

1.—THE GLAUCONITE DEPOSITS AT GINGIN, SOUTH-WEST DIVISION.

(F. R. Feldtmann.)

Introduction.—The chalky limestones at Gingin, in particular those capping One Tree and Molecap hills, were worked many years ago as a source of industrial lime. At a later date some attempt was made to utilise for agricultural purposes the phosphatic nodules which occur at several horizons in the Cretaceous rocks, but are particularly numerous in a zone occurring partly in the lower portion of the chalk, partly in the underlying greensand. A fair amount of the phosphatic material was quarried on the north-eastern slope of Molecap, but the deposit proved to be too narrow to be worked profitably. Recently, attention was drawn to the greensand beds as a source of the mineral glauconite ($\text{KMgFe}_2(\text{SiO}_3)_2 \cdot 3\text{H}_2\text{O}$), which is an important constituent of the greensand and which has been found to be an effective water softener.

The Gingin area was visited by earlier observers such as Gregory, Brown, and Göczel, but although it has been of considerable interest to geologists, not only on account of the economic possibilities of the rocks, but also because of the abundant fossil remains found in the chalk, but little detailed geological mapping has been attempted. In 1909 and 1910 the area was examined by Mr. L. Glauert in connection with the limestone deposits, and a brief description of the geological features was given by him in the Annual Report of the Survey for 1910 (pages 29 and 30), and also in Bulletin 36, the latter report being accompanied by a small map and section on a scale of a mile to the inch. At the time of Mr. Glauert's examination, the lower bed of glauconitic sandstone, usually known as the Lower Greensand, was not exposed in a sufficiently unweathered state, in the area examined by him, to be identified and separated from the underlying shales.

A brief description of the geology of the Gingin area, accompanied by a geological section, was given by Dr. E. S. Simpson in his description of the occurrence of the rare mineral gærksutite on Loc. 457, about $1\frac{3}{4}$ miles east of Gingin. (Mineralogical Magazine, May 1920, Vol. XIX, No. 89, pages 23-39.) The existence of the lower greensand was recognised by Simpson, who assigned to it a thickness of 100 feet.

The district was visited in 1930 by my colleague, Mr. F. G. Forman, in connection with an investigation by officers of the Department of Agriculture of the affection of stock by a disease known as "Gingin Rickets." Mr. Forman's description of the geology of the district on pages 8 and 9 of the Annual Progress Report of the Survey for 1930 covers a somewhat wider area than that described by Mr. Glauert.

Location and Topography.—The small farming town of Gingin is situated on the Midland Railway Company's line to Geraldton, about 50 miles by rail north of Perth. It lies on both sides of Gingin Brook which, north-east of the town, flows in a south-south-westerly direction but makes an abrupt U-shaped bend to the east where it is joined by Moonda Brook before flowing in a west-south-westerly direction through and west of the town.

The country around Gingin is strongly undulating, particularly north and south-east of the town. Several hills rise to a fair height above the level of Gingin Brook which, immediately west of the town, is about 270 feet above sea-level. The most prominent hills near the town are Moorgup, about $1\frac{1}{2}$ miles south-east of the railway station, and about 667 feet above sea-level; Molecap, rather more than half a mile south-east of the station and about 510 feet above sea-level; One Tree Hill, $1\frac{1}{4}$ miles north-north-west of the station and about 515 feet above sea-level; and Ginginup, $2\frac{1}{4}$ miles north of the station, and about 666 feet above sea-level. The positions of the first three hills are shown on the accompanying map. The highest hill in the neighbourhood of Gingin is Poison Hill or Udoinup, about four miles north-north-west of the railway station, and 724 feet above sea-level. This hill has a steep escarpment facing north and north-west.

