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 assymetric 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 structure. 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.

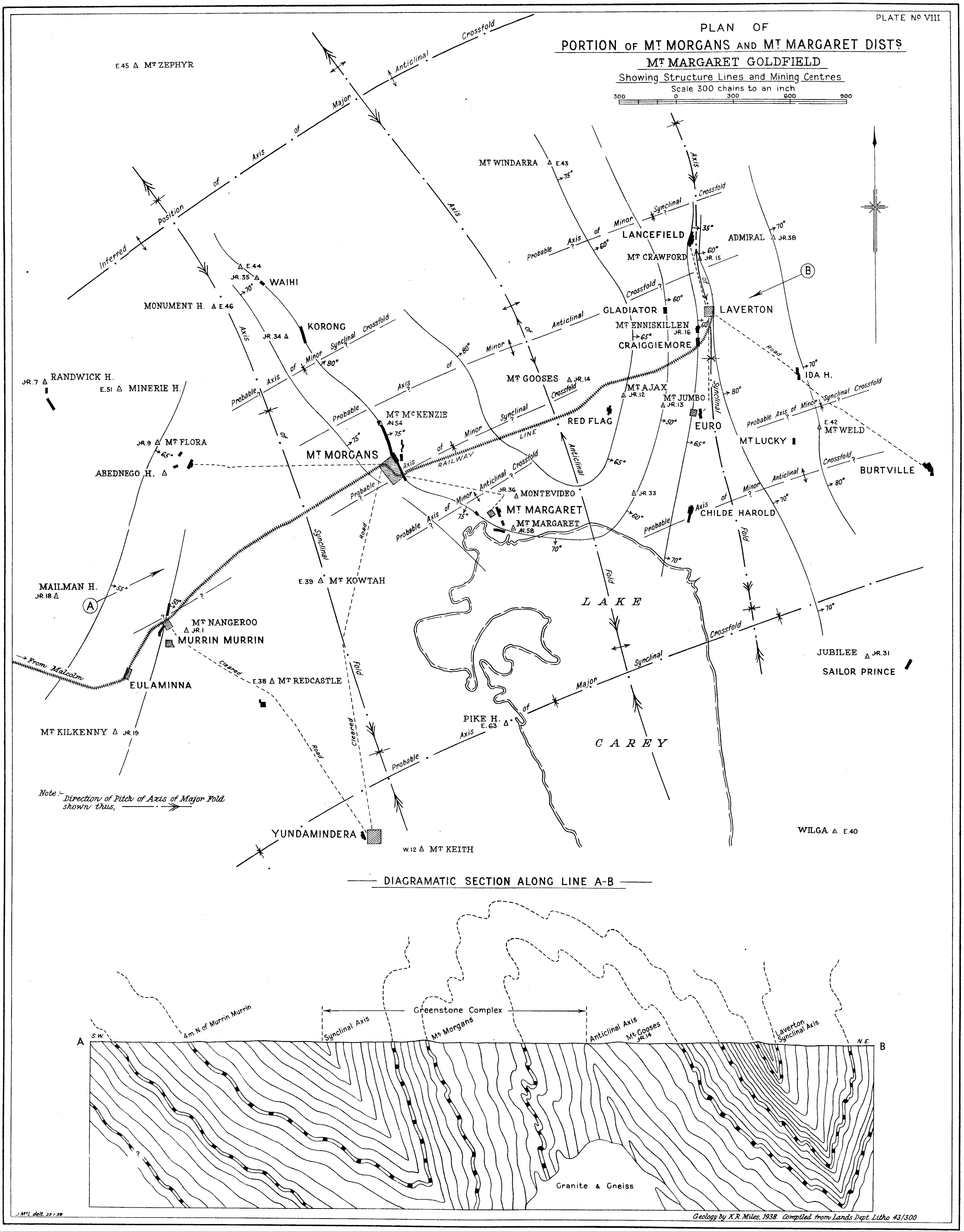

PLATE No VIII
PLAN OF
PORTION OF MT MORGANS AND MT MARGARET DISTS
MT MARGARET GOLDFIELD
Showing Structure Lines and Mining Centres
Scale 300 chains to an inch
300 0 300 600 900
E.45 Δ MT ZEPHYR
Inferred Position of Axis of Major Anticlinal Crossfold
Axis
MT WINDARRA Δ E.43
Axis
Probable Axis of Minor Synclinal Crossfold
LANCEFIELD
ADMIRAL Δ JR.38
MT CRAWFORD Δ JR.15
B
E.44
JR.35 Δ WAIHI
MONUMENT H. Δ E.46
KORONG
Crossfold
GLADIATOR
LAVERTON
MT ENNISKILLEN JR.16
CRAIGGIEMORE
Axis of Anticlinal
Probable Axis of Minor Synclinal Crossfold
JR.34 Δ
Probable Axis of Minor
Road
IDA H.
JR.7 Δ RANDWICK H.
E.51 Δ MINERIE H.
MT GOOSES Δ JR.14
MT AJAX JR.12
MT JUMBO JR.13
Synclinal
Probable Axis of Minor Synclinal Crossfold
MT McKENZIE N.54
Probable Axis of Minor Synclinal Crossfold
RED FLAG
EURO
E.42 MT WELD
JR.9 Δ MT FLORA
MT MORGANS
RAILWAY LINE
MT LUCKY
ABEDNEGO H. Δ
Anticlinal
Crossfold
BURTVILLE
Probable Axis of Minor Anticlinal Crossfold
JR.36 Δ MONTEVIDEO
JR.33
Probable Axis of Minor Anticlinal Crossfold
MT MARGARET
MT MARGARET N.58
CHILDE HAROLD
Synclinal
Road
Fold
Fold
MAILMAN H. JR.18 Δ
E.39 Δ MT KOWTAH
A
LAKE
MT NANGEROO Δ JR.1
MURRIN MURRIN
Crossfold
JUBILEE Δ JR.31
Synclinal
SAILOR PRINCE
From Malcolm
Cleared
E.38 Δ MT REDCASTLE
Fold
EULAMINNA
Major
of
PIKE H. E.63 Δ
Axis
Road
Cleared
MT KILKENNY Δ JR.19
CAREY
Probable
Note:- Direction of Pitch of Axis of Major Fold shown thus,
YUNDAMINDERA
WILGA Δ E.40
W.12 Δ MT KEITH
DIAGRAMATIC SECTION ALONG LINE A-B
Greenstone Complex
A
S.W.
4 m. N. of Murrin Murrin
Synclinal Axis
Mt Morgans
Anticlinal Axis
Mt Gooses JR.14
Laverton Synclinal Axis
N.E.
B
Granite & Gneiss
J McL delt. 23.1.39
Geology by K.R. Miles, 1938. Compiled from Lands Dept. Litho 43/300

STANDARD SYMBOLS

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

PLATE No IV

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

J.McL.

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.