

of glauconitic sandstone may occur interbedded with the shales. Small boulders of somewhat laterised ferruginous sandstone derived by weathering from glauconitic sandstone were observed in the northern portion of Loc. 370, east of the road which runs north towards One Tree Hill, and about the 300 feet horizon, and compacted material also derived by weathering from glauconitic sandstone was observed in a gutter on the same road at a much lower point some 500 or 600 feet north-west of Gingin Brook. Whether these exposures are *in situ* or have travelled a considerable distance from their source could not be determined.

Workings in the Glauconitic Sandstones.—The only place where the glauconitic sandstone has been quarried is on Loc. 103 in the lower greensand on the north-eastern slope of Molecap, on the site originally quarried for limestone and phosphatic nodules. The extent of the quarry and its position relative to the former trigonometrical station (now dismantled) on Molecap is shown on the accompanying plan and section. The southern end of the original quarry in the chalk is approximately 125 feet east-north-east of the old trig. site, that of the deeper cut in the greensand about 20 feet farther north. At this last point the greensand has been quarried to a depth of nearly 15 feet below the base of the chalk. The deepest end of a small cut from 10 to 19 feet in width, near the northern end and in the western half of the quarry, extends to a depth of about 16 feet below the base of the chalk. The main cut in the greensand is about 86 feet in length, the width ranging from about 14 feet at the northern and shallower end to a maximum of 35 feet close to the southern end.

Conclusions and Recommendations.—The geological sketch map accompanying this report covers barely half the area of the Cretaceous rocks definitely known to occur near Gingin. The average height of the area to the north of that shown on the map is considerably greater than the average of the area shown and the proportion occupied by the upper greensand must therefore be much greater, as is indicated by Mr. Glauret's map (Bull. 36, fig. 4). Any estimate of the quantity of glauconitic material available is at present impossible, but the sketch map and section indicate that it must be very great indeed running into millions of tons in the area shown. The actual quantity existing in the known areas of Cretaceous rocks is, without doubt, enormous.

The site chosen for working the deposit is favourably situated, being near a good road and less than a mile by road from the railway station.

The best method of testing the thickness and glauconitic content of the greensand beds would be to put down a vertical bore with a drill, such as the Calyx, that would give a suitable core, the core to be sent to the Geological Survey for determination of the rocks and the choice of representative samples for analysis. A bore put down from the top of Moorgun to a vertical depth of 400 feet would not only test the glauconitic content at different horizons of both the upper and lower greensands and the vertical extent of the latter, but would also show whether other bands of glauconitic material are interbedded with the underlying shales.

The desirability of a survey to determine, so far as possible, the boundaries of the Cretaceous rocks,

together with a more detailed examination of the Gingin area, has already been mentioned.

2.—INGLISTON CONSOLS EXTENDED AND FENIAN GOLD MINES, MEEKATHARRA.

(F. G. Forman, B.Sc.)

These two properties at present held and worked by the Ingliston Extended Gold Mining Syndicate are situated about one and a half miles south-east of Meekatharra township on the southern part of the main portion of Paddy's Flat.

A detailed description of the geology and ore deposits of Meekatharra is given by E. de C. Clarke in G.S.W.A., Bulletin 68. This includes a description of the Ingliston Consols Extended and Fenian workings (included with the Marmont as the "Consols Group") as far as they had been developed at the time of his survey in 1915. The present examination of the two mines was confined to the workings developed since that date, together with such re-examination of the old workings of these and other mines as was necessary to a clear understanding of the geological features at present exposed.

At the time of the survey in 1915, the deepest development in the Fenian workings was at the No. 9 level (850 feet) and in the Ingliston Consols Extended workings at the No. 6 level (746 feet). Since that date development on the Fenian has extended to the No. 11 level (1150 feet) and on the Ingliston Consols Extended to the No. 12 level (1365 feet). Of these later workings the Nos. 7 and 8 levels of the Ingliston Consols Extended were of necessity excluded from examination owing to inaccessibility of the drives and stopes.

Bulletin 68 contains a detailed description of the petrology of the rock types encountered in the district, and also of the distribution of the rocks as exposed in the mine workings.

