1926.

WESTERN AUSTRALIA.

ANNUAL PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

FOR THE

YEAR 1925.

With Six Plates and One Figure.

PERTH:
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† 1140/26.

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FIGURE.

LIST OF PLATES.

ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY FOR THE YEAR 1925.

The range of activities of the Geological Survey during the year ending the 31st December, 1925, has been similar to that of recent years.

Having regard to the somewhat limited personnel, most of whom were occupied in work at headquarters, engaged in the preparation of reports, etc., very little field work became possible.

As has been the case in the past, a good deal of time has been taken up in answering inquiries for information relating to the geology and mineral resources of Western Australia, some of which has been imparted verbally to those making application in person, and some given in the form of correspondence and published reports and maps.

In addition to the normal work of the Survey a number of advisory reports have been made on matters arising out of the Mining, Mining Development, and Land Acts, the latter relating to the alienation of mineral-bearing lands.

Administrative, routine, and other important office duties left practically no time for active work in the field.

A good deal of my own time was taken up with the editorial and other duties connected with the publication of bulletins, comprising 448 pages of typescript, together with 42 figures and 31 maps. Geological reports lose a very large part of their value if not scientifically indexed, a work which naturally takes time.

The only field work it was possible for me to undertake during the year was a very brief visit, in company with the Government Mineralogist and Analyst, to Lake Brown, about 20 miles north of Burracoppin, in connection with an inquiry under the Mining Act relating to the occurrence of a deposit of alunite at Campion. A note relating to the occurrence of alunite in the bed of a salt lake or clay pan has already been given by Dr. Simpson.*

An article was prepared during the year on the Phosphate and Pyrites Deposits of Western Australia for presentation to and publication by the International Geological Congress, held in Spain during the month of May, 1926, in the volume relating to the world's resources in Phosphates and Pyrites.

THE STAFF.

The staff in 1888, the first year of its active existence, consisted solely of the Government Geologist, Mr. H. P. Woodward, whilst at the end of 1925, besides the Government Geologist, it numbered two field geologists, together with an acting petrologist and his assistant, in addition to one clerk and a messenger. There has been no change in the personnel of the staff during the year under review.

FIELD WORK.

The attached table shows the distribution of the field work during the year, together with the names of the officers so engaged and the districts in which they were employed:—

Table showing the distribution of Field Work during the year 1925.

Goldfield or Land Division.	F. R. Feldtmann.		A. G. D. Esson.	
	No. of days in the field.	Percentage of working days.	No. of days in the field.	Percentage of working days.
South-West Division	26	7·1	...	...
East Coolgardie Goldfield	50	13·7	...	...
Total ...	76	20·8	...	...

F. R. Feldtmann, Field Geologist.

The early portion of the year 1925 was largely taken up by Mr. Feldtmann with the examination of certain gypsum deposits and the preparation of reports and maps in connection therewith. The period between 22nd January and 6th February was spent in field work on the Gypsum Deposits of the Baandee neighbourhood; that between the 16th and 20th February on the Woolundra Deposits; and that between the 2nd and 6th March on the Gypsum Deposits in the vicinity of Cunderdin. Field work at Kalgoorlie occupied Mr. Feldtmann's time from the 2nd of November to the 22nd December. In all, 76 days were spent by this officer in the field during the year, particulars of which are set out in the table above.

A. G. D. Esson, Field Geologist.

No time was devoted by Mr. Esson to work in the field, the whole of his time having been occupied in work at head-quarters in connection with the preparation of reports, maps, etc., of the previous year.

PRINCIPAL RESULTS OF THE YEAR'S FIELD OPERATIONS.

1.—SOME GYPSUM DEPOSITS OF THE AVON DISTRICT, SOUTH-WEST DIVISION.

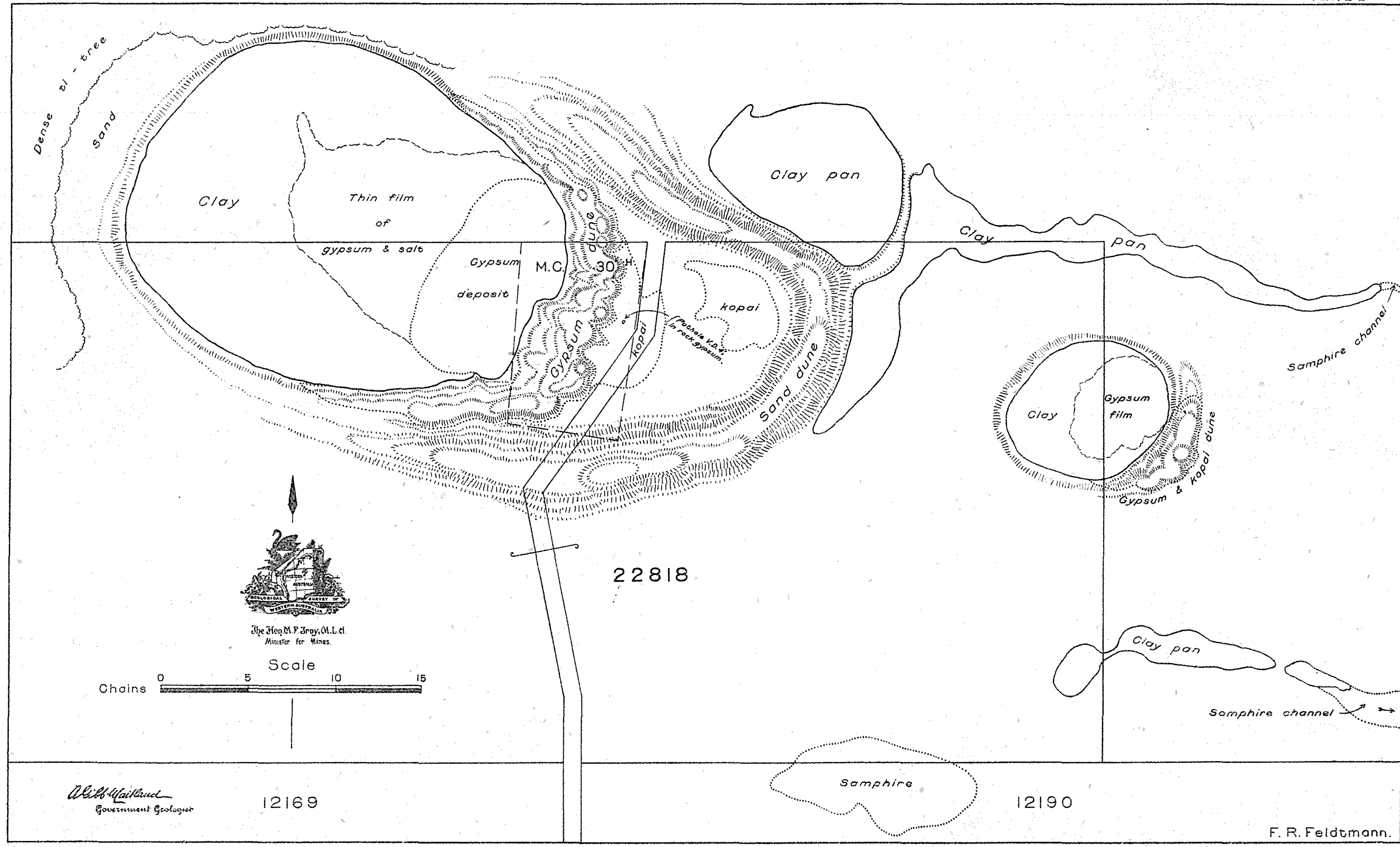
(F. R. Feldtmann.)

GENERAL STATEMENT.

A number of gypsum deposits were examined during the year, in connection with applications for mineral claims. These included deposits at Baandee, North Baandee, Woolundra, and Cunderdin. Deposits

* Sedimentary alunite at Campion, E. S. Simpson, Appendix II., Annual Report of the Chemical Branch, Mines Department, for the year 1925, p. 18, Perth: By Authority, 1926.

MAP OF THE GYPSUM DEPOSITS, NORTH BAANDEE, SOUTH—WEST DIVISION.



FRED. WM. SIMPSON, Government Printer, Perth.

at Dukin,* on Lake Cowcowing, and at Hines Hill† were examined in previous years. All these localities are situated in the Avon District.

Most of the deposits examined, including those at North Baandee, Baandee, Hines Hill, and Woolundra occur along a very long and important lake system—mentioned on page 20 of the Annual Report for 1923—which includes Lakes Seabrook and Deborah, in the Yilgarn Goldfield and Lake Brown, west of No. 1 Rabbit-proof Fence. The Dukin deposit, as well as one at Koorda, is, as stated, on Lake Cowcowing, and that at Cunderdin is on a small isolated clay pan, a short distance south of a well-defined salt river, which runs west and joins Mortlock River.

West of Lake Brown the previously-mentioned lake system runs in a general southwesterly direction towards Burran Rock townsite, about eight miles NNE. of North Baandee. South of Burran Rock it is joined by another lake system, which comes in from the North. The combined system then runs in a general southsoutheasterly direction towards the Eastern Goldfields Railway. About two miles N. of the railway the system splits, the main branch running southwest to Baandee, the other to Hines Hill. South of the railway, the main branch runs approximately westsouthwest to south of Woolundra, thence turning westnorthwest for a short distance. Thence it runs in a general southwesterly direction—passing to the north of Mount Stirling—towards Avon River, which it joins about 10 miles E. of Mount Kokeby Siding, on the Great Southern Railway.

In the areas examined, the system consists for the most part of a great number of salt lakes or clay pans of greatly varying size and usually of eliptical shape, separated by low-lying areas of soil and, in places, sand dunes; narrow river-like channels connecting the clay pans in places; and samphire swamps.

Only a relatively small proportion of the clay pans contain gypsum in sufficient quantities to be workable. Still, fewer contain workable deposits of salt.

The gypsum deposits may be classified according to:—

1. Their mode of occurrence relative to the lakes or clay pans on which they occur, namely; whether (a) occupying small areas on a large lake, or (b) occupying the greater portion of a small clay pan. The deposits at Dukin are typical of the first group, most of the other deposits falling into the second group. Those at Baandee, however, are intermediate between the two.

2. The type of deposit, namely; whether (c) deposited from solution and situated on the lake bed, or (d) wind-blown and forming a dune on or close to the edge of the lake or clay pan. The second type is secondary, relative to the first type. In places both types occur on the one lake. The Woolundra (in part) and Cunderdin deposits are typical of (c). Fairly large typical dunes of seed gypsum occur at North Baandee and Hines Hill. At Dukin the dunes fringing the lake are mainly composed of the earthy form "kopai."

3. The form of the gypsum, namely, whether (e) deposited as a layer of uncompacted seed gypsum; (f) as a more or less compacted aggregate of coarser crystals; or (g) of large crystals of the arrowhead type or large masses formed of two or more imperfect crystals of that type occurring in a band of puggy clay. Most of the deposits fall into group (e). The Cunderdin deposit and part of a deposit on one of the Woolundra lakes belong to group (f). Group (g) is represented by a deposit at Dukin, about 24 chains W.N.W. of the southwest corner of Lot 125.‡ A fourth type, consisting of seed gypsum compacted to form a cellular rock, may also be mentioned. A deposit of this kind occurs at North Baandee.

The deposits on the larger lakes appear to be mainly confined to small bays on the southeastern sides of the lakes, and on the smaller lakes or clay pans a greater accumulation of gypsum on the southeastern portions is noticeable in many cases. Moreover, the gypsum and kopai dunes appear to be confined mainly, if not wholly, to the southeastern sides of the lakes. This accumulation of gypsum on the southeastern sides of the lakes is obviously due to the action of northwesterly winds in the dry season.

GYPSUM DEPOSITS ON AND NEAR MINERAL CLAIM 30H, NORTH BAANDEE.

GEOGRAPHY.

Location.—Baandee Siding§ is situated on the Eastern Goldfields Railway, approximately 149 miles E. of Perth. North Baandee townsite is situated, as the crow flies, approximately 15 miles W. of N. of Baandee Siding.

Mineral Claim 30^{H} is siuated near the middle of the northern portion of Loc. 22818 and 3¾ miles ENE. of North Baandee townsite. It is approximately 17½ miles, by road, north of Baandee siding, and about 14 miles, as the crow flies, south of Kwelkan townsite on the Dowerin-Merredin Railway. A track to Locs. 12190 and 12169,‖ south of and adjoining Loc. 22818, and thence to Loc. 22818, leaves the main Baandee-North Baandee road north of Loc. 12186, 3 miles SE. of North Baandee townsite.

Topography and vegetation.—Between Baandee and North Baandee, north of the York road, the country is undulating, the lake system being, except immediately north of the York road, from 2 to 6 miles east of the main road. The country consists of soil flats or valleys separated by low ridges on some of which granite outcrops, others being covered by sand. The track from the main road to Loc. 22818 is mainly over a high sand-plain. The drainage is in an easterly or southeasterly direction towards the lake system.

The vegetation is varied, but near Baandee much of the country has been cleared. Salmon and other gums occur on the better flats and valleys, but on some of the poorer soil on the slopes of the ridges white gums are prevalent. Small patches of cypress pine occur in a few places. The vegetation on the sand-plain on the track to Loc. 22818 is largely mallee with patches of ti-tree and spearwood, but a narrow salmon gum flat occurs on the southern portion of Loc. 22818. Dense ti-tree fringes the western side of the lake on the northern boundary of Loc. 22818. On the gypsum dune on M.C. 30^{H} are occasional salmon gums, cypress pine, sheoak, and quandong.

GEOLOGY.

The country rock of the district is granite, but outcrops are comparatively few. At Bocanning Soak, 2¾ miles N. of Baandee Siding and a few chains north of York Road, is a low bare ridge, trending

* Feldtmann, F. R., The gypsum deposits at Dukin, Avon District, South-West Division: W.A. Geol. Survey Ann. Rept., 1924, pp. 9–10, 1925. † Feldtmann, F. R., The gypsum deposits on Mineral Claims 27H and 28H, Hines Hill, Avon District, South-West Division: W.A. Geol. Survey Ann. Report. 1923, pp. 20–21, 1924. ‡ *op. cit*, p. 10. § *Vide* Lands and Surveys Department Lithograph 25/80. ‖ *Vide* Lands and Surveys Department Lithograph 34/80.

about northeast, composed of fairly coarse-grained biotite granite, more or less sheeted. A fairly well defined zone of sheeting from 100 to 120 feet wide, striking about N.28°E. and practically vertical, is noticeable immediately east of the highest point at the southwest end of the ridge. A few outcrops of granite were noted near the North Baandee road, one being a partly bare ridge about halfway between Baandee and North Bandee and a short distance south of Medway Tank. Other small outcrops occur on Loc. 12186, south of the track to Loc. 22818. Granite also outcrops on the northern portion of Loc. 12190, southeast of Loc. 22818, where it forms a low breakaway on the southwest edge of a small lake.

THE GYPSUM DEPOSITS.

As may be seen on the accompanying map, a number of small lakes or clay pans occur along the northern and eastern boundaries of Loc. 22818, including three on the northern boundary and two on the eastern. These, particularly the northern three, were probably originally joined to form one lake, but have been gradually separated by the formation, through wind action, of dunes of sand or sand and clay. In the case of the three northern lakes this is strongly suggested by their shape and relative position. The eastern portion of the easternmost clay pan is of river-like form and the line of the channel east of the clay pan is continued by a samphire swamp. The western end of the clay pan bends south along the edge of a large sand dune, 25 or more feet in height. This clay pan is separated from the second clay pan, which lies to the northwest, by a low bank of sand from about 30 to 80 feet in width. The sand dune, which is acutely crescent-shaped with the concave side facing west, forms the southwestern edge of the second clay pan and separates the two clay pans from a small depression on the concave side of the dune. A crescent-shaped dune of gypsum separates the third and most westerly and largest clay pan. This clay pan, the southeastern end of which is partly covered by the northwest portion of M.C. 30^H, forms an ellipse with the major axis striking in an east-southeasterly direction. The axes measure approximately 1,600 feet and 1,260 feet.

Of the two clay pans on the eastern boundary of the location, the more northerly is elliptical in shape with axes about 620 feet and 520 feet in length, the major axis striking ENE. The other clay pan is of the narrow river or creek-like type.

Two of the lakes are gypsum-bearing, namely: the main western lake on the northern boundary of the location, and the more northerly clay pan on the eastern boundary. The small depression between the sand and gypsum dunes east of the main lake may be regarded as an easterly extension of that lake after the sand dune had started to separate it from the two more easterly lakes.

On and east of the main lake, the gypsum occurs in four ways:—

(a) As a deposit of seed gypsum covering the extreme southeast portion of the lake bed;

(b) as the crescent-shaped dune, previously mentioned, of seed gypsum fringing the southeastern edge of the lake;

(c) as two small deposits of the earthy form, kopai, on the depression separating the gypsum and sand dunes; and

(d) as a deposit of rock gypsum underlying the more westerly of the kopai deposits.

(a.) The deposit on the lake bed ranged, where tested, from a film to 19 inches in thickness, averaging 3 or 4 inches. Most of the gypsum is moderately clean, but where the deposit is thick the upper portion is cleaner than the lower. The thickest portion was on the extreme eastern edge of the lake, where cut by the northern boundary of Loc. 22818. Here the deposit was composed of an upper layer of 6 inches of fairly clean gypsum followed by 13 inches of gypsum of a dirty grey colour due to the presence of a small proportion of clay. The whole was underlain by puggy grey clay. A sparse growth of samphire marked this portion of the lake, the rest being practically bare of vegetation. West of the gypsum deposit and occupying the centre of the lake was a small area marked by a very thin film of salt and gypsum, covering the clay of the lake bed. On those parts of the lake north, west, and south of this area, a trace of salt was visible on the surface of the clay.

(b.) The dune fringing the southeastern portion of the lake has a total length of about 2,300 feet with a maximum width of about 300 feet, and rises to a maximum height of about 18 feet above the floor of the lake. It is composed, so far as examined, of comparatively clean seed gypsum—the top four inches being practically pure—but owing to the growth of cypress pines, sheoaks, and smaller bushes, contains numerous rootlets, which, however, might be separated by a suitable washing plant. A trace of sand was visible in a few places on the surface of the dune, and a small amount appeared to be present in the dune itself, but probably not in sufficient quantity to materially affect the treatment of the gypsum.

Mineral Claim 30^H covers the southeastern and better portion of the dune.

A sample (Lab. No. 598/25) of typical gypsum from this dune was reported on by the Government Mineralogist and Analyst as follows:—

Rather coarse crystals of gypsum, slightly tinted:

	per cent.
Insoluble in acid	4·28
Acid soluble lime, CaO	0·94
Equal to calcite, $CaCO_3$ ...	1·68
Water soluble lime, CaO	30·36
Equal to gypsum, $CaSO_4 \cdot 2H_2O$	93·21
Salt, NaCl	traces.

Yields a good white plaster, slow setting (25 minutes) and with strong body. It is inferior to Lab. No. 597/25 (from the northern lake at Baandee) but of good commercial grade.

(c) The more westerly of the two small areas of kopai adjoins the eastern side of the gypsum dune, south of the north boundary of Loc. 22818. It has a length of about 550 feet and averages for the most part about 200 feet in width. The kopai, where tested, ranged from a film to about 14 inches in thickness. The eastern portion appeared to be mainly underlain by seed gypsum, part of the western portion by the rock gypsum.

The other kopai area occupies the eastern portion of the depression and adjoins the middle portion of the concave side of the sand dune. It has a length of about 440 feet and a maximum width of about 300 feet. It was tested in one place, near the northern end, where it consisted of about 18 inches of cream-coloured kopai, underlain by seed gypsum of a dirty buff colour.

(d) The deposit of rock gypsum was exposed in a small pothole 300 feet south of the north boundary of Loc. 22818, and between the eastern side of the gypsum dune and a surveyed road which runs through the location, being about 60 feet west of the western peg marking an angle of the road. The pothole exposed about four inches of kopai underlain by rock gypsum. The pothole was deepened by me to a total depth of four feet without reaching the bottom of the deposit. The deposit is composed of small gypsum crystals cemented together to form a somewhat porous but tough rock of biscuit colour. The extent of the deposit was not determined. It appeared to be fairly clean and pure, but owing to its toughness might be difficult to work.

The deposits on and east of the small elliptical clay pan on the eastern boundary of the location are not of any great size. They consist of a film of gypsum, too thin to be workable, on the eastern portion of the clay pan, and a small dune on the southeastern edge. The dune has a length of about 500 feet, and a maximum width of about 170 feet. It is composed in part of kopai, in part of dirty brown seed gypsum. The dune rises to a height of some 10 or 12 feet above the lake-bed, but probably only the top half, or less, consists of gypsum, the remainder consisting mainly of sand.

