry dykes of various types, quartz reefs.

Greenstone Complex: lavas, tuffs, agglomerates, epidiorites, coarse-grained greenstones (probably intrusive) with thin bands of erosion sediments. Includes the jaspilites.

In the paragraphs preceding the above table, a very brief summary of the geology has been given. In the following paragraphs it is not intended to give a more detailed account of the general geology, but only to draw attention to certain features.

Soil and alluvium.

Large portions of the area under examination are covered with a reddish brown to yellow sandy soil, and a spinifex and stunted mallee vegetation. In these areas typical sand dunes frequently occur. Immediately south of Mt. Windarra, and also 2 miles S.S.W. of J.R. 33 soil of this type is seen to be blown against jaspilite ridges, and sometimes through gaps in the ridges. Almost without exception no rock outcrops occur in areas covered with soil of this type. The writer has, however, seen small outcrops of granite, and at one place soil of this type is seen to overlie a much weathered granite exposed in a break-away. Areas with this type of soil and vegetation are regarded as being covered with transported soil, which obscures the underlying geology. Other areas of sandy soil, but with mulga vegetation and scattered small outcrops of granite or gneiss are regarded as overlying granite and/or gneiss.

Alluvium covers very extensive portions of the country, and is readily recognised by the absence of outcrops, the flat nature of the country and the vigorous growth of the vegetation.

Glacial erratics.

These were first seen by the writer, who knew of their existence in the district, on the Beria-Cox's Find road, about 8 miles from Beria. Their presence in the district was recognised by Clarke,⁹ and later by Talbot,¹⁰ who may have seen the boulders referred to above. They have now been recognised in the vicinity of Beria and Morgans.

No faceted boulders have been found, but flattened boulders are of frequent occurrence. A big variety of rock types is found, many of which are recognised in the district. A collection of boulders has been made, and should make an interesting petrological study.

Granitic Series.

A striking feature of the Mt. Margaret Goldfield, to one who has recently been in the Yilgarn Goldfield, is the almost complete absence of pegmatite dykes. Except for minor occurrences of pegmatite at granite "rocks" no pegmatite was seen by the writer or his colleagues.

Porphyry dykes are particularly abundant, while aplite dykes are of frequent occurrence. Porphyry dykes may be either sheared or massive, and at least some are of pre-gold age. The quartz reef at the Gladiator Gold Mine occurs at some levels in a porphyry dyke.¹¹ It is considered probable that the sheared dykes and the massive dykes are, for the most part, of the same age, and that the difference is merely one of degree. However, some massive fresh looking dykes, e.g., the one cutting through lavas and agglomerates on the Mt. Weld Station road, 6 miles S.S.E. from Laverton, is probably of a later age. Various types of porphyry are known to exist, but no petrological examination of specimens has yet been made. All are intrusive into rocks of the Greenstone Complex.

Greenstone Complex.

The Greenstone Complex consists of a highly folded series¹² of basic lavas, tuffs, agglomerates, epidiorites, coarse grained greenstones, with fairly frequent relatively thin bands of erosion sediments. The most interesting and important of the erosion sediments is the jaspilite, which is the subject of a separate report by my colleague, Mr. K. R. Miles. Throughout the area there are fairly numerous bands of graphitic schist which can sometimes be traced for some distance along their strikes. There are also isolated occurrences of more massive graphitic rocks, sometimes containing chistolite or andalusite, and at one place a rock believed to be a greywacke. These bands of metamorphosed sediments vary in width from a few feet, as for example in the vicinity of Laverton, to over half a mile at Murrin Murrin.

Good exposures of lava are to be found in the deeper mines, and on low rounded hills, which are of frequent occurrence. Less frequently lavas and agglomerates form fairly conspicuous hills. Small and much weathered exposures of greenstone schist are frequently to be found in areas which at first sight appear to be completely soil covered.

⁹ Clarke, E. de C., op. cit., Bulletin 84, p. 37.

¹⁰ Talbot, H. W. B., personal communication to Government Geologist.

¹¹ P. 27.

¹² For a description of the structural geology refer to a report by Mr. Miles on page 29.

A very coarse grained greenstone, forming fairly conspicuous outcrops, is believed to be intrusive into the other rocks of the Greenstone Complex, but no evidence has yet been obtained to indicate whether it occurs as sills or is transgressively intrusive.

Because of the general paucity of outcrops it is very unlikely that it will be possible to sub-divide the Greenstone Complex on the maps. Distinctive varieties of greenstone are, however, being indicated.

It is proposed to continue field work in this area during the 1939 field season.

REPORTS ON SOME MINING GROUPS IN THE YILGARN GOLDFIELD.

(North of the Great Eastern Railway.)

(R. S. Matheson, B.Sc.)

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PILOT GROUP.

YILGARN GOLDFIELD.

(By R. S. Matheson, B.Sc.)

GENERAL INFORMATION.

The Pilot Group is situated on the western side of the Southern Cross-Bullfinch railway, approximately $6\frac{1}{4}$ miles from Southern Cross, and is $1\frac{1}{4}$ miles W.S.W. from the 6-mile peg on the main road between these two centres.

At the time of inspection (May-June, 1938), there were two existing leases, "Pilot" G.M.L. 3414 and "Exonia" G.M.L. 3483 both under the control of T. J. White and W. J. Heydon, and prospecting was being done in the old workings on the late "Colleen Bawn" G.M.L. 2544.

The present lessees of the "Pilot" G.M.L. 3414, first pegged the ground in December, 1932, but official records show that gold was discovered in this vicinity in the year 1909.

A 5-head battery and cyanidation plant is in operation on the "Pilot" mine, but only on rare occasions it is available for public crushings.

Water for domestic and mining purposes is obtained from the Southern Cross-Bullfinch water supply pipeline, which passes through the group.

There are adequate supplies of morrel, gimlet and salmon gum in the vicinity, which are suitable for mining purposes.

It is impossible to determine accurately the total production from this group, as some production may be included under "sundry claims" in the Hope's Hill official grouping, but a study of the official figures shows that 12,075.20 tons of ore have been treated yielding 6,739.86 fine ozs. of gold, and specimens total 17.81 fine ozs.

GENERAL GEOLOGY.

The group is situated in an area of highly metamorphosed interbedded, greenstones, jaspilites and erosion sediments, which are presumably of Pre-

Cambrian age and the country grades eastwards into replacement gneiss of granitic origin. The rocks are sheared and contorted, but have a general north-west strike and steep dips varying from 70° N.E. to 70° S.W.

A geological subsurface map of the area, on a scale of 5 chains to 1 inch, has been compiled, and it will be included in a later publication dealing with all the mining groups in the northern portion of the Yilgarn Goldfield.

Greenstones.—Metamorphosed basic lavas and tuffs constitute the major portion of the greenstones. The lavas are dark greenish in colour, and dense to medium-grained varieties occur. They are often amygdaloidal, and exhibit only a rude schistosity.

The tuffaceous rocks are distinguished from the lavas by their greyish-green colour and their greater schistosity.

Anthophyllite Schist.—A band of this rock 15 chains wide, occurs 45 chains south-west of the leases. It is believed to be a pre-folding, ultra-basic sill. It is yellowish to grey in colour, and is everywhere associated with chromite-bearing ironstone and cellular quartz, which are believed to be its decomposition products. The anthophyllite schist is regarded as a component of the greenstones, and it would probably be green in colour, if it could be seen in a fresh state.

Irregular masses of intrusive, coarse-grained, greenstone are associated with the anthophyllite schist in a few places.

Jaspilites.—Two main beds of jaspilite, approximately 16 chains apart, are present in the area, and there is some suggestion that these may be the same bed repeated by folding on a north-west-south-east axis.

The western bed occurs fairly continuously throughout the group forming a sinuous outcrop line. In places along its strike, two or more outcrop lines appear, and this is thought to be due to the presence of dragfolds.

The eastern bed is poorly represented, and can be best seen in the vicinity of the "Pilot" workings. To the north-west it is obscured by a thick overburden, while to the south-east it becomes almost completely granitised.

Erosion Sediments.—A band of metamorphosed erosion sediments, 10-15 chains wide, and consisting of quartzites and grey garnetiferous phyllites, occurs $\frac{1}{4}$ mile south-west of the workings. Numerous flows of amygdaloidal basic lava are interbedded with the erosion sediments, and are of necessity mapped with them.

At the time of inspection it was impossible to be certain whether these erosion sediments were a syndinal remnant of the Whitestone Series, or only a sedimentary band in the Greenstone Series. It is hoped that this point will be elucidated by future fieldwork.

Gneiss.—The gneiss is granitic in composition, and in the area mapped, is believed to have been formed by the replacement of greenstones. Owing to the mode of origin of the gneiss, its boundary with the greenstone is not sharp. A zone of intermediate rocks occurs between the greenstone proper and gneiss proper.

Structure.—The group is on the northern extension of the Southern Cross belt of country, which has been determined from previous mapping, to be situated on the western limb of a large anticline folded on a north-west-south-east axis. The eastern limb of this anticline embraces the Koolyanobbing belt of country.

From a study of the dragfolds in the jaspilites, it will be seen that they pitch 55° S. in the vicinity of the main workings, while north-westerly pitches prevail at the north-west and south-east ends of the area. This reversal in pitch was brought about by another system of folding with an approximately east-west axis, and is generally referred to as cross-folding. Gold deposition appears to have occurred close to the axis of this crossfold.

Normal faulting, with a displacement of approximately 5 chains, has taken place at the south end of the area, and milky-white quartz reefs occur along the line of the fault. The faulting appears to be post-gneiss in age because of the displacement of the greenstone-gneiss boundary, but this interpretation is open to question. Granitisation frequently ceases at a definite horizon, and it is probable that pre-gneiss faulting would not materially affect the process.

THE MINES.

"Pilot" G.M.L. 3414 and "Exonia" G.M.L. 3483.

At the time of inspection (May-June, 1938), mining activity was confined to the "Pilot" lease.

The ore body consists of greenstone lode material with quartz veins and stringers, which has been mined sporadically over a length of 225 feet and a width of 70 feet, between the surface and the 70 feet V.D. level. Payable values occur erratically through this block of country, and the limits of the ore shoots are ill-defined. The actual mined portions of the lode formation can be seen on the accompanying plans. (Plate V.).

The available ore has practically been stoped out between the surface and the 45 ft. V.D. level, and at the time of inspection overhand stoping was in progress in the south-east workings at the 70 ft. level. The jaspilite has also been mined in places, where ore shoots occurred.

The workable ore is limited in depth by the sulphide zone, which begins at approximately 70 feet V.D. from the surface. Values are said to occur in the sulphide zone, but there are no facilities for the treatment of such ore at the mine, and a loss is incurred if the sulphide ore is sent to Kalgoorlie for treatment. Specimens of the sulphide-bearing ore were submitted to the Government Chemical Laboratory for mineral determination and the sulphide present proved to be marcasite.

All the known ore shoots are either in, or stratigraphically above the jaspilite, and they bear a close relation to its structure.

The structural control is best understood by taking the lode formation as a whole, rather than the individual ore shoots. By referring to Plate V., it will be seen that the jaspilite has been folded into west, anticlinal limb, dragfolds, which pitch 55° S.S.E., and the lode formation is confined to the synclinal trough of the north-western of these two dragfolds. Because of this, the ore shoots in the mine are expected to have a south south-east pitch, although it

was impossible to observe the pitch of the shoots in the workings. Greenstone occurs stratigraphically above the jaspilite, and mica schist, believed to be an intermediate stage in the granitisation of the greenstone, predominates below it.

The production figures given below have been taken from the official records and are complete to 31st July, 1938.

Ore Treated.	Gold Therefrom.
11,665 tons.	2,004.06 fine ozs.
Sands.	2,819.73 fine ozs.
Total 11,665 tons.	4,823.79 fine ozs.

Some of the production from the sands shown above, may possibly be from public crushings carted from elsewhere, but it is reported that a large percentage of the gold in the "Pilot" ore is recovered by cyanidation.

RECOMMENDATIONS AND CONCLUSIONS.

1. The workings have not yet penetrated ground water level, and this fact along with the erratic distribution of the values, suggests a secondary origin for the majority of the lode material. It is not intended to imply that lode material will be entirely absent below ground water level, but there will be a marked decrease in lode material due to the disappearance of the secondary enriched portion, and any that remains will be in the proximity of the auriferous quartz veins and stringers.

2. Because of the poor extraction obtained from the treatment of sulphide ore at the mine, there is obviously a close association between the gold and the sulphides.