During the present examination no fresh evidence was obtained which would serve to change the general ideas expressed in Bulletin 68. A detailed description of the rocks and of their mode of origin is therefore considered unnecessary in this report.

The writer wishes to acknowledge his indebtedness for information set out in Bulletin 68 and to the staff and employees of the Ingliston Consols Extended Gold Mining Syndicate, all with whom he came in contact supplying much valuable information which would otherwise have been extremely difficult to obtain.

General Geology.

The oldest rocks in the vicinity of the workings are a complex of greenstones of Pre Cambrian age, which may be subdivided into a number of distinct types, some of which have a doleritic and others a peridotitic origin.

Rocks of Doleritic Origin.

These are represented chiefly by the "flecked schists" which are green or grey-green highly sheared rocks containing duller chloritic patches which give the rocks a flecked appearance. The flecked schists are the chief wall rocks of the lode above the Fenian No. 4 level (326 feet) and the Ingliston Consols No. 5 level (621 feet).

Chloritic slates, which enter the Ingliston Consols Extended shaft below the No. 8 level plat, and are found as a narrow band in the flecked schists at the lower levels, are probably also of doleritic origin, being presumably highly altered derivatives of the original dolerite in a zone of more intense shearing. They are grey-green imperfectly fissile rocks with a blocky fracture.

Fuchsite-quartz carbonate rocks, little sheared, and usually having a bright green colour due to the presence of the green chromium bearing mica, fuchsite, are also thought to have a doleritic origin. These rocks are usually found in close association with the porphyry dyke of the lode channel and are important because of their possible influence on the ore body in certain sections of the mines. See below.

Rocks of Peridotitic Origin.

These rocks are represented by a little sheared black carbonate rock which encloses the ore body below the Fenian No. 4 level (326 feet) and the Ingliston Consols Extended No. 5 level (625 feet). The rocks vary in appearance from place to place, the more highly sheared varieties being in some cases difficult to distinguish from the flecked schists.

Porphyry.

This is an albite quartz porphyry which varies in appearance from an extremely fine grained translucent white rock difficult in the hand specimen to distinguish from a bucky quartz or quartzite to a greenish or brownish green rock with distinct porphyritic texture. It is economically the most important rock in the mines because of its intimate association with the ore deposits.

The Main Lode Channel.

The main lode channel is a shear zone in the old greenstone complex, striking N.N.E., and dipping east. In the upper part of the workings the average dip of the lode is about 68°, but in the lower workings the lode steepens considerably; between the No. 10 and No. 12 levels of the Ingliston Consols the average dip being 80°.

This shear zone has been the path followed by a porphyry dyke (Paddy's Flat Dyke of Bulletin 68) and subsequently also by the ore bearing solutions.

The Porphyry Dyke.

The dyke does not everywhere reach the surface. In the northern part of the Ingliston Consols Extended Lease and in the southern part of the Marmont Lease, which adjoins the Fenian Lease on the south, the porphyry is present as a continuous dyke from 15 to 60 feet wide. In the upper levels of the main workings of the Ingliston Consols Extended and Fenian mines, the porphyry is present only in disconnected peaks which, however, join together below the No. 6 level of the Ingliston Consols Extended to form a continuous body lying in and more or less filling the shear zone. The dyke has an average width of 40-50 feet at the Ingliston Consols Extended No. 12 level (1,365 feet).

Brecciation of Porphyry and Formation of Cross Fissures.

Subsequent to the injection and cooling of the porphyry renewed earth movement caused the development of cross fissures in the porphyry with,

in places, a complete brecciation of the rock. Movement on several of the larger cross fissures caused actual sideways displacement of the dyke. Viewed in the mine workings this displacement has been almost invariably towards the west when looking north, the strike of the fissures being towards the south-east and the dip north. However, large displacements of the dyke seen in the northern ends of the drives at the Nos. 10 and 11 levels of the Ingliston Consols Extended are exceptions, the movement in these cases being towards the east looking north, the dip of the planes along which the movement took place being towards the south.

The Ore Deposits.