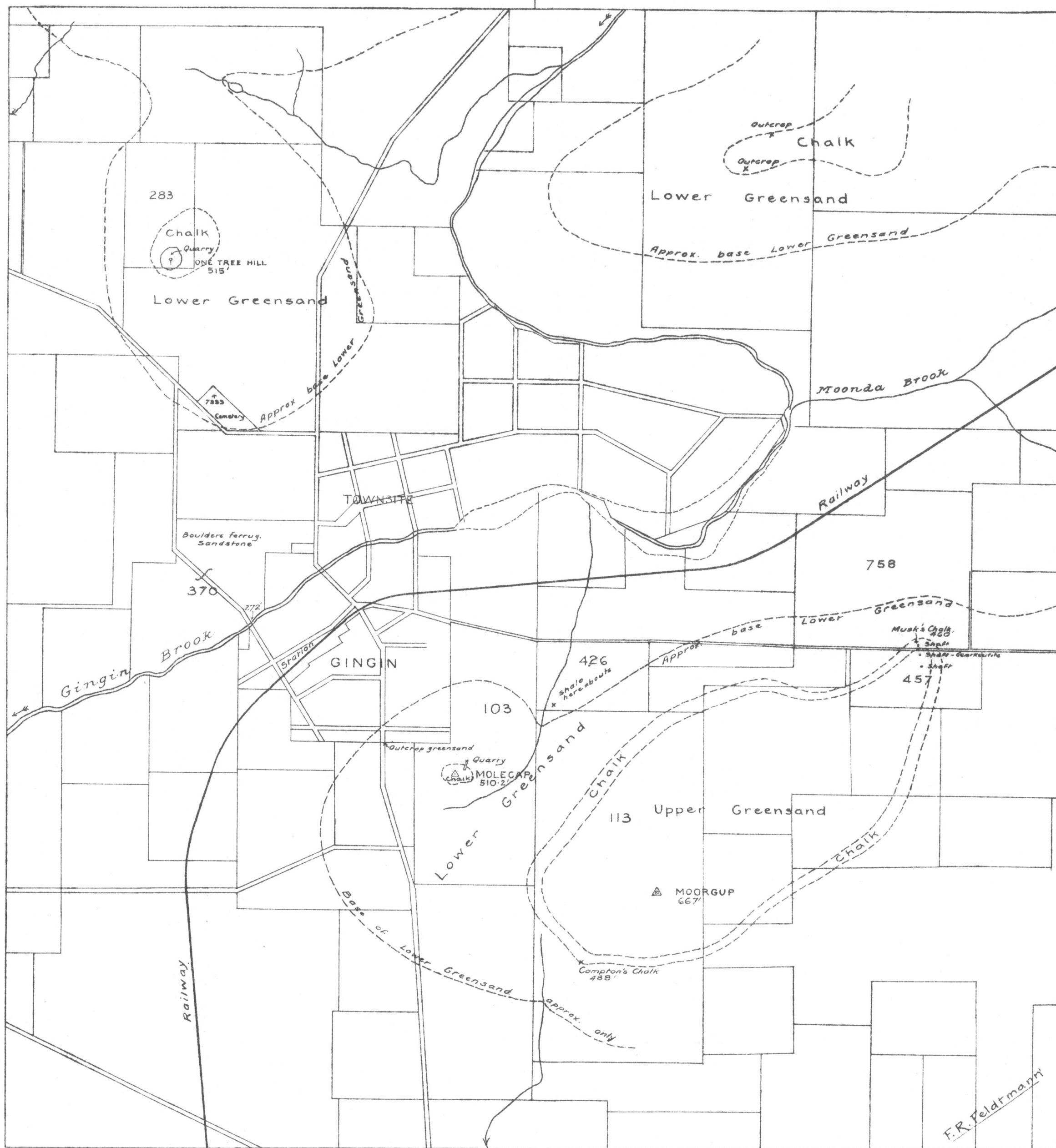
Geology.—Gingin lies in an area of Cretaceous rocks, the boundaries of which have not been determined. Cretaceous rocks including both chalk and ferruginous sandstone (weathered greensand) and containing bands with phosphatic nodules are known to occur at Dandaraga and Yatheroo, about 54 and 42 miles, respectively, north-north-west of Gingin. They have been traced from about eleven miles north of Dandaraga to about two miles south of Yatheroo, but whether the Dandaraga and Gingin rocks form parts of a continuous area is uncertain. In view of the economic possibilities of the Cretaceous rocks, a geological survey to determine their boundaries is desirable. On the west they appear to be bounded, in part at any rate, by the Darling Range scarp, which strikes about north-north-west and is considered, on topographical and other evidence, to be a fault scarp. In the Gingin area, the western boundary probably lies a short distance west of Poison Hill and One Tree Hill. East of Gingin the Cretaceous rocks probably extend to within a short distance of Mooliabeenie, where, I was informed orally by Dr. Simpson, small outliers of probably Cretaceous rocks overlie the granite. The positions of the northern and southern boundaries are quite unknown.

