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PROGRESS REPORT ON THE GEOLOGY AND MINES OF THE YILGARN GOLDFIELD (South of the Great Eastern Railway).

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

GENERAL GEOLOGY.

In a resumé of the general geology of this area made by the writer at the conclusion of the 1935 field-season and published in the Annual Progress Report of the Geological Survey for 1935, several tentative conceptions of the geological structure were set out, it being pointed out at the time that these ideas were subject to revision as progress in field-work was made.

Up to the close of field-work in 1935, no evidence sufficient to establish the intrusive nature of any of the greenstone had been discovered, but towards the end of the 1936 field season, examination of the hilly country immediately south of Southern Cross, where exposures are reasonably good, revealed the presence there of unshaped basic igneous rock transgressive into a highly sheared basic rock composed mainly of a variety of hornblende classified by Dr. Simpson, Government Mineralogist and Analyst, as anthophyllite.

Associated with this basic igneous intrusive rock is a liberal development of small patches of a basic pegmatite, occurring in the intrusive rock in much the same manner as does a normal pegmatite in granitic masses.

Examination of black mineral concentrates from very decomposed basic rocks from the vicinity of Marvel Loch reveals the presence of chromite, hence it is reasonable to assume a probable ultra-basic composition for these rocks, and also attribute to them a probable intrusive habit.

It can now be stated that some of the greenstones are intrusive, but this feature has in no way been found to affect or influence the occurrence of gold.

One result of the regional mapping has been to establish an order of succession for the various rock-types occurring in this portion of the Yilgarn Goldfield. This system of metamorphic rocks starts off with the greenstone series at the base and passes upwards, with the increasing development of the sedimentary phase, to the metamorphosed sediments of what has been known as the Yilgarn series.

It has been decided to refer to the whole of the metamorphic rocks of the Yilgarn Goldfield as the Yilgarn system, and to subdivide this system into two series, namely, the greenstone series and the whitestone series, of which the former is the lower in the stratigraphical succession and hence the older.

The greenstone series embraces the rocks of a basic or intermediate composition derived from a volcanic or intrusive igneous origin. The term includes the dark coloured sediments, tuffs, and all fragmental volcanic material associated with the flow and intrusive volcanic rocks.

The whitestone series embraces the recognised metamorphosed sediments of an acid composition, previously referred to as the Yilgarn system by Mr. Blatchford (G.S.W.A. Bulletin No. 63).

THE BROAD GEOLOGICAL STRUCTURE.

The ultimate key to the major geological structure of the gold-bearing belt of the Yilgarn Goldfield, south of the Great Eastern Railway, was found in the distribution of the ferruginous quartzites or jaspilites ("Jaspers" of the prospector), and when these failed, in the distribution of a recognisable band in the greenstone series characterised by being composed of anthophyllite with associated ironstone, and cellular and banded secondary silica formations.

The structure can be fairly completely indicated as far south as the Cheriton group at the southern end of Parker's Range, but the paucity of outcrops and the dense scrub from this point south to the southern boundary of the goldfield, has prevented the elucidation of the major structure in this portion of the area investigated. The only known auriferous locality south of Parker's Range in the Yilgarn Goldfield is Forrestonia, and from structural data obtainable from the South and Middle Ironeap, this occurrence would appear to be situated on or near the axis of an anticlinal crossfold trending north-east and south-west.

The structure of the Yilgarn system, and hence the distribution of the rock types, is controlled primarily by two sets of folding, the axes of which lie practically at right angles to each other. The first system took place along axes having a general north-north-west and south-south-east trend, and resulted in a series of generally parallel, tightly folded anticlines and synclines. These folds were not always symmetrical, and overturned asymmetrical anticlines and synclines form part of this folded system, the major folds of which are anticlinoria and synclinoria.

Superimposed upon this series of folds, either subsequent to or coincident with the folding period during which the first series was formed, is a series of crossfolds which has produced a buckling of the main N.N.E.-S.S.W. series, and has been re-

sponsible for the changes in strike of the beds, producing curved, divergent, and convergent outcrop lines.