An examination of the lake country southeast of the area examined would doubtless reveal other workable deposits of gypsum. I was shown some moderately clean gypsum which was stated to have been obtained from a lake some miles southeast of those described. The deposit was said to be of some extent.

THE BAANDEE GYPSUM DEPOSITS.

Geography.

Location.—As stated in the preceding report, Baandee Siding is situated on the Eastern Goldfields Railway, 149 miles E. of Perth. Mineral Claim 31H, in connection with the application for which this area was examined, is situated 2¾ miles (3¼ miles by road) S.W. of the siding.

Topography.—The country in the immediate vicinity of Baandee, and for a considerable distance south, is much flatter than that north of York Road, which lies about 2½ miles north of the siding, and the only areas rising above the general level of the country are low ridges or banks of sand or soil. The siding and townsite lie within the lake area, what appears to be the main channel passing close to, and northwest of, the townsite. Here the lake system is more river-like in form and its general trend is southwesterly. About a quarter of a mile south of the railway, at a point 1½ miles west of the siding, the lake channel opens out to form a large elliptical clay pan or lake about 1¼ miles long by nearly a mile wide, the major axis lying north and south. This clay pan is enclosed on the north and west by low banks of soil or sand, and on the east and south by much higher and steeper banks of brownish-grey clay, sandy in places. At the extreme southern end a low narrow bank of sand separates the clay pan from a short winding river-like channel which runs into a second and larger lake. This second lake forms an ellipse, imperfect on the northwest side, the longer axis of which trends southwest. The lake measures approximately 2 miles in length by nearly a mile in width. Mineral Claim 31H is situated on the northeastern portion of this lake, the southeast corner being 27 chains northwest of the southwest corner of Loc. 10717.*

A second claim, 36H, was pegged to the south of M.C. 31H. An area on the eastern side of the northern lake and immediately west of Loc. 10716 was pegged by Joseph Saunders.

The Gypsum Deposits.

The northern lake.—The gypsum deposits on this lake appear, from the brief inspection made, to be confined to a narrow strip along the foot of the bank on the eastern edge, west of Loc. 10716. The gypsum, which is of the seed type, is largely obscured by a covering of sand or clay of varying thickness, but the line of the deposit may be traced by a series of small exposures, mostly only a few inches in extent, along a general line situated from 10 to 40 feet east of the lake edge and between it and the high bank. Owing to the covering, the width of the deposit was not determined. It was traced for a length of more than 2,000 feet.

The deposit had been tested in two trial holes, one situated about 700 feet north of the southwest corner of Loc. 10716, the other about 800 feet south of the northwest corner. A trench had also been dug between the two potholes and about 1,200 feet south of the north-west corner of Loc. 10716.

The material exposed in the northernmost pothole was as follows:—

0 to 7 inches	..	gypsum streaked with clay.
7 to 15 „	..	cleaner gypsum.
15 to 19 „	..	clayey gypsum.
19 to 25 „	..	gypsum with streaks of clay.
25 to — „	..	clay.

In the trench, at the western end, a layer of gypsum about an inch thick was exposed from a depth of 15 inches; at the eastern end, gypsum was exposed from a depth of 5 to 17 inches. The gypsum layer was overlain by clay with a little gypsum.

In the southern pothole the material exposed was:—

0 to 13 inches—gypsum streaked with thin layers of clay.

13 to 18 inches—fairly clean gypsum.

This was underlain by clay containing a little gypsum. The material contained a few rootlets to a depth of about 13 inches.

A sample (Lab. No. 597/25) of typical gypsum from this area was analysed by the Government Mineralogist and Analyst with the following results:—

Rather fine prismatic crystals of gypsum (seed gypsum), very white and clean looking:

	per cent.
Insoluble in acid	2·94
Acid soluble lime, CaO	0·40
Equal to Calcite, $CaCO_3$	·71
Water soluble lime, CaO	31·46
Equal to Gypsum, $CaSO_4 \cdot 2H_2O$ ...	96·59
Salt, NaCl	traces

Yields a rather slow setting (20 minutes) plaster, pure white in colour and of strong body. This is an excellent sample of gypsum for plaster making or other purposes.

The southern lake.—Unlike the northern lake, the surface of which is practically even, the southern lake consists of a series of comparatively small clay

* *Vide* Lands and Surveys Department Lithograph 25/80.

pans separated by slightly higher areas mostly covered by a sparse growth of samphire. A samphire swamp averaging about 750 feet in width fringes the southeastern edge of the lake, the southeastern portion of which consists largely of a channel-like clay pan.

On this lake the gypsum occurs:—

(a) As a long narrow dune fringing the southeastern side of the main clay pan and separating it from the samphire swamp;

(b) as low narrow banks on the surface of the northeastern portion of the lake;

(c) as a deposit on the bed of the clay pans; and

(d) in places as a deposit on the higher areas covered by samphire.

(a) The gypsum dune is of great length as compared with its width and height. It rises to a maximum height of about 6 feet but for a considerable part of its length it is little more than a low bank, and is very narrow at its northeastern end. It was traced for a distance of about 1½ miles. It passes close to the southeast peg of Loc. 9155 on the southern portion of the lake. At this point the dune is only a low bank but has a width of nearly 50 feet. The gypsum is very fine in grain and fairly clean except for numerous rootlets due to the presence of a fairly thick growth of ti-tree.

(b) The largest of the low gypsum banks runs diagonally through M.C. 31^H. It starts about 180 feet north of the northwest corner of the claim (as pegged) and runs in a southeasterly direction to a point about 500 feet NW. of the southeast corner. Thence it runs south, gradually turning southsouthwest. It was examined for a length of about 2,500 feet, but extends for some distance farther south. The width ranges from about 35 feet to 110 feet, averaging about 70 feet.

Several long trenches had been cut on this bank, including one, about 300 feet in length, along the top of the bank near the middle of M.C. 31^H and one, across the bank, from 135 feet to 235 feet west of the southeast corner of the claim. From this last trench two others ran at right angles. In this trench seed gypsum was exposed to a depth of 16 inches. The gypsum was underlain by puggy grey clay.

At a point on the middle of the bank about 480 feet SW. of the southeast corner of the claim the deposit consisted of about 14 inches of fairly clean gypsum underlain by 3 inches of thin layers of gypsum and what appeared to be salt, followed by fine, puggy red clay.

A sparse growth of samphire covered the gypsum bank.

A typical sample (Lab. No. 596/25) from the main trench west of the southeast corner was reported on by the Government Mineralogist and Analyst as follows:—

The sample consisted of rather coarse crystals of gypsum (seed gypsum), slightly tinted.

	per cent.
Insoluble in acid	0·31
Acid soluble lime, CaO	0·06
Equal to Calcite, $CaCO_3$ ...	0·11
Water soluble lime, CaO	32·42
Equal to Gypsum, $CaSO_4 \cdot 2H_2O$	99·53
Salt, NaCl	traces

Yields a slow setting plaster (25 minutes), white in colour but containing a number of minute black specks due to the presence of organic matter. This gypsum, however, could be used for plaster making.

Washing in a suitable plant would probably remove much of the organic matter which probably consists of samphire rootlets.

Another smaller bank runs southsouthwest from the edge of the lake at a point about 880 feet NNE. of the southeast corner of the claim, and extends to about 160 feet NE. of that corner. The bank also extends north for a short distance along the edge of the lake from the point where it joins the edge. This bank has a total length of about 900 feet, and averages about 30 feet in width, the southern portion being the narrower.

A pothole about 100 feet south of where the bank joins the lake edge showed about nine inches of gypsum, of which the upper portion was moderately clean, overlain by 2 inches of clay and underlain by 2 inches of clay with thin seams of gypsum, followed by reddish clay. Near the southern end of the bank, the deposit consists, at the top of the bank, of 18 inches of dirty gypsum.

(c) Two clay pans near M.C. 31^H were treated for gypsum. One runs south from the river-like channel connecting the two large lakes, and lies immediately west of the smaller gypsum bank, ending about 170 feet N. of the southeast corner of the claim. No gypsum was found on the eastern portion of the clay pan near the northern end of the gypsum bank, the lake bed here consisting of a thin layer of black mud underlain by red clay, but near the northeast peg of the claim the bed of the clay pan consisted of 1½ inches of clay overlying a layer, from 2 to 3 inches thick, of gypsum underlain by clay.

West of the larger gypsum bank is a larger clay pan, which was tested at a point about 30 feet W. of the bank, and about 350 feet S. of the south boundary of the claim. Here the lake bed consisted of about a quarter of an inch of cinnamon-brown clay followed by an inch of blackish-grey clay, below which was a band 4 inches thick, composed of alternate layers of fine gypsum and salt (?) underlain by reddish clay.

(d) As stated, a large part of the lake consists of irregular areas covered by a sparse growth of samphire and slightly higher than the clay pans. The southeast corner of the claim is situated on one of these areas. Here the lake bed consisted of an inch of black mud underlain by 9 inches of clean seed gypsum, about the size of rice grains, followed by bluish-grey clay.

Another samphire covered area separates the northern portion of the main gypsum bank from the more easterly clay pan, and occupies the northeastern half of M.C. 31^H. This area was tested at three points. About 100 feet W. of the northeast corner of the claim, the lake bed consisted of 2 inches of grey clay followed by 9 inches of fairly clean gypsum overlying grey clay. About the middle of that portion within the claim, the samphire area consisted of half an inch of black mud underlain by gypsum to a depth of several inches—the thickness not being determined. Immediately east of the northwest corner of the claim the bed consisted of a film of grey clay followed by 11 inches of fairly clean gypsum.

The deposits forming the low banks and the long dune should pay to work, unless the latter is found to contain sand in any quantity. No sand, however, was observed, but the vegetation on the dune might interfere to some extent with the working of this deposit. Possibly, portions of the samphire-covered areas might be worked, but the samphire would interfere to some extent with the removal of the overlaying clay, and where this consisted of black mud the gypsum might be found to contain organic matter. Such deposits as were found on the clay pans appeared to be unworkable.

The layer of black mud mentioned as covering the gypsum in places on the clay pans and samphire area is of interest. The layer is usually from half to three-quarters of an inch thick, and was nowhere observed to exceed an inch. When *in situ* it is jet black in colour and has a somewhat sulphurous odour, but on exposure it gradually loses moisture and becomes grey in colour.

A sample (Lab. No. 595/25) that had been kept for a few weeks and was of a grey colour when analysed, gave the following results:—

A fine-grained mixture of gypsum, salt, sand, clay, and finely-divided organic matter.

	per cent.
Gypsum, $CaSO_4 \cdot 2H_2O$	44·55
Magnesium suphlate, $MgSO_4 \cdot 7H_2O$ ...	1·70
Magnesium chloride, $MgCl_2 \cdot 6H_2O$ ...	5·59
Sodium chloride, NaCl	12·40
Free sulphur, S	·22
Carbon, C. 4·15, equal to humus ...	7·14
Insoluble in water	25·13
Moisture	3·87
	100·60

Salt.

Salt has been obtained from a small clay pan south of the railway and about half a mile west of Baandee siding. According to information supplied by Mr. Joseph Saunders, who worked the deposit, a total of 166 tons of crude salt with a gross value (including railway freights) of approximately £370 was forwarded to Messrs. Cumming, Smith, & Co., at West Guildford, during 1919 and 1920.

THE WOOLUNDRA GYPSUM DEPOSITS.

Geography.

Location.—Woolundra Siding* is situated on the Eastern Goldfields Railway 137¾ miles E. of Perth. Mineral Claim 32^H, in connection with which the area was examined, is 1¾ miles S. of the siding, in the northern portion of Loc. 17183, the northeast peg of the claim being 320 feet SW. of the northeast corner of the location.

Topography.—Viewed broadly, the country round Woolundra is undulating, the area northeast of the siding, namely that north of the railway between Woolundra and Doodlakine, being more markedly so than that to the south. Between Baandee and Woolundra the main lake system occupies a broad valley with, east of Woolundra siding, a fairly steep northern escarpment. Southwest of Woolundra the valley appears to be less defined. South of the valley the country rises again, but the rise is less marked.

Though occupying a fairly well defined valley, the lake system near Woolundra is irregular and ill-defined and consists of a number of small, more or less isolated, clay pans, it being difficult to determine the main drainage channel. From Woolundra the system appears to run approximately westnorthwest to a point about three quarters of a mile south of the 135 mile peg on the Eastern Goldfields Railway. Thence it turns in a southerly direction.

Geology.

The country rock of the district is granite, of fairly coarse grain where examined. Outcrops are not uncommon in places on the higher ground. A fairly prominent feature about a mile east of the siding is Badgetopping Rock, a small bare granite knoll on Lot 50 and at the top of the slope north of the lake valley. The nearest outcrop to the lake area seen was near the southwest corner of Lot 48 and about half a mile from the nearest lakes.

The soil resulting from the degradation of the granite appears to vary considerably, ranging from a good chocolate-coloured or dark-red loam to a gray sandy loam. In places on the lower ground, the soil occupying the areas between the lakes contains a large proportion of kopai, the earthy form of gypsum.

The Gypsum Deposits.

Four of the lakes near Woolundra contain, or contained, gypsum deposits of fair size. These lakes are: —a small more or less elliptical lake on the northern portion of Loc. 9136; a comparatively narrow lake, elongated in a north and south direction and west of the first lake, on the common boundary of Locs. 7554, 7659, 9136, and 12933—both these lakes are to the north of M.C. 32^H; a somewhat larger lake, more or less elliptical in shape, but elongated at its south west end, on the northern portion of Loc. 17183 and covered by M.C. 32^H; and a small elliptical lake, southeast of the last, on the boundary between Locs. 8723 and 10198. I was informed by the Ajax Plaster Company's representative at Woolundra that he had examined the lake country for a considerable distance south and west of the above-mentioned lakes, but had seen no other lakes containing gypsum deposits of any size.

The first two lakes contained deposits of seed gypsum, mainly on the eastern portions of the lakes. Both lakes are flanked, in places, by high banks on the eastern side. These banks consist mainly of fine clay and sand with some kopai, and contain, in places, layers of gypsum. An attempt was made to work a fairly thick layer on the eastern side of the more westerly lake, but the deposit was found to contain too much sand to be workable. Both these lakes are now practically worked out.

The lake on the boundary between Locs. 8723 and 10198 was being worked at the time of my visit. It is about 1,400 feet long by 1,100 feet wide. It contains a fair-sized deposit of gypsum on the bed of the lake, mainly on the southern portion. Although a fair proportion of seed gypsum is present, the gypsum of this lake is, as a whole, somewhat coarser than usual, and a band of particularly coarse gypsum, striking about northeast, was noticeable immediately north of the boundary between the two locations. This band extends to a depth of more than three feet in places and consists of a compacted mass of interlocking crystals of various sizes, many being more than an inch in length. The crystals are very imperfect.

The lake on Loc. 17183 covered by M.C. 32^H, is somewhat larger than the other three. It occupies most of that portion of Loc. 17183 between Locs. 9136 and 10307. In shape the lake approaches the enclosed elliptical type, the major axis of the ellipse striking between northeast and northnortheast. The ellipse would, if perfect, measure about 3,000 feet by 2,100 feet. It is, however, broken by a reentrant angle on the southern side, and the southwest end is

* *Vide* Lands and Surveys Department Lithograph 25/80.

elongated in a southerly direction, the lake bearing in outline a resemblance to a bearded aboriginal head, facing west. The elongation at the southwest end forms a narrow channel, which runs toward the northeastern edge of another lake, occupying the eastern portion of Loc. 18208, a low narrow bank separating the two lakes. The lake covered by M.C. 32H is mostly surrounded by low banks, somewhat broken on the western side. The concentration—due to wind action—of the gypsum in the southeastern portion of the lake, observed in the examination of other deposits and noticeable to some extent on the two northern lakes, is not marked on this lake, where the gypsum occurs as a fairly even layer on the middle and greater portion of the lake, the deposit being almost entirely surrounded by a deeper channel in which there is little or no gypsum, but in which salt, which crystallises out at a higher degree of concentration, is deposited. A comparatively thin and narrow layer of wind-blown gypsum, probably containing too much sand to be workable, occurs on the eastern and southern edges of the lake, and the bank, near the southeastern corner contains a fair amount of kopai in places.

The main gypsum deposits occupies an area of 57 acres. It consists for the most part of somewhat dirty gypsum of fine grain, mixed with a proportion of clay. The grain is fairly even and fine throughout, but, as a rule, the lower portion is slightly coarser than the upper. The gypsum is underlain by a puggy dark-grey clay, but in places a layer, about two inches thick, of dark clay containing numerous small fibrous rootlets of samphire separates the gypsum from the main body of the clay. In places a second layer of very impure gypsum, at a depth of about 16 inches from the surface, was noticed.

The main deposit ranges from 1½ to 10 inches in thickness, but is mostly from four to six inches. Twenty trial holes put down in various parts of the deposit gave a mean of 5.17 inches. This gives a total of 1,072,954 cubic feet and, after allowing a deduction of 30 per cent. for air spaces and impurities, a total of 47,900 tons for the deposit. A small portion at the bottom of the deposit is, however, usually left, and I was informed by the Ajax Plaster Company's representative that it was found that the gypsum from those lakes which they had worked out, after carting and washing, averaged out at one ton per cubic yard of the deposit (83lbs. to the cubic foot). On this average, the net product of the deposit, taking the above area and average depth, would be 34,575 tons. As stated, the gypsum contains a considerable proportion of clay and, in places, samphire rootlets, but should be easily cleaned at the very efficient washing plant erected by the Ajax Plaster Company, close to the eastern edge of the lake on Loc. 9136.

The absence of well-defined gypsum dunes in this area may be accounted for by the fact that, the country southeast of the gypsum lakes being open, the wind-blown gypsum is not concentrated in a restricted area to form dunes, but is spread over a relatively wide area.

THE GYPSUM DEPOSIT ON MINERAL CLAIM 33H, NEAR CUNDERDIN.

Geography.

Location.—Cunderdin townsite* is situated on the Eastern Goldfields Railway, 104 miles E. of Perth. Mineral Claim 33H is situated immediately north of the railway line, on Loc. 13052†, 4½ miles E. of the townsite and 1½ miles E. of No. 2 Rabbit-proof Fence. The datum peg of the claim is 5½ chains NW. of the southeast corner of Location 13052.

Topography.—The country for some distance north of the railway line is almost flat. The main drainage channel is in the form of a fairly well defined salt river, or comparatively narrow salt lake channel. East of Loc. 20630, which adjoins Loc. 13052 on the north, this channel comes from a northeasterly direction, but about 11 miles NE. of Loc. 20630 the trend is from the northwest. No evidence is, however, available to show with what lake system this channel is connected. In and west of Loc. 20630 the channel runs almost due west and eventually joins the east branch of Mortlock River about three miles NE. of Meckering.

South of the railway line the country is more undulating, and about 1¼ miles SW. of Cunderdin rises abruptly to form Cunderdin Hill, a prominent landmark, which, however, is more marked from the south than from the townsite.

Geology.

The main rock of the district is, without doubt, granite, but except at and near Cunderdin Hill, and along a low ridge running east from the hill, outcrops are infrequent, the rocks being almost entirely obscured by soil.

The hill itself is composed of granite, in part coarse-grained with felspars up to about 1½ inches in length, in part fine-grained with coarse pegmatitic veins. The coarse-grained facies appears to predominate. Owing to the steep slope, the hill is partly bare, particularly near the base on the northern and western sides. The strike of the hill is nearly northeast. The granite forming the hill is traversed by a remarkably parallel series of very fine-grained epidiorite dykes striking approximately northeast. Owing to their superior resistance to weathering, the dykes stand out slightly above the enclosing granite and form in places a series of terraces. The dykes range from a mere thread to about 12 feet in width, most being, roughly, between 3 and 6 feet in width. They appear to be nearly vertical. In some of the dykes are numerous fragments of granite that have been caught up during their intrusion. These fragments range from a fraction of an inch to more than 6 inches in length. Some of the dykes appear to be paler in colour, possibly due to their having assimilated portions of the granite.

The Gypsum Deposits.

Mineral Claim 33H is situated on a small isolated lake of the enclosed elliptical type. The lake forms a nearly perfect ellipse with the major axis striking approximately northnortheast. The axes measure about 1,030 feet by 800 feet. The gypsum deposit occupies the middle portion of the lake and covers an area, according to my survey, of exactly 7 acres. Its boundary is nearly parallel to that of the lake but is slightly straighter on the western side. The boundary of the deposit is somewhat ragged, particularly on the eastern side. The deposit is surrounded by a deeper channel, wider on the western than on the eastern side. There is a trace of gypsum in this channel, but salt predominates, particularly in the southwest portion.