The general sequence of the Cretaceous rocks at Gingin, in descending order, appears to be:—

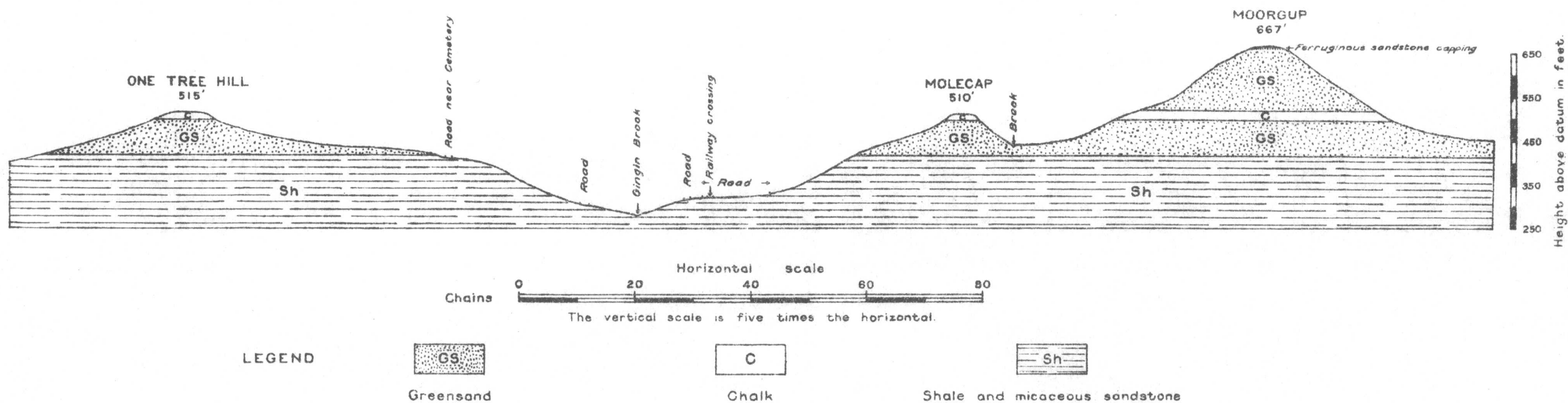
1. The Upper Greensand or glauconitic sandstone.
2. The chalk.
3. The Lower Greensand or glauconitic sandstone.
4. Shale and micaceous sandstone with little or no glauconite.

Accurate determination of the boundaries of the beds, their thickness, and the direction and degree of their dip is somewhat difficult, as over the greater part of the area they are obscured by soil, sand or ironstone gravel. In places their approximate position may be recognised by the character of the soil, the chalk, in particular, giving rise to a fine black soil easily distinguished from the red somewhat coarse and sandy soil derived from the greensand, but the shales are largely obscured by the accumulation of material derived in part from the overlying rocks.

GEOLOGICAL SKETCH MAP OF GINGIN.



SECTION THROUGH ONE TREE HILL, MOLECAP, AND MOORGUP, GINGIN.



The most satisfactory method of determining the boundaries, thickness and dip of the beds would be a contour survey, with the location of outcrops and quarry exposures, by means of the tachometer. A series of tachometer traverses in the vicinity of Gingin has been made by students of Geology of the University of Western Australia, and a copy of a contour map embodying the results of their work was obtained through the courtesy of the Department of Geology of the University. I am indebted to Professor E. de C. Clarke for permission to make use of the data afforded by this map, which has been of great assistance in fixing the approximate boundaries of the beds where no exposures were observed.

The profile shown on the geological section through One Tree Hill, Molecap, and Moorgup, is also based on the contours shown on this map. Additional work of this character is desirable.