The axes of these cross folds appear to strike a little north of east and a little south of west, and the degree of folding varies considerably. The axes of these cross folds are naturally not always horizontal and changes in pitch in both degree and direction can be expected. No information as to the effect this variation in pitch of the axes of the cross folds has on gold occurrence has yet been obtained.

The manner in which these two series of folds have determined the broad geological structure of the gold belt from Southern Cross south as far as the Cheriton Group is illustrated in Plate VI. With the exception of the short structure line drawn in a southerly direction through Greenmount from near Southern Cross, and the two lines concave to the east and west in the vicinity of Harris' Find and the Great Victoria respectively, the structure lines represent the general line of outcrop of a band or bands of ferruginous quartzite or jaspilite ("jasper" of the prospector) occurring in the Greenstone Series, probably somewhere towards the base of that series.

The structure line drawn from near Southern Cross southwards through Greenmount represents the line of outcrop of a basic igneous rock composed essentially of anthophyllite and is at a different horizon to the jaspilites. Similarly, the lines concave to the east and west previously mentioned represent the general trend of the outcrop lines of the Whitestone Series which constitutes the upper portion of the Yilgarn System.

The degree and direction of regional dips are indicated by arrow-heads attached to the structure lines, and where these are absent, the dips are vertical. The outstanding feature of Plate VI. is the two opposing structure curves convex to the south and north respectively in the vicinity of Nevoria and Parker's Range, and the two hyperbolic curves flanking them on either side. This distribution of beds represents the cross folding of an antilinal structure by a cross syncline, and the steep northerly pitch of drag folds at the Great Victoria and the steep southerly pitch of similar structures at Nevoria indicate that the axis of this cross fold must lie somewhere between these two points.

The partially completed oval-shaped curve passing through Magowan's Find, Toomey's Hills, Parker's Range and then round through the Olga, Duleie and Cheriton Groups, is shown by its regional dip and distribution to be an antilinal structure folded by a cross antilinal fold. Such a structure can only be formed by two bounding synclinal cross folds, hence there must be another synclinal cross fold immediately south of the Cheriton Group, and it is probably a very strong fold. Some evidence can be produced in support of the existence of this cross-fold. The westerly continuation of the cross-fold passing between Nevoria and the Great Victoria in a general east by north and west by south direction is indicated at Edward's Find, where steep northerly pitches occur. Still further west at Felstead's Find, steep southerly pitches are to be seen, and it is not unlikely that the influence of this strong cross fold has extended further west.

Between the Great Victoria and Edward's Find, and Edward's Find and Felstead's Find, are extensive areas of granite and/or gneiss, and at the latter

two localities the cross-fold passes through only very narrow greenstone belts. The occurrence of gold in these two isolated localities seems to have some connection with the structural influence brought about by the cross fold.

The canoe-shaped pattern resulting from the cross folding of an antilinal structure, which the structure-line map on Plate VI. indicates is the case in the gold belt south of Southern Cross as far south as the Cheriton Group, gives us a base from which to attack the structures lateral to this major one, where such structures remain. A major synclinal axis is depicted extending south-south-east from just west of Southern Cross, and since the structure lines running through Kennyville and Mt. Rankin are on the same horizon, the regional dip indicates a synclinal structure between these two places. The position of the axis is fixed by the occurrence of part of the Whitestone Series (the upper portion of the Yilgarn System) as a narrow band flanked by rocks of the Greenstone Series on either side, along the line of the axis where mapped. Between Greenmount and Mt. Rankin and west of Blackbourne's, an antilinal axis is shown, and this antilinal structure is an antiline on the limb of a larger syncline.

The convergence of the structure lines south of Blackbourne's can only be due to cross folding, or in other words, change of pitch in the N.N.W., S.S.E. axes.