* *Vide* Lands and Surveys Department Lithograph 26/80. † *Vide* Lands and Surveys Department Lithograph 26c/40, 1917 edition.

The gypsum deposit consists of slightly raised small rounded areas a few feet in diameter, surrounded by narrow depressions. Fairly coarse gypsum outcrops on the raised areas, but in the depressions the gypsum at the surface is of fine grain. A few small deeper depressions, which appear to consist of clay without gypsum, occur near the edge of the deposit, particularly at the northern end. These, however, are not of any extent.

The raised portions of the deposit have been better tested than the lower. About a dozen trial holes have been dug, including a cut several feet in length near the southeastern edge, but of these probably 10 are in the raised areas, where the gypsum ranges from about 7 to 18 inches in thickness, averaging, in the trial holes, 11.6 inches. The gypsum of the raised areas is all of comparatively coarse grain, but the lower half of the deposit is usually considerably coarser than the upper portion and consists of a compacted aggregate of interlocking crystals. The maximum length of the crystals, which are very imperfect, is about 2½ inches, and a large proportion are more than an inch in length.

In the lower areas the upper portion of the deposit consists of a layer of fine-grained gypsum crystals, of a pale reddish or yellowish colour owing to impurities, underlain by a layer of coarse gypsum similar to that of the raised areas. In the only hole in the lower areas examined, the upper layer of fine-grained gypsum was 4 inches in thickness and was underlain by 5 inches of coarse gypsum. The whole deposit is, as usual, underlain by puggy grey clay. A small proportion of red clay occupies the interstices between the crystals of the coarse-grained portion of the deposit.

Samphire rootlets do not appear to be so common as in many other gypsum deposits, but a little dead samphire, in addition to a few larger bushes, was noticed, particularly on the northern portion of the deposit.

As stated, the average depth of the gypsum of the raised areas is about 11.6 inches, that of the lower areas being probably about 9 inches. The raised portions appear to occupy the larger area, and, allowing for the few small clay areas near the edge of the deposit, the average depth of the deposit for the area of 7 acres is probably about 10.66 inches. This gives a total of 270,769 cubic feet and, at a rate—after allowing for air spaces and impurities—of 100 lbs. to the cubic foot, a total of 12,088 tons of gypsum for the deposit. Owing to the irregular surface of the bottom of the deposit and the fact that the crystals are so closely interlocked, it is difficult to estimate what proportion of the gypsum would have to be left.

The unusually coarse grain of the deposit is a disadvantage, necessitating a greater amount of crushing and probably the alteration of a plant designed to handle seed gypsum of normal size.

The Government Mineralogist and Analyst's report on a typical sample of the coarser gypsum is as follows:—

Lab. No. 599/25.

A compact mass of large ironstained gypsum crystals :

	per cent.	per cent.
Insoluble in acid		1·74
Acid soluble lime, CaO ...	1·10	
Equal to Calcite, $CaCO_3$		1·96
Water soluble lime, CaO ...	31·00	
Equal to Gypsum, $CaSO_4 \cdot 2H_2O$ ...		95·18
Salt, NaCl		traces

This sample was discoloured with ferruginous clay giving a pink-coloured powder on fine grinding. It yields a slow setting (35 minutes) plaster of good body but too cream-coloured to be of any commercial value except as a land dressing, for which purpose there is at present almost no demand. Washing the crystals with water would, however, probably remove a large proportion of the iron and improve the colour of the plaster.

2.—PROGRESS REPORT ON THE KALGOORLIE SURVEY.

(F. R. Feldtmann.)

Location of area examined.—During the year the mapping of the Kalgoorlie auriferous area on a scale of 100 feet to an inch was continued, the area in which operations were carried on being that covered by Sheet 22 of the 2-chain series of maps. This sheet covers an area south of Sheet 20 and east of Sheet 21 published with Geological Survey Bulletin 69. Among the old leases covered wholly or in part by this sheet are the Golden Point G.M.L 1028E, Kalgoorlie G.M.L 1026E, Golden Chain G.M.L. 1027E, Oratava G.M.L. 1029E, Brown Hill Consols North G.M.L. 860E, Brown Hill Consols G.M.L. 552E, and the Iron Hill G.M.L. 1007E. Among the more recent leases are the Marne G.M.L. 4630E, Lucelle G.M.L. 5375E, and G.M.L. 5247E, but much of the southern portion of the area has been held as machinery or tailings leases.

Topography.—The southern portion of the flat which lies to the south of Williamstown occupies the north-west corner of the sheet. East of the flat is a low saddle, on the northern boundary of the sheet, on which the Lucelle lease is situated. This saddle runs southsoutheast from Mount Ferrum and links it with the Brown Hill Consols hill. A small creek runs southwest from the saddle and crosses the west boundary of the sheet about 400 feet south of the old Golden Point No. 4 Shaft. This creek drains a fairly extensive area.

The most prominent feature covered by the sheet is the Brown Hill Consols hill or ridge, which occupies a large part of the middle and southern portions of the sheet and was covered by parts of the Brown Hill Consols mine and the Iron Hill, Golden Chain, and Oratava leases. This ridge, which has a southwesterly trend, rises to a height of about 55 feet above the Leucelle saddle and about 80 feet above the point where the creek crosses the Brown Hill Railway.

Geology.—A short distance south of Mount Ferrum the eastern portion of the great Younger Greenstone dyke form a comparatively short, broad tongue, the exact dimensions of which are difficult to determine. The western boundary of this tongue runs northwest into Williamstown, but exactly how far cannot at present be determined. Boring in this locality will, however, throw some light on this point. West of the tongue the eastern boundary of the dyke runs slightly east of south, gradually bending till nearly due south. It appears to cut the northwest boundary of the Marne G.M.L. 4630E about 200 feet NE. of the west corner. It continues south through former G.M.L. 4259E and, so far as can be determined, crosses the Brown Hill Railway a short distance northwest of the south corner of G.M.L. 4259E, close to where the previously mentioned creek crosses the railway. The eastern boundary of the dyke is thus for the most part situated close to the western boundary of Sheet 22, the area covered by the sheet being almost wholly in the Older Greenstones.

A noticeable feature in this area is that whereas the Older Greenstones have been intensely sheared and have been completely chloritised and carbonated, being mainly represented by chlorite-carbonate schists, the Younger Greenstones are massive and have undergone practically no vein alteration and are represented by quartz dolerite epidiorite. The shearing of the older rocks is particularly noticeable near the junction. Both rocks are almost entirely obscured by superficial deposits—by soil to a depth of fully 5 feet, in places, on the flat, and by a deposit of dense laterite on the Brown Hill Consols ridge. Completely oxidised rock outcrops in places on the northwest side of the ridge, but on the south-east side the rock is largely obscured and that portion of the ridge southwest of the Brown Hill Railway is now covered by tailings.

A long albite porphyrite dyke runs diagonally southeast across the sheet. It is most noticeable in the southeast portion of the Marne G.M.L. 4630^E, where it is from about 20 feet to 100 feet south-west of the northeast boundary. The northwestern end of the dyke is obscured by the soil of the flat, and in general the dyke can only be traced by close examination. The southeastern portion is obscured by detrital material on the north-west slope of the Brown Hill Consols ridge. This dyke is practically on the line, extended southeast, of the large Williamstown dyke. It was partly indicated by a small "felsite" dyke on Mr. Campbell's map, but was omitted from Mr. Gibson's map. Fragments of albite porphyrite, apparently from another dyke west of the first, are noticeable on the dumps of three shafts on the northwest slope of the ridge, close to the southeast boundary of G.M.L. 4630^E, but the exact position of this dyke cannot be determined without an examination of these shafts, which are at present inaccessible. Fragments resembling weathered albite porphyrite were also observed on the dumps of shallow shafts close to the junction of the Older and Younger Greenstones. The material was, however, too weathered for determination and may be only decomposed and bleached quartz dolerite epidiorite.

Lodes and quartz veins.—Four lodes are shown on the southern portion of Sheet 20 of Plate XIII., Bulletin 69. The westernmost is the southerly continuation of a long line of shearing, striking nearly north and south and with unusually shallow dip, which from the Bulong Road to south of Mount Ferrum is situated along or close to the junction of the Older and Younger Greenstones. The exact position of the southern extension of this line, which south of Mount Ferrum is entirely in the Older fine-grained greenstones, is uncertain, and the line could not be definitely traced in the area covered by Sheet 22, but probably runs close to the south corner of former G.M.L. 4550^E.

Two lodes, east of the above, were worked by Sassella Bros. in the former Williamstown G.M.L. 4499^E, and have been recently worked by Hansen and Lynch in the Leucelle G.M.L. 5375^E, which covers the northern portion of G.M.L. 4499^E. These lodes appear to be very nearly on the southerly continuation of the Hidden Secret lodes, but are in the fine-grained greenstone, whereas the Hidden Secret lodes are in dolerite greenstone or its bleached equivalent. Good patches have been obtained from these lodes, but most of the ore obtained by Sassella Bros. was of low grade. What appear to be the southerly extensions of the lodes were observed a few feet southeast of the southeastern boundary of the Leucelle and from about 110 to 120 feet and 150 to 190 feet, respectively, east of an old shaft with a high dump, from which some prospecting is said to have been done by one of the Sassellas. The occurrences noted at these points were two parallel zones of intense shearing, which, apparently, had not been tested. The more westerly lode or shear zone is about 8 feet wide at this point, the other about 30 feet. They strike towards the lodes worked by Sassella Bros. Southeast of the points mentioned these shear zones are obscured by the detritus from the Brown Hill Consols ridge, but should pass close to the tunnel on the northeast end of the ridge.

The fourth line shown on Sheet 20 is that of the Mt. Ferrum Consols West lode. It appears to be converging, going south, towards Sassella Bros.' lodes, but could not be definitely traced south of Sheet 20. A quartz reef observed in a pothole about 130 feet southeast of the more easterly of the two shear zones previously mentioned is, however, approximately on the strike of this lode.

The old Brown Hill Consols lode is situated in the northeast corner of Sheet 22 about 500 feet ENE. of the mouth of the previously mentioned tunnel. A fair amount of work, including open-cutting, has been done on this lode, which is about 3 feet wide. It does not, however, appear to have been followed over any great length and most of the ground to the south is now obscured by tailings.

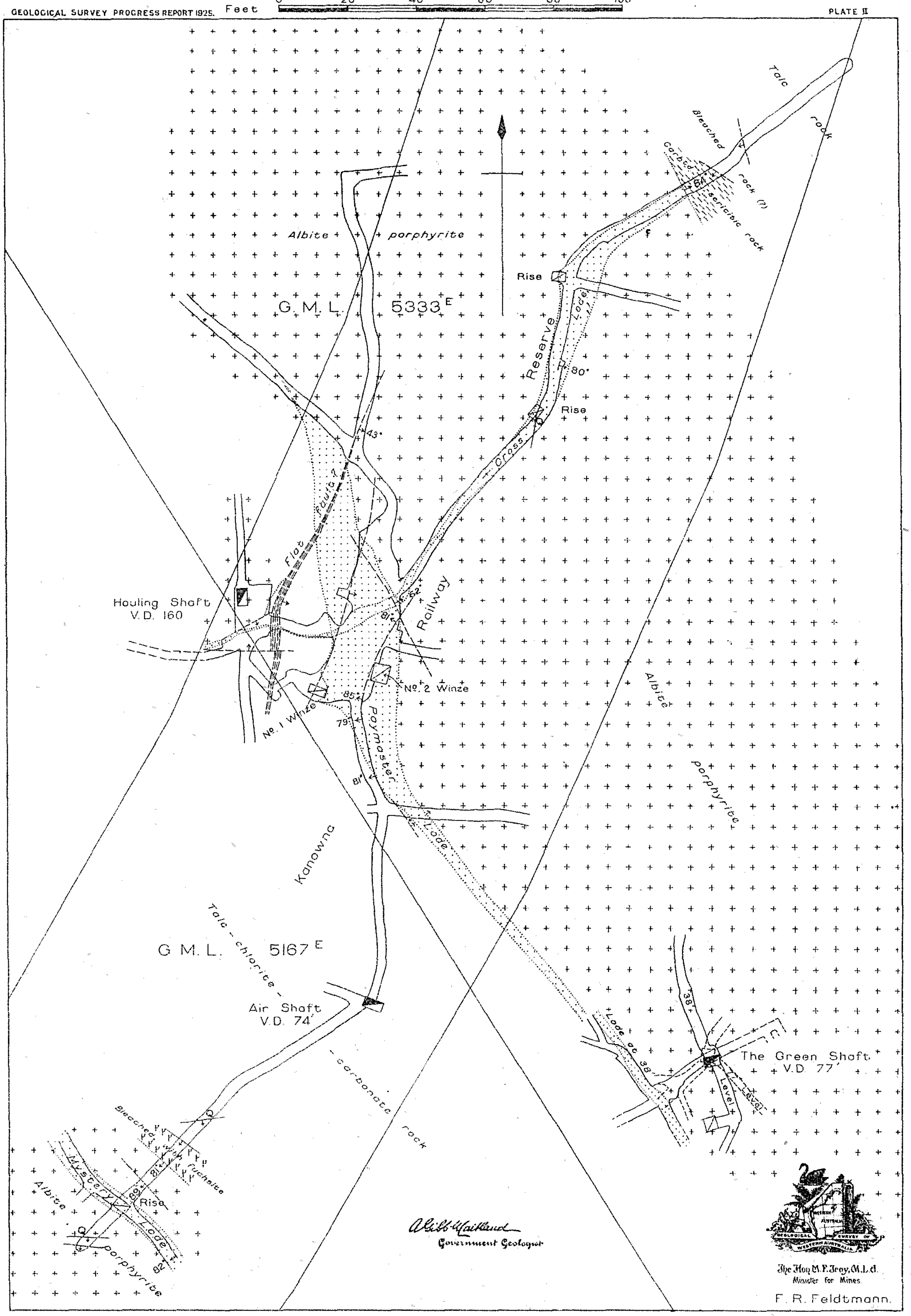
Two lodes have recently been worked by Black and Levy on the northern slope of the Brown Hill Consols ridge and near the northwest boundary of G.M.L. 5247^E. The more easterly cuts the northwest boundary of that lease about 240 feet from the west corner, and has been worked from an underlay shaft at this point. This lode is situated about 200 feet southwest of the southeasterly extension of the line of the Lucelle West lode. The lode strikes about 10° or 12° west of north and dips west at about 70°. It has been driven on north for about 90 feet at a depth of 29 feet, but only one small shoot of payable ore, between about 40 feet and 55 feet north of the shaft, was found.

The second lode has been worked from a shaft about 265 feet south of the shaft on the first lode and about 200 feet southeast of the west corner of G.M.L. 5247^E. The shaft, which has a depth of 63 feet, cuts the lode about 5 feet from the surface. The lode has been driven on for about 40 feet north and 60 feet south of the shaft at the 63ft. level. A small shoot of fair ore was cut by the shaft between the 39ft. and 63ft. levels but did not extend for more than a few feet north and south of the shaft, the remaining portions of the drives being in very low-grade lode matter. A fair amount of cross-cutting has been done east of the shaft at the 63ft. level, what is probably the southerly continuation of the first lode being cut about 50 feet east of the shaft. The lode, however, only contained a trace of gold at this point.

As stated in the description of the geology of this area, the fine-grained greenstones are much sheared near their junction with the quartz dolerite epidiorites. On account of the general intensity of the

PLAN OF THE 80 FEET LEVEL, PAYMASTER G. M.
KALGOORLIE, EAST COOLGARDIE G. F.

GEOLOGICAL SURVEY PROGRESS REPORT 1925. Feet 0 20 40 60 80 100 PLATE II



Fred. Wm. Simpson, Government Printer, Perth.

shearing it is difficult to trace any particular lode or shear zone for any great length. One line, striking slightly east of south, follows the junction between the two rocks for some distance. It has been worked from several shallow shafts in the northern portion of former G.M.L. 4259^E, but evidently was not payable. Most of the lodes or shear zones, however, strike about southsoutheast, diverging from the junction at an acute angle. One, on which a little work has been done from two shallow shafts, follows the southwest boundary of the Marne G.M.L. 4630^E very closely. Another lode, southwest of the last, has been worked in the southern portion of G.M.L. 4259^E from two shafts, one on each side of the creek. North of these shafts the lode passes about 60 feet east of the old Golden Point No. 4 shaft, put down by the Hannan's Proprietary Company. A little stoping has been done on this lode from the shaft south of the creek.

No lodes appear to have been found in the quartz dolerite epidiorite west of the junction, and from the absence of vein alteration and the massive character of the rock it is unlikely that payable lodes occur therein. Small cross veins of quartz, however, occur, and some of those have been worked at the surface. Most of these veins are too small and the enclosing rock too hard to pay to work.

Prospecting on the flat occupying the northwest portion of Sheet 22 and parts of the adjoining sheets has been much hindered by the covering of superficial deposits, and the only portion of the flat where systematic prospecting has been done is at the southern end, where four shafts were put down in the early days of the field by the Hannans Proprietary Company. About 950 feet of cross-cutting from these shafts, which are now inaccessible, and short drives were put in, in places, but the results were evidently not encouraging. Nevertheless, as the gold content of the lodes in the fine-grained greenstones is very erratic, it is possible that short shoots of payable ore occur in the lodes cut by these crosscuts. As only the two more westerly shafts are connected, and the easternmost of the four shafts is only about 800 feet east of the junction of the two rocks, a considerable width of possibly auriferous country remains untested.

3.—WORK DONE DURING 1925 IN THE VICINITY OF THE PAYMASTER AND MYSTERY LODES AND DYKES AT THE NORTH END, KALGOORLIE.

(F. R. Feldtmann.)

Introduction.

While continuing the survey of Kalgoorlie during 1925, a brief examination was made of some of the work done on the northern portion of the field subsequently to my examination of that area in 1924, in particular of that from the Paymaster main workings, with a view to obtaining further data relating to the Paymaster and Mystery lines of lode and the Paymaster albite porphyrite dyke. A good deal of work was done during the year by the Paymaster Syndicate, including most of that recommended during the previous examination. Some crosscutting near the northern end of the Paymaster dyke has also been carried out by Bandinette and party, as well as a crosscut to, and a little driving on, what appears to be the Mystery line of lode, north of the Belgravia hill and east of the Broad Arrow Road.

THE PAYMASTER GOLD MINE.

(Plate II.).

In the description of this mine given in the Annual Report of the Survey for 1924, mention was made (p. 13) of what appeared to be the easterly continuation of the Surprise North Cross lode in the east crosscut from the plat of the haulage shaft at the 80 feet level. This lode has since been driven on northeast from the east side of the stope, on the main ore body at the 80 feet level, the drive extending for a distance of about 210 feet from the stope. On meeting the western edge of the Paymaster albite porphyrite dyke, immediately west of the stope, the lode, which in the Surprise North workings strikes slightly south of east, changes its course and strikes about N. 40°E to a point about 70 feet NE. of the stope. From this point it strikes about N. 12° E. for about 38 feet, thence bending to strike about N. 50° E. for a further 40 feet, at which point it hits the eastern wall of the Paymaster dyke, against which it appears to end. The remaining portion of the drive is in decomposed talc-chlorite-carbonate rock, somewhat sheared and sericitised for about 10 feet from the junction. For the greater portion of the drive the lode is not very well defined. It appears to range from a foot to about 10 feet in width, probably averaging nearly four feet. The lode was stated to carry gold, but not in sufficient quantity to warrant further work. The lode is nearly vertical in places, but for the most part dips southeast at about 80°. The apparent cutting off of the lode by the east wall of the porphyrite dyke is probably due to faulting along the margin of the dyke.

From a point in the south drive, off the main east crosscut, about 56 feet north of the air shaft, a crosscut was put in east for 42 feet. This crosscut cuts the Paymaster main lode from about six to 12 feet east of the drive. The lode, however, was not payable in this crosscut, which east of the lode is in kaolinised albite porphyrite.