3. Diamond drilling to test the downward continuation of the lode formation, has been done by the Western Mining Corporation, who at one time held an option over this property. Two bores were drilled on the same site (see plan), and all the available information concerning these bores is tabulated below.

Bore No.	Angle of Depression.	True Bearing.	Bore Depth.	Remarks.
1	71° 31'	70°	235' V.D.	6ft. lode at 140ft. Recovery value, 4.1 dwts. gold per ton.
2	81°	70°	428' 5" V.D.	7ft. lode at 330ft. Recovery value, 3.8 dwts. gold per ton.

From a study of the section accompanying this report (Plate V.), it will be seen that diamond drilling has not been done to the best advantage. The bores do not intersect the main lode formation, which has pitched away to the south above them, and the values that were intersected probably occur in the downward continuation of the western leg of the dragfolded jaspilite. Owing to this error in the selection of the bores, the nature of the lode formation at depth is still unknown.

4. The southern dragfold shown on the plan has been inferred from fragmentary evidence. The displacement of the outcrop line, and the absence of

faulting in the mine workings, makes this inference fairly conclusive however. It is feasible therefore, to expect other ore shoots in the synclinal trough of this dragfold, and prospecting for them is strongly recommended.

Other shoots of ore may also exist in similar structures, north-west or south-east along the strike of the jaspilite.

Late "*Colleen Bawn*" G.M.L. 2544.

These old workings were being prospected in June, 1938, but owing to their dangerous state they were not examined by the writer.

From information received, the ore body appears to have been a series of rich quartz reefs, parallel with the enclosing greenstone country, which were lenticular both horizontally and vertically. The reefs have been stoped out to ground water level, reported to be 90 feet V.D. from the surface. The ore shoots pitch to the south-east, and their lensing out coincides with a change in strike or dip, which suggests the presence of gentle folding. Shearing is more intense near the ore channel, and the greenstone is represented by tale schist.

This line of workings is approximately 16 chains south-east of the "*Pilot*" workings, and the official production figures show that to July, 1938, 410.20 tons of ore had been treated yielding 1,916.07 fine ozs. of gold, and specimens totalled 17.81 fine ozs.

KOOLYANOBING GROUP.

YILGARN GOLDFIELD.

(By R. S. Matheson, B.Sc.)

GENERAL INFORMATION.

Koolyanobbing is situated on the north-western side of Lake Seabrook, approximately 30 miles north-east of Southern Cross. The distance by road between these two centres is slightly greater however, being about 40 miles.

The Koolyanobbing belt of country extends north-west from Lake Seabrook for a distance of 22 miles, but mining activity is confined to the country in the immediate vicinity of Trig. M.Y. 1. At the time of inspection (July-August 1938), mining was in progress on "*Chadwick's Reward*" G.M.L. 3514 and the late "*Golden Wishbone*" G.M.L. 3581, and prospecting was being done on the late "*Rainbow*" leases.

Gold was discovered in this locality in 1904, by a Mr. Chadwick of Southern Cross, but the area has never attained importance as a gold mining centre.

Iron, copper and gypsum also occur in the district.

The main Koolyanobbing range contains some high grade lenses of iron ore,* which show promise of being of economic importance.

Copper carbonates are reported in several places, but no deposits of economic value have been disclosed.

Gypsum deposits are being worked on the south-eastern shore of Lake Seabrook, immediately opposite the Koolyanobbing Range. The gypsum is

crystalline, and has been built up into dunes by the action of wind blowing across the surface of the lake.

A two-head battery, with no cyanidation plant, is in operation on G.M.L. 3514, and it crushes all the ore mined at Koolyanobbing.

Water for domestic purposes is obtained from an excavated tank, 36 chains west of the late "*Rainbow*" leases, which has a capacity of 50,000 gallons. After rain, domestic water can also be obtained from rock holes at Condenser Rocks and Flat Rocks, but the supply is small. Water for mining purposes is obtained from the underground workings on G.M.L. 3514, ground water level being 138 feet V.D. from the surface.

A thick forest of morrel, salmon gum and gimlet, which are suitable for mining purposes, covers the area.

The official production returns show that to the 31st December, 1937, 1,958.05 tons of ore were treated, yielding 1,022.64 fine ounces of gold, and alluvial gold totalled 0.26 fine ozs.

GENERAL GEOLOGY.

A geological map, on a scale of 40 chains to 1 inch, embracing 13 miles of the main range, and an area of 150 square miles, has been compiled, and is available for inspection at the Geological Survey Office.

The area is composed of rocks of the Greenstone Series, consisting of interbedded basic lavas, agglomerates, tuffs and jaspilites, which are intruded by biotite granite, and quartz porphyry dykes. The greenstone belt has a maximum width of 5 miles, and grades eastward and westward into granitic gneiss of replacement origin. All the rocks are presumably of Pre-Cambrian Age.

The general strike of the country is N. 40° W. and the dip varies from 50° N.E. to vertical. The country has been highly folded and the dragfolds have a general pitch 50°-80° N.W., but a temporary reversal in the direction of pitch occurs near the north-west end of the area mapped. An interpretation of the folds shows that Koolyanobbing is on the east limb of an antiform.

The main range is composed of contorted jaspilite and is very conspicuous, attaining a height of 400 feet above the general level of the country in some places. Another prominent line of hills occurs along the western gneiss-greenstone boundary, and granitic quartz forms the backbone to these hills.

Koolyanobbing is believed to be the northern extension of the Mt. Palmer† belt of greenstone.

THE MINES.

"*Chadwick's Reward*" G.M.L. 3514.

This lease is situated 2¾ miles south-east of Trig. M.Y. 1.

A plan‡ of the accessible underground workings on a scale of 50 feet to 1 inch has been compiled.

According to the official production returns, to the 30th April, 1938, 990.05 tons of ore were mined from this lease for the recovery of 497.24 fine ozs. of gold.

* A detailed survey of the iron deposits at Koolyanobbing, by the Geological Survey of Western Australia, has just been completed. (November, 1938.)

† Ellis, H. A., G.S.W.A. Bull. No. 97.

‡ Plan not published.

Two parallel quartz reefs, striking N. 30° W. and dipping 65-75° N.E. with the schistosity of the enclosing greenstone country, have been mined on this lease. The western reef has been the main ore body.

Main Reef.—The reef is very lenticular in nature, and is reported to have had an average width of 1 foot. The average length of the ore shoot is 130 feet, and it has been practically stoped out between the surface and ground water level, 146 feet V.D. from the top of the dump. The workings were only partially accessible, and for this reason the details of the workings are meagre. The pitch of the ore body is not definite, but appears to be to the north-west. This is probably correct, however, since the regional pitch in this vicinity is to the north-west.

Eastern Reef.—The reef is very lenticular in nature and is reported to have had an average width of 6 inches. The only work on this reef is at the 117ft. level, where it has been driven on for 136 feet and overhand stoped for 50 feet. Overhead and underfoot the reef was apparently an unpayable proposition.

Structure.—The country rocks are gently folded on an axis pitching 70° N.W. and the structure appears to have had some control over quartz deposition. The quartz lenses occur in the synclines (or downfolded portions), and the quartz pinches to a stringer over the anticlines. This control is noticeable at the 117ft. and 143ft. levels. The lessees should not overlook the fact that this control may also occur vertically. Owing to a large portion of the workings being inaccessible, an investigation along these lines was impossible at the time of inspection (July, 1938).

Recommendations and Conclusions.

1. There is reported to be a 200ft. level on the main reef, but it was under water at the time of inspection, and could not be examined. Owing to an increase in mining costs due to pumping water, and a slight decrease in the values, the reef cannot be worked profitably at this level. This information was supplied by the lessees. The mine therefore has no prospects at depth.

2. The lessees have overlooked the possibility of the ore shoot having a north-west pitch, and a north-west drive at the 143ft. level is recommended. This is the only prospecting warranted on the known ore bodies.

3. Lateral prospecting for the occurrence of parallel ore bodies may be done to advantage.

4. The tailings dump should be thoroughly sampled to see if the erection of a cyanidation plant is warranted.

Late "Golden Wishbone," G.M.L. 3581.

This lease is situated 3½ miles south-east of Trig. M.Y. 1.

The lease was forfeited in 1936, but was being worked as a prospecting area at the time of inspection (July 1938). To the time of forfeiture, 339 tons of ore were treated for the recovery of 203.89 fine ozs. of gold.

The ore body on this lease consists of a mass of small quartz lenses, which strike N. 30° W. and dip 50-60° N.E., with the enclosing kaolinised greenstone

country. The shoot has been mined on three levels, by means of an underlay shaft, to a vertical depth of 107 feet. The shaft underlies at 50 degrees to the 38ft. V.D. level, where the dip steepens to 65 degrees.

The shoot has an average length of 12 feet and an average width of 4 feet, and has been stoped out between the surface and the 78ft. V.D. level. The shoot was being mined between the 78ft. and 107ft. levels at the time of inspection. The ore body pinches to a stringer in both the north-west and south-east faces of the drives throughout the workings, but is 4 feet wide underfoot at the 107ft. V.D. level. The gold is reported to have had an erratic distribution throughout the quartz, indicating secondary enrichment. The pitch of the shoot is steep to the south-east.

The country rock is kaolinised throughout the workings, and is believed to be decomposed, partly granitised, sedimentary greenstone. Some barren quartz veinlets, transverse to the strike of the country, are present in the workings.

Recommendations.

1. The shoot should be stoped out to ground water level, as an enrichment may occur at that level. Ground water is expected to be encountered at approximately 140 feet V.D. from the surface.

2. Values are reported to have been best, where the flatter dip occurred, that is, between the surface and the 38ft. V.D. level. In the course of mining the shoot to ground water level the prospectors should watch for any flattening in dip as it may mean an increase in values.

3. A shoot of these dimensions will not be worth mining below ground water level, unless the gold content increases considerably.

4. Lateral prospecting for parallel ore bodies should not be overlooked.

Late "Rainbow" Leases.

These old leases are situated 3 miles north-east of Trig. M.Y. 1.

Prospecting was being carried out on these leases at the time of inspection, but the underground workings were inaccessible. Some of the workings have been described by Blatchford* in Bulletin No. 71. The ore bodies have been quartz reefs with lenticular habit, parallel to the schistosity of the enclosing country. The country has been extensively granitised, consisting of alternate bands of greenstone and gneiss.

HOPE'S HILL GROUP.

YILGARN GOLDFIELD.

(By R. S. Matheson, B.Sc.)

The main leases at this group are situated on a prominent ridge approximately 4½ miles north-west of Southern Cross.

* Blatchford, T. G.S.W.A. Bull. No. 71, p. 188.

No mining operations were in progress at this group at the time of inspection (May, 1938) and the underground workings were all inaccessible. The main Hope's Hill G.M., which closed down in July, 1905, has been reported on, however, by Gibson* and Montgomery. Montgomery states that—

The lode is a very large low-grade ore body, striking N.W. and S.E., which has been worked extensively on the surface by open-cutting, and underground down to the 160 ft. level, below which it became unprofitable to work. There are four levels, the lowest being 300 or 350 feet below the surface. The ore body has been driven along for about 1,800 feet at the 160 ft. level, has been taken out in places as large as 30 feet in width, averaging probably between 15 and 20 feet wide.

The lode occurred on the footwall side of a large barren quartz reef, which is parallel with the enclosing country, striking N. 35° W. and dipping 70° S.W. The lode consisted of "Alternating seams of rubbly quartz, with much kaolinic material, pale-coloured tale schist, and brown chlorite schist," according to Saint Smith.†

From a study of a geological map of country in the vicinity of the workings, which was compiled by the writer, the lode is seen to occur between two parallel jaspilite bands, which are interbedded with greenstones. The jaspilites are contorted, and the shape of the dragfolds suggests the two beds are in reality one bed repeated by synclinal folding on a north-west, south-east axis. Also there are reversals in the direction of pitch of the dragfolds indicating the presence of crossfolding. At the north-west end of the main open cut the dragfolds pitch 30° S.E., and at the south-west end they pitch 65° N.W., so that ore deposition has occurred very close to the intersection of the axes of the two systems of folding. As a result of the broad geological mapping, the Hope's Hill mining centre is shown to be on the western limb of a major antiform with a north-west-south-east axis.

The country rocks grade eastwards into replacement gneiss of granitic origin. The granitisation process actually commences on the footwall of the large barren quartz reef, and the mica schists and quartzites, which occur between the greenstone proper and gneiss proper, are partly granitised greenstones and jaspilites respectively. All the rocks are presumed to be of Pre-Cambrian age.