The major syncline is asymmetrical, and likewise the regional dips of the major antilinal structure to the east indicate that it, too, is asymmetrical in the same direction. The general nature of this major asymmetrical antilinal and synclinal folding is indicated in the section on Plate VI., and it is intended to convey the impression that the limbs of these major folds have subsidiary, but still fairly large, minor antilinal and synclinal folds imposed upon them, and that the general nature of the folding along the N.N.W., S.S.E. axes has resulted in the formation of tight chevron types of folds.

The asymmetry of the folds suggests that the structures with which we are dealing form portion of a limb of an antilinerium or synclinerium, the other limb of which may possibly be found in the Coolgardie Goldfield, or on the other hand, it may have been assimilated by the invading granite.

At Southern Cross there is a gradual increase in the pitch of the drag folds to the north in a northerly direction, and an antilinal cross fold has been indicated here.

At Marvel Loch centre the convergence of strike lines and the changes of pitch of drag folds again indicate cross folding, while at Palmer's Find the detailed mapping done by Messrs. Hobson and Matheson indicates that the main mine there is situated in a minor synclinal cross fold on a larger antilinal cross fold.

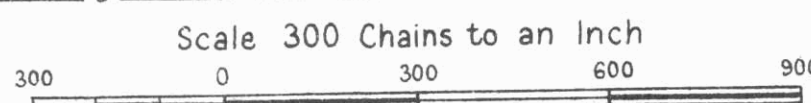
There is some suggestion of periodicity in the occurrence of the stronger cross-folds, but it would be unwise to arrive at any definite conception of the wave lengths of these folds at the present juncture.

THE BROAD RELATION BETWEEN STRUCTURE AND GOLD DEPOSITION.

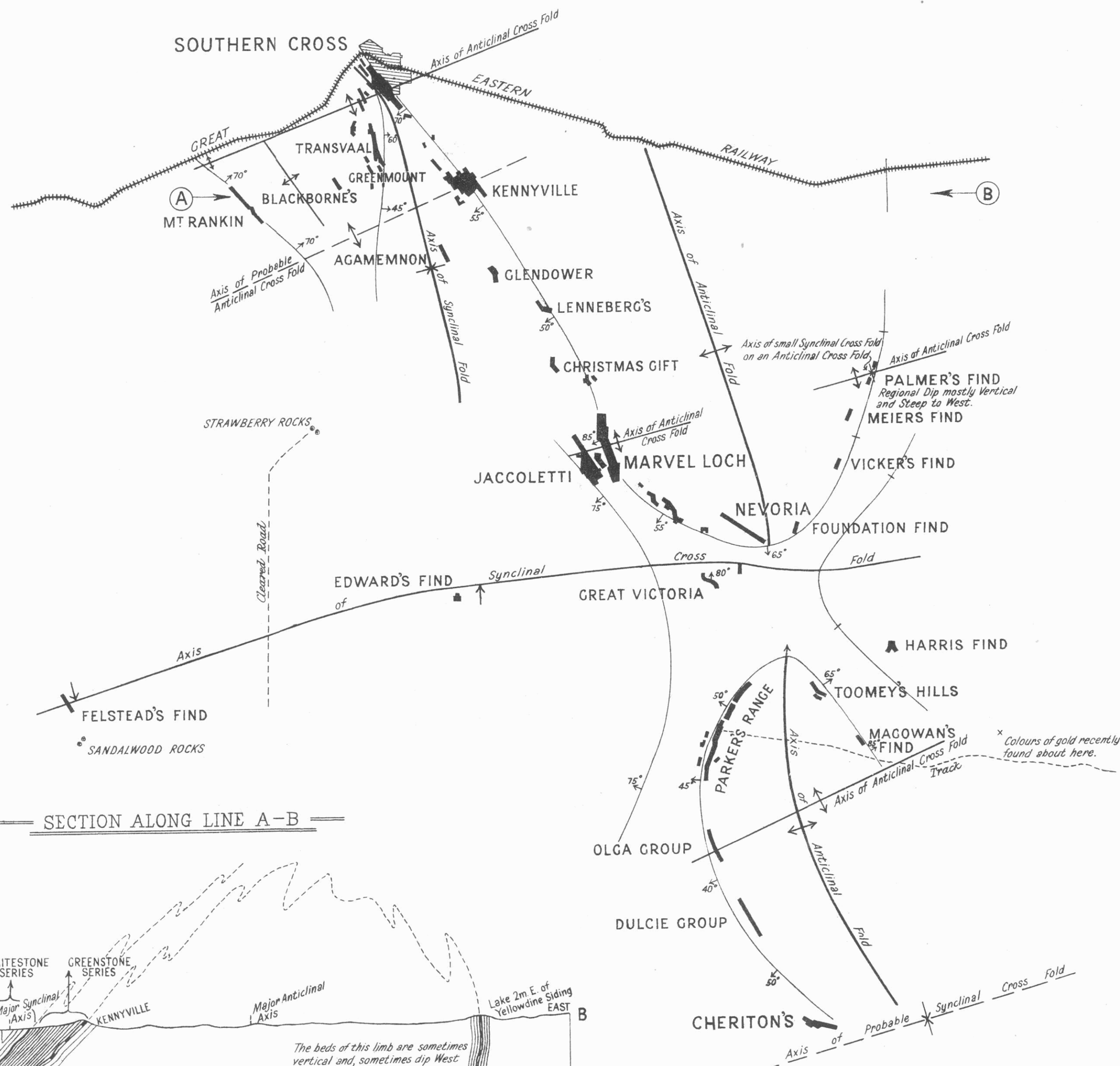
Of an area of about 5,500 square miles geologically surveyed during the course of the field work in 1935 and 1936, only about 5 per cent. of exposures exists, and geological observations in the rocks of the Green-