Acting on a suggestion given orally to members of the syndicate, a crosscut was driven southwest from the air shaft to cut the Mystery-Lone Hand line of lode on the eastern margin of the main (Mystery) albite porphyrite dyke. The lode was cut at 91 feet from the air shaft and was driven on, northwest for 26 feet, and southeast for 23 feet. The lode is about five feet wide at the crosscut, but the walls are not well defined and the enclosing rock is intensely sheared to about 10 feet southwest of the drive. In these workings the lode is wholly in the albite porphyrite, but the exact position of the eastern margin of the dyke is, owing to the alteration and bleaching of the talc rock in its vicinity, very difficult to determine, particularly as the rocks are completely weathered. It appears to lie between seven and 23 feet northeast of the lode, most probably at 15 feet, with a band of fuchsite-carbonate rock between it and the talc rock. As the lode carried sufficient gold to encourage further work, though not to be payable, an irregular rise was put in above the crosscut to a total height of about 30 feet above the level and a few feet of driving was done northwest from the rise in places. No payable shoot being found, however, the work was abandoned. The average gold content of the lode was, I was informed, about 4dwts. The lode is highly schistose in these workings, consisting of highly sheared kaolinised sericitic albite porphyrite, with some ferruginous matter in places. A few quartz veins striking east, and dipping south at a steep angle, occur, but do not appear to carry gold.

The lode cut in the main workings of the Paymaster Mine have now been tested pretty thoroughly. The only patch of payable ore found was at the junction of the main lode with the cross lode and the only hope of obtaining another shoot appears to be in the discovery of a junction of the main lode with another cross lode.

Workings at the Northern End of the Paymaster Dyke.

Prior to my previous examination of this area, an old shaft, 300 feet north of the west corner of the Paymaster G.M.L. 5333E, had been deepened by Bandinette and party to a vertical depth of 58 feet and a crosscut driven southwest for 77 feet.* This crosscut cut the eastern edge of the Paymaster albite porphyrite dyke at 68 feet from the shaft. It was stated in the previous report that the dyke, going north, should pass between two old shafts, both in the talc rock, east of the Broad Arrow Road.

During 1925, another shaft was sunk to a depth, I was informed, of 54 feet by Bandinette and party 190 feet WNW. of that previously deepened by them, and crosscuts were driven west for 50 feet and east for 42 feet, the west crosscut being mainly on a cross quartz vein. This shaft was inaccessible at the time of my visit, but I was informed that the eastern edge of the porphyrite dyke was cut in the west crosscut about 15 feet from the shaft, and the crosscut continued in albite porphyrite without reaching the western edge of the dyke. The more southerly of the two old shafts mentioned is about 80 feet SW. of Bandinette's shaft, and this shaft is in the talc rock, but a trace of albite porphyrite was found on the dump, indicating that the dyke was cut in the workings. A pot hole, about half-way on the line, between this shaft and Bandinette's shaft, is in the albite porphyrite, the western edge of which must lie between the pothole and the old shaft. The dyke is much narrower here than in the Paymaster main workings and probably does not extend much farther north. Apparently no payable ore body along the western edge of the dyke was cut in the workings from the old shaft.

Another shaft, some distance southwest of those mentioned, had been sunk by Bandinette to a depth of about 50 feet on the northern slope of the Belgravia hill and a short distance northeast of the Broad Arrow Road. A crosscut driven west from this shaft cut what appeared to be the Mystery line of lode from 10 to 13 feet west of the shaft. The lode is ill-defined and the shearing much less marked than in the Surprise North and Paymaster Proprietary leases and quartz veins are absent, and the general appearance of the lode at this point is not encouraging. A small patch of payable ore was, I was informed, cut in the crosscut, but only extended for about 5 feet north, and a similar distance south of the crosscut. It would be advisable to extend the crosscut a short distance farther west, to determine whether the main lode has been cut.

4.—ALUNITE AT THE NORTH END, KALGOORLIE.

(F. R. Feldtmann.)

During the year the opportunity was taken of examining the workings from Clay's Shaft, situated in former G.M.L. 584 (213E), one of the more northeasterly of the old Mt. Charlotte leases.† This shaft, which is 210 feet west of the Kanowna Road and opposite the former Red White and Blue haulage shaft on that road, was inaccessible for many years, but ladders were recently put in by Howard and party. The shaft has a vertical depth of 104 feet and a crosscut extends west for about 470 feet at the 50 feet level. The shaft was sunk on a narrow jasper which is practically vertical and is, so far as could be determined, entirely in albite porphyrite—the southerly extension of the big Mystery dyke. Owing to the extreme degree of weathering, it was impossible to determine the rocks in the west crosscut with any certainty, but a short crosscut east of the shaft shows the rock east of the jasper to be decomposed albite porphyrite, which appears to extend for a few feet west of the jasper. East of this the rock is probably decomposed quartz dolerite greenstone, but extending east for some distance from a point about 20 feet west of the shaft is completely kaolinised rock with irregular veins and lenses of iron ore, which may be sheared and decomposed albite porphyrite. In the west crosscut, between the shaft and a point about 20 feet west are a number of veins of alunite, mostly a few feet apart and striking northwest and dipping southwest at a comparatively shallow angle. From about 9½ to 11½ feet west of the shaft, on the south side of the crosscut, is a shear zone, dipping at a steep angle, in which are a few thin veinlets of alunite. A few alunite veins also occur west of the band of kaolinised rock, and a few were likewise observed in the east crosscut. The veins are lenticular in habit, with lenses of alunite up to about a foot in length and about 2 inches in maximum width.

The occurrence is of interest as alunite has not previously been recorded from Kalgoorlie. The corresponding sodium compound natroalunite has, however, been noted at two localities in Kalgoorlie,‡ namely, on the Maritana lease on Mt. Gledden, and on a dump between T.L. 15 and T.L. 19, Lake View Townsite. The first occurrence was a narrow vein, about half an inch wide, in a shallow shaft in quartz dolerite greenstone, about half-way up the northeast slope of Mt. Gledden and 210 feet north of the cairn.

The alunite veins in the workings from Clay's Shaft do not appear to be sufficiently large or close together to be payable. There is no evidence as to the length of ground over which they occur. The following is the Government Mineralogist and Analyst's report on a typical sample from the west crosscut from Clay's Shaft.

L. 3319. This is alunite carrying K_2O, 7·24 per cent.; Na_2O, 2·50 per cent.; soda soluble SO_3, 37·48 per cent. By calculation this indicates 95.78 per cent. of clean alunite. Under the microscope the mineral is seen to be crystallised in minute pseudo-cubes, which appear to be the common form.

* W.A. Geol. Survey Ann. Rept., 1924, p. 12, 1925. † W.A. Geol. Survey Bull. 69, Plate XIII., Sheet 13, 1917. ‡ W.A. Geol. Survey Ann. Rept., 1917, p. 17, 1918.

5.—PEAT IN WESTERN AUSTRALIA WITH PARTICULAR REFERENCE TO ITS GEOLOGICAL OCCURRENCE IN THE BAYSWATER DISTRICT, METROPOLITAN AREA, SOUTH-WEST DIVISION.

[ALEXANDER G. D. ESSON, M.A. (Aberd.), Field Geologist.]

CONTENTS.

I.—INTRODUCTION.

The wealth of a country is to be largely interpreted in terms of its mineral resources and of their potential value in regard to application and utilisation in various industries. It is only of comparatively recent years that some nations throughout the world have been "stock-taking" in this way and have had peat under consideration from this point of view. Up to the present practically nothing has been done in Western Australia to investigate the scientific and economic aspects of peat, although deposits have been known to occur throughout the coastal area in the swamps from Geraldton to Israelite Bay. There is an undoubted economic value and importance for peat if sufficiently extensive deposits can be found.

Official literature issued by this department contains very few references to peat occurrences, and a brief summary of such information as is available is given below. In Bulletin 4, A. Gibb Maitland, Government Geologist, refers to the wind-blown origin of sand covering the coastal plains and makes brief mention of peat swamps. In Bulletin 6, E. S. Simpson notes the occurrence of peat in most of the swamps along the coast from Geraldton to Albany. In Bulletin 44, E. C. Saint-Smith briefly describes coastal limestones and wind-blown sand dunes in the vicinity of Bunbury, as well as some swamps associated with these.

In the past it has been customary to regard peat swamps as inferior land on account of the immediate difficulty of drainage, but when public opinion has been properly broadened and educated, people will realise that these peat swamps are commercially of high value and economically of great importance. Their close proximity to markets makes their utilisation assured so long as the drainage problem can be mastered.

In the vicinity of Perth there are a number of swamps and swamp-lakes, of which some are undoubtedly peat-forming. Many of these have been used in the past for intensive market gardening by Chinese and of more recent years white people have been putting them to the same use. In most cases, however, rough and ready methods of utilisation are the rule. Hence scientific experimental work in this regard is urged wherever it is found practicable and the advice of an agricultural chemist will be found of value. In these enlightened days of scientific farming and manufacture, it ought not to be necessary to stress the close co-operation needed between the scientific aspect and practical aspect of peat utilisation. In this report an attempt will be made to demonstrate what may be done with our local peat deposits in addition to ordinary market-gardening utilisation.

In originating an investigation into the peat deposits of the State, the preliminary work has been centred in Bayswater on account of the easy accessibility of that place and of its proximity to Perth. There are other known deposits close to Perth, *e.g.*, Monger's Lake, the drained Herdsman's Lake, and various other lakes and swamps in the Wanneroo district, and doubtless the consideration and examination of these will come later. Hence this report must be regarded merely as an introduction to the wider consideration of what may prove to be a valuable addition to the known mineral resources of the State of Western Australia. Much more work would be necessary to deal with the matter from a broad State point of view and it is hoped that this preliminary investigation may prove of sufficient value and interest to lead to that in the future.

A certain amount of official field work and unofficial spare-time work has been done by the writer, and a map showing the results of these field investigations accompanies this report. In addition a geological section will be found along with this report. This section has been compiled by the writer partly from the result of field work and partly from the available reports upon artesian bores throughout the metropolitan area. Although a complete examination of these bore cores has not as yet been made, the writer has endeavoured to correlate beds of various kinds and to show their probable stratigraphical relationship and position along the line of section. The examination of bore core reports and the projection of strata has entailed much investigation and work, and it is hoped that the section will be of some value in the consideration and elucidation of the general geology of the metropolitan area and of the Western Australian coastal area.

II.—Geology.

1. *Geology*.—The area examined, comprised, roughly, within the limits of the Bayswater Roads Board district, forms portion of that extensive coastal strip of Western Australia lying between the Indian Ocean and the Darling Range. Before going into the detailed geology of Bayswater, it will be necessary to briefly recapitulate the generally accepted ideas held regarding the broad geology of this western coastal area.

The greater portion of Western Australia can be considered to be an extensive plateau of gently grading level now approximating to about 1,400 feet in height above sea-level in the interior. In the main this plateau consists of pre-Cambrian rocks. There are extensive portions of the plateau consisting of rocks of a later age, but the foundations of the plateau may be considered to be Pre-Cambrian in age. Certain stratigraphical strains and movements developed a line of weakness which became ultimately a line of fault where now the Darling Ranges occur. Hence the so-called Darling Ranges can be considered to be merely the escarpment of this fault towards the sea. Jutson * has pointed out that this scarp is due to fairly recent faulting along an old line of fault running roughly parallel to the present coast line and extending further north and south than the present Darling Ranges scarp line. Other fault lines have been observed, but, as these do not come within the scope of this report, it is not considered necessary to discuss them.

Hence a coastal strip of the great plateau slipped down along the Darling fault escarpment to below sea-level and became submerged by the sea. Examination of cores from various artesian bores throughout the Metropolitan Area would show that there must have been considerable vertical movement. The deepest of these bores have not penetrated to the older underlying crystalline rocks, and hence it is impossible to state the exact amount of movement. Upon this submerged shelf various sediments were deposited. The exact relationships of the sediments encountered in artesian bores have, as yet, not been fully determined and will not be until very careful investigation has been undertaken by petrologist, palæontologist, and chemist.

There is little doubt that a number of the sedimentary beds are lenticular in form, an occurrence that would militate against correlation of them at separate points throughout the Metropolitan Area. The writer has attempted to make a general correlation of similar beds in the section accompanying this report. Reference to this section shows that the uppermost beds are more or less unconsolidated sand dunes which are consolidated near the coast and popularly but erroneously known as coastal limestone. These are recent beds and are now named the "Coastal Calcareous Sandstone Series." From information given by old settlers, it would appear that these sand dunes—particularly in the vicinity of Bayswater—were covered by a heavy growth of timber, which would tend to arrest movement. Within the last thirty years this timber has been cut out and there would seem to be distinct evidence of a resultant movement of the dunes. These dunes are in themselves wind-blown deposits and there is a tendency for them to move in some direction governed by prevailing winds. In France and Ireland it has been found necessary to arrest this movement by planting trees such as *Pinus silvestris*. The Public Works Department issued a series of contour maps of the Metropolitan Area in 1897 and a later series in 1920. Discrepancies between the two series might be explained by this tendency of sand dunes to migrate when the restraint of tree growth is removed.

By action of rain, etc., these wind-blown deposits become consolidated. If there is an excess of limey matter in the sand, consolidation will produce a sandy limestone which will gradually grade into limey sandstone. On the other hand the cementing matter may be limonite, hydrated oxide of iron, and in this case the resultant product will be a ferruginous sandstone known locally as "coffee rock."

In connection with the aeolian nature of "coastal limestone" it is to be noted that Simpson and Jutson† have proved it to be of this nature at Albany. They find it to be composed mainly of foraminiferae and fragmentary calcareous algæ which have been blown into their present position by prevailing winds. This seems to be explanatory of the "coastal limestones" of the Metropolitan Coastal Area, and doubtless the division between resultant sandy limestone and calcareous sandstone is by no means exact. One will be found to grade into the other according as calcareous matter occurs in greater or less content in the sand. Hence there is no very marked division between the two except as regards comparative chemical composition.

The calcareous coastal sandstone series have a thickness varying up to 140 feet, but in general to about 100 feet.

Partly overlain by the Coastal Sandstone Series are the Guildford clays. These are lenticular and would represent Swan River beds denoting four ages of the Swan River. The lowermost of the three beds has been marked "dark clays and boulders" and it would represent the earliest deposit of the river on underlying sandstones. Above this bed are "clays and silts" deposited as estuarine deposits while the river was still quick-flowing. The topmost bed is marked "clay" and represents a flood plain of the river. This flood plain is now being cut into and eroded by the river in its present form.

Beneath the Guildford Clay beds are sandstones which are comparable to those of the present day forming the Coastal Calcareous Sandstone Series. These sandstones may represent wind-blown dunes upon underlying beds and gradually grading into the Coastal Calcareous Sandstone Series.

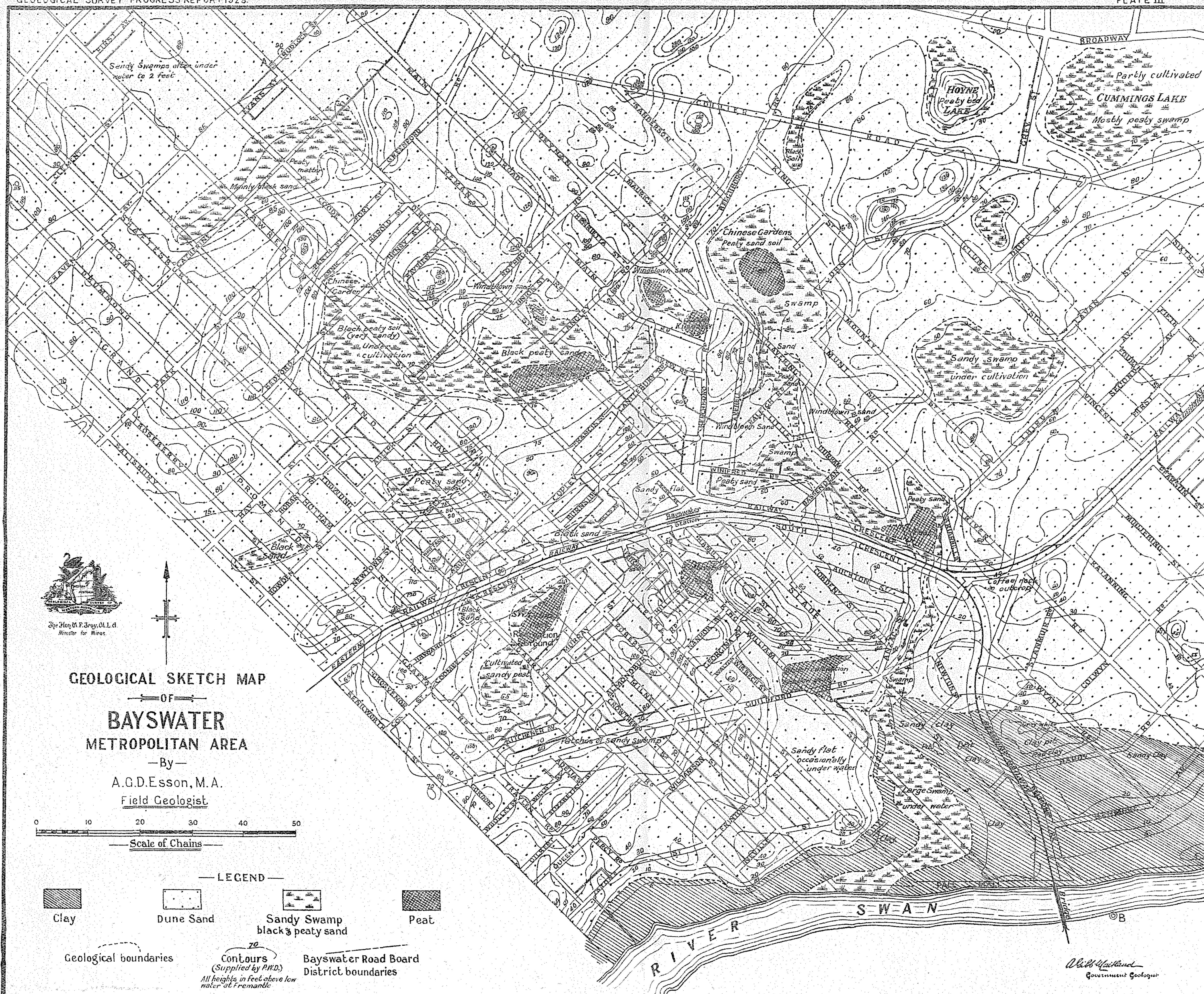
Underlying the sandstones are marls and gritty sands containing much glauconitic matter. Whether these are extensions of the Gingin glauconitic deposits is not at all clear, as no direct evidences of the overlying Gingin chalk are to be found in bores in the Metropolitan Area. It is possible, however, that the Gingin chalk may be represented by the marls associated with glauconite in the Metropolitan Area. In both cases dark shales are found underlying the glauconitic beds and sandstones overlying (c.f. Section, Fig. 69, p. 43, "Summary of Geology of Western Australia," by A. Gibb Maitland, G.S. Memoir No. 1, Chap. 1, 1919).

The shales underlying the glauconitic beds are marked "sandy carbonaceous shales and mudstones" which may represent estuarine or shallow-sea conditions. It is possible that these are underlain—in part at least—by fossiliferous limestones with a general tilt westwards. These are followed by further carbonaceous shales interbedded with somewhat calcareous sandstones, all having a general dip westwards.

It would be foolish to dogmatise upon the relative age of these beds until further examination of them

* J. T. Jutson, Bull. 61, G.S., W.A., "An Outline of the Physiographical Geology of Western Australia."

† "Notes on Geology and Physiography of Albany," by J. T. Jutson and E. S. Simpson, B.E., B.Sc., F.C.S., Journ. Roy. Soc., W. Australia, Vol. II., 1915–16.


GEOLOGICAL SKETCH MAP
OF
BAYSWATER
METROPOLITAN AREA
By
A.G.D. Esson, M.A.
Field Geologist
0 10 20 30 40 50
Scale of Chains
LEGEND
Clay
Dune Sand
Sandy Swamp black & peaty sand
Peat
Geological boundaries
70 Contours (Supplied by P.W.D.)
All heights in feet above low water at Fremantle
Bayswater Road Board District boundaries
The Hon. M. F. Troy, M.L.A. Minister for Mines
Government Geologist
Sandy Swamps often under water to 2 feet
Partly cultivated
CUMMINGS LAKE
Mostly peaty swamp
HOYNE Peaty bed LAKE
Chinese Gardens Peaty sand soil
Swamp
Windblown sand
Black peaty soil (very sandy) Under cultivation
Black peaty sand
Sandy swamp under cultivation
Peaty matter
Mainly black sand
Peaty sand
Sandy flat
Black sand
Coffee rock outcrop
Cultivated sandy peat
Recreation Ground
Patches of Sandy Swamp
Sandy flat occasionally under water
Large Swamp under water
Sandy clay
Clay pit
Clay
RIVER SWAN
BROADWAY
RAILWAY
SOUTH CRESCENT
GUILDFORD RD
EASTERN
GRAND PROMENADE

has been undertaken, but it is hoped that the basis of differentiation of beds adopted by the writer may be of some value when final determinations are made. There seems reason for believing that rocks of Cretaceous age are represented in the series of beds and the Government Geologist reports † that Mesozoic rocks, consisting chiefly of shales, sandstones and limestones, are found in the Coastal Area overlying the older crystalline and Palæozoic rocks and underlying Tertiaries. He reports also that in artesian bores in the Agricultural Show Ground, Hospital for Insane (Claremont), and in Rottnest Island, Cretaceous rocks were observed. Assuming this to be determined, then a basis for interpretation of strata underlying and overlying the Cretaceous can be got.