Main Lode.—The gold bearing solutions which were responsible for the formation of the ore deposits presumably travelled up along the same path as the porphyry dyke, and after its brecciation and displacement by the cross fissures or faults. The main lode in the upper levels consists of a network of gold bearing quartz veins and veinlets in a matrix of sheared rock, impregnated with arsenopyrite. In the lower levels where the porphyry is present as a continuous dyke more or less filling the shear zone, the lode is found either on the hanging wall or on the footwall of the dyke, while the fissures formed by the brecciation and cross faulting of the dyke are filled with veins of auriferous quartz. The lode must, therefore, be considered as including not only the sheared rock of the main shear zone, but the brecciated and fissured porphyry of the dyke. This is recognised by the mine management; the porphyry and the wall rock where it is found to carry values all being crushed in the mill.

Spur Veins.—Spur veins, which are auriferous quartz veins occupying cross fissures in the porphyry, are of frequent occurrence throughout the mines, but do not usually extend far into the country rock. Where they do extend into the country it is usually in the hanging wall or east side of the porphyry. These spur veins are usually richer than the main lode, indeed, it is said that were it not for the presence of these cross veins or spurs in the lower levels, the lode could not be worked at a profit. The strongest and most important of these spurs is the Fenian South-east spur, which has in the past contributed considerably to the total tonnage obtained from that mine. The cross fault on which this spur lies has displaced the porphyry from 40 to 45 feet in the Fenian workings, and the quartz vein carrying the gold averages 60 to 70 feet in length. The downward continuation of this spur, which dips to the north, is now being worked in the Ingliston Consols Extended mine at the Nos. 11 and 12 levels, but here the spur appears to be neither so strong nor so extensive as in the upper levels of the Fenian. Clarke, in Bulletin 68 (page 159), notes the poorness of the main ore channel south of the Fenian South-east spur for which he suggests that diversion of the ascending solutions by this and the Marmont No. 2 spur is responsible. This, combined with the influence of the country rock in the southern part of the channel (see next section), is in the opinion of the present writer responsible for the poorness of that part of the ore body south of the main south-east spur in the Ingliston Consols Extended. (Fenian S.E. Spur of Bulletin 68.)

Influence of Country Rock on Productiveness of the Ore Body.

In Bulletin 68 (page 90) the statement is made: "The ore bodies of the Paddy's Flat Belt are most productive where they lie in the 'flecked schists' (sheared dolerites), are less productive when in the 'black schists' (sheared peridotitic rocks), and are patchy in the fuchsite rock."

The present writer agrees with this statement and suggests that the varying tenor of the ore in the three rock types is due to the relative ease with which the solutions, which introduced the gold, were able to circulate. The flecked schists are more highly sheared than the others, and would be, therefore, presumably more porous. On the other hand the fuchsite rocks are very little sheared and are frozen or dovetailed on to the porphyry with which they are usually in contact, so that there was relatively little opportunity for the circulation of solutions. The rich patches which do occur in the fuchsite rocks are associated with local areas of more intense shearing or with strong cross faults of which the Marmont No. 2 spur is an example.

Mine Development since Previous Survey.

In the main section of the workings the chief development has been at the Nos. 10 and 11 levels from the Fenian Shaft, and at the Nos. 7 to 12 levels from the Ingliston Consols Extended shaft. In addition to this there are shallow workings in the northern part of the Ingliston Consols Extended lease from two shafts, the "Whip Shaft" (vertical depth 170 feet) with levels at 120 feet and 170 feet below the surface; and the "New Shaft." The latter shaft was not examined as all the necessary information was available from an examination of the "Whip Shaft" workings. A shaft near the south boundary of the Ingliston United lease, now known as Candy's Shaft, and identical with shaft D on sheet 7, plate XIII. of Bulletin 68, has been sunk to a vertical depth of 214 feet, the last 30 feet with an easterly underlay, with levels at 52 feet, 116 feet, 154 feet, 183 feet, and 214 feet, below the brace.

Shallow Workings.

In the shallow northern workings stoping has been confined to the richer cross leaders in the porphyry which here averages 50 feet in width. No stoping has been done in the main north-south drive at the 120 feet and 170 feet levels of the Whip Shaft which follow the hanging wall or east side of the porphyry. Because of the entire absence of assay plans of these and other parts of the mine it is impossible to gauge accurately the value of the lode material.