The official production returns for this group, to the 31st December, 1937, are as follows:—

	Dolled and Specimens.	Ore Treated.	Gold Therefrom.
Alluvial.	Fine ozs.	tons.	Fine ozs.
5.04	107.13	125,435.07	35,649.23

and Westley's cyanidation plant recovered 106.93 fine ozs. of gold from the treatment of sands.

A fuller report will be written later, when the writer has time at his disposal to refer to all previous literature on this mining centre.

* Gibson, C. G. G.S.W.A. Bull. No. 17, p. 23.
Montgomery, A., Report on the Mines of the Yilgarn G.F., 1908, p. 26.
† Saint Smith, E. C. G.S.W.A. Bull. No. 49, p. 160.

COPPERHEAD SYNDICATE.
BULLFINCH.
YILGARN GOLDFIELD.
(By R. S. Matheson, B.Sc.)

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GENERAL INFORMATION.

The leases controlled by the Copperhead Syndicate are situated on a ridge approximately 1 mile north-east of the Bullfinch townsite, and they embrace the workings of the late Bullfinch Pty. (1919), Ltd. The following leases were being held by the syndicate at the time of inspection (April, 1938):—

"Copperhead" G.M.L. 3345, "Copperhead Deeps" G.M.L. 3378, "Copperhead Central" G.M.L. 3836, "Copperhead South" G.M.L. 3660, "Copperhead West" G.M.L. 3826, "Easter Gift" G.M.L. 3337, "Frances May" G.M.L. 3400, "Goldfinch" G.M.L. 3397, "Rising Sun" G.M.L. 3350, "Jupiter" G.M.L. 3458, "Aisla Joan" G.M.L. 3819 (3463 on the posts).

Gold was first reported from this locality by C. Jones, the working partner of a prospecting syndicate formed by D. L. Doolette, whose application for mining leases was lodged at the Warden's Court, Southern Cross, on 29th December, 1909. The early crushings were extremely rich in gold content and a phenomenal mining boom resulted. From the time of its discovery to 1920, the mine was a consistent producer, but since that time mining operations have been very spasmodic. At the time of inspection (April, 1938), underground work was being done mainly by tributary parties.

A 10-head battery and cyanidation plant is in operation on the mine, and it is available for public crushings.

Morrel, salmon gum and gimlet are abundant in the vicinity of Bullfinch, and are used for fuel and mining timber.

Water for domestic and mining purposes is obtained from the Southern Cross-Bullfinch pipeline, which is a branch line from the main Eastern Goldfields Water Supply Scheme. The ground water is very saline, and original ground water level in the main shaft, is reported to have been 268 feet V.D. from the surface.

According to the official production returns, the production from the ground now held by the Copperhead Syndicate to 31st July, 1938, is 195,292.67 fine ozs. of gold from the treatment of 521,642.35 tons of

ore, and specimens total 64 80 fine ozs. The Copperhead Cyanide Plant has produced 10,033.99 fine ozs. of gold from the treatment of sands, which is not included in the above figures, and some of the gold has undoubtedly come from this property, but it is impossible to determine the amount.

Retreatment of the old tailings was in progress at the mine at the time of inspection, and 1 dwt. gold per ton is reported to be recovered by cyanidation.

The geological investigations at the mine were considerably hampered, as the only accessible underground workings were portions of the Nos. 1, 2 and 3 levels. The mapping of the geology in the underground workings was done in collaboration with Mr. H. A. Ellis.

GENERAL GEOLOGY.

The leases are situated in an area of highly metamorphosed, interbedded, greenstones, jaspilites and erosion sediments, which are presumably of Pre-Cambrian age, and the country grades eastwards into replacement gneiss of granitic origin. The rocks are contorted, and have a general strike N.N.W. and a general dip 60° W.S.W. Outcrop conditions are good, except in the immediate vicinity of the workings, where drifted tailings cover the surface.

A geological subsurface map of the area, on a scale of 5 chains to 1 inch has been compiled, but it will be published at a later date.

Greenstones.—Metamorphosed, basic lavas, tuffs and probably greywackes constitute the greenstones.

The basic lavas have a fairly wide distribution, and there are two varieties, which show marked differences in hand specimen. The lavas occurring stratigraphically above the main jaspilite band, are hard, fine to medium grained rocks, which have a dark greenish colour and often a rude schistosity. This type of lava forms good outcrops, and can be seen underground at the No. 2 level, in the crosscut from the main shaft to the dolomite lode. Stratigraphically below the jaspilite, the lavas are soft, highly sheared rocks, which are from all appearances tale schists. The tale schist is greenish-grey in colour, and decomposes more readily than the other variety of lava, but is more resistant to weathering than the tuffaceous rocks. The weathered surface is often pitted, and this is thought to be due to the weathering out of amygdulæ.

The remainder of the greenstones is composed of highly sheared rocks, which are predominantly dark grey in colour, and which often have a noticeable banding. In contrast to the reddish brown decomposition product of the tale schist, these rocks weather to yellow and purplish schists. These rocks are believed to be of sedimentary origin, and to be tuffs and/or greywackes.

Jaspilites.—Between the surface and the No. 2 level the weathering of the country rocks has been extensive, and the jaspilite appears mainly as a rock composed of alternate bands of quartzite and iron oxides (hematite, limonite and magnetite). In some places in this zone however, owing to leaching by surface waters, the iron oxides are absent, and the jaspilite is represented by a white friable quartzite.

At the No. 2 level, where the action of weathering is diminishing, the jaspilite changes to a laminated rock, with alternate bands of quartzite and ferromagnesian (amphiboles and pyroxenes), which can only be distinguished with difficulty from the enclosing greenstones.

The jaspilite is believed to be a metamorphosed sediment.

Metamorphosed Erosion Sediments.—The metamorphosed erosion sediments do not have a wide distribution in the area mapped, and the only occurrence of them is in a costean approximately 24 chains south-easterly from the south peg of G.M.L. 3819. They consist of grey to purple phyllites, and are believed to be a thin band in the Greenstone Series.

Gneiss.—The gneiss has been formed by the replacement of greenstones by granitic material, during a period of granitic intrusion. The replacement origin for the gneiss is substantiated, by the occurrence of a marginal zone of rocks, which are intermediate in composition between greenstone and gneiss, and by the parallelism of the gneissosity and schistosity of the gneiss and greenstone respectively.

THE ORE BODIES.

Three types of ore bodies have been mined on this property: jaspilite lodes, yellow lodes and dolomite lodes.

Jaspilite Lodes.—The accompanying plan* (Plate VI.), shows the distribution of the jaspilite at the No. 2 level, and the structure outlined by the jaspilite on this level persists throughout the mine.

The ore bodies of this type are mainly confined to the southern band of jaspilite shown on the plan, and have been formed by the mineralisation of the jaspilite and the injection of auriferous quartz veins presumably emanating from a granitic magma. The quartz veins have penetrated the jaspilite where it was fractured, sheared and contorted during folding. The ore shoots occur mainly in the crests and troughs of the dragfolds, and are generally absent in the limbs. The best values are reported to occur in the vicinity of the quartz veins and stringers. The occurrence of paint gold in fractures in the lode is suggestive of secondary enrichment, and the ore bodies will probably diminish in size and decrease in values below ground water level (260ft. V.D.). Actually, mining of this type of ore body ceases at the No. 3 level. The lessees report that mining of this class of ore has been discontinued between the Nos. 3 and 5 levels, not because the values have become unpayable, but because the ore has become highly mineralised with sulphides, for which there are no facilities for treatment at the mine.

The sulphide zone commences at about the No. 2 level (210ft. V.D.) but the workings on the sulphide ore at this level could not be examined due to bad air. The Nos. 4 and 5 levels were still under water, and were also inaccessible. Blatchford† states however, that the sulphides are galena, and various sulphides of iron, chiefly pyrites, but probably some marcasite and pyrrhotite.

The ore bodies locally known as the "Discovery Lode" or "Southern Series," the "Main Lode" and the "Watershaft Lode" are all mixtures of jaspilite and yellow lode material.

Yellow Lodes.—The main ore bodies of this type occur stratigraphically above, and in proximity to, the ore bodies in the southern band of jaspilite. There are a few exceptions to this however, for instance the yellow lode exposed in the workings off

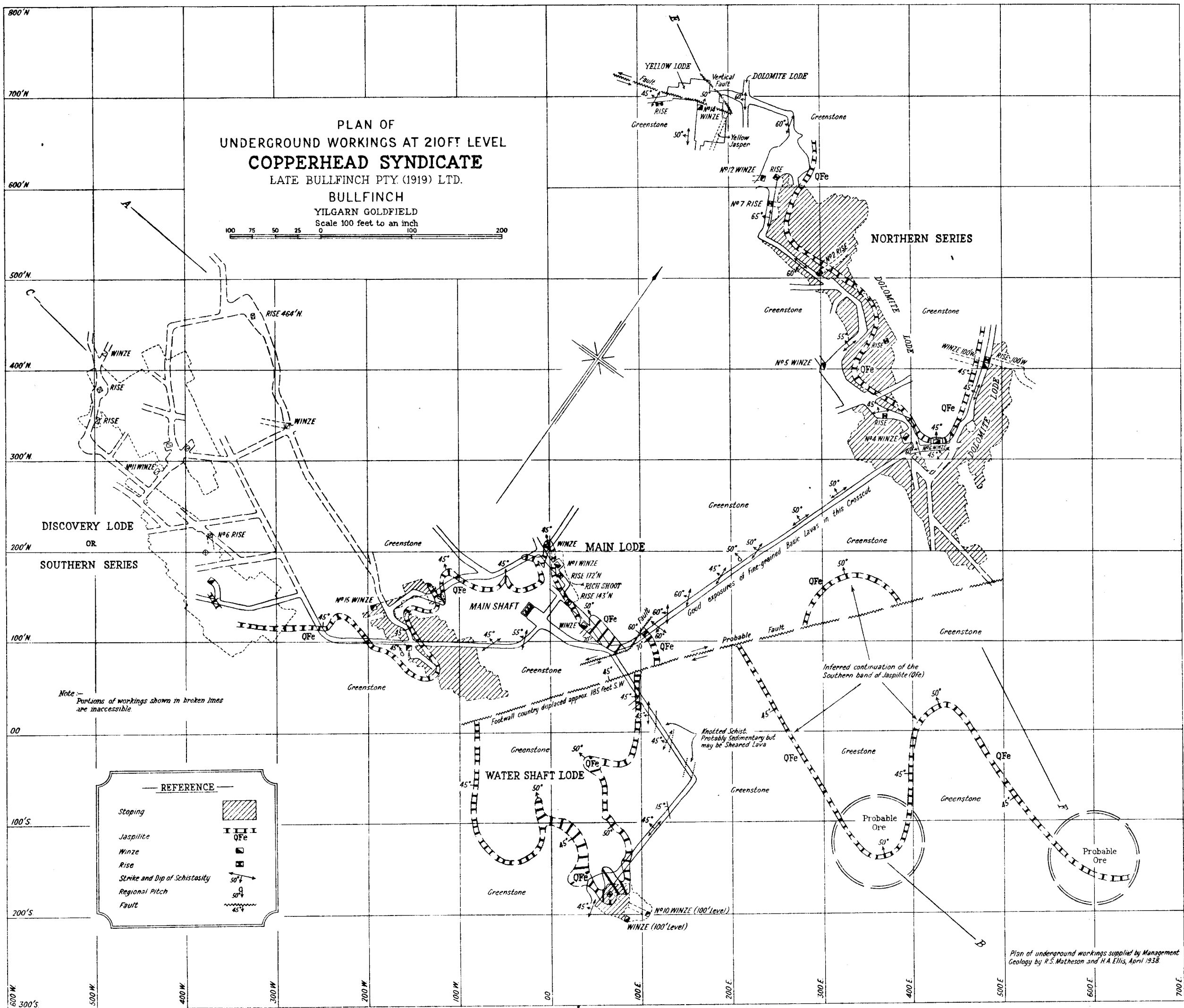
* A surface plan and a plan of the No. 1 level, have also been compiled, and are available at the Geological Survey Office.

† Blatchford, T. G.S.W.A. Bull. No. 71, p. 81.

PLAN OF
UNDERGROUND WORKINGS AT 210FT LEVEL
COPPERHEAD SYNDICATE
LATE BULLFINCH PTY (1919) LTD.

BULLFINCH
YILGARN GOLDFIELD

Scale 100 feet to an inch



the New Shaft at the north-west end of the dolomite lode, which appears to be in no way associated with jaspilite. The yellow lodes exist only above ground water level, and consist of secondary enriched decomposed greenstone schist, which is intersected with auriferous quartz veins and stringers. As is expected of a lode of secondary origin, the shape of the ore bodies is very irregular and the distribution of the values erratic. Yellow replacement jasper frequently occurs with the yellow lode material.