There is little doubt of the age of the uppermost sand dune or Coastal Calcareous Sandstone Series, and we can confidently place this as Recent. The Guildford clays can be regarded as Post Tertiary, but it is not clear whether the underlying sandstones are of greater age than Post-Tertiary. If they are assumed to be an early sand dune formation upon which, by subsidence, the Guildford clays were deposited, then it is not unreasonable to give their age as Tertiary or Post Tertiary. The next beds, marked "Greensands, Marls and Gritty Sands," might correspond to the Cretaceous beds referred to above.

That there have been uplifts and general alterations in level is evidenced by wave-cut platforms observed by the writer on Rottnest Island at at least three different heights above sea-level; by estuarine oyster beds found as far up the Swan River as Perth; and by raised beaches found at various points throughout the Metropolitan Area.

With this brief mention of the geological features of the coastal strip in the vicinity of Perth, Guildford and Fremantle, the writer will pass on to the description of the more detailed geology of Bayswater district.

2.—*Detailed Geology of Bayswater.*

Examination of the map and section accompanying this report will show that almost the total area is covered with aeolian or wind-blown deposits of characteristic sand dune formation. These sand dunes have the usual ridge and valley form and gradually decrease in height as they spread towards the River Swan until the Guildford clays appear on the surface. These dunes attain in places a height of 155 feet above sea level and their total thickness vertically would appear to be about 100 feet on an average at some distance from the river and about 140 feet in the higher points.

They are unconsolidated at the surface and they contain successive thin layers or lenses of "coffee rock" at varying depths. "Coffee rock" is a brown iron-stained sandstone formed from the sand of the sand dunes by percolating waters. It may be due in part to a form of silicic laterisation, in part to the cementing action of calcareous layers or of calcareous solutions and most probably to the action of organic matter in solution in leaching iron materials from overlying or adjacent layers of sand. Specimens of coffee rock obtained by the writer appeared to consist of dune sand cemented by hydrated oxide of iron (limonite). This coffee rock when not open to and affected by the atmosphere is very hard, but occasionally a somewhat incoherent sandstone is found. It is possible and indeed probable that these lenses or layers of coffee rock form impermeable or slowly permeable barriers which restrict normal drainage, hold up water and form springs.

The Guildford Clay deposits, which appear at the surface near the River Swan at a lower level than the sand dunes, have been discussed under the general geology above, but it is to be noted that the uppermost clay deposit would appear to be the latest deposit of the Swan River before it assumed its present attenuated form. This river, which Jutson has described as being "precociously mature" is now eroding the flood plain deposited by itself in its late youth. The maturity of the Swan is well evidenced by its meanderings and many twistings back upon itself.

These river clays, or "Guildford Clay" deposits are lenticular and would appear to die out on either side of the Swan River. On the edges they would seem to be overlapped by sand dunes or the Coastal Calcareous Sandstone Series. That this should be so is quite understandable when one considers the aeolian nature of sand dunes and their tendency to "creep." Upon the surface the clays are found to vary considerably and to grade from heavy black, red or white clays to sandy clay or sandy gravel—all of them evidently of fluviatile deposition. In some places abandoned clay pits are found. Some of these are of fair size and apparently a quite considerable manufacture of bricks was at one time undertaken.

The natural drainage would appear to be towards the Swan River and the section shows a gradual decrease in level in that direction. Most drainage channels seem at one time to have been connected up with a main drainage channel emptying into a swamp lying between King William Street and Slade Street south of the Guildford Road. Along these drainage channels there are now a series of lakes and swamps which are caused by the formation of barriers across the channels at convenient points. These barriers may have their origin in a number of ways.

(1) They may be "coffee rock" deposits.
(2) They may be caused by "creep" or driftage of dune sand.
(3) They may be caused partly by (1) and (2) in conjunction, and carbonaceous matter may choke up channels so as to produce restricted drainage. This would seem to be the most likely cause of the lakes and swamps.

With restricted drainage, carbonaceous matter and black, heavy muds will be deposited in the beds of lakes and thus there is a commencement to the formation of peat. Where water is able to stand for some time, or, at the best, to percolate away very slowly, there plant life will flourish. This plant life is of a particular kind and includes ti-trees, paperbark trees, bull-rushes, sedges, ferns, bracken, reeds, grasses, occasional mosses and aquatic plants similar to cress, etc. With plenty of water these will have strong growth and every year the resultant dead growth will accumulate in the water, thus causing further checking of drainage and incidentally aiding in the formation of swamp and its resultant peat.

At a number of places throughout the Bayswater area swamps were observed and in most of them peat was obtained. The depth or thickness of peat varied and would appear to be dependent upon the extent of restriction in drainage. Peat swamps were found to be confined to no particular height above sea

† "The Artesian Water Resources of Western Australia," by A. Gibb Maitland, Mining Handbook, Geol. Survey, Mem II., Chap. ii., Sec. 24, 1919.

level, the height varying from 20 feet to 80 feet or more. The dominant factors in the formation of peat would seem to be a steady supply of water and improper or restricted drainage.

The age of peat deposits in the Bayswater area cannot be greater than that of the dune sands upon which it occurs. If we assume that the dune sands are recent, then approximately the same age must be given to the peat. Hence the peat is a present day occurrence, originating soon after the formation of the dunes. It must be noted, however, that peat deposits may be of varying ages—a fact that is proved by its occurrence throughout the world. Peats have been formed in all ages and indeed the present day formation of peat is merely a modern picture of the first stages in the formation of many coalfields in the past. Earlier peat deposits may now be found in a modified form such as lignite, coal, etc.

Le Conte considers that many European peat bogs are the product of a growth of not more than 1,800 years as they were forests in the time of the Romans. In Britain this is evidenced by the finding of Roman coins, Roman weapons, cut stumps of trees, etc., at the bottom of peat deposits.

III.—Detailed General Discussion on Peat.

1.—*What is Peat?*

Essentially Peat is carbonaceous matter arising from the partial decomposition of organic remains, *i.e.,* of plants and animals and chiefly of the former. Dana defined peat as half decomposed vegetable matter, accumulating in wet or swampy places over the interior of a continent or about its estuaries.

A more detailed definition of peat is that *it is an accumulation of organic matter whose accumulation is dependent upon the fact that the matter collects below water level at a greater rate than the rate of decomposition in such a way that excess is preserved by means of peaty acids which are caused in the first instance by partial decomposition.*

In temperate climates peat has been found to consist largely of spongy mosses (Sphagnum Moss), which are very absorbent of water, with lesser amounts of the remains of sedges, grasses, heather, reeds, pond weeds, ferns, bracken, trees. Animals are occasionally found embedded in these deposits, usually in a fair state of preservation owing to the antiseptic action of the peaty acids. Subsidiary amounts of various minute infusoriae as well as of fresh water sponge spicules are also found in these temperate climate deposits.

Osbon* draws attention to the confusion resulting from inaccurate use of the names "peat" and "muck." He gives a definition of each substance and it may be worth while to note these definitions, as there is little doubt he has drawn attention to rather an important point. Briefly peat is partly carbonised organic residuum, and it contains much of the carbon of the original vegetable matter. Vegetal structure is easily seen under the microscope and in general peat is acidic. Inorganic matter is in a much less proportion than organic (down to 4 per cent. inorganic in purer peats). Muck on the other hand is uncarbonised organic soil containing a large proportion of inorganic material. Muck may grade into peat, but relative uses and values are not the same.

The relative purity of various peats is dependent largely upon ash content, *i.e.,* of contained inorganic material. This may vary, the purer peats in anhydrous form containing about 4 per cent. of ash. This percentage is dependent upon various factors, the chief being the rate of deposition of the peat. If peat is formed slowly there will be a gradual increase in ash content, as with slow deposition there must be a corresponding large amount of decomposition of organic matter and hence unaltered inorganic matter must increase. Dana gives a number of analyses of peats, but it is regretted that he gives no corresponding ash content. According to him ultimate analyses of presumably air-dried peat give 50.86 to 59.71 per cent. of carbon, 5.27 to 6.52 per cent. of hydrogen, 31.51 to 42.57 per cent. of oxygen, and .77 to 2.59 per cent. nitrogen. In Irish peats it has been found that air-dried peat (containing about 25 per cent. of water) has a calorific value of about 7125 B. Th. U. per lb. (net calorific value = 6845 B. Th. U.). Hence Professor Purcell estimates that one ton of coal (calorific value of about 14,000 B. Th. U. per pound) has the same calorific value as two tons of Irish peat. This point is interesting, and has an important bearing upon the economic use of peat.

There is a high percentage of water in peat, a percentage varying from 88 in well-drained peat bogs to 95 in badly drained bogs. The aim generally, is to produce, by air drying, peat of about 25 per cent. water content. This aspect, also, has an important bearing upon the economics of peat as it means a big wastage of energy in preliminary handling.

The Government Analyst examined a sample from the Hill Street or Number One Swamp in Bayswater. This, after air-drying, gave 23.43 per cent. moisture, 43.66 per cent. volatile matter, 26.51 per cent. fixed carbon, and 6.40 per cent. ash. This compares favourably in some ways with some of the peats of temperate climates, but a full discussion regarding this will be found in its proper place below. It is sufficient meantime to note that so far as our investigations have gone in Western Australian peats, they seem to be formed from the remains of paper bark and ti-trees, reeds, bull-rushes, ferns, bracken, grasses, sedges and various aquatic plants, with mosses in a very minor degree.

2.—*How is peat formed?*

In the present day formation of peat there is found an analogy to the older formation of coals, for, after all, coal is simply consolidated peat and, although the species forming coal is in large measure different from those forming peat, the mode of accumulation would seem to be the same in each. It would appear, however, that coals have the additional changes brought about by changes of temperature and pressure. These additional changes are consolidation and lessened moisture content as well as some changes in physical properties. It has been proved that certain later lignites, found in old estuaries, are in reality the product of hardened peats. The process of peat formation seems to have been one that would early arise with the growth of plant life, etc., and there seems to be no reason why it should not continue so long as life upon this earth is dependent upon carbon, oxygen and hydrogen for continuance.

It has already been pointed out that peat is due to the accumulation of organic remains below water level at a greater rate than that of decomposition. This brings us to the consideration of two questions:

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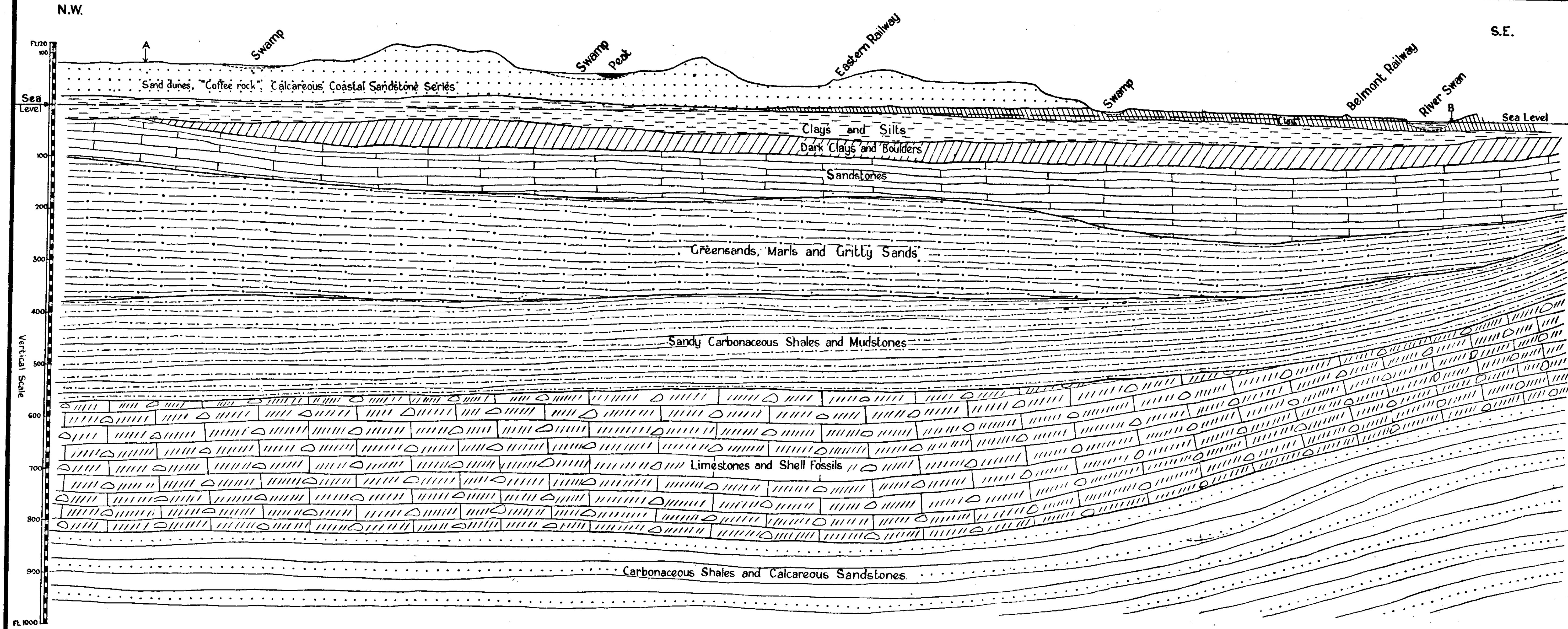
* Res. U.S., 1918, Pt. II., Non-metals, United States Geol. Survey, 1921.

PLATE IV



BAYSWATER METROPOLITAN AREA

Section AB along Drake and Slade Streets from Rudlock Road to South Bank of River Swan

by

A. G. D. Esson M.A. Field Geologist.

Chains 10 0 10 20 30 40 50 60 Chains

Horizontal Scale

This section shows the probable stratigraphical formation and is based partly upon field work and partly upon information gained from various artesian bores throughout the Metropolitan Area.

The Hon. M. F. Troy, M.L.A.
Minister for Mines.

A. Gibb Maitland
Government Geologist

Fred. Wm. Simpson, Government Printer, Perth.

"What causes decomposition?" and "What arrests decomposition?"

An important condition upon which the formation of peat depends would seem to be that an excess of moisture is always present, *i.e.,* that withered and excess plant growth should fall into and be covered by water. Normally, withered growth, open to the atmosphere, is attacked by fungi and bacteria and rapidly decomposes. These micro-organisms transform plant cellulose (a compound of carbon, hydrogen and oxygen) into Carbon Dioxide (CO_2) and water (H_2O). Under water, however, the oxygen supply is much lessened and hence the action of the micro-organisms is restricted. For that reason decay is slow, much of the fixed carbon is retained as such, methane as well as carbon dioxide is formed, and peat collects. During this change, certain peaty acids would seem to be evolved and these, having an antiseptic value, help, in turn, to preserve the deposited and depositing peat. A number of writers have remarked upon the effect of these acids in preserving the bodies of men and other animals that have become engulfed in the peaty matter of bogs and swamps. The famous example is that of the woman found in 1747 in an English peat bog and, despite the fact that the body must have been a considerable number of years entombed, skin, nails and hair were found to be in almost perfect preservation. Trunks of trees have been found preserved in the same way. There is no reason why such relics of life should not be found in deep bogs in Western Australia. That deep bogs have existed in Western Australia is evidenced by the fact that a thickness of about 45 feet of peaty matter was met in bores in the Albany district. It is to be noted also in this connection that carbonaceous shales of some considerable thickness are found in artesian bores in the metropolitan area.

In the writer's opinion, certain writers have been inclined to lay too much stress upon the effect of cold as a condition of growth of peat. It is not the most important condition and it may be considered to be merely an accessory condition. The most important condition of growth of peat would seem to be that of excessive moisture and that, in turn, requires the ultimate condition of inefficient drainage so that the water may not lose its average content of peaty acids. If cold were the most important condition, then we should not expect to find peats forming in Western Australia to-day.

We have already enumerated the plants forming peat in Western Australia and briefly we can summarise the method of growth of peat in Bayswater in so far as we can do so from personal observations there. In all sand dune country we would expect the surface configuration to be similar, *i.e.,* high hills of sand with intervening steep valleys, both dependent upon the direction of prevailing winds. Springs will arise near the base of these dunes, and valleys will carry off excess water. With the formation of "coffee rock" or driftage sand barriers and with choking by carbonaceous matter, etc., dams are created. These dams will interfere with normal drainage. Water will therefore be held up in depressions and plant life will flourish. The remains and waste of this plant life will accumulate in the water as peat so long as conditions of drainage remain the same.

3. *How can peat be utilised?*

For long, peat bogs and swamps were regarded as so much waste land, but with advanced knowledge and careful experimental work, they have come to occupy a more elevated position in popular estimation. The great problem and the main difficulty has been that of drainage. Without efficient drainage they will never be properly utilised.

In Great Britain numerous peat bogs (or "peat mosses," as they are often popularly named), are found throughout Scotland, England and Ireland, and it is estimated that in the United Kingdom of Great Britain and Ireland there is a total area of 14,000 square miles of peat bog. Other countries have correspondingly big areas of peat deposits and their respective Governments have, for economic reasons, been forced to investigate the practical utility of these areas and of their contained peats. Much remains yet to be done, but a considerable advance in our knowledge of peat and of its applications has been made. We shall briefly deal with these below:

(a.) *Agricultural Uses.*

To the ordinary man the first practical application of peat is its use in agriculture. There are a number of ways in which peat can be utilised in agriculture and we shall correlate these under three main headings.

(i.) *Cultivation of peat areas.* Actual peat areas may be cultivated, and if proper methods are taken, the resultant soil and crops well repay the necessary expense and labour. In the past, peat bogs and swamp land have been regarded as being of less value than properly drained soil and there is little doubt that this is justified. Drainage is a problem of paramount importance and wherever it is found impossible to institute efficient drainage, there is little use in attempting to bring peat swamps under proper cultivation. The drainage question is largely an engineering question dependent upon the contour of the surrounding country. Certain areas may be found to present a problem involving too great expense to be worked with economic results.

First of all the actual peat bog must be trenched and thin (2 inch) pipe drains placed in it as a series of roughly parallel drains leading into main drains carrying the water to a lower level. These leader drains should not have their pipes cemented, as it is necessary that the pipes should be able to gather up excess water from the immediately adjacent ground. The next process needing to be done is that of deep ploughing and breaking up accompanied by lime dressing. This will keep the soil loose and the lime will neutralise the acidity of the peat, enabling humic decomposition to ensue. First croppings and, indeed, periodic croppings should consist of peas, beans and such leguminous plants as are known to be able to store up nitrogen in soluble form. For preference the roots and stems of these legumes should be turned into the ground to form a valuable available storage of nitrogen for plant life.

Manures are not necessary for some years after preparation in the manner described above, and the aim should always be to keep the soil as loose as possible, properly drained and non-acidic (*i.e.,* neutral).

In Western Australia, owing to the difficulties experienced in tilling peaty soils, it has been customary to leave their cultivation to the ubiquitous Chinaman who has utilised them in places for intensive cultivation in the form of market gardens. When properly treated, peat and peaty soils can be transformed into the most fertile of all soils. It is obvious that, where peat is of sufficient purity and extent to be economically used for other purposes, it would be foolish to use it merely for cultivation. On the other hand, peats containing much inorganic matter (*i.e.*, having a high ash content) or "muck," which has already been defined, would be highly suitable for ordinary intensive cultivation. In this connection it might be noted that Professor Purcell,* A.M.I.C.E., reports H.R.H. The Prince of Wales has reclaimed 300 acres of peaty moorland with success and that he intends to reclaim a further 1,100 acres in Dartmoor which has a rainfall of over 80 inches per annum. In the same way thousands of acres of the swampy "fens" of Lincolnshire and Cambridgeshire have been reclaimed to produce excellent potato soil. In Western Australia some of the peaty swamps grow excellent truck crops. In various countries throughout the world it has been found possible to raise on reclaimed peaty soils wheat and other grains such as oats and corn, and truck crops such as pumpkin, marrow, potato, lettuce, turnip, carrot, celery, cabbage, kale, etc. In addition the growing of leguminous plants is advisable for enrichment of the soil with soluble free nitrogen although, in general, varying percentages of soluble nitrogen may be found in most peats.