Main Workings.

The relationship of the mine openings to the geological features of the lode is shown clearly on the accompanying plans* and will therefore not be described in detail.

It was originally planned to show by a distinctive marking the position of the lode in relation to the drives at the various levels, but when it was found that the profitable ore included not only the hanging wall and footwall shoots, but the porphyry itself, it was considered that the distribution of the porphyry as shown on the plans was a sufficient

* Plans not published.

ent indication of the lode. In the Fenian workings where it has been the practice to mine only the lode material on the walls of the porphyry and in the spur veins, the stopes do indicate the position of the richer shoots of ore. These ore shoots are indicated on the plans.

The main south-east spur vein last seen in the Fenian Mine at the No. 10 level (1,000 feet) has not cut out below that depth, but passes into the Ingliston Consols Extended Mine, between the No. 9 level (1,030 feet) and the No. 10 level (1,150 feet), and is now being worked at the Nos. 11 and 12 levels as a spur off the main south drives. Failure to cut the spur vein at the Ingliston Consols Extended No. 10 level is accounted for by the presence of a complicated system of faults which have displaced the lode channel and the porphyry. The probable positions of the displaced porphyry dyke and the spur vein are indicated approximately on the accompanying plan* of the Fenian No. 11, and the Ingliston Consols Extended No. 10 levels.

The spur vein 80 feet north of the crosscut at the Ingliston Consols Extended No. 11 level, and a similar vein opposite the crosscut at the No. 12 level, are considered to be one and the same ore body. Stopping on this spur was started at both levels, but was discontinued when the values cut out. The patchy distribution of the values is characteristic of both the main lode and the spurs, and further exploratory work at least on this spur is advisable, either by continuing the stope above the No. 12 level and using the broken rock as filling elsewhere, if of unprofitable grade, or by winzing on the spur from the No. 11 level.

The entire absence of assay plans and sections makes the question of development both laterally and at depth a difficult one to decide.

An examination of the Fenian workings shows that in the lower levels at least a considerable amount of prospecting driving has been done on the main lode channel south of the Fenian south-east spur, but that no stoping of any importance has been carried out from these drives. This suggests that the ore body was here found to be unpayable owing probably to the diversion of the gold bearing solutions by the spur, and to the unfavourable nature of the fuchsite carbonate rock enclosing the southern part of the ore channel at the lower levels. Although it cannot be definitely stated that a payable ore body does not exist in the southern continuation of the ore channel, past experience in the Fenian mine, as set out above, suggests the advisability of looking elsewhere for development.

The workings at the 120 feet and 170 feet levels from the Whip Shaft show that the main lode channel continues north of the present workings from the Main Shaft, but the absence of stoping except on the richer cross veins in the porphyry suggests that the main lode is here of low grade. Bulking the low grade ore with the richer cross veins, as is done elsewhere in the mine, may make the lode payable below the present development in this northern section.

The irregularity in longitudinal section of the northern limits of the stoping at the various levels from the Ingliston Consols Extended shaft suggest

that other causes than the falling off in gold values were responsible. This idea is confirmed by the present management who state that stoping limits were determined by the increase in size of the porphyry dyke which increased the cost of mining by the hand drilling methods earlier in use to such an extent as to make further development unprofitable. With the modern machine drills now in use development to the north would seem to have a reasonable chance of success.

The increasing width of the porphyry dyke with depth in the lower levels is accompanied by a falling off in the gold values. This may be due to the same amount of gold which filled the ore channel where the dyke was narrow being distributed over a much greater area where the dyke is wide; or to a less extensive fracturing of the porphyry owing to its greater width, and therefore greater resistance to pressure, reducing the available space for the deposition of gold from the solutions.

There is no available evidence to indicate the behaviour of the porphyry dyke at depth below the present bottom level, No. 12 (1,365 feet). Exploratory boring with a diamond drill below the No. 12 level would indicate the width of the dyke and the existence of the ore channel at lower levels. Such boring, however, should not be relied on to indicate the presence or absence of payable ore, because of the characteristically patchy nature of the lode and the chance of the bore holes penetrating poor zones.