The auriferous quartz veins and stringers probably persist below ground water level, but have been too small to be worked profitably.

The yellow lodes owe their name to their appearance near the surface, but they gradually become green in colour as ground water level is approached.

Dolomite Lode.—This ore body consists of a mixture of granitic quartz and dolomite, which is associated with minor amounts of greenstone lode material. It occurs on the stratigraphic footwall of the northern band of jaspilite, and is locally known as the "Northern Series." The dolomite was not present in the lode in the oxidised zone, appearing first at approximately 120 feet V.D. from the surface, and this is due to leaching by surface waters. According to Blatchford* :—

"The lode from the 100ft. level upwards, and to a depth of 20 to 30 feet below the level, consists of a mixture of ferruginous clayey lode material partially cemented together, with irregular masses of jasper, the whole ore body being traversed by narrow quartz veins. These veins are comparatively flat with a general north-west-south-east strike and an underlie to the north-east."

The dolomite lode appears to have been the most consistent ore body in the mine, and has been worked from the surface to the bottom level, 510ft. V.D. From a study of the plans of the mine, it will be seen that the ore body diminishes in size below ground water level, indicating that secondary enrichment has played some part in the formation of the ore body in the upper levels.

The sulphide zone commences at about the 210ft. level, and as in the case of the jaspilite lodes, the sulphides have a close association with the gold.

An analysis† of a specimen of the dolomite lode from the 210ft. level gave the following result:—

G.S.M. 1/826.					G.S.L. 8886D.				
SiO ₂	..	..	..	..	15.83				
Al ₂ O ₃	..	..	..	..	0.29				
Fe ₂ O ₃	..	..	..	..	0.11				
FeO	..	..	..	..	4.86				
MnO	..	..	..	..	0.27				
MgO	..	..	..	..	17.21				
CaO	..	..	..	..	27.64				
Na ₂ O	..	..	..	..	0.18				
K ₂ O	..	..	..	..	0.06				
H ₂ O hyg.	..	..	..	..	0.06				
H ₂ O comb.	..	..	..	..	0.80				
TiO ₂	..	..	..	..	0.02				
Co ₂	..	..	..	..	31.99				
P ₂ O ₅	..	..	..	..	0.07				
Fe ₂ S ₃	..	..	..	..	0.48				
Cr ₂ O ₃	..	..	..	..	nil.				
V ₂ O ₅	..	..	..	..	0.04				
					99.91				

* Blatchford, T. G.S.W.A. Bull. No. 71, p. 80.

† Vide G.S.W.A. Bull. No. 71, p. 80.

Gold—15 grs. per ton. Sp. gr.—2.94. Analyst, H. Bowley.

The chief constituents are dolomite, about 55.2 per cent.; Calcite, about 14.3 per cent.; actinolite, about 25 per cent.; with smaller amounts of pyrrhotite and probably serpentine, albite and quartz.

The boundaries of the ore body in the underground workings are not sharp, as carbonation extends beyond it into the adjacent country.

The occurrence of isolated "horses" of greenstone within the lode, substantiates the belief that the lode has been formed by metasomatic replacement.

Owing to the attitude and size of the ore body, and the broken nature of the adjacent country, some difficulty was experienced in mining the lode, and square set stopping was resorted to.

STRUCTURE.

Broad Geological Structure.—Detailed mapping in the vicinity of Bullfinch has shown that the country has been folded into the form of a syncline, which pitches 45° N.W., and is overturned to the north-east at 70 degrees. The structure is clearly outlined by the southern jaspilite band. This syncline has been shown by areal mapping to be situated on the western limb of a large anticlinal fold, with a north-west-south-east axis.

No reversals in the pitch of folds were noted in the vicinity of the Bullfinch leases, the pitches being constantly to the north-west, so that the mine is not situated on a crossfold axis. At the Corinthian group of mines, approximately 10 miles south of Bullfinch, the regional pitch is to the south-east, so that there is at least one crossfold between the two centres, but it is impossible to determine with accuracy the position of its axis. This crossfold may have had some influence on ore deposition at Bullfinch.

Structural Control of Ore Deposition.—The rocks between, and including the two jaspilite bands, have been the most favourable for the deposition of gold. This is partly due to their composition, but mainly to their structure. From a study of the accompanying plan it will be seen that gold deposition has occurred in isolated places in the favourable host rocks, and these areas of mineralisation are related to the geological structure. Viewing the zone of mineralisation broadly, it will be seen to have taken place in the trough of the pitching syncline outlined by the southern jaspilite band. Numerous dragfolds are present in the trough of the syncline, and ore deposition is mainly confined to the crests and troughs of these minor folds. The ore bodies are everywhere fairly close to one or the other bed of jaspilite, and the jaspilites have probably acted as the means of access for the gold bearing solutions.

The dolomite lode occurs in the trough of a pre-existing synclinal dragfold, and has been formed by the metasomatic replacement of greenstone country on the stratigraphic footwall of the northern jaspilite band.

Faulting.—Three post-gold faults, which have caused considerable difficulties in mining, and prevented a previous understanding of the geological structure, were mapped in the workings.

Two of these faults are shown on the plan of the No. 2 level (Plate VI.), and they can be conveniently described together. The faults strike north-easterly and dip 45°-60° N.W. The footwall country of the

southern fault has been displaced approximately 185 feet south-west, and is clearly shown on the accompanying plan. In order to indicate the faulting more clearly, and show where further ore bodies may exist, the probable position of the jaspilite in unexplored country has been inferred. The northern fault has displaced the "rich shoot" at its southern end approximately 30 feet north-east, and work was in progress on this section of the lode between the two faults at the time of inspection.

The third fault is seen best in the workings off the New Shaft at the north-west end of the dolomite lode, but is also intersected in the workings at the No. 2 level. Yellow lode, associated with replacement jasper, has been mined on the footwall of this fault, and the difficulty of locating the continuation of this ore body on the hanging wall, has arisen from the fact that the fault is parallel to the schistosity of the country for a considerable amount of its exposed length. The fault strikes north-easterly and dips 50°-60° N.W. The ore body has been located on the hanging wall of the fault at the 100ft. and 210ft. levels, and prospecting for it should be done at the 150ft. level.

In the square setting at the 200ft. level a fault striking north-westerly appears to branch off the north-east striking fault, and although it was impossible to determine the displacement on this subsidiary fault, the writer is fairly certain that as a result of faulting the block of country between the two faults has been displaced to the south-west. The difficulty of interpretation is due to the presence of folding, as well as faulting, in this vicinity.

DIAMOND DRILLING.

Two underground diamond drill bores are indicated on the plan of the No. 3 level, but unfortunately no information concerning them was available.

1. Recommendations and Conclusions.

From the evidence available there is good reason to believe that the southern jaspilite band has an extension, which up to the present time (April, 1938) has not been prospected. This extension is shown on the plans* of the Nos. 1 and 2 levels, and also on the 5 chain to 1 inch geological subsurface map, where its boundaries are indicated by dotting.

Prospecting for further occurrences of jaspilite lode material and for yellow lode material is strongly recommended in this area, especially above ground water level (260ft. V.D.). This area is covered by the tailing dump, and diamond drilling, either from the surface or underground, would probably be the best method of prospecting. Several bores would be necessary to prospect the area thoroughly.

2. In the vicinity of the New Shaft, owing to faulting, folding and the highly oxidised condition of the country, it has been extremely difficult to follow the ore bodies. The true nature of the faulting is not properly understood, but, as mentioned above, it is very probable that as a result of faulting, the block of country between the two faults has been displaced to the south-west.

The yellow lode material, which has been mined at the 100ft. level and 210ft. level, should be encountered at the 150ft. level by crosscutting in a westerly direction from the north-west end of the workings.

* Only the plan of the No. 2 level accompanies this report.

The possibility of parallel ore bodies occurring on the hanging wall of the yellow lode should not be overlooked.

3. At the No. 2 level, prospecting north from the crosscut connecting the square setting to the north-west end of the main dolomite lode is warranted.

If the assumption that folding has occurred here is correct, a prospecting drive commenced 60 feet from the square setting should become a crosscut as the work proceeds. A dolomite lode may be encountered in this direction.

4. Between the two faults off the south-east end of the "rich shoot" at the No. 2 level, jaspilite lode material with quartz veins is being mined. Because of its position between the two faults the length of the ore body is limited, as will be proved by driving on the ore body. Provided that ore is still in the face when the southern fault is encountered, then the west leg of the water shaft jaspilite should be investigated, because it is the continuation of the ore body, and has been displaced by faulting.

5. At the No. 1 level, in the most western synclinal trough of the Water Shaft jaspilite, typical yellow lode has been mined, and this ore body may exist in the same structural position at the No. 2 level. If the values were good at the No. 1 level, the prospecting of this structure should be carried out.

6. A crosscut north, from the vicinity of the No. 2 rise in the workings on the dolomite lode at the No. 2 level (see Plate VI.) also has possibilities of locating other ore bodies. This cross-cut should be continued until it intersects the continuation of the eastern leg of the dolomite lode.

7. The ore bodies in the sulphide zone should be thoroughly tested, to see if the erection of a plant, for the treatment of such ore, is warranted.

8. Approximately ¾ mile north-west of this property, the jaspilite is contorted into another large fold, and it is the extension of the western leg of the southern jaspilite band. The synclinal trough of this fold warrants prospecting.

ERLISTOUN GOLD MINE.
COX'S FIND.
MT. MARGARET GOLDFIELD.
(By R. S. Matheson, B.Sc.)

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PLANS.

Opposite Page

Plate VII.—Underground Geological Map of the Erlis-	
toun Gold Mine, Cox's Find (Scale—	
50 feet to 1 inch)	26

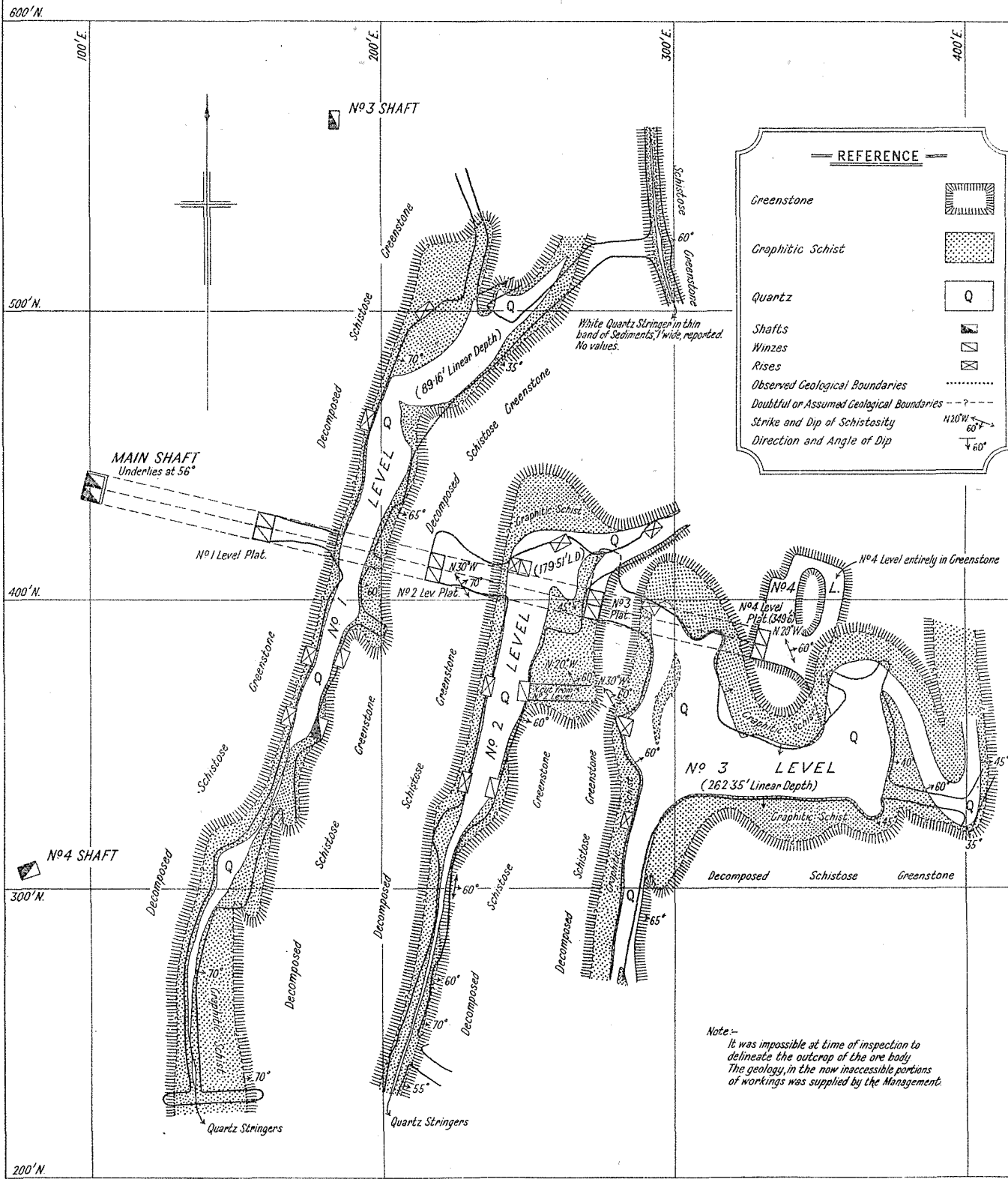
GENERAL INFORMATION.