The most convenient horizon for estimating the dip of the beds is the base of the chalk at its junction with the lower greensand. Good exposures of this junction are shown in the quarry on the north-eastern slope of Molecap and below the limekilns on the southern side of One Tree Hill. The mean of my observations at Molecap shows the base of the chalk to be 15.6 feet below the top of the hill, the height of which is shown on the University map to be 510.2 feet above sea-level. The base of the chalk at Molecap is, therefore, approximately 495.6 feet above sea-level. At One Tree Hill, the base of the chalk below the limekilns was roughly estimated at about 18 feet below the top of the hill which is shown as 515 feet above sea-level on the University map. Allowing for slight errors owing to the inadequate means for accurate survey at my disposal, these observations show the chalk to be practically horizontal between these two points, nearly $1\frac{3}{4}$ miles apart. Of the other exposures of the chalk examined, one, a small outcrop, a few feet in length, on the south-western slope of Moorgup and usually known as "Compton's Chalk," is shown on the University map as 488 feet above sea-level; another, known as "Musk's Chalk," in a small open cut on Loc. 758 at a point $1\frac{3}{4}$ miles east of the railway station, and 90 feet north of the road to Mooliabeenie, is shown at about 460 feet above sea-level. Compton's Chalk occupies its present position owing to a landslide that is known to have taken place in recent years, and the configuration of the ground near Musk's Chalk suggests that its present position may also be due to a somewhat older landslide. Practically all the other exposures known occur at or about the 500 feet horizon. On the accompanying map and section the base of the chalk is, except at the two last places mentioned, assumed to be approximately horizontal and 496 feet above sea-level.

The original thickness of the upper greensand is unknown. At Moorgup, where it is exposed on the top and on the south-western slope of the hill, the thickness is approximately 150 feet (*vide* the geological section). At Ginginup it is probably about the same. The rock composing this bed may not be of similar composition throughout. Simpson (*op cit.* p. 30) mentions that some bands are distinctly shaly, one such being seen about 20 feet above the gearsutite horizon on Loc. 457, but from the exposures observed it appears probable

that by far the greater proportion of the bed consists of glauconitic sandstone similar to that quarried in the lower greensand. Bands containing phosphatic nodules occur near the base of the upper greensand.

The thickness of the chalk can be estimated approximately although the exact figure is uncertain and the thickness may vary slightly from place to place. Simpson's estimate is 15 to 20 feet. At Molecap nearly 12 feet of chalk is exposed at the southern end of the quarry, the top of the chalk at this point being nearly three feet below the top of the hill. At One Tree Hill approximately 17 feet is exposed in the quarry and below the limekilns. On both hills the chalk is covered by black soil averaging about one foot in thickness, and resulting from the weathering of the chalk, so the original thickness was probably slightly greater. Near Compton's Chalk, exposures of both the upper and the lower greensand and above and below the chalk, respectively, indicate that its thickness at this point cannot be much more than 20 feet, which is assumed to be its thickness on the section.

The main portion of the lower greensand is separated from the chalk in the Molecap quarry by a band, between $2\frac{1}{2}$ and 3 feet thick, of glauconitic sandstone containing numerous phosphatic nodules and a small proportion of chalk. The main bed of glauconitic sandstone is exposed in the quarry to a depth of 12 feet below the phosphatic band. Only about 3 feet of the rock underlying the chalk is exposed below the limekilns at One Tree Hill, and this is very similar in appearance to the phosphatic band at Molecap, consisting of somewhat weathered glauconitic sandstone with small fragments of chalk. It is, without doubt, underlain by glauconitic sandstone similar to that in the Molecap quarry.

Owing to the lack of exposures in the area examined the exact thickness of the lower greensand could not be determined. Simpson (*op. cit.* p. 26) estimates it at 100 feet, but it is probably not so great as this. On the main road running south from the town, a definite outcrop of the greensand is exposed above, and in a gutter on the east side of the road at a point about 170 feet south of the short cross road running east towards Molecap. This outcrop was estimated to be about 430 feet above sea-level or 66 feet below the base of the chalk. A somewhat doubtful exposure, that might be either massive or detrital, was observed a few feet lower down in the gutter. North-east of Molecap, an outcrop of the underlying shale occurs on Loc. 426 at a point a few feet below the 400 feet contour as shown on the University map. The lower greensand, therefore, is at least 66 feet and not more than 100 feet in thickness. On the section it is assumed to be about 80 feet. The determination of the true thickness of the lower greensand is of importance, as it will be understood, from examination of the geological section, that each additional foot in thickness means a proportionally greater increase in the quantity of glauconitic material.

Relatively, little is known of the beds underlying the lower greensand or the depth to which they extend. The few exposures known indicate them to be mainly shales and micaceous sandstones with little or no glauconite, but it is possible that there is some lateral variation in the beds and that bands

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. Glaucert'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).