PLAN OF PORTION OF GOLD BELT SOUTH OF SOUTHERN CROSS

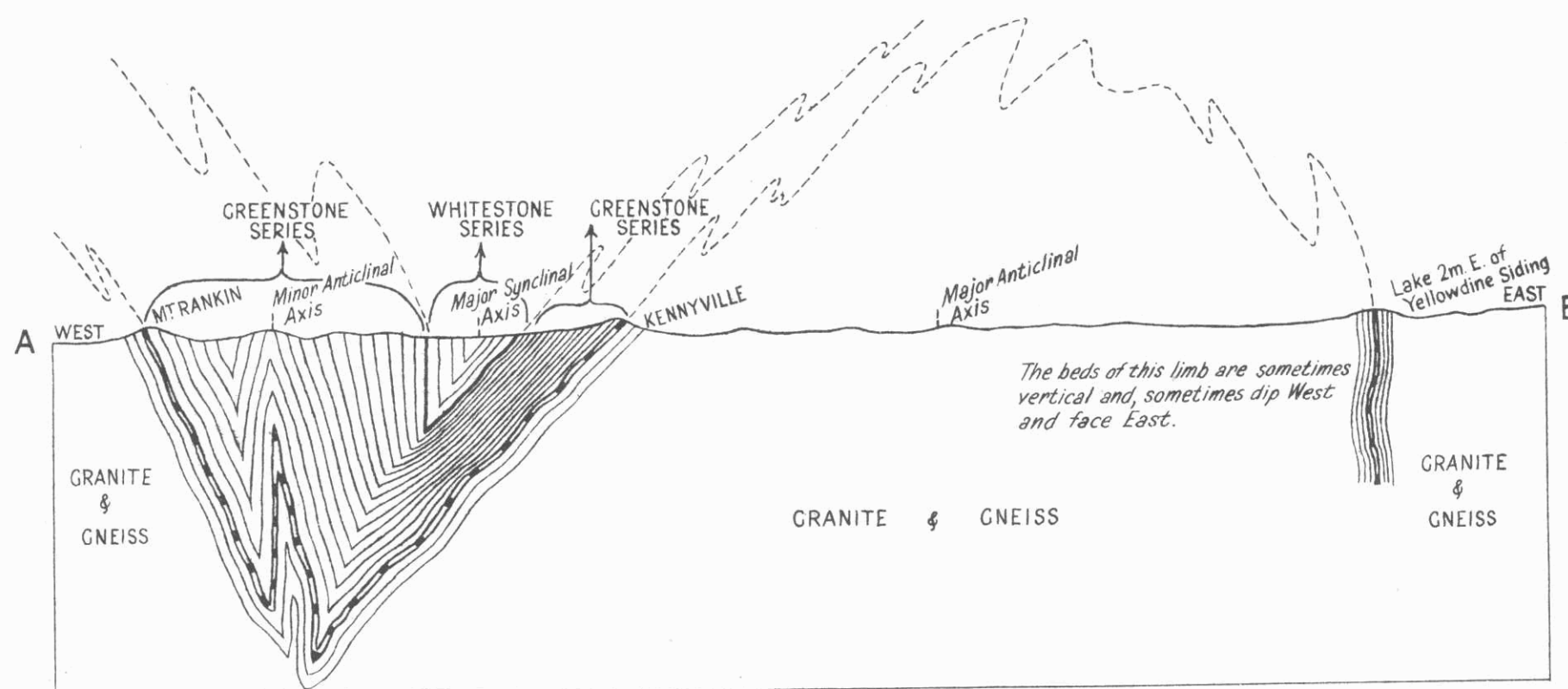
Showing Structure Lines and Mining Centres