The Erlistoun Gold Mine is situated on a low rise approximately 41 miles north of Laverton, but the distance by road is slightly greater. The Erlistoun

UNDERGROUND GEOLOGICAL MAP
OF
ERLISTOUN GOLD MINE
COX'S FIND

MT MARGARET GOLDFIELD

Scale 50ft. to an inch



REFERENCE

- Greenstone
- Graphitic Schist
- Quartz
- Shafts
- Winzes
- Rises
- Observed Geological Boundaries
- Doubtful or Assumed Geological Boundaries
- Strike and Dip of Schistosity
- Direction and Angle of Dip

Note:-
It was impossible at time of inspection to delineate the outcrop of the ore body. The geology in the now inaccessible portions of workings was supplied by the Management.

townsite is approximately $4\frac{1}{2}$ miles N.N.W. of the mine, and Mt. Clarke is 1 mile to the west.

The ground was first pegged by E. A. Cox, J. Escreet and G. W. Cox on the 20th May, 1935, and it has since proved to be one of the most important discoveries in recent years. The Western Mining Corporation acquired an option over the find almost immediately after its discovery, and finally exercised the option in December, 1935.

At the time of inspection (September, 1938), the company held G.M.Ls. 2345T, 2353T, 2348T, 2349T, 2346T, 2406T and 2407T embracing an area of approximately 163 acres, and G.M.Ls. 2368T, 2357T, 2351T and 2356T were under option.

A 10-head battery, ball mill and cyanidation plant is in operation on the mine, and is reported to treat an average of 1,500 tons of ore per month.

Mulga is the predominant type of vegetation and is unsuitable for mining purposes except as fuel, but the company has resorted to the use of fuel oil as a means of creating electrical power to work the plant.

Owing to the nature of the country rock, and the shape and attitude of the ore body, square set stopping is resorted to, which necessitates the use of large quantities of timber. Salmon gum and oregon are being used for square setting, and costs are consequently high.

Water for mining purposes is obtained from the underground workings, ground water level being 95 feet V.D. from the surface.

Water for domestic purposes is obtained from some old workings approximately 3 miles south of the main lease, G.M.L. 2345T, and is at present (September, 1938) being carted. A pipeline is in the course of construction, however, and in the near future domestic water will be pumped to the mine.

According to the official production returns, from the time of discovery to 21st August, 1938, the mine produced 33,197 fine ozs. of gold from the treatment of 35,821 long tons of ore.

It is reported that the tailings contain 1.1 dwts. gold per ton, which is not recoverable by cyanidation.

The writer is indebted to the management for information concerning the now inaccessible portions of the mine, and for copies of the mine plans.

GENERAL GEOLOGY.

There was not sufficient time at the writer's disposal during this visit to allow for the compilation of a geological map of the country surrounding the mine, but this is contemplated later.

A brief reconnaissance of the area was carried out however, and it is composed of contorted, interbedded greenstones, meta-sediments and jaspilites, which are presumably of Pre-Cambrian Age. Quartz porphyry dykes are reported in the area but were not seen. The rocks have a general strike N. 10° - 15° W. and dip of 60° E. Except for the jaspilites, the rocks are highly decomposed at the surface, and appear as yellow, brown or purplish schists. A hard, brown capping often overlies the outcrops.

The mine is situated between two jaspilite bands approximately 10 chains apart, which persist for some distance north and south. Although these two bands

of jaspilite have not actually been traversed, they are believed to be the bands which occur in the same relative positions at the "Westralia Tasmania" Group and the "Midas" Group, which are respectively $2\frac{1}{2}$ and $4\frac{1}{2}$ miles north of the Erlistoun mine. From the top of the brace at the Erlistoun mine these groups appear to be in a straight line, and are probably situated in the same favourable horizon throughout. Dragfolds are frequent in the jaspilites, especially the eastern band, and reversals in pitch occur indicating the presence of crossfolding. In the vicinity of Cox's Find the dragfolds pitch 45° southeasterly, while north-westerly pitches prevail at the "Westralia Tasmania" Group. The axial planes of the dragfolds are everywhere overturned to the west. It is believed that crossfolding has played an important role in gold deposition, and that various finds are located where the axes of crossfolds intersect the favourable horizon.

There is a noticeable convergence and brecciation of the two jaspilite bands approximately $\frac{1}{2}$ mile north of the late "Westralia Tasmania" which is probably near a crossfold axis, and this convergence suggests that the two bands of jaspilite are in reality one band repeated by folding on a north north-west-south south-east axis.

It is hoped that these ideas may prove of some value for future prospecting in this area, but it must be borne in mind, that only one type of crossfold may bring about gold deposition. For instance, an antinormal crossfold may be more favourable than a synclinal crossfold or vice versa.

THE COUNTRY ROCKS.

The rocks described hereunder are only those exposed in the underground workings.

Greenstones.—The greenstones are decomposed throughout the workings and are believed to be metamorphosed basic tuffaceous rocks. They occur interbedded with the erosion sediments but are distinct from them. Between the surface and the No. 3 level the greenstone is in a highly decomposed state and consists of a mixture of white, yellow, brick red and brownish pugy material. On the No. 3 and 4 levels the greenstone is in a slightly fresher state, and appears as a cream coloured schist, with black streaks which may be due to the presence of biotite.

Metamorphosed Erosion Sediments.—These consist of grey phyllites and graphitic schists occurring as a narrow band, interbedded with the greenstones. These rocks do not suffer greatly from weathering, and their appearance is practically the same throughout the mine. This sedimentary horizon appears to have been the means of access for the gold-bearing solutions.

THE ORE BODY.

The ore body at the Erlistoun mine is a bluish-grey vughy quartz reef, which is intersected by a network of white quartz veinlets. It is confined to a contorted band of metamorphosed erosion sediments consisting mainly of graphitic schist, and is roughly parallel to the band in strike and dip. At the No. 1 level (74.75 feet V.D.) the ore body has a general strike N. 20° E. and a general dip of 60° E.S.E., while the pitch is 45° in a direction S. 40° E. At lower levels, however, owing to the folding becoming more complicated, there is no general strike or dip.

At the time of inspection stoping was in progress at the No. 3 level (217.10 feet V.D.), the No. 1 level and the No. 2 level (148.60 feet V.D.) having practically been stoped out, and crosscutting to intersect the ore body was being carried out at the No. 4 level (289.30 feet V.D.). The quartz is reported to contain good values throughout, and has only been left where its width has become too narrow to be worked profitably.

It is reported that both the bluish-grey and the white quartz are auriferous, but the gold occurs mainly in the bluish-grey variety. The values are said to be fairly uniform, but enrichments occur at the footwall of the main synclinal portion of the ore body. This portion of the ore body was extremely rich at the No. 3 level.

That secondary enrichment has played some part in the formation of the ore body is suggested by the occurrence of gold in cross fractures above ground water level (95 feet V.D.). The graphitic schist is much more pervious to water than the greenstone country, and during crosscutting to the ore body at the Nos. 3 and 4 levels, there was a considerable make of water when the graphitic schist was encountered.

Mineral Associations.—Sulphides occur abundantly in the quartz at the No. 3 level, and are reported to have first been noticed in the ore body at 130 feet V.D. from the surface. As a result of determinations carried out by the Government Chemical Laboratory on specimens of the sulphide-bearing quartz, the sulphides were found to be entirely pyrite with only traces of chalcopyrite.

It is reported, however, that galena occurs in the ore body near the local enrichments, but does not have a wide distribution.

The sulphides are said to cause no treatment difficulties, the assay values agreeing closely with the plant returns. This suggests that little, if any of the gold, is in solid solution in sulphides.

The graphitic schist in proximity to the ore body is highly mineralised with sulphides, and the absence of payable values in it, is further evidence for the belief that there is practically no association between the gold and sulphides, in this manner.

Structure.—As is pointed out in the section of the general geology, the broad geological structure in the vicinity of Cox's Find, will only be determined after further geological mapping, but the find is expected to be in some way related to crossfolding.

With regard to the geological structure in the underground workings (see Plate VII.), the ore body conforms approximately to the shape of a folded band of graphitic schist. The folding becomes more evident with depth and is very pronounced at the No. 3 level. This is suggestive of a change in pitch, but investigations show that no change in pitch has occurred. An interpretation of the folding of the ore body at the No. 3 level, shows that it is a minor fold on the eastern limb of an anticline, pitching 45° south-easterly, and having an axial plane overturned 50°-60° to the west.

Apart from the folding of the ore body, fracturing has taken place and three main sets of fractures are developed. Two of the sets are approximately parallel to the schistosity and cleavage respectively, and the third is roughly horizontal.

Mode of Origin.—The area originally consisted of horizontal, interbedded, greenstones and erosion sediments, which were later subjected to folding. Simultaneously with or subsequently to the folding there was a period of granitic intrusion associated with mineralisation. Due partly to the composition and partly to the inherent structure, the graphitic schist band was the more favourable host rock, and ore deposition occurred therein by means of metasomatic replacement. The replacement was only partial and variations in the amount of replacement occur both vertically and horizontally. This accounts for the occurrence of "horses" of graphitic schist within the quartz, and the greenstone as walls to the ore body in some places. The bluish-grey colour of the majority of the quartz, is also due to the fact that the replacement of the graphitic schist has been incomplete.

The network of white quartz stringers through the ore body, are thought to have been formed by the refusion of portion of the original quartz, and its intrusion into fractures which occurred in the quartz when the area was subjected to another set of forces.

RECOMMENDATIONS AND CONCLUSIONS.

1. Prospecting for parallel ore bodies is recommended and they should be looked for north-westerly and south-easterly from the main ore body. Underground diamond drilling would probably be the best method of attack, and the east-west section of the ore body at the No. 3 level would be the best point to commence operations.

2. Prospecting along the strike of the graphitic schist band is also warranted, as other folds containing ore shoots may exist. Owing to the mode of origin of the ore body, other reefs may or may not outcrop.

The main ore body offers scope for prospecting north along the strike, at the Nos. 1, 2 and 3 levels. In the extreme eastern workings at the No. 3 level a quartz reef with unpayable values strikes in a northerly direction into the wall, and this should be followed as other folds, containing ore shoots, may occur along the strike. The syncline immediately to the west of these eastern workings at the No. 3 level, contains good values, and by projecting this structure back along the pitch, it will be seen that it has been unexplored at the Nos. 1 and 2 levels. This position is obvious at the No. 2 level, and at the No. 1 level, this structure will probably be found where the main reef joins the thin quartz stringer at the north end.

3. The prospects of the ore body persisting for a considerable depth were very promising at the time of inspection (September, 1938). The replacement of the graphitic schist by auriferous quartz was becoming more complete with depth, and the values showed an improvement. This is a particularly pleasing feature, as ground water level is now nassed, and the increase in values cannot be attributed to secondary enrichment.

4. What influence the major structure will have on the life of the ore body, is at present problematical.

GLADIATOR (LATE AUGUSTA) GOLD MINE.

MT. MARGARET GOLDFIELD.

(K. R. Miles, B.Sc. (Hons.).)

The Gladiator Gold Mine is situated some 4 miles due west of Laverton. The company at present operating this mine holds a mining reserve which includes G.M.Ls. 2212T, 2213T, 2128T and T.A. 85T, the workings of the late Augusta G.M.

The rocks in the vicinity consist of fresh fine-grained greenstone lavas (probably typical trachy-andesites), medium-coarse grained greenstone or epidiorite, and decomposed greenstone schists (probably sheared greenstones).