It is not necessary to enlarge further upon the economic value of peat land from the point of view of cultivation for agricultural purposes, especially as the average cultivator in dealing with the coastal dune sand finds in practice that it is "hungry" and certainly of far less ultimate value than any peaty soil.

Peat, being generally black, is heat absorbent. Other advantages are its affinity for moisture and its humus content.

Before being cultivated, peats should be examined by an agricultural chemist so as to decide what chemical fertilisers, if any, are necessary for their proper utilisation. Some may need potash and some nitrates, and some may be in no immediate need of either. Generally in all, acidity must be counteracted by treatment with lime, slaked or unslaked. Unslaked lime seems to have a more immediate effect upon the peaty matter and, in addition to neutralising the acid content, it aids in loosening the soil and in killing grubs. Unburned lime may remain inactive for some time after application. It may be further noted that the addition of lime serves to break up potash containing minerals and helps to set free nitrogen.

The author tested in his own garden, Bayswater, peat from the Hill Street swamp. The garden, which was situate upon a sandy ridge at a height of 90 feet above sea-level, consisted solely of wind-blown sand. The steep contouring of the ridge assured a quick drainage of surface waters and rendered the garden very dry in all weathers. To one bed peat was added after the latter had been well broken up. No lime was used and the ground was found to remain sour for some considerable time during the rainy season. Growth was slow and only average results were obtained. The bed was shaded and, later on, shade-loving plants such as pansies and violas did fairly well upon it. On the other hand a bed, prepared in the same way but with the addition of lime, showed quickly a marked difference in growth of plants. Liming resulted in a big improvement in growth. Again, a bed dug up, unlimed, and without peat, was prepared with the addition of superphosphate and bone dust and it was found that growth, although quick, was not lasting, and in addition was somewhat scraggy and poor when compared with that of the limed peat bed.

(ii.) *Peat as a fertiliser.* In America peat is being largely used as a direct fertiliser or as an ingredient of commercial nitrogenous fertilisers. To be utilised as fertiliser, the peat must be black, loose, friable peat and the deposit must have been cultivated, drained, and ploughed for some years before use. After being thoroughly powdered, it can be added as an ingredient of commercial fertilisers. When required as a direct fertiliser, the peat must first be composted with manure or else inoculated with nitrifying organisms.

As a source of plant food, peat is found to hold an important position, and Osbon† has pointed out that the average nitrogen content is about 2 per cent., although some grades may contain a somewhat higher percentage. This nitrogen may be extracted as ammonium sulphate by treatment, but it is not necessary that it should be extracted. From the nature of peat it will be easily seen that bacterial action will help to release soluble nitrogen gradually.

Osbon points out further that a new process of the commercial application of bacteriology to soil fertilisation consisted in cultivating the peat deposit for several seasons and in excavating, air-drying and neutralising it (or rendering it slightly alkaline). It is then used as a carrier and energiser of several varieties of legume and of other bacteria. This theoretical process is capable of being carried into practice by ploughing up and cultivating a thoroughly drained peat swamp as indicated, and by lime-dressing to neutralise acidity or to render the peat slightly alkaline. The practical process is completed by growing and turning in leguminous plants such as peas and beans.

As a means of adding "body" and giving humus to sandy soil, the experiments of the writer prove peat to be unequalled.

(iii.) *Stock food, etc.*—In some parts of the world peat is utilised as stock food, but it does not seem likely that this aspect of peat utilisation is of immediate application in Western Australia. Such peat is, in the main, formed from sphagnum moss, and few, if any, of the peats observed here seem to be derived from such mosses. In some cases purer peats, after reduction by closed distillation to charcoal, have been used as correctives in stock food in much the same way as pure charcoal is used as a medicinal corrective in human digestion.

(b.) *Fuel Uses.*

(i.) *Hand Cut.*—Of the known uses of peat throughout the world, this use is perhaps the oldest and commonest. People would early find that, in lighting a fire on top of a dry peat bog, they were tempting Providence in the same way as if they were to light a fire on top of a big heap of dry wood shavings. Peat bogs, when dry, have been known to burn for many months on end, and considerable damage has been done, with, at the same time, a big depth of peat destroyed. Wilful burning of peat swamps and peat bogs is reprehensible and deserves drastic measures. It is understood by the writer that the Hill Street (Bayswater) peat swamp has been set on fire on more than one occasion. Once it burned for some months until the winter rains came, and in consequence several feet (depth) of peat were destroyed. Obviously this is wilful waste and wanton destruction due to ignorance of the nature of peat. Careless burning of peaty swamps, when clearing, will result in lessened available peat or humus and in lessened purity of the peat.

The writer has travelled for many miles through the outlying country districts of Scotland where peat was the main fuel, and in some cases the only fuel. There is littte doubt that if deposits can be obtained sufficiently large areally, then these will form potential sources of fuel. In Scotland it has been customary to prepare peat for fuel in the same manner for centuries, but in Canada, United States, and in

* "The Peat Resources of Ireland" Fuel Research Board, Special Report, No. 2. † *Loc. cit.*

various countries where coal is scarce and expensive, additional methods of preparation have been devised. With slight variations of method, peat in Scotland, England, and Ireland is hand-cut. With a specially made peat-cutting spade the peat is cut into rectangular blocks. In Scotland these blocks were generally about 12 inches by 6 inches by 4 inches thick, and in Ireland 10 inches by 10 inches by 3 inches thick. These blocks or "peats" as they are sometimes called, may, when first cut, consist of 80 per cent. to 90 per cent. of water, and hence they have to be air-dried down to a moisture content of about 25 per cent. To do this the peats are up-ended and built in stacks or rested upon poles so that prevailing winds may play their part in drying. The drying ground utilised is generally the drained upper surface of the cleared peat swamp, which must be properly cleared and grubbed before peat cutting. Air-dried peat will obviously be much lighter than wet, newly cut peat.

(ii.) *Machine handling.*—Hand cutting of peat is laborious and necessitates much handling, but it is quite suited for areas of less than 100 acres of good peat. For use on larger areas, special peat cutting and drying machines with caterpillar driving devices have been invented, and it seems likely that these will soon near a state of perfection that will enable costs to be minimised considerably.

In Holland and in other places on the Continent new peat is well macerated and pulped by machinery upon the peat bog and the resultant liquid is pumped and flooded on to drying fields where it is cut into blocks. In Germany wet peat is macerated and pressed in briquettes. Of late some nations have been using powered dry peat as an important constituent of briquettes, and there is little doubt that there are great possibilities in this direction. The main difficulty connected therewith meantime seems to be that of finding a convenient and cheap binding for the briquettes, but doubtless that difficulty will soon be overcome.

As a source of fuel and electric power peat has long been established, but, where coal is convenient and cheap, obviously peat will not find a place except for use in the immediate vicinity. It is reported that the Russian power station at Bogerodsk is now the largest station of its kind in the world completely run on peat which, by the way, is machine prepared. Much has been said in Ireland regarding the utilisation of the large Irish peat reserves for power purposes, but certain eminent authorities do not seem to be agreed that this proposition is meantime economically sound.

Reference has been made to reports of a deposit in Albany 50 feet thick, and if this is sufficiently pure and extensive, evidently there should be a source of cheap fuel for use in that district. A number of large lakes in the vicinity of Perth seem to have beds composed of fairly pure peat, but in some cases the peaty matter contains much infusorial matter derived from small diatoms. For that reason peats should be examined by experts before being exploited for any particular purpose. Diatomaceous peat may, after preparation, be suitable for use as an abrasive of the same nature as tripoli.

(c.) *Other Uses of Peat.*

During the Great War sphagnum mosses, which are the main constituents of peats of temperate climates, were utilised as absorbent pads in surgical operations. By distillation of purer peats, coke and charcoal can be produced as well as certain valuable by-products in small quantity, viz.: oils, spirit, alcohol, ammonia, ammonium sulphate, acetic acid, waxes, phenol, etc. The charcoal produced, being very pure, is highly suited for smelting purposes.

Peat that has been dried and powdered is a non-conductor of heat, and hence it is suitable for packing fruits and vegetables as well as for interstitial packing of walls of ice-chests and ice chambers. If suitable packing material can be obtained from local peats, obviously there is here an efficient substitute for imported cork in packing grapes and other fruits.

In addition, pulverised peats, when of sufficiently long fibre, have been found to be suitable for pulping into cardboard, cloth, paper, rugs, etc., usually with the addition of various substances such as wool. Evidently sedgy peats would be highly suited for such purposes, and a number of these peats are known to occur in Western Australia.

Germany has been long famed for "mud baths" prescribed for rheumatic troubles. These mud baths utilise well-macerated and powdered fine-grained peats. The writer is not qualified to discuss the medicinal or curative properties of peat, and doubtless a medical practitioner is better able to state its value in this direction.

IV. Details of Particular Peat Deposits in Bayswater District.

The writer examined a number of deposits of peat throughout Bayswater district and in most cases it was found that, although peat of excellent quality could in many cases be obtained, the areal extent was not sufficiently great to justify their utilisation for fuel purposes but that in the main they could be used as areas of intensive cultivation or sources of fertiliser and humus for local purposes.

(1.) *Swamp at intersection of Hill Street and King William Street.*—Old residents have informed the writer that about 30 years ago this swamp was completely surrounded by high timber which clothed the slopes of the surrounding sand dunes. Nowadays very few trees are seen, and in consequence the sand would seem to be moving forward over the peaty flat. The value of Bayswater as a residential district would have been much enhanced if the cutting of timber on sand dunes had been restricted or prevented. This swamp was formerly known as Number One Swamp, and nowadays it has a total area of about 3 acres. Samples of the peat were taken and found to be quite suitable for fuel although unsuitable for distillation. Part of the swamp is cultivated and appears to produce excellent truck crops.

The extent of peat in area is small, but its depth in some parts of the swamp would appear to be in excess of 15 feet. With proper drainage and treatment there is no doubt that there is here an area highly suited for intense cultivation and possibly suited also as a source of humus for building up "hungry" soils. Specimen 1/4003A (G.A. 1435/25), collected from the surface of the swamp, was examined by the Government Mineralogist and Analyst, and the following proximate analysis is the result of that examination:—

Proximate Analysis of Air-dried Sample.

Moisture	23.43 per cent.
Volatile matter	43.66 per cent.
Fixed carbon	26.51 per cent.
Ash	6.40 per cent.
	100.00 per cent.

Colour of ash is white with red specks
Nitrogen (N) .. .. 0.95 per cent.

Remarks.—This is a peat of average value for fuel purposes. It is low in nitrogen however, and is not, therefore, suited for distillation; peats for this purpose contain from 2 per cent. to 3 per cent. nitrogen.

It will be noted that the ash content is comparatively low, and if the extent of similar material were greater there would be little doubt of the suitability of utilising this deposit for fuel purposes. Even with the low percentage of nitrogen, the writer feels sure that the deposit is suited as a small reserve for humus purposes and as an area of intense cultivation.

The material obtained in this swamp may be taken as an example of a peat of medium quality, and will serve to refute any insinuation that we have no real peat in Western Australia. When examined under the microscope by the writer it was found to consist of blackish-brown carbonaceous matter derived evidently from plant growth—a deduction made from observation of stringy, fibrous structure in places. In addition spicules of fresh water sponges could be seen, and no diatoms were present.

In this case the peat is formed from such plant growth as bracken, bull-rushes, grasses and various aquatic plants. The swamp is fed by small springs which run from the bottom of surrounding sand ridges, and a creek drains the middle of the valley. Evidently this swamp formed portion of a longer creek running about southeast between sandhills towards the River Swan. Wells on the sand ridges in the immediate vicinity, without exception, proved to go down through somewhat incoherent sandstone or sand with occasional hard layers of "coffee rock" at varying depths. This lends support to the theory of formation of these swamps given by the writer under sections iii. and ii. In most cases the usual spearhead pump is found to be quite sufficient for use in windmill and hand pump wells in the Bayswater district. The height of the swamp would be about 40 feet above sea level.

(2.) *Swamp at intersection of Guildford Road and King William Street.*—This swamp is somewhat irregular in shape, and has an area of about seven acres. The height above sea level is about 20 feet, and there would seem to be here a continuation of the drainage channel referred to under 1. The swamp is now fed by springs arising near the base of the sandridges, and excess water is carried off by drains constructed by the Bayswater Roads Board.

Practically all this swamp has been under cultivation as market gardens and private householder's blocks. Much of it consists simply of windblown sand with an admixture of carbonaceous matter. In places peat to a depth of one foot is found, but in that case the peat is sandy and, on the whole, the area would seem to be suited for intense cultivation only. Close to Slade Street and about six chains from the Guildford Road higher banks of peaty matter are found upon the side of the sandhills rising at that point. This peaty matter is formed from ferns and bracken, and is of no great extent.

Taken as a whole the swamp has the appearance of an old flood plain of the creek which must have meandered along the present site of King William Street in days gone by. The artificial drainage ditch appears to be placed so as to avail itself of the contours of this old creek formation, and ultimately leads into a deep swamp nearer the Swan River and further along King William Street. This lower swamp was absolutely impassable on account of the depth of water, but it would appear to be upon a lower portion of the old clay flood plain of the Swan. Vegetation flourishes in it, and it is likely that peat is here in process of formation. In drier portions near the river bank peaty matter was observed.

(3.) *Swan Lake or "Duck Lake," lying across Garratt Road between the intersections with Murray Street and the railway line.*—Swan Lake, occasionally known as Duck Lake, has an elevation of between 55 feet and 60 feet above sea level. By means of drains it has been partially rid of its stagnant water. The drains are not, however, of sufficient depth to secure proper drainage, as there is a strong inflow of water from springs at the bottom of sand ridges on the north and northwest side of the lake. Upon digging at some points on the north side, the ridges were seen to be incoherent, and indeed in places to be composed of quicksands. Peat has been deposited on the central portion of the lake, and about 25 acres of peat of varying quality occupies that position.

That portion lying on the southwest side of Garratt Road is almost completely utilised for market gardens by Chinese. The peat occurring here has been much cultivated, and is now admixed with sand to some extent. It appears to have a depth of at least 4 feet, and tails off gradually towards the edges of the lake. Excellent results are being obtained in these areas of intensive cultivation, although in the opinion of the writer drainage could be more efficiently done. The Chinese are now adding sand to the peat so as to loosen the soil, but it is not known if they are adding or have added lime to counteract acidity and to keep the soil loose.

The portion northeast of Garratt Road has been partly utilised as householders' building blocks and part, which has not been under cultivation, is enclosed within the Bayswater Roads Board Recreation Ground. Householders have evidently been obtaining good results, and strawberries, tomatoes, beans, peas, cabbages, fruits, flowers, etc., grow excellently and produce fine crops. Here again it is not known if lime has been utilised to sweeten the soil, and it is suspected that far better results would be obtained if this were done.

On the Recreation Ground the Roads Board have had the task of reclaiming the swamp and relevelling equally so as to obtain a grassy park suitable for sports such as football and cricket. A certain amount of shallow ploughing and later harrowing was done, and a drain placed below the surface. The peat apparently was not limed, and it seems likely that drainage will remain a serious problem during winter months. On the surface, sand from adjoining ridges has been spread to a depth of about one foot, and upon this grass has been planted. It still remains to be seen if this experiment will be successful, and the writer would anticipate a greater measure of success if the peat had been properly limed to enable decomposition of the peaty matter to proceed apace, and if small feeder drains had been placed below the surface so as to lead into the main drains.

Upon the Recreation Ground the peat is of a dark-brown colour when wet, and of a greyish-black when dry. It seems to contain a large amount of fine carbonaceous matter, and it has been derived from the usual swamp material, viz., reeds, rushes, fern, bracken, decayed paper-bark, etc. The depth of peat appears to vary, and in some places would seem to be not less than five feet, although at the edges it thins out to quite a superficial covering.

(4.) *Coode Street Lake near Patterson Street.*—This is a fairly extensive lake-swamp that seems to have occupied about 76 acres. It has been drained by large open drains, which appear to fulfil their function fairly well. It is formed by two large portions joined by a narrow neck crossing Coode Street and the longer axis runs about east and west.

The western portion consists in the main of black peaty sand, in which carbonaceous matter has been incorporated with siliceous matter from the surrounding dunes, and patches of heavier peat are to be found also. This portion of the lake was under water to the depth of five feet in places at one time, but drainage ditches have reduced water-level considerably, and now only a few deeper portions hold water for any length of time. The western portion is partly under cultivation as market gardens worked by Chinese and as small dairy farms owned by white settlers. In each case good results seem to be obtained and good crops of cabbages, potatoes, maize, etc., were to be seen at the time of visit.

The eastern portion of the lake lying between Coode Street and Drake Street is largely occupied by Chinese market gardens, and consists of much black carbonaceous sand with a central patch of grayish peat. The black sand would approximate to the American definition of "muck." The peat, on the other hand, seems to be a real peat which, when wet, is dark brown in colour, and when dry a light grey. There is a marked difference in weight when wet and dry, and it burns readily. It is very productive when cultivated, and in the Chinese gardens truck crops thrive well wherever the soil is the result of careful cultivation.

Further east beyond Drake Street extends the extreme eastern portion of the lake terminating in small adjoining lagoons. Messrs. Brookes and Pennell's market garden is situate partly upon the extension of the grey peat deposit, and occupies an area of about five acres. The deposit is irregular, and the depth of peat varies from over four feet in places to nothing on the edges. Apparently no lime has been used in the treatment of this peat, but superphosphate and bonedust have been added in places. Efficient drainage enables the garden to produce pumpkins, beans, celery, cabbage, lettuce, etc., with much success. During the very hot summer months watering by sprinklers is resorted to.

North of this garden there is a small tail of the lake, and in this was found the nearest approach to British peat that has as yet been observed in Western Australia by the writer. This deposit was very small in extent, but seems to be derived largely from a species of moss comparable to the sphagnum mosses of temperate climates. It was much admixed with sand, and appeared to have a depth of a few feet. It was uncultivated.

What would appear to be an extreme eastern extension of the main lake body filled a small depression and formed a small swamp, now under cultivation. In this case the surface material consisted mainly of an impure peaty "muck," the impurities being mainly sand derived from the surrounding ridges. Various flowers (including roses), truck crops, strawberries, etc., were cultivated on it with success.

Although the writer is not of the opinion that the Coode Street Lake has been cultivated in the best way possible, still he has little doubt that it may be cited as a typical example, showing what can be done with similar areas where the surface soil consists largely of impure peaty matter.

A glance at the map would show that contouring would prove the area to be composed of a number of depressions, but there is little doubt that these at one time would form part of a main swampy lake body surrounded by high sand dunes, which have a height up to 160 feet above sea level. The whole area varies in height from about 70 feet to 75 feet above sea level, but peat would appear to occur mainly at the lower elevation of 70 feet. Comparison with height above sea level of other deposits proves the contention that throughout Bayswater district peat does not occur at any fixed level, and that it occurs in the deeper portions of depressions between sand dunes. The writer would estimate that about 10 acres of grey peat occur at the 70 feet level in this lake.

5. *Catherine Street—Coode Street Swamp.*

This swamp occurs on the northwest extension of Coode Street, at its intersection with Catherine Street, and it occupies an area of about 45 acres. In the main, it lies in a depression with a height of about 80 feet above sea level. It has been customary for water to rise to a fair height in this swamp during rainy seasons, but there is no great deposition of peat. In places black peaty matter with much sand occurs and it would probably be better identified as "muck." The bulk of the swamp is black sand, consisting of siliceous particles from the surrounding sand dunes and fine black carbonaceous matter.

There are swampy areas further northwest, along Coode Street, where water rises to two or three feet above the surface level, but in none of those that were examined could peat be found. Nevertheless, it is reported that good crops have been grown there in black sands—wheat to a height of 4½ feet and maize to a height of 8 or 10 feet.

Throughout these areas the so-called "coffee rock" is found in thin lenses at varying depths below the surface—in some cases within a foot of the surface. These lenses would appear to be responsible for the flooding.

6. *Killarney Lake and Swamp.*

This swamp lies between Main Road, Beechboro Road, Langley Road and Drynan Street. Close to Beechboro road, the southeast end of the swamp forms what is known locally as Killarney Lake. The total area of this swamp would be about seven acres of which five acres are excellent peat and the remainder a black sandy loam. The average level of the deposit approximates to 70 feet above sea level.