YILGARN GOLDFIELD



SECTION ALONG LINE A-B



stone Series (the chief gold hosts) have had to be made under very unfavourable outcrop conditions. These facts prevent the making of statements more definite than those given below, when the subject under the above heading is being discussed.

The structure-line map on Plate VI. indicates in a definite manner the occurrence of most of the gold centres in a relatively narrow zone along the outcrop portions of limbs of anticlines and synclines. When it is realised that the rocks in which the gold occurs form part of a folded series, there is hardly anywhere else where they could form, hence this discovery in itself is not of any significance, except perhaps, in so far as a somewhat definite horizon, namely, that immediately above, below, and including the jaspilites, has been found to be a gold horizon in the area investigated.

Of the many aspects of the problem concerning the reasons for and causes of gold deposition, perhaps the main one is that embracing the structure of the rock masses in which the gold is found. The distribution of the gold localities in groups both along and across the strike of the host rocks surely has some significance, and the observations made during the course of this survey have indicated that this localisation of gold deposition has been associated with cross folding.

The concentration of gold localities in the synclinal cross fold between Great Victoria and Nevoria is significant, as is also the occurrence of gold at Edward's and Felstead's Finds on the supposed westerly extension of this fold.

The vast area over which gold occurs in Western Australia indicates no lack of suitable granitic magmas, and the general similarity of the rocks in which it occurs, namely the Greenstone Series, shows that the influence of rock type is not paramount. It would seem then that this problem of geological structure and associated gold deposition, evidence for the close connection between which has been found during the survey, is of vital importance.

Only a few of the facts relating to this problem have been elucidated so far in the area investigated, and the value of predictions based on these facts suffer accordingly. Useful results based on the interpretation of geological structure can only come after the broad structural details of several goldfields have been investigated.

PROSPECTING RECOMMENDATIONS.

The recommendation made in the progress report of this survey for 1935 concerning the advisability of lateral prospecting from underground workings in existing mines is again made with confidence. An additional guide to this method of prospecting lies in the fact that the influence which folding has had on the origin of the ore bodies causes them to be frequently arranged *en echelon* in a steeply dipping series of rocks. This indicates the advisability of continuing a drive some distance beyond the end of an ore body which "peters out," and then by either cross-cutting or diamond-drilling, testing the country laterally.

There is some evidence to support the belief that the pitch of the ore shoots is coincident with the pitch of minor folds which may be observed in the wall rocks in the initial stages of opening up a mine.

Recognition of this probable relation should greatly aid the setting out of a development programme on any new mine.