Running through the area in an approximately north-south line with a broad arc facing eastward, are four roughly parallel bands of highly ferruginous banded jaspilite, each dipping 60°-70° E. Of these bands, which range from 8 to 14 chains apart, the two western lines are most continuous, and are traceable over a total length of about 90 chains. The two eastern bands, consisting of greatly folded, broken and irregular lenses, cannot be followed for much further than half a mile. About 45 chains to the south-west of the main shaft is a bold ridge, 14 chains long, of highly contorted jaspilite, enclosed by G.M.L. 1868T, late "Monarch." This ridge is running in a north-easterly direction about 35° to the line of the parallel bands, and is apparently the middle limb of a sharp dragfold which at its northern extremity pitches steeply N.E., and at its southern end steeply to the south.

To the north all the jaspilite bands disappear under a wide expanse of alluvial soil, while to the south the western-most line, after a break of about 70 chains, is traceable in an approximately continuous line for many miles south of the mine. The Gladiator G.M. is situated on the westernmost jaspilite line. This "line" appears to consist of two or more parallel bands varying in width from 10 to 100 feet and closely folded together in some places.

Broadly speaking, the rock on the western side of this line is of the fine-grained greenstone type while that on the eastern side is the coarser grained epidiorite.

Both the greenstone and the jaspilites have been intruded by later dykes of fine-grained quartz porphyry which has here and there been sheared to a "felsite." Gold-bearing quartz veins have been later introduced into all of the above rock types.

THE ORE BODIES.

There are two lodes, the Main Lode which had been worked prior to the mine being taken over by the present company, and the West Lode, which has been located since that date (1931) and was, at the time of inspection (June, 1938) in course of development.

The Main Lode.

This consists of a quartz reef varying in width from 6 inches to 5 feet, which occurs running longitudinally through an 80ft. wide band of jaspilite. The jaspilite has been intruded by quartz porphyry

which in the upper levels runs in a number of parallel bands or tongues following its strike and dip. In the lower levels the number of these tongues is reduced to two. In places this porphyry has been sheared to a soft felsite. The quartz, which has later intruded the jaspilite and porphyry is frequently to be found following the contact of these two rocks.

The jaspilite, at its contact with the quartz, is mineralised and here usually carries fair values.

Where the quartz lode forsakes the jaspilite contact and cuts through the felsite (or porphyry), as can be seen on following the lode down from the No. 3 (280ft.) level through the No. 4 to the No. 5 (450ft.) level, the values invariably drop. The quartz appears to have formed in tension cracks in the jaspilite and greenstone. In places the lode has a marked "herring-bone" structure, i.e., numerous roughly parallel vertical veinlets may be seen emerging on both sides of, and approximately at right angles to, the central "back bone" of the quartz reef.

Stoping has been carried out extensively in the upper levels, down to about 350 feet. At the time of inspection the Main Lode had been opened up over a payable length of about 450 feet on the No. 5 (450ft.) level and the main shaft was being sunk in preparation for development on the No. 6 (600ft.) level.

Surface boring has located a further extension of the Main Lode at approximately 750ft. V.D. A longitudinal section showing the stoping at present completed suggests a northerly pitch for the values, but the writer has been assured that only the richest parts of the lode have previously been worked and that moderate values for the most part extend throughout the length of the lode. There are, however, reported to be two richer shoots of ore on the No. 3 level, one at approximately 50 feet south of the main shaft which pitches steeply to the south and another about 80 feet north of the main shaft pitching steeply to the north.

The West Lode.

This lode consists of quartz in bleached and mineralised fine-grained greenstone. It is situated on the western or footwall side of the Main Lode. The quartz reef is very irregular in width and varies from thin stringers up to lenses 3-4 feet wide. Slight bleaching and mineralisation of the greenstone extends over a width of 12 to 15 feet.

The lode runs in the direction of N. 17° E. making an angle of 35°-40° with the Main Lode. It was first found on the No. 3 (280ft.) level where it was opened up for a distance of about 320 feet south of the main shaft. The lode dips very steeply to the east (80°-85°), steepening to almost vertical at the south end of the mine. On the No. 5 level it has been opened up for a length of about 480 feet and the quartz here appears rather more regular. At the time of inspection the northern end of this level (at about 200 feet north of the main shaft) ceased in quartz porphyry, a dyke which here cuts the lode, and runs approximately east and west. It appears probable that by piercing the porphyry dyke, a northern continuation of the lode should be located. No free gold was to be seen in the quartz of this lode which will probably prove to be rather spasmodic and low in value.

PRODUCTION AND GENERAL REMARKS.

A previous investigation of this mine, then the Augusta, G.M.L. 371, was made in 1905 by C. G. Gibson (Bull. No. 24, pp. 21-22). Prior to that time the lease was the property of the Golden Rhine G.M. Co. It had been worked by them from 1897-1903, during which time Mines Department records show that 15,497.5 tons of ore were treated for an average yield of 14.2 dwts. per ton. From 1905 to 1911 production was continuous, 12,969 tons yielding an average of 21.1 dwts. per ton. No production is recorded from 1911 to 1913, but from 1913 to 1915, and from 1916 to 1920, figures show that 4,883.51 tons of ore were crushed for a total of 1,655.55 ozs. of gold including 21.61 ozs. of specimen gold. The average yield for this period is thus 6.6 dwts. per ton. The average grade of ore produced since 1897 is then 13.96 dwts. per ton, but this includes a number of very rich patches found in the upper levels only.

The present company put through several trial crushings at the State Battery, Laverton, early in 1938, the details of which according to official returns are as follow:—

	Ore treated.	Gold therefrom.	Grade dwts. per ton.
	tons.	fine ozs.	
February, 1938 ...	109.25	11.15	...
March, 1938 ...	122.50	25.72	...
March, 1938 ...	205.25	60.83	...
	<u>437.00</u>	<u>97.70</u>	<u>4.46</u>

Minerals in the ore associated with the gold, which is usually in a very fine state, are quartz, pyrite, pyrrhotite, with small quantities of calcite in the bleached lodes. Graphite frequently occurs on the contact walls of the jaspilite; and the greenstone, where it lies in contact with jaspilite, frequently shows a narrow chloritic schistose zone.

Water level is at approximately 180-200 feet V.D.

Since the writer's inspection in June 1938 the company has completed the erection of a 10-head battery and cyanidation plant, and has now commenced production (December, 1938).

RECOMMENDATIONS AND CONCLUSIONS.

It appears certain that the management will have to depend almost entirely upon the Main Lode for its payable ore—at least in the earlier stages of production. The grade of ore in the West Lode, probably will prove, on the average, to be very low and the values irregular in occurrence. No obvious structural control for the presence of the ore bodies has been noted. The jaspilite band which lies immediately east of the Gladiator line and which parallels it so closely, could well bear further investigation, by drilling, for the presence of further parallel lodes. The fact that prospecting at various times has shown traces of gold there rather supports this suggestion. There appears to be no obvious geological reason for suggesting that the Main Lode channel may not prove to extend further, both south and north of the points to which it has so far been developed.

THE MARY MAC GOLD MINE, G.M.L. 2261T, LAVERTON.

K. R. Miles, B.Sc. (Hons.).

The following notes are the result of a brief inspection of the Mary Mac G.M. made in September, 1938:—

The Mary Mac G.M.L. 2261T, is situated on a strong ridge of highly dragfolded and very ferruginous banded jaspilite which runs in a direction slightly west of south from Laverton. The lease is about 110 chains south of the town, its northern boundary passing about 2 chains south of Enniskillen Trig., J.H.R. 16. The country on both sides of the jaspilite ridge is a sheared and decomposed greenstone.

The main shaft underlays at about 60° E. which is the dip of the jaspilite at this point. There are two levels—the upper (No. 1) at about 150' on the underlay and the lower (No. 2) at about 200' (underlay depth).

The lode material consists of mineralised jaspilite and stringers of quartz and, in places, thin wedges of sheared greenstone enclosed in the highly folded jaspilite. The dragfolds have a vertical or steep northerly pitch for the most part. The values follow no defined lode channel or wall, and workings so far appear to have been confined to the oxidised zone above the water table.

The lower level consists of a winding drive extending for about 200 feet north of the main shaft. The upper level extends for approximately 400 feet north of the main shaft, following the jaspilite through-out, and about 600 feet south of the main shaft to the water shaft. A crosscut just south of the main shaft cuts through the jaspilite-greenstone contact and runs westward for about one hundred feet in greenstone.

Preparations have been made to break out ore of good value on the No. 1 level at approximately 300 feet south of the main shaft. Here the lode material consists of jaspilite and decomposed greenstone schist, folded into a number of broad noses which pitch away steeply in a direction slightly south of east. Values up to 15 dwts. per ton are reported here.

A considerable amount of stoping has been carried out both north and south of the main shaft, above the No. 1 level. The water table is at about 180' V.D.

According to Mines Department records production at this mine was continuous from 1909 to 1913 during which period 4,756.5 tons of ore yielded 2,566.17 ozs. of gold at an average grade of 10.8 dwts. per ton. Since 1913 there is no record of any further mining activity here.

From 1934 to April, 1938, however, retreatment of tailings on this lease has produced 1,678.26 ozs. of gold.

At the time of inspection (September, 1938), preparations were being made for the erection of a small mill and treatment plant, and a gas producer was then being installed.

No large bodies of quartz nor any extent of small veins were noticed. Apparently the mine has not been opened up to any extent below water level, but the spasmodic distribution of values, in crumbly jaspilite, and the lack of definition of apparent lode channel,

rather suggests that there has been considerable surface secondary enrichment and a sharp drop in values may be expected where the lode enters the zone of sulphides below the water table.

NOTES ON THE GEOLOGICAL STRUCTURE OF PORTION OF THE MT. MARGARET GOLDFIELD.

(K. R. Miles, B.Sc. (Hons.).)

An examination of air-photos of different portions of the Mt. Margaret Goldfield furnished evidence for the conclusion that the Laverton-Morgans district would prove an area of which an interpretation of the geological structure could readily be obtained. This idea has been fully borne out after a field season of areal and detailed geological mapping.

A description of the general geology of the area under consideration will be found elsewhere (page 15). In brief it appears to consist essentially of a thick series of basic lava flows, tuffs and agglomerates, and (probably intrusive) coarse-grained greenstones, interbedded in which are a number of horizons of thin, acid-sedimentary rocks. This series of basic, predominantly igneous, rocks and thin sedimentary bands, has been tentatively called the Greenstone Complex. It has been intruded and replaced in a number of localities by masses of granite and/or gneiss. In areas reasonably suspected of overlying this rock type, outcrops are generally poor and structural information is almost completely lacking.

THE BROAD GEOLOGICAL STRUCTURE.

As was found in the re-survey of the South Yilgarn Goldfield in 1935-36, the key to the elucidation of the major geological structure—and also some of the minor folding—was provided by a study of the distribution of the thin sedimentary layers in the Greenstone Complex. These are represented by banded ferruginous quartzites, or jaspilites, and blue-grey graphitic slate, described elsewhere (page 16).

An illustration of the structure of that portion of the Mt. Margaret Goldfield which has been mapped up to the end of the 1938 field season (December, 1938) is provided in Plate VIII. This structure-contour plan represents the outlines of three distinct sedimentary horizons, which on the eastern (Laverton) side of the area, are represented by jaspilite beds. The Mt. Crawford-Laverton line marks a fairly continuous jaspilite zone, and the Lancefield-Euro line is traceable as a discontinuous line of outcrops of jaspilite running from a little north of Lancefield to the north shore of Lake Carey. The Gladiator-Mt. Jumbo horizon of jaspilite runs in an almost continuous series of outcrops from Gladiator down through Mt. Margaret and Morgans, and up to Waihi.

The Windarra-Ajax horizon consists of a fairly continuous jaspilite line running southerly from Windarra to about 5½ miles south of Mt. Ajax, where it swings westward. Its north-westerly continuation is represented by a few broken outcrops only. North of a point 10 miles due east of Mt. Korong, all trace of this horizon is lost in a wide expanse of granite and/or gneiss.

The contour line immediately west of Morgans-Waihi represents the outcrop of a fairly continuous band of graphitic slate and jaspilite which probably constitutes the same sedimentary horizon as the Lancefield-Euro and the Mt. Crawford-Laverton beds. The same horizon is also probably represented by a short line of graphitic slate which runs in a direction slightly east of north through Murrin Murrin.

West of Murrin Murrin the structure line which passes through Mt. Flora indicates the approximate position of a broken line of jaspilite outcrops, which have not yet been mapped in detail. North of Mt. Flora, and both north and west of Waihi, are extensive areas of granite and/or gneiss.