At the time of examination Killarney Lake was more or less dry except in the centre proper, and it was possible to get samples of peat from the bed of the lake. These consisted in the main of carbonaceous matter derived from the partial disintegration of sedges, reeds and bulrushes. From the shape of the depression, the writer would estimate the peat to have a depth of at least 10 feet in its deeper portions, athough only practical examination by digging could prove this. Careful drainage of this lake should yield a good though small deposit of peat of good quality and highly suited for such agricultural puposes as fertiliser. Taking the method of calculation, given by Osbon, there should be between 1,000 and 1,600 tons of average quality air-dried peat in the body of the lake.

Part of the northeast portion of the swamp is separated from Killarney Lake by a slight elevation. This part has been reclaimed and is included in Shackleton's garden. A considerable amount of work is being done on this block, but the holder seems to be handicapped by want of efficient drainage, as water rises above the surface during the winter months. The peat here is a very heavy, black, combustible peat of high value in intensive cultivation. The introduction of proper pipe leader drains leading into an efficient main exit drain would enhance the value of this portion of the swamp and would be an immense improvement for intense cultivation. In addition, liming with quicklime should be done, as the deposit in its present condition is undoubtedly sour and acidic, and as liming will help to keep the soil loose. Some attempt has been made to conserve soluble nitrogen by growing peas and by digging the shaws and roots into the soil. This should be continued.

The peat itself increases from a film at the edge to more than five feet in the centre of the marsh. This was proved by digging. Although the block has been only a few years under treatment and cultivation, Mr. Shackleton, in spite of inefficient drainage, has had excellent results with rhubarb, peas, beans, lettuce, strawberries, roses, etc., and citrus trees (off the flooded portions.)

The original swamp intervening between Shackleton's and Killarney Lake portions contains excellent peat derived from reeds, bulrushes, sedges, ti-trees, paper bark trees, etc. The whole swamp lies in a depression, receiving water from springs arising at the base of surrounding sand ridges.

7. *King Street-Beechboro Road Swamp.*

In this locality are a number of swamps in which peaty sand occurs. On the southwest side of King Street is a large swamp which has long been successfully cultivated as market gardens by Chinese. The central portion of this swamp consists of about 5 acres of brown peat. Drains carry off excess water towards the Swan River and seem to follow an old drainage basin which doubtless was choked up at various points, thus enabling peat to be deposited.

Following this drainage channel southwards we come to a small swamp with about 4 acres of peat on the north side of the main Eastern Railway line and close to the intersection with the Belmont Branch line. Here the peat is a black compact material containing much woody substance derived from roots. The usual swamp flora contributes to the formation of this peat, viz.: paper-bark trees, ti-trees, reeds, bulrushes, ferns, bracken, grasses and various minor aquatic plants. The depth of peat would appear to be at least 3 feet, and is probably greater in places. The deposit seems to contain less sand than is usual in Bayswater peaty matter, and evidently this formation is due to arrested drainage. Drainage creeks following the surface contours lead on to the deep swamp on King William Street near the river and south of the Guildford Road. At a point close to the intersection of Slade Street and Guildford Road there is a small deposit of peaty material.

On the southwest side of Clune Street there is a sandy swamp of fair size now under cultivation as a dairy farm. It is composed mainly of black carbonaceous sand, and a drainage channel leads on to the main drainage channel discussed above.

On the north side of King Street there is a small patch of sandy swamp consisting of black peaty sand. In the northeastern end of this swamp, on the north of Collier Road, water is held up and the peaty matter increases in content. This swamp is under cultivation and has been utilised for growing such crops as maize.

8. *Hoyne Lake.*

This is a placid sheet of water on the north side of Collier Road near to and west of Grey Street. At time of examination there was about 11 acres of clear, pellucid water, which has a depth towards the middle of the lake of up to about 10 feet. The bottom is peaty and there is a narrow margin of peaty swamp surrounding the lake and showing up in marked contrast to the white sands of the surrounding sand dunes. The lake is fed by springs upon its north side.

9. *Cumming's Lake.*

This is an extensive swampy lake lying near to Hoyne Lake and on the east side of Grey Street. There is a large deposit of peat forming the bed of the lake which is drained in places for use as Chinese gardens. The flora forming the peat consists mainly of tall bulrushes and reeds which cover most of the lake. The lake lies outside the Bayswater Road Board District proper, but as it partly lies within the map its boundaries have been roughly indicated on the map.

From a cursory examination of this deposit, the writer is of the opinion that there may be found here a peat suitable for use in fertiliser. The drainage problem will, however, require some consideration.

10. *Essex Street-Lawrence Street Flat.*

Southwest of Lawrence Street near its intersection with Essex Street there is an extensive flat which apparently is the bed of an old lake. It consists of much peaty sand or "muck" with occasional patches of more peaty material. Evidently this formed an extension of the Coode Street-Patterson Street Lake discussed under 4. This area should not require much drainage, and its "muck" and peat deposits ought to be found suitable for market gardening or other form of intense cultivation.

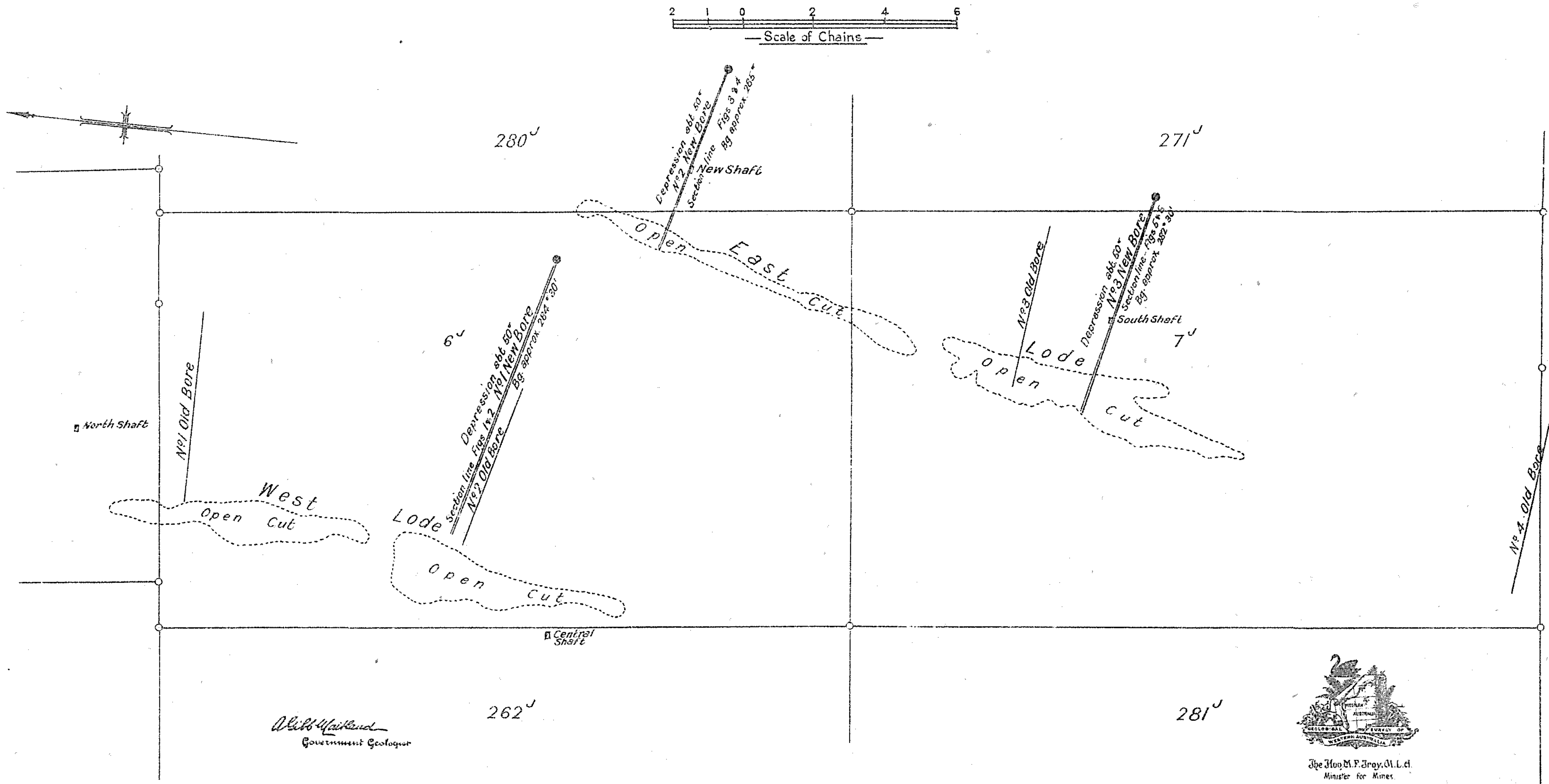
In the description of these deposits selected *supra*, it is recognised that there may be more deposits throughout the Bayswater district. Some of these are indicated on the map. It is hoped, however, that, to save reiteration of general qualities, enough has been said to give a general idea of the properties and possibilities of peat deposits throughout the Coastal Plain of Western Australia.

V. General Conclusions and Future Possibilities.

The subject of peat, both generally from the scientific point of view and particularly in regard to Bayswater, has been discussed at length in this report, and a few words in conclusion are still necessary.

In all the areas examined it was found that, although good peat was undoubtedly present, no single area could be used as a machine-fuel proposition. The areas are in general somewhat too small and scattered to be considered as business propositions. Nevertheless in one or two cases sufficient peat is present to be used as a local source of fuel to be cut by hand and used locally or also as a local source of fertiliser or fertiliser constituent. In addition, with proper drainage, all can be used for the intensive cultivation of truck crops, maize, oats, wheat, roses and other flowers, strawberries, and citrus trees. Of recent years in California it has come to be recognised that peat soil is highly suited for citrus cultivation, but it is obvious that great care has to be taken to see that roots do not go down into a *sour* peat deposit. Some of the purer peats may, after treatment, be used for packing as described in III. 3 c.

PLAN OF LEASES SHEWING POSITIONS OF Nos 1 2 & 3 NEW BORES AS SET DOWN BY THE COMPANY
WILUNA DEVELOPMENT SYNDICATE WILUNA, EAST MURCHISON G.F.



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Minister for Mines

Fred. Wm. Simpson, Government Printer, Perth.

Undoubtedly these peat deposits constitute a potential source of wealth, and with proper treatment and cultivation their value will soon be recognised. The promiscuous burning off of peat swamps cannot be too much deprecated, and it is hoped that measures will be taken to stop this wasteful practice, which is a danger to the community at large. The writer will be well pleased if this report helps to bring about the utilisation of more extensive peat deposits throughout the State.

PETROLOGICAL WORK.

(C. O. G. Larcombe, D.Sc.)

Much time was devoted during the year to a special detailed investigation into the petrology of Wiluna, which involved a close investigation of 2,166 feet of core from the Nos. 1, 2, and 3 new bores put down by the Wiluna Development Syndicate.

The object of the petrological investigation was to work out the underlying principles controlling the geology of the area, and as a result a box containing 20 polished cores has been prepared. These cores will serve as an "index" or "key" to future economic petrological work on rocks from Wiluna. In addition, mineralogical and physical conditions were taken into consideration—especially evidence of dynamic effects— and consequently much light has been thrown on the rock formations, as well as on the nature, origin, occurrence, and economic aspects of the ore bodies on Leases 6J and 7J, held by the Wiluna Development Syndicate.

At the end of July, Perth was visited and an examination was made of the core from the Nos. 1, 2, and 3 bores in the Supreme Court buildings. Material was selected for later petrological investigation. Details of the report made to the Government are attached herewith.

In addition to the numerous duties in the form of discussions with the Government Geologist, field, and other departmental officers, as well as interviews with the public and the supply of information, the result of petrographic investigation, the following may be regarded as a summary of the more important work carried out during the year:—

1. A petrographical investigation into the cores from Nos. 1, 2, and 3 New Bores put down on Leases 6J, 7J, 271J, and 280J by the Wiluna Development Syndicate, Wiluna, East Muchison Goldfield.

2. Petrological report on rocks from the No. 19 level in the Menzies Consolidated Gold Mine, Menzies.

3. Petrological examination of two bores put down at Wiluna by the Mararoa Gold Mining Company.

4. Petrology: Leonard Range, Eastern Division.

5. Boring for Oil, Boddington, South-West Division.

6. Determinations and reports for other departments, as well as for the general public:—

(a) Graphite from Wagin.

(b) Granite from quarry at Parkerville.

(c) Unakite from Gilgarna rock, 20 miles north-east of Kurnalpi, for the Government Mineralogist; and

(d) Leucophyllite schist from Pedamulla Station, for Mr. Blatchford.

I. A Petrological Investigation into the Cores from Nos. 1, 2, and 3 New Bores put down on Leases 6J, 7J, 271J, and 280J by the Wiluna Development Syndicate, Wiluna, East Murchison G.F.

TABLE OF CONTENTS.

1. Introduction.

I first inspected the No. 2 New Bore on 31st July, 1924, in the presence of the State Mining Engineer, Mr. John McDermott and others. I visited Perth on 17th August, 1925, and inspected 2,166 feet of core taken from these three bores, and selected 197 pieces of rock from various depths, viz.: No. 1 Bore, 85 samples; No. 2 Bore, 75 samples; and No. 3 Bore, 37 samples. Fifty-three microscopic sections were examined in connection with this report.

Three bores were put down in a westerly direction as follows:—

No. 1 New Bore: Depth 1,002 feet; inclination from horizontal, 50 degrees; direction of bore, N. 75° W.

No. 2 New Bore. Depth, 544 feet; inclination from horizontal, 50 degrees; direction of bore, N. 75° W.

No. 3 New Bore: Depth 620 feet; inclination from horizontal, 50 degrees; direction of bore, N. 77° W.

A plan, Plate V., is submitted, showing the position of these three bores as well as the open cuts. Plate II. contains sections through No. 1 Bore on a scale of 200 feet to one inch, and Nos. 2 and 3 bores on a scale of 100 feet to one inch, together with enlarged sections on a scale of 20 feet to one inch, showing the distribution of values where the bore passed through the lodes.

2. Geology.

The State geological map indicates that Wiluna is situated in a extensive area of greenstone, surrounded on all sides by granite. This belt of greenstone country is 50 miles wide towards its northern end, where Wiluna is located, and five miles wide towards its southern end.

The examination of core from these three new bores has revealed the fact that the four chief rock formations at Wiluna belong to the same family—even though they are not lithologically the same in every way—as the rocks on the Kalgoorlie goldfield.

The chief rock formations are:—

A. Quartz dolerite greenstone.
B. Fine-grained greenstone ("calc schist.")
C. Felsite (keratophyre?).
D. Porphyrite.

Petrographical investigations indicate that these four rocks at Wiuna have, on account of their inherent physical, structural, chemical, and mineralogical properties, a similar influence on the distribution of the gold, the lines of weakness which control the occurrence, and the ultimate economic aspect of the ore deposits, as the analogous rocks of Kalgoorlie on the ore deposits of the Golden Mile, *e.g.*, the quartz dolerite greenstone makes good ore; so does the calc schist along its line of contact with the quartz dolerite greenstone. But more information is yet required to be certain about the behaviour at depth of the lodes in the "calc schist" away from the contact zone, such as in the No. 1 deep bore, beneath the western lode. The ore in the felsite (keratophyre ?) has not yet proved to be satisfactory, while the porphyrite does not carry payable values. However, experience has shown that in those places in Western Australia where earth forces have been sufficiently powerful to form a well-defined shear channel, and the auriferous solutions have been present in sufficient quantities, and under suitable conditions, ore deposits will form.

A. *Quartz dolerite greenstone.*

This is a compact, dense, pale green to dark green rock, presenting a somewhat mottled appearance. It is characterised by (a) abundant glassy pseudo-phenocrysts of quartz, (b) patches of dirty gray dull leucoxene—well seen on wetted surfaces, and (c) small patches of dark green, almost black, chorite.

Under the microscope the mineral constituents are: Quartz, plagioclase felspar, carbonates, chlorite, leucoxene, sericite, a little apatite, and occasional grains of iron pyrites. The quartz, which contains dust-like inclusions and exhibits shadowy extinction in places, is much in evidence. It is cracked and in part replaced by carbonates. The plagioclase is greatly altered. All the original ilmenite has practically been converted into whitish leucoxene. The rest of the rock has been broken down into an indefinite mixture of carbonates and chlorite with a little sericite. In places the quartz dolerite greenstone is bleached—a common feature in Western Australian greenstones. The bleached form is much paler, almost whitish-gray in colour. The leaching is due to increased carbonation, sericitisation, and sometimes the introduction of pyrites. Micropegmatitic patches are common. The quartz dolerite greenstone is continuous in the No. 2 Bore from the surface to 471 feet, at which point it is replaced by calc schist. In the No. 3 Bore it continues from the surface to 356 feet and contains the main lode formation. It is not present in the No. 1 Bore, which is evidently too far to the west.

B. *Fine-grained greenstone ("calc schist.")**

This rock is best seen in the core from the No. 1 Bore, which is almost entirely within it. It is also present from 471 to 544 feet in the No. 2 Bore and from 386 to 620 feet in the No. 3 Bore.

The fine-grained greenstone is not constant in physical appearance, but for the most part it is a dense, compact, felsitic looking rock of an ash-gray to greenish-gray and slaty colour. In some places it is dark green—the greenstone type. This rock possesses three distinctive features, viz.: (a) minute acicular cracks, (b) a "feathery" texture, and (c) in places a spotted appearance, due to the dissemination of black patches of chlorite. Under the microscope the rock is for the most part a dense mass of carbonates and chlorite. The curious colourless lines and "feathery" textures are in many places a feature of the rock. The patches of green chlorite are quite distinctive. Veins of carbonate—with a little chlorite—frequently traverse the rock.

C. *Felsite (keratophyre?).*

This rock was met with in the No. 3 Bore, between 358 and 386 feet. It was not seen in either the No. 2 Bore or the No. 1 Bore. It evidently forms an old dyke, about 18 feet wide. It was certainly in existence before the ore bodies were formed.

In hand specimens it might easily be mistaken for the calc schist. It is a compact, dense, pale brown to pale gray or ash coloured felsitic rock, with a somewhat resinous-looking lustre. Specimens from 372 feet show small glistening laths of felspar. The rock is pyritic throughout, traversed by small veinlets of carbonates, and contains small values.

Under the microscope the freshest specimens are made up of a plexus of small plagioclase laths lying in all directions. These laths are separated by indefinite carbonated material. The rock has suffered dynamic action, and small sheared lines are filled with colourless sericite. The felspars are carbonated, kaolinised, and sericitised.

D. *Porphyrite.*

This rock was met with in the No. 1 Bore between 971 and 1,002 feet. In hand specimens it is a dense, soft, greenish-gray rock with distinct rectilinear white phenocrysts.

Under the microscope it consists of decomposed, rectilinear plagioclase phenocrysts set in a base of felspar microlites and chlorite. So far as assayed it does not carry any gold.

3. Description of No. 1 New Bore.

General Remarks.—This bore reached a total depth of 1,002 feet along the incline, or a vertical depth† of 767 feet.

Detailed microscopic investigation shows the rocks met within this bore, and the depth drilled, to be as follows:—

Depth drilled (in feet).	Nature of Rock.
0—185	Rotten decomposed greenstone.
185	Bottom of zone of oxidation (weathering).
185—970	Fine-grained greenstone "calc schist" in various stages of alteration.
970—1,002	Porphyrite.

* The term "calc schist" is used in the same sense as Dr. Maclaren used it at Kalgoorlie. † Assuming that there was no deflection.

DIAGRAMMATIC REPRESENTATION OF COUNTRY ROCK, AURIFEROUS ZONES & LODESTUFF

(as determined by petrological investigation)

PASSED THROUGH IN THE Nos 1.2 & 3 NEW BORES PUT DOWN BY THE WILUNA DEVELOPMENT SYNDICATE ON G.M.L. 6J, 7J, 271J, 280J AT WILUNA, W.A.

Quartz dolerite greenstone · Fine grained greenstone (Calc schist) · Keratophyre (felsite) dyke · Surface soil · Lodestuff (in Quartz dolerite greenstone) · Lodestuff (in Fine grained greenstone) · Low grade (L 4dwt.) material

Note:- Values are expressed in dwts. per ton & in shillings per ton of ore as determined by the Mine authorities & by the Government.