Surface prospecting operations on this field must be very largely confined to methods involving the extensive use of loaming, and in most of the localities suggested below, it will be found the only practicable means of testing. The following localities are suggested as being those most favourably situated for the possible occurrence of gold:—

(1) The country south-westwards from Lenneberg's Find between that locality and the old Southern Cross-Marvel Loch Road.

(2) The country for half-a-mile west of the 15½-mile position on the Yellowdine-Parker's Range Road. The most southerly turning point of the Nevoria jaspilite should be situated somewhere in this locality, but a thick mantle of soil covers the flat country here.

(3) The northern end of the belt of mica schists, etc., in which Harris' Find (Mundy Hills) is situated.

(4) The jaspilite band occurring at Parker's Range, Toomey's Hills and Magowan's Find, must curve round in an anticlinal nose somewhere about 1 to 2 miles east of the 20-mile peg on the Yellowdine-Parker's Range Road, and this flat soil covered area is worth prospecting in this locality.

(5) At about 1 mile south from the main Parker's Range Dam a track turns east from the main road, and after crossing some lake country a short distance in, follows a general easterly direction across heavily forested, flat, red sandy soil-covered country. At from 13 to 14 miles in along this track the south-easterly continuation of the Harris' Find country is encountered, and this belt is worthy of prospecting in this vicinity, and to the south-east.

(6) The country for 1 mile west and parallel to the Olga and Dulcie lines of leases, south of Parker's Range.

(7) About 9 miles west by south from Edward's Find and on the western side of a long cleared north-south road which comes into Strawberry Rocks is situated on Locations 460 and 462 (Lands Department Litho. 23/80). On soil and vegetation occurrence only, it appears that there are some rocks of the Greenstone Series here though none could be found outcropping.

(8) The narrow belt of greenstone running from Boddalin south-eastwards to Sandalwood Rock, a length of some 25 miles. This is a difficult belt to trace, and guides to its occurrence may be found in the following places:—

- (a) Near the S.W. corner of Location 492 (Lands Department Litho. 23/80).
- (b) Near the N.W. corner of Location 340 (Lands Department Litho. 23/80).
- (c) Near the S.W. corner of Location 334 (Lands Department Litho. 23/80).
- (d) Near the S.E. corner of Location 498 (Lands Department Litho. 23/80).
- (e) Near the S.E. corner of Location 516 (Lands Department Litho. 23/80).

(9) Locations 473 and 474 on Lands Department Litho. 23/80 consist largely of greenstone, and as this is a newly mapped patch of possible gold-bearing country it should be worth investigating.

Several other patches of greenstone not previously mapped have been located, but as these are of small extent only, they have not been included in the above list.

In the course of working a small mine, difficulty is sometimes experienced in obtaining sufficient filling for stopes. Cross-cutting from suitable positions in the softer oxidised rocks of the upper levels would, in these cases, serve the double purpose of providing stope filling and lateral exploration.

NOTES ON SOME MINING GROUPS IN THE YILGARN GOLDFIELD.

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

The following notes are a continuation of those already published in the Annual Progress Report of the Geological Survey for the year 1935, and represent a summary of the work done during the 1936 field season.

BURBIDGE GROUP.

The following G.M.L.'s, at the north end of the group, are to be considered:—G.M.L.'s Nos. 3731, 3732, 3733, 3734 and 3735.

At the time of inspection no work was being done on these leases. The only work, which had been done in the past, consisted of a few shallow holes, and an occasional costean in a greenstone belt crossing G.M.L.s. 3733 and 3734. As these leases lie to the north of the Great Victoria main workings, it was hoped that they might contain a continuation of the Great Victoria lode formation. Although it was not possible to trace this for more than a few chains beyond the western end of the open-cut, it is most probable that it continues in a north-westerly direction. This being so it would lie to the west of the leases under consideration. Outcrops, on the leases being discussed, are scarce, but it is likely that they are underlain to a great extent by a grey micaceous schist, which in the neighbourhood of the Great Victoria workings contains no values. There is a belt of biotite-hornblende gneiss, striking N. 35° W., and with an approximate width of 11 chains, in the central portion of the leases. There is no suggestion of the structural conditions in the neighbourhood of the Great Victoria workings existing anywhere on the leases under consideration.