Possible Extension of Ingliston Extended East Lode. (Mud Lode.)

Exploratory diamond drill boring eastward from the end of the long east crosscut at the No. 9 level from the Fenian shaft, has explored the country to the east of the Main Lode channel for a distance of approximately 1,000 feet. Records of this boring have been lost so that no definite information is available. However, it seems likely that had any lode material been cut in the bores, some knowledge of it would be in existence to-day, even if only in the form of rumours which are common with most matters geological at Meekatharra. The complete absence of legends about this boring seems to indicate that no lode channel was cut in the bores. The east lode, therefore, if it extends southwards at all, would seem not to reach as far as the southern part of the Consols Group. No evidence other than that set out on pages 149 and 164 of Bulletin 68 is available which would help to decide this question.

Conclusions.

From the present investigations the following conclusions have been reached:—

1. There is an intimate association of the lode channel and the Paddy's Flat porphyry dyke, such that the dyke and the ore body may be considered as one.
2. The dyke is deep seated in origin and there is no likelihood of its "cutting out" within the limits of economic mining.

3. Lateral development at the southern end of the ore channel is not likely to reveal payable gold values because,

- (a) its great width (90 feet in the east crosscut of the Fenian No. 9 level) has enabled the dyke to resist the forces which further north have caused a fracturing and brecciation of the rock. Consequently, there was relatively little chance for the circulation of gold bearing solutions within the dyke such as has occurred in the fractured and brecciated zones,
- (b) circulation of gold bearing solutions has been retarded in the southern part of the ore channel by the diversion along the Fenian South-east Spur,
- (c) the encasing rock of the ore channel in its southern extreme is mainly fuchsite quartz carbonate rock, little sheared, which because of its relative freedom from shearing and its close contact with the porphyry dyke has further retarded the circulation of gold bearing solutions.

4. Although the absence of assay plans and sections makes a definite decision impossible it seems likely that the values have not cut out at the northern ends of the Ingliston Consols Extended drives, but that further northerly development was prevented by the difficulty of mining the porphyry dyke by hand labour.

5. The Fenian South-east Spur passes into the Ingliston Consols Extended lease between the No. 9 and No. 10 levels. It is identical with the main spur at present being worked at the Ingliston Consols Extended No. 11 level and No. 12 level, and in a winze below the No. 12 level.

6. Failure to find the main spur at the Ingliston Consols Extended No. 10 level is due to the displacement of the lode by faulting. The probable position of the displaced lode is indicated on the accompanying plan.*

7. The spur vein 80 feet north of the crosscut at the Ingliston Consols Extended No. 11 level, and a similar vein opposite the crosscut at the No. 12 level are probably one and the same ore body. If the present dips observed on this spur and the more southerly main spur are maintained, the two should cut at a depth of approximately 200 feet below the present No. 12 level. Enrichment at, and for some distance above and below their junction can be expected.

8. There is no evidence available by which to make a definite prediction of the width of the porphyry dyke below the No. 12 level. Such dykes are characteristically irregular in section and the present average width of 50 feet at the No. 12 level may represent only a bulge.

9. Exploratory diamond drilling eastwards from the east crosscut at the Fenian No. 9 level indicates that, if the Ingliston Extended east lode does extend southward of its present known limits (no further evidence than that set out on pages 149 and 164 of Bulletin 68 is available on this point), it does not reach as far as the east side of the Fenian lease.

* Plan not published.

Recommendations.

1. Lateral development northwards, particularly from the upper levels of the Ingliston Consols Extended mine, where the northern faces of the drives and stopes are said to have been in ore of fair grade.

2. Exploratory driving on the footwall side of the porphyry at the No. 10 level north of the crosscut. The geological plan shows that the footwall of the porphyry has not been cut anywhere in the north drive.

3. Southwards extension of the Ingliston Consols Extended No. 11 south drive to pass under the winze sunk from the Fenian No. 11 level in which good gold values are said to have been obtained.

4. Continuation of the drive on the hanging wall side of the porphyry south of the crosscut at the Ingliston Consols Extended No. 12 level.