The rocks of the Greenstone Complex have undergone primarily two sets of folding, the axes of which lie approximately at right angles to each other. This folding is reflected in the distribution of the rock types in the area.

In the first system the axes of folding trend north-north-west and south-south-east, swinging further west in the northern portion of the area so far mapped, and they represent a series of parallel anticlines and synclines. As indicated by a constant fairly steep regional dip to the east throughout the area, these folds are almost uniformly overturned towards the west. Two of the major folds in this system form a more or less isoclinal anticlinorium and synclinorium on the eastern side, while there is a third broadly asymmetric synclinorium or major synclinal fold on the western side. This axis of the major anticlinal structure, swings from S.W. to S.S.W. from a point 9 miles west of Mt. Windarra to 5 miles east of Mt. Margaret, and thence probably continues southwards down the centre of Lake Carey. The axis of the eastern major syncline passes southwards between Mt. Crawford and Lancefield and through Laverton along a line which runs through a point approximately 3 miles east of Childe Harold. The axis of the western major syncline probably runs from a little east of Monument Hill to a point approximately 3 miles east of Yundamindera.

The second system of folding which is superimposed upon the first, consists of a series of cross-folds whose axes run approximately E.N.E.-W.S.W., and which have produced changes in strike in the rocks of the Greenstone Complex, resulting in the broad curving, and the convergence and divergence of the lines of the jaspilite outcrops as illustrated by the structural lines in Plate VIII.

The most striking feature of this structure-contour plan lies in the two central concentric structure lines which form a wide belt sharply curved to form a rather flattened double parabola, with convexity facing southwards in the vicinity of Mt. Margaret, where it shows a steep southerly dip. The regional southerly dip at Mt. Margaret thus becomes the pitch of the major anticlinal structure. This structural pattern represents portion of that which is produced by the imposition of a broad east-west synclinal crossfold upon a major anticline whose axis lies approximately north and south, and is overturned steeply to the west.

The complete structure would show a second flattened parabolic curve with convexity and dip to the north in such a position as to be diametrically opposite the first, at some distance south of Mt. Margaret.

The axis of the synclinal crossfold would lie somewhere between the reversed parabolas. It is anticipated that future mapping will disclose the presence of portions, at least, of this opposed structure, but the record will probably prove to be rather incomplete due to lack of outcrops in the alluvial covered flats of Lake Carey.

Now, the broad synclinal east-west crossfold has produced reversals in pitch not only in the axis of the central major anticlinal structure, but has also in the axes of the two lateral major synclines. The result of super-imposing one synclinal fold at approximately right angles upon another is to produce a divergence in the structure lines. Such a divergence of the structure lines on opposite sides of the N.-S. synclinal axes is seen to exist, in going south from Lancefield to Childe Harold and from Monument Hill to Mt. Kowtah.

A line representing the position of the axis of this major synclinal crossfold has been drawn, tentatively, running in an east-north-easterly direction from a point 3 miles north of Yundamindera through Pyke Hill, to about 6 miles south of Burtville. Further mapping in the southern part of the district will, no doubt, establish the exact position of this axis.

The distribution of the structure lines near Monument Hill suggests a probable maximum convergence somewhere north of this point. This fact, and general observations of the distribution of jaspilite horizons in the country north of Laverton, not yet mapped, indicate the presence of a major anticlinal crossfold. In Plate VIII. the axis of such a crossfold is represented as passing through a point about 6 miles north of Monument Hill, and running in an east-north-easterly direction. There is no evidence at present as to the exact position or orientation of this axis, however, and it has been included merely further to illustrate the writer's conception of the general structure of the area.

THE MINOR GEOLOGICAL STRUCTURE.

Enclosed in the major N.N.W.-S.S.E. anticline and syncline, there are many smaller folds with axes parallel to them, but none of a size sufficiently large to show up on a plan of the scale of 300 chains to an inch, have so far been recognised. These small dragfolds usually have a steep variable pitch which may show reversals in direction from southerly to northerly, over short distances. Such reversals in pitch of the axes of N.N.W.-S.S.E. folds infer the presence of minor east-west crossfolding, or buckling. There is a certain amount of evidence of the presence of a number of these minor crossfolds.

The broad undulations of the structure lines on the western side of the major central north-south anticline produced by alternating convergence towards and divergence from the central north-south axis, are reflected in some cases by broadly similar undulations of the same respective horizons on the eastern side. This is exactly what we would expect to find in the plan of an overturned anticline upon which has been super-imposed a number of minor synclinal and anticlinal crossfolds. At a point about 1 mile north of Mt. McKenzie is the centre of a structural curve with convergence to the east. The same curvature is seen in the structural horizon immediately east of this. Such a curvature could only be produced by the action of an anticlinal crossfold upon the overturned western limb of the major anticlinal struc-

ture. On the eastern side of the central anticline, the Windarra-Ajax structure line curves broadly with convexity facing east at a point about 10½ miles south of Mt. Windarra. This means that the axis of the minor anticlinal crossfold probably passes through this point. This axis probably crosses the Lancefield-Euro and the Mt. Crawford-Laverton horizons at a point ½ mile or so south of Mt. Crawford, where the latter structure line shows a westerly convergence towards the Laverton synclinal N.-S. axis. Corroborative evidence of this anticlinal crossfold is found in a regional northerly pitch at the Lancefield G.M., the presence of steep south-pitching dragfolds in the jaspilite outcrops between Mt. Crawford and Laverton, and, on the western side, the occurrence of strong southerly pitches in the dragfolds between Morgans and Mt. McKenzie.

A curvature of the structure line to the westward, at Morgans, and at a point about 2 miles south of Korong, suggests the presence of two parallel minor synclinal crossfolds lying on opposite sides of the anticlinal crossfold already described. The axis of the Morgans crossfold appears to run in an east-north-easterly direction towards Laverton. No decisive evidence of the presence of this synclinal crossfold on the Laverton side of the area, can be obtained. The axis of the Korong crossfold probably runs parallel to the others. On the eastern side, the presence of a slight westerly curvature of the Windarra-Ajax structure line, at a point about 5½ miles south of Mt. Windarra, and the occurrence of steep southerly pitches in the jaspilite outcrops immediately south of Windarra, with pitches to the north at Lancefield, point to the existence of a continuation of the Korong synclinal crossfold at somewhere about 2 miles north of Lancefield. Corroborative evidence of crossfolding from the distribution and direction of pitch of dragfolds in jaspilite beds throughout this district, is not particularly conclusive, however, as the angles of pitch of the axes of the dragfolds are usually very steep (from 65° to 90°), and reversals of direction over distances of only a few yards are quite common.

A further set of undulations in the structure lines between Mt. Margaret and Morgans, reveals the probable presence of another minor anticlinal crossfold whose axis runs from about 3 miles north of Mt. Margaret Trig., in the direction of Mt. Jumbo. Here also, direct evidence of this crossfold can only be found on the western limb of the major anticlinal structure.

A marked reversal in the pitch of the N.-S. axes of dragfolds was seen on the Admiral-Mt. Weld jaspilite line on the eastern side of the area. For several miles south of Mt. Weld the dragfolds in jaspilite outcrops all pitch steeply to the north. Further northwards, towards Ida H., the few recognisable pitches were predominantly southerly, indicating the possible presence of a minor synclinal crossfold whose axis passes, probably, about a mile north of Mt. Weld; and a corresponding anticlinal crossfold at some point south of this. At about 3 miles south of Mt. Weld the structure line curves westward towards the major synclinal N.-S. axis, and the axis of the anticlinal crossfold probably passes through this point in the direction of Childe Harold. This structure is not, however, particularly well reflected in the distribution of the structure lines to the immediate westward.