BANKER GROUP.

Locality.—3¼ miles, E. 12° N. from Burbidge townsite.

There are three G.M.L.s. in this group, all three controlled by the Yilgarn Gold Mine, N.L. Because of labour troubles, and subsequent trouble with water and plant, it was not possible to inspect the main workings on Banker, G.M.L. 3404, during the past field season. It is hoped, however, that before the final report is written, it will be possible to make an examination of these workings. Work of a prospecting nature was being carried out in three other places at the time of inspection.

While the major portion of the area is underlain by greenstones, varying from fine to coarse-grained, there are, on the western side, conspicuous outcrops of a massive, fine-grained, jointed quartzite. The most conspicuous outcrop of these quartzites forms a ridge, rising in parts from 100 to 150 feet above the general level of the country, and extending for approximately half a mile in the north-west corner of

the area. At either end the ridge dies away and passes into soil covered flats. Strikes vary from N 10° W.-N. 70° W., and dips from 70° N.E. to vertical.

TOOMEY'S HILLS GROUP.

Locality.—4¼ miles north-eastward from Parker's Range Residence Areas.

There are no G.M.L.s. in existence in this group, and very little prospecting work was being done at the time of inspection. Old workings, now abandoned, were not inspected.

The area is almost entirely greenstone. There is, however, a band of quartzite, varying from 6-16 chains in width, towards the south-west corner. Strikes vary from N.50°W.-N.70°W., while the dip is consistently to the north-east at angles varying from medium to high. It is probable that many of the greenstones are metamorphosed lavas. Most of the work in the past has been done on three leases, G.M.L.s. 520, 289, 237. On G.M.L. 520 two parallel quartz reefs have apparently been worked, while on G.M.L.s. 289 and 237 it appears that there was only one reef. The strike and dip of these reefs are parallel to the strike and dip of the country.

Magowan's Find.—This find was made towards the end of 1936 by Mr. A. Magowan. Although it is not within the Toomey's Hills group area this will be a convenient place to discuss it. The find is located about 4 miles east-south-east from Blue Hill, old G.M.L. 520, at Toomey's Hill, and is approached by a track from the south-east corner of this group. At the time of inspection, although there were seven P.As. pegged, only one was being actively worked. The finder and his mate had done a certain amount of work on their P.A. Two grab samples collected by the writer for assay gave the following results:—

Y.523.—From a small heap of ore at the side of a shallow hole—gold, trace; silver, trace.

Y.524.—From the west face of the same shallow hole—gold, 10grs. per ton; silver, 13grs. per ton.

Both results are very low, but insufficient work has been done to judge the prospects in the immediate vicinity of the original find. Values were being obtained from a banded ferruginous quartzite, similar to those occurring in many places in the Yilgarn Goldfield. Outcrops are poor, laterite and soil covering most of the area. There appear to be at least six ferruginous quartzite bands in the neighbourhood of the original find, and possibly more. Scattered outcrops of ferruginous quartzite and fragments can be traced for just over a mile. Scattered fragments of greenstone were observed south of the present workings. The general strike is east-south-east, and the dip is probably steep, but this could not be observed with certainty.

It is believed that the ferruginous quartzites found at Magowan's Find are the continuation of those seen at Parker's Range, and the various groups south of there. Magowan's Find is therefore structurally similarly situated to the northern groups on the Parker's Range line (see report by H. A. Ellis, page 78). It is reasonable, therefore, to expect somewhat similar conditions with regard to gold deposition. Because of this the place seems a reasonable one in which to prospect, and the prospectors are advised:—

(1) To look for values in the banded quartzites. Values in these are likely to be generally low and erratic, but there may be richer patches.