5. Continuation of the north drive at the No. 12 level where values should at least equal those obtained in the north drive at the No. 11 level.

6. Exploratory boring with a diamond drill below the No. 12 level in order to determine the width of the dyke at greater depth.

7. Exploration by actual mining operations below the No. 12 level to determine the tenor of the lode at greater depth. Because of the characteristically patchy nature of the ore body, diamond drilling cannot be relied on to determine the presence or absence of gold values.

3.—LADY CENTRAL GOLD MINE, MEEKA-THARRA.

(F. G. Forman, B.Sc.)

Whilst engaged in an examination of the Ingliston Consols Extended and Fenian Gold Mines, the writer was told of recent developments on the Lady Central Lease, where it was said that at the 210 feet level from the New Shaft—supposed to be on the Ingliston Extended East Lode—the drive, which was in a northerly direction from the shaft, had cut basaltic dolerite in the face. It was known previously that somewhere in this vicinity the East Lode was cut off by a later basaltic dolerite dyke. It seemed, therefore, that the New Shaft workings were on the southern side of the dolerite, and consequently that the east lode extended further south than was previously known. Definite evidence of the presence of the Ingliston Extended East Lode on the south side of the dolerite would open up the question of its possible extension as far south as the Ingliston Consols Extended leases.

New Shaft Workings.

The New Shaft is situated about sixty feet south of the southern end of the old Ingliston Extended open cut on the East Lode. Short northerly drives have been put out from the shaft at the 100 feet and 210 feet levels.

The No. 1 level (100 feet) extends for about 62 feet north of the shaft in brown weathered schist with flecks and patches of fuchsite. The quartz

leader in which the gold values occur, lies in and strikes parallel with the schist and has an average width of about two feet and dips east at about 80°.

The No. 2 level (210 feet) extends north of the shaft about 100 feet, the country rock being a weathered black schist similar in appearance to the wall rock of the East Lode in the adjoining Ingliston Alberts Lease. The gold values occur in a quartz leader averaging about 1ft. 6in. in width with a dip of 75° to 80° to the west. The strike of the leader is parallel to the enclosing schists. Near the face the black schist becomes much harder than elsewhere in the drive. It was the increased hardness and the fine grained black appearance of the rock which lead the leaseholder, Mr. B. Rinaldi, to believe that he had cut the basaltic dolerite dyke.

Conclusions.

The drive at the 210 feet level of the New Shaft is entirely in black schist, probably an altered peridotite. The hardness of the schist in the face of the drive is due simply to its being less weathered than the schist elsewhere in the drive, and will be found to be the normal condition of the rock at lower levels in the sulphide zone.

The position of the dolerite dyke is indicated on Sheet 5, Plate XIII. of Bulletin 68. The New Shaft is on the northern side of the dolerite and its position in relation thereto is shown on the accompanying plan.*

There is some doubt as to whether the quartz leaders exposed at the No. 1 and No. 2 levels are one and the same because of the discordancy of their dips. The brown schist at the No. 1 level might quite easily be a more weathered form of the black schist at the No. 2 level, but the fuchsite flecks and patches seen in the schist at the No. 1 level are absent from the schist at the No. 2 level. If the dips observed in the schist at the No. 1 level are maintained in depth, similar country should be found to the east side of the No. 2 level drive. This should be tested and the extension of the No. 1 level leader looked for by an east crosscut at the No. 2 level.

Western Workings.

The workings in the western part of the Lady Central lease lie in, and along, the walls of the Paddy's Flat porphyry dyke which averages about 35 feet in thickness. Stopping has been confined to rich quartz cross leaders in the porphyry. The leaders, which apparently lie in pre-gold fault fissures, run at various angles across the porphyry. They are said usually to carry gold throughout their length, but enrichment is found to take place where two leaders intersect and cross, particularly if the intersection takes place in schisted country on either side of the porphyry. The accompanying plans* show the relationship of the workings to the porphyry dyke, but the numerous auriferous cross leaders are not shown, as to do so would not serve any useful purpose and the work necessary to map them was, therefore, not justified. Several of the cross leaders, drives on which are already indicated on the mine plans, are shown and illustrate the mode of occurrence of the whole system.

* Plan not published.