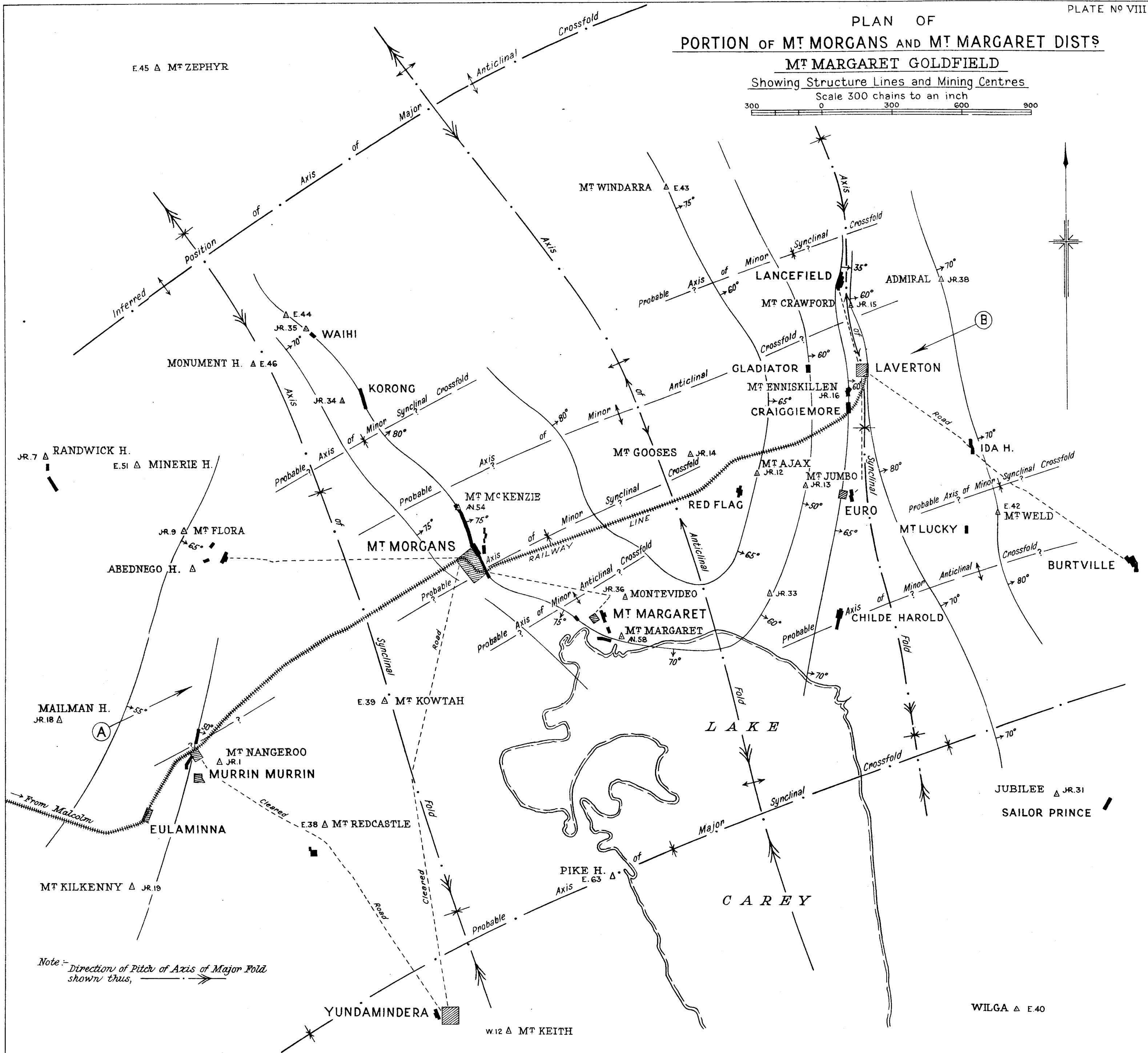
PLAN OF PORTION OF MT MORGANS AND MT MARGARET DIST^s

MT MARGARET GOLDFIELD

Showing Structure Lines and Mining Centres

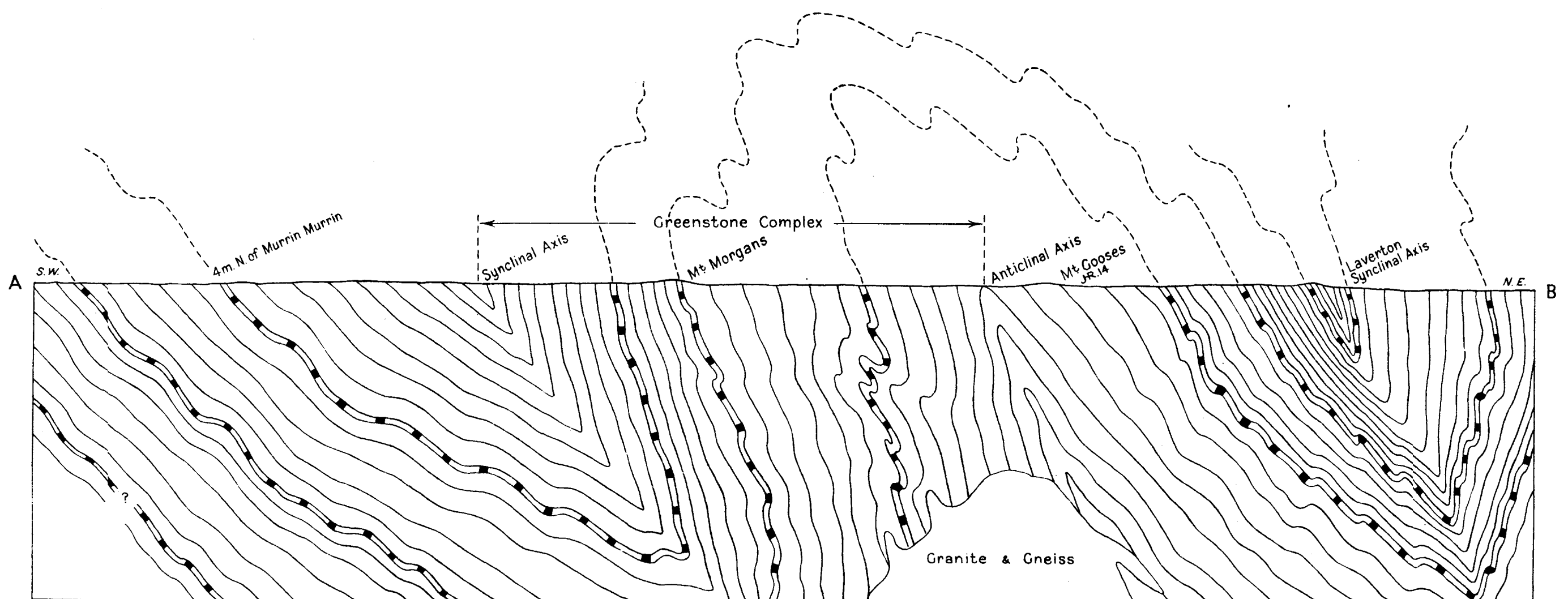
Scale 300 chains to an inch

300 0 300 600 900



Note: Direction of Pitch of Axis of Major Fold shown thus,

DIAGRAMATIC SECTION ALONG LINE A-B



STANDARD SYMBOLS

As Adopted by G.S.W.A. 1935

PLATE No IV

Observed Geological Boundary	.....	Top of Beds as indicated by Cross Bedding	
Doubtful or Assumed Geological Bdy.	---?---	Top of Beds as indicated by Gradation in Grain	
Outcrops with no observed Strike and Dip	+ + +	Regional Pitch of Minor Folds	
Strike and Dip of Foliation in Granite	N.30°W 65°	Bluffs and Breakaways	
Strike of Vertical Foliation in Granite	N.30°W	Open Cuts	
Strike and Dip of Schistosity	N.30°W 50°	Costeans	
Strike of Vertical Schistosity	N.30°W	Dry Blown Areas	
Schistosity with Curving Dip	50° 30°	Roads or Tracks	-----
Strike and Dip of Bedding	N.30°W 75°	Railways	=====
Strike of Vertical Bedding	N.30°W	Telegraph Lines	—○—○—○—
Bedding with Curving Dip	60° 30°	Fences	—#—#—#—
Strike and Dip of Jointing	N.10°W 60°	Watercourses	—>—>—>—
Strike and Dip of Fracture Cleavage	10°	Form Lines	—○—○—○—
Overtuned Strata	70°	Swamps	—*—*—*—
Relative Direction of Shearing Movements	↗	Quartz	—Q—
Fault	~~~~~	Jasper (not Jaspilite)	—J—
Probable Fault	~~~~~	Jaspilite	—JFe—
Pitch of Fluting on Fault	~~~~~ 25°	Main Shafts (Number of Compartments may vary)	
Fault Observed indicating Vertical and Horizontal Components of Movement.	(Up)U (Down)D 30°	Shafts	
Strike and Plunge of Dragfold	~~~~~ 45°	Winze	
Dip of Axial Plane in Dragfold	~~~~~ 40°	Rise	
Axial Plane of Large Fold	—·—·—·—	Cross-section of Crosscut or Drive approaching Observer	
Axis and Direction of Pitch of Major Fold	—·—·—·—	Cross-section of Crosscut or Drive receding from Observer	
Anticlinal Axis	↑	Buildings	
Synclinal Axis	↓	Elevation in Feet above General Level	143'
Direction in which Lava Flow Tops face	↑	Elevation in Feet above Sea Level	1312'
Top of Beds as indicated by Cleavage and Bedding Relationships	↗	Locality and Number of Specimen	X 2/825

Thus it appears that there is a certain amount of evidence for at least two, and possibly three, minor synclinal crossfolds—which, of course, infers the presence of their corresponding anticlinal crossfolds—on the eastern and the western limb of the central overturned structure within the major crossfolding system, between Childe Harold and Mt. Windarra. In all probability the axes of these minor crossfolds extend from west to east right across the area under consideration, but evidence in proof of this fact is very inconclusive. The “wave length” of these minor crossfolds, that is, the distance between any two points in the same phase, is approximately 8 miles.

Probably there is a great deal of still smaller-scale cross-buckling within these minor folds, but poor exposures and lack of underground workings make it almost impossible to obtain sufficient evidence for their elucidation.

THE RELATIONSHIP OF GOLD DEPOSITION TO GEOLOGICAL STRUCTURE.

Though mining activity in the Laverton, Morgans and Murrin Murrin districts has undergone a revival in the last few years, there are in existence very few new mines which have reached such a stage of development, that an underground examination might be expected to provide clues as to the minor structures in which they are situated. Most of the older centres such as Ida H., Childe Harold, Euro, Burtville and Mt. Margaret are almost deserted, and their underground workings inaccessible. Consequently, it is impossible to arrive at any specific conclusions as to the effects of isolated geological structures upon the production of gold bearing formations in the different mining centres.

However, a study of the distribution of the mining centres in relation to the geological structure of the area as it has been interpreted in Plate VIII., reveals one or two interesting facts.

Firstly, there appears to be a definite grouping of the mining centres along certain parallel lines which run in an approximate E.N.E.-W.S.W. direction, i.e., parallel to the axes of major and minor crossfolding. The actual position of the centres in relation to the axes of minor crossfolds varies considerably, but in some cases important mining centres appear to lie on or close to these axes. Very possibly the distribution of gold in many centres has been controlled by still smaller scale structural features which have not been revealed in Plate VIII.

Another interesting point that may be noted is that in many cases the mining centres appear to be associated with the jaspilite horizons in the Greenstone Complex.

It appears probable, then, that localisation of gold deposition in this area has been to a certain extent controlled by the crossfolding structures. As to whether the major crossfolds are those of prime importance, and if so, whether certain portions of these folds are more favourable for the introduction of gold solutions than others, it is as yet impossible to say. Similarly if the distribution of gold is controlled primarily by the minor crossfolds, it may later be possible to prove that certain phases of these folds, such as, some parts of the crests of anticlines, or the troughs of synclines, or certain portions of the limbs are the most favourable for the introduction of auriferous solutions.

Though a certain amount of field data has already been obtained, considerably more evidence, both in this and other goldfields, will be required to satisfy these very important questions.

NOTES ON THE BANDED JASPILITES OF THE MT. MORGANS-MT. MARGARET DISTRICT.

MT. MARGARET GOLDFIELD.

(K. R. Miles, B.Sc. (Hons.).)

To even the most disinterested traveller from Morgans to Laverton one of the noticeable features of this part of the Mt. Margaret Goldfield should certainly be the numerous low broken ranges and long ridges, frequently topped by ragged knife edges of naked rock, whose bare outlines stand out in marked relief from the flat red mulga-strewn plains, and the low rounded dull-brown, greenstone hills.

These ridges usually consist of one or two steeply dipping beds of a variety of banded iron-bearing quartzite, to which has been given the name of “Jaspilite” (better known on the goldfields as “Jasper”). The high content of quartz—a chemically inert mineral—in the jaspilite beds, and its fine texture, has generally resulted in these beds having resisted the agents of weathering far more successfully than the surrounding rocks.

Consequently they are usually to be found outcropping as long narrow sinuous ridges, which stand up above the general level of the country. Several of these long broken lines have been traced over distances of 20 miles and more.

Detailed mapping in the Laverton-Morgans district has established the fact that there are three, possibly four, distinct horizons of these jaspilite beds. These “horizons” are not usually represented by the one continuous bed of jaspilite, but more often consist of several separate bands or beds, which vary in thickness from 2-3 chains down to a few inches. A band may sometimes lens out, its place often being taken by another parallel band at some distance further along the general strike of the horizon. The bands are frequently tightly folded and contorted.

The general characters and the mode of origin of the jaspilite beds in the different horizons are essentially the same, but it appears that some at least of the horizons show certain distinctive characteristics, while in all of them can be seen, in different places, variations in composition, structure, texture, granularity and degree of alteration or decomposition.

A most striking feature of the jaspilites is their remarkably uniform banding. This is usually due to parallel layers of dark (either brown, black or red) iron oxides alternating with white or grey bands of fine-granular quartz. These alternating layers, of widths varying from 1 inch down to fine hairlines, frequently show the remarkable continuity characteristic of “varve” structures in younger and less disturbed sedimentary deposits, and even in highly contorted and dragfolded portions of the jaspilite beds, contiguous individual layers are often traceable for many chains.

The jaspilites of this area may be divided into two groups: the Siliceous Jaspilites, or those which have a very low iron content; and the iron-bearing Jaspilites.

The former, of which the Mt. Crawford (JHR 15)-Lancefield lines (see structure-contour plan, Plate VIII.) are examples, consists essentially of a closely interlocking quartzite through which run narrow parallel pencil lines of darker material—probably finely divided graphite, or iron oxide. It frequently shows evidence of re-silicification, the result of intrusion by later quartz. This type has been seen to grade into the iron-bearing variety in a number of places, e.g., south of Mt. Crawford, at Mt. Weld (E 42), ½ mile south of the Gladiator G.M., etc.

In the iron-bearing jaspilites, which make up the bulk of the Jumbo (JHR 13)-Morgans, and Windarra (E 43)-Ajax (JHR 12) horizons, and portion of the Laverton-Euro line, the iron ore is usually present in the form of bands of either black, granular hematite, or brown-yellow amorphous limonite, the one often grading into the other.

At Mt. Windarra the iron-bearing bands are associated with a light-brown coloured platy mineral, probably an amphibole.

In two places jaspilite beds have been seen to grade, across the strike into pebble conglomerates.

At about one mile south of Mt. Windarra, the bed grades imperceptibly, eastward, into a coarse quartzite or grit containing narrow beds of highly sheared and lensed-out quartzite pebbles. At about 4 miles S.S.W. of Child Harold, where the Euro jaspilite line approaches Lake Carey, its eastern boundary passes into a coarse pebble rock of obviously sedimentary character.

Another rock type which is probably closely associated with the jaspilites of this district is a blue-grey graphitic slate, or phyllite, which frequently carries narrow lenses of banded quartzite very similar to a siliceous jaspilite. A well-marked horizon of this slate exists at about 1¼ miles west of the Morgans-Korong jaspilite line, and at Murrin Murrin, while

numerous narrow belts occur in greenstone schist, both east and south of Laverton.

About one mile west of Mt. Korong (J.H.R. 34) the blue-grey slate horizon is cut off by intrusive granite, and close to the contact, the slate has been converted into a micaceous chialstolite-bearing rock.

The jaspilites were very probably laid down under shallow seas in early Pre-Cambrian times, in the form of impure sandy beds, the detrital material of which being derived from the denudation of ancient land surfaces consisting of predominantly basic rocks.

There were at least three periods of sedimentation and probably four, or more, separated by periods of volcanic activity during which thick layers of basic lavas, tuffs and later, agglomerates were deposited in succession over the thin sedimentary beds.

STANDARD SYMBOLS

As adopted by The Geological Survey of Western Australia, 1935.

(Reference Note by H. A. Ellis.)

In Plate No. IV. of this report will be found a reference table explaining the conventional signs which are in use on geological plans prepared by officers of the Geological Survey since the year 1935.

A number of these signs have been adopted from the published plans of other Geological Surveys, particularly those signs having reference to structural features.

While each geological plan is always accompanied by a legend in which an explanation of those conventional signs used in its compilation is given, it has been thought desirable to reproduce in one plate, all the signs used.

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