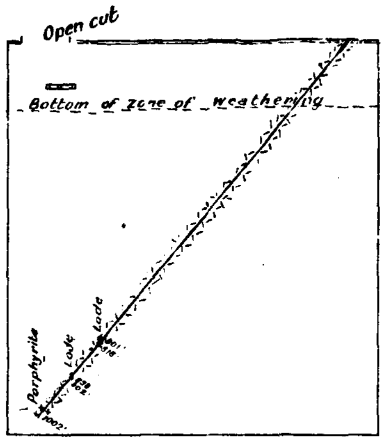

Figure 1
Geological Section through No 1 New Bore

Scale 0 100 200 Feet

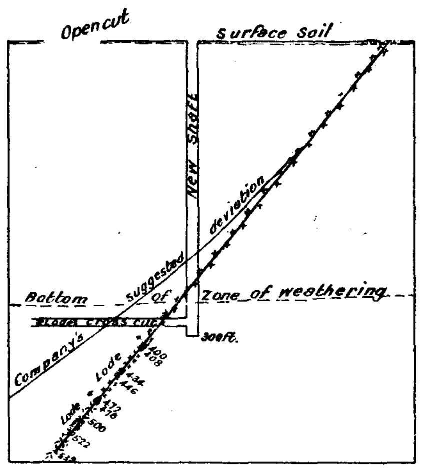

Figure 3
Geological Section through No 2 New Bore

Scale 0 50 100 Feet

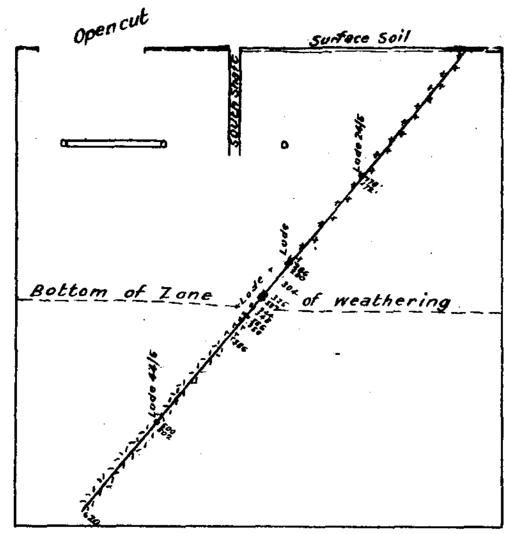

Figure 5
Geological Section through No 3 New Bore.

Scale 0 50 100 Feet

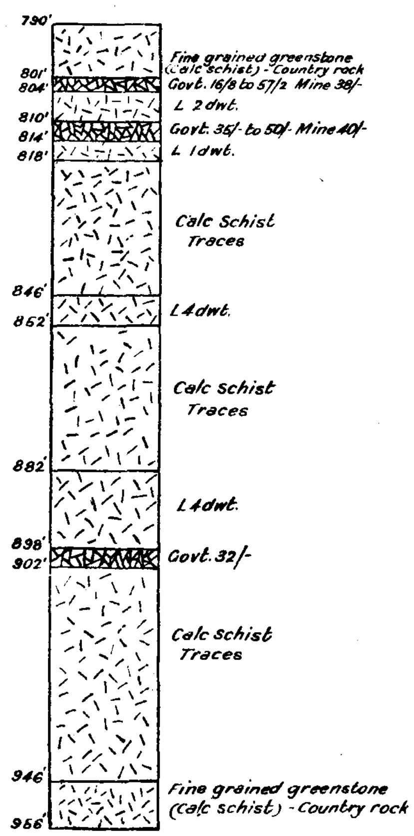

Figure 2.
Enlarged diagrammatic section of core between depths of 790 feet and 956 feet showing distribution of values in No 1 New Bore

Scales
Vertical 0 10 20 Feet
Horizontal 0 ½ 1 Inch

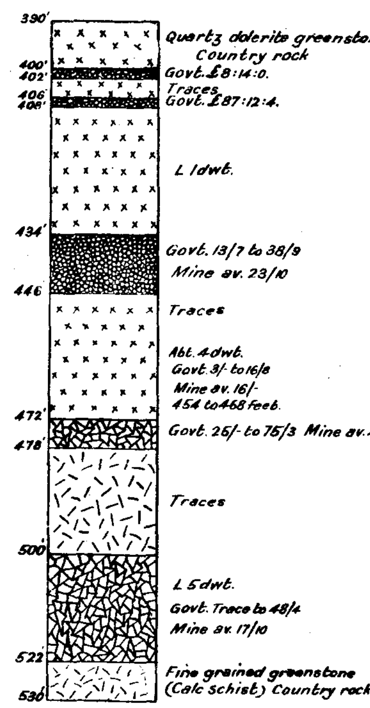

Figure 4
Enlarged diagrammatic section of core between depths of 390 feet and 530 feet showing distribution of values in No 2 New Bore

Scales
Vertical 0 10 20 Feet
Horizontal 0 ½ 1 Inch

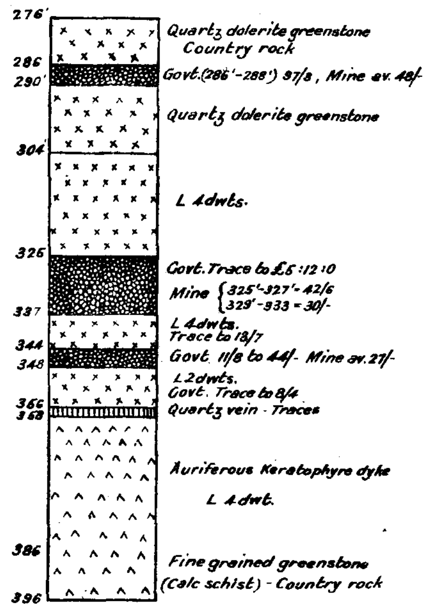

Figure 6
Enlarged diagrammatic section of core between depths of 276 feet and 396 feet showing distribution of values in No 3 New Bore

Scales
Vertical 0 10 20 Feet
Horizontal 0 ½ 1 Inch

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Minister for Mines.

Distribution of Values.—The cross section, Fig. 2, Plate VI., shows the distribution of the values indicated in the following table:—

Depth in Bore (in feet).	Inclined distance (in feet).	Horizontal distance (in feet).	Value, per ton. Government: 2,240lbs. Mine: 2,000lbs.
801—804 (801′ 5″—804′ 6″	3	2	Govt.: 801′ 5″ to 804′ 6″, 16/8 to £2 17s. 2d. Mine average: 801′ to 804′ 38/–.
804—810 (804′ 6″—810′)	6	3·8	L. 2 dwt.
810—814	4	2·6	Govt.: 34/11 to 50/3. Mine average: 40/–.
814—818	4	2·6	L. 1 dwt.
818—846	28	18·0	Traces.
846—852	6	3·8	L. 4 dwt.
852 882	30	19·3	Traces.
882—898	16	10·3	L. 4 dwt.
898—902	4	2·6	Govt.: 32/–. Mine: 29/9.
Total ...	101	65·0	

The rock was first assayed from a depth of 540 feet. No values of any account were encountered till 801 feet 5 inches.

It will be seen from the above table that the area over which gold has been distributed extends from 801 feet 5 inches to 902 feet, a distance of 100 feet 7 inches along the direction of inclination of bore, or a horizontal width of 65 feet. But throughout this horizontal width of 65 feet there is only 7.2 feet of ore, split up into widths of 2 feet, 2.6 feet, and 2.6 feet respectively, none of which will average more than 40s. per ton.

Rock formations.—Practically the whole of No. 1 New Bore was in fine-grained greenstone ("calc schist"), with the exception of 32 feet of porphyrite between 970 and 1,002 feet. The bore ended in porphyrite.

Sheared lines.—At 796 feet there is evidence of fracturing and shearing. Between 801 and 814 feet the rock is distinctly silicified and fractured. A powerful schisted line was noted at 808 feet, and at 810 feet there is a strong chloritic sheared line.

4. Description of No. 2 Bore.

General Remarks.—This bore reached a total depth of 544 feet along the incline, or a vertical depth of 410 feet, *i.e.* assuming an inclination of 47 degrees to 300 feet and 51½ degrees from 300 to 544 feet.

The rocks met with in this bore, and the depths drilled, are as follows:—

Depth drilled (in feet).	Nature of the rock.
0—383	Rotten pinkish to whitish decomposed mottled quartz dolerite greenstone.
383	Bottom of zone of oxidation (weathering).
383—471	Quartz dolerite greenstone with lode material as shown in Figs. 3 and 4, Plate VI.
471—544	"Calc schist" with lode material as shown in Figs. 3 and 4, Plate VI.

Distribution of Values.

The cross section, Fig. 4, Plate VI., shows the distribution of values indicated in the following table:—

Depth in Bore (in feet).	Inclined distance (in feet).	Horizontal distance (in feet).	Value, per ton. Government: 2,240lbs. Mine: 2,000lbs.
400—402 (402′ 2″—402′ 2″)	2	1·3	Govt.: £8 14s 0d. Mine: £8 19s. 3d.
402—406	4	2·6	Traces.
406—408 (406′ 2″—408′ 2″)	2	1·3	Govt.: £87 12s. 4d. Mine: £89 11s. 0d.
408—434	26	16·7	L. 1 dwt.
434—446	12	7·7	Govt.: 13/7 to 38/9. Mine average: 23/10.
446—454	8	5·0	L. 1 dwt.
454—472	18	11·6	Govt.: 3/– to 16/8. Mine average: 454′ to 468′ 16/–. About 4 dwt.
472—478	6	3·8	Govt.: 25/– to 75/3. Mine average: 46/–.
478—500	22	14·0	Traces.
500—522	22	14·0	Govt.: Traces to 48/4. Mine average: 17/10.
Total ...	122	78·0	

The assays were first commenced on rock taken from a depth of 392 feet 2 inches in the bore. No values were then encountered till a depth of 400 feet 2 inches. From this point, as shown in the above table and in the cross section, Fig. 4, Plate VI., values occurred intermittently to a depth of 522 feet, below which to the end of the bore at 544 feet nothing more than traces were recorded.

The values in the bore ranged from traces to £87 12s. 4d. per ton. The crosscut put out from the main shaft at a vertical depth of 290 feet passed through (according to the Company) 42 feet of lodestuff of an average value of 39s. 6d. per ton.

The distribution of gold-bearing rock extends over an inclined distance of 122 feet or a horizontal distance of 78 feet. Over this distance of 122 feet assays indicate that 60 feet of rock contained less than 1 dwt. per ton, and 18 feet less than 5 dwts. per ton. The lodestuff indicated in the bore as occurring between 500 and 522 feet does not appear to have been cut in the crosscut.

Figures 3 and 4 of Plate VI. show that the auriferous solutions were extensive enough to make lodestuff in both the quartz dolerite greenstone and the calc schist. The lodestuff in the calc schist, along its immediate line of contact with the quartz dolerite greenstone, makes just as rich ore as the best average in the quartz dolerite greenstone. But away from the quartz dolerite greenstone, *e.g.*, between 500 and 522 feet, the ore is set down as averaging 17s. 10d. per ton.

The high values appear to be confined to very limited zones, controlled by small shear planes and sheeted lines, where there has been a concentration of the gold. In the matter of bulking the ore a great deal will depend on the number and distribution of these lines of enrichment, because the calc schist and quartz dolerite greenstone are so dense that replacement takes place with some difficulty away from the lines of sheeting and shattering, and it is not easy to bring about a sufficient coalescence of ore particles to make large payable ore bodies.

Rock formations.—Only two rocks were met with in this bore, viz., quartz dolerite greenstone and fine-grained greenstone ("calc schist"). The quartz dolerite greenstone is normally dark green in colour and very compact, though in places it has been much bleached. The fine-grained greenstone is mostly of the calc-schist type, a dense, grayish bleached form with numerous minute fractures and "feathery" textures. In places it is decidedly greenish with black patches of chlorite.

5. Description of No. 3 New Bore.

General Remarks.—This bore reached a total depth of 620 feet along the incline, or a vertical depth of 475 feet. The rocks met with in the bore, and the depths drilled, are as follows:—

Depth drilled (in feet).	Nature of the rock.
0—340	Brownish-red decomposed greenstone, somewhat hardened and greenish in places, with values from 170 to 172 feet and from 286 to 340 feet.
340	Bottom of zone of oxidation (weathering).
340—356	Quartz dolerite greenstone, with values.
356—358	White quartz vein.
358—386	Intrusive dyke of dense pale brownish pyritic felsite (keratophyre), with values.
386—620	Fine-grained greenstone ("calc schist"), showing between 500 and 502 feet ore worth 44/5 per ton.

The geological section, Fig. 5, Plate VI., shows the above distribution of rock formations.

Distribution of values.—The cross section, Fig. 6, Plate VI., shows the distribution of values indicated in the following table:—

Depth in Bore (in feet).	Inclined distance (in feet).	Horizontal distance (in feet).	Value, per ton. Government: 2,240lbs. Mine: 2,000lbs.
170—172	2	1·3	Govt.: 24/5. Mines: 25/6.
286—290	4	2·6	Govt.: 286′ to 288′, £4 17s. 3d. Mines average: 286′ to 290′, 48/-.
290—304	14	9·0	Rock: traces.
304—325	21	13·5	L. 4dwt. Govt.: Nil to 18/11. Mine: Traces to 17/-.
325—337	12	7·7	Govt.: Traces to £5 11s. 11d. Mine: Traces to £5 12s. 2d. Mine average: 325′—327′, 42/6. 329′—333′, 30/-. 334′ 10″—336′ 10″, £5 12s. 2d.
337—344	7	5·0	L. 4dwt. Govt.: 6d. to 13/7. Mine: Traces to 14/5.
344—348	4	2·6	Govt.: 11/8 to 44/5. Mine: 12/9 to 41/7. Mine average: 27/-.
348—356	8	5·0	L. 2dwt. Govt.: Traces to 8/4. Mine: Traces to 7/8.
356—358	2	1·3	Quartz vein: trace.
358—386	28	18·0	L. 4dwt. Govt.: 11d. to 17/-. Mine: Traces to 18/8.
Total, 286—386	100	64·7	
500—502	2	1·3	Govt.: 44/5. Mine: 42/6.

The assaying was first commenced on rock from a depth of 131 feet. Nothing but traces (with one assay of 8s. 8d. per ton between 163 feet 1 inch and 164 feet) was obtained till a depth of 170 feet was reached. From 170 to 172 feet the ore assayed 44s. 5d. per ton. From 172 to 286 feet nothing more than traces were obtained.

Values, as indicated in the above table and diagrammatically represented in Fig. 6 of Plate VI., were obtained between 286 feet and 386 feet. The highest assay was £5 11s. 11d. per ton between 334 feet 10 inches and 336 feet 10 inches. From 386 feet to 620 feet, the end of the bore, no assays worth mentioning were recorded, with the exception of an assay of 44s. 5d. per ton between 500 feet and 502 feet.

Between 286 and 340 feet the lodestuff was all in decomposed rotten rock from the zone of oxidation.

At 356 feet a 2 feet wide quartz vein was cut.

From 358 feet to 386 feet the rock in the bore consisted of a dense brown pyritic felsite—evidently a keratophyre dyke of intrusive origin. This dyke is auriferous throughout, but it nowhere carried values greater than 17s. per ton.

Rock formations.—Three rocks were met with in this bore, viz,: quartz dolerite greenstone, felsite (keratophyre?), and a fine-grained greenstone ("calc schist"). The bulk of the quartz dolerite greenstone is highly decomposed; it carries the lode between 286 and 356 feet. A little dark green fresh quartz dolerite greenstone was noted between 340 and 356 feet. The felsite (keratophyre?) is a dense brown fine-grained rock. It is evidently a dyke rock—pre-gold in origin, and therefore older in age than the lode formations. Throughout its 27 feet in the bore it is pyritic, more or less fractured with veinlets of quartz, and contains an average of less than 4 dwts. of gold to the ton. The fine-grained greenstone changes somewhat in physical appearance. For the most part it is the usual dark gray "calc schist" type, with minute fractures and curious feathery textures. In some places it is strongly bleached and somewhat pyritic; in other places it is a typical soft chloritic greenstone.

6. The Ore Deposits.

A. *Classification and mode of occurrence.*

All the ore bodies on Leases 6J and 7J may be regarded as lode formations, *i.e.* more or less vertical zones of rock that gradually merge into the surrounding rock, which is of similar origin but distinct from it in carrying metallic ores disseminated through it in payable quantites.

As a result of the circulation of siliceous, carbonated, sulphide-bearing solutions, auriferous deposits have formed in the rocks; but these deposits seldom have any definite horizontal boundaries, except those determined by a decrease in the assay value of the rock.

The eastern lode, on which the new shaft has been put down to 300 feet, has formed along a contact zone of shattering and sheeting between quartz dolerite greenstone and calc schist. In the No. 3 New Bore the western wall of this lode is occupied by a pyritic felsite dyke 18 feet wide.

The western lode is entirely in calc schist. So far as can be determined by the No. 1 Bore, this lode, between 801 and 902 feet, has been split up into two channels: an easterly one 8½ feet wide, and 54 feet to the west, a westerly lode 2.6 feet wide. This western lode has been formed by the replacement of calc schist along sheared and somewhat shattered lines.

The lode formations occur in three rock formations, viz.: (a) quartz dolerite greenstone, (b) calc shist, and (c) felsite (keratophyre?).

(a) *Lodes in quartz dolerite greenstone.*—The typical lodestuff in quartz dolerite greenstone may be seen in the No. 2 Bore between 434 and 446 feet. The very high values, viz., £8 14s. per ton between 400 feet 2 inches and 402 feet 2 inches, and £87 12s. 4d. per ton between 406 feet 2 inches and 408 feet 2 inches, came from the lode stuff in quartz dolerite greenstone.

In hand specimens the ore in quartz dolerite greenstone has the appearance of pale grey pyritic (iron and arsenical) lodestuff. It gives no clue as to its origin. The iron pyrites is irregularly distributed in small grains—in part crystallised. The mispickel is also in shapeless grains, but it is frequently in small needle-like crystals. In places the sulphides are more or less aggregated into patches.

Under the microscope the lodestuff is seen to contain the following minerals: Quartz, felspar (plagioclase), carbonates of lime and magnesia, sericite, leucoxene, a little chlorite, occasional rods of apatite, iron pyrites, and mispickel. The iron pyrites is in very small grains; the mispickel is also granular, but it often occurs in needle-like forms. Both sulphide and sulph-arsenide show a strong tendency to replace the white leucoxene—important evidence of metasomatism. There is a tendency for these two minerals to arrange themselves along minute shears and cracks; in fact, wherever there is a line of weakness the sulphides segregate. Carbonates of lime and magnesia are abundant; they occur in shapeless patches and grains all through the rock—thus indicating that carbonation was an important process. Much of the original quartz has been broken up into "archipelagoes." There is not excessive secondary silicification, but secondarily introduced mosaics of quartz were observed in patches in the vicinity of shear tracks or lines of weakness. Relict micropegmatitic textures were noted. Some slides showed a good deal of sericite. Chlorite is quite subordinate. The aforegoing facts afford positive proof of the metasomatic origin of the ore.

(b) *Lodes in calc schist.*—The typical lodestuff in calc shist may be seen in the ore from 473 feet in the No. 2 New Bore and in ore from 811 and 899 feet respectively in the No. 1 New Bore.

In the eastern lode, along the contact zone, the calc schist lodestuff has been, in places, intensely silicified. In hand specimens it is a dense gray flinty rock with small patches of carbonates and glassy quartz, and contains pyritic carbonate veinlets. The whole rock is impregnated with fine-grained pyrites.

Under the microscope it consists of an exceedingly dense microcrystalline aggregate of carbonates and quartz, impregnated with fine-grained pyrites, collected in places into patches. Veinlets of pure carbonates are common.

This intensely silicified flinty form is not the common type of ore. The typical ore is usually a dense, felsitic, pale olive green rock, somewhat silicified, traversed mainly by carbonate and some quartz veinlets, and impregnated with fine-grained pyrites and some mispickel. The ore in places is riddled with carbonate veinlets. Minute cracks and a curious feathery texture are typical features.

On the western lode in the bore at 811 feet the rock is dense, siliceous and flinty, with patches of pale olive-green calc schist impregnated with fine-grained pyrites. At 899 feet the rock is more chloritic. Along the western lode at these depths the ore is so shattered and cut up by carbonate veinlets as to form a pyritic calc schist breccia. The residual patches of calc schist are very heavily impregnated and replaced by iron pyrites.

(c) *Lodes in felsite* (*keratophyre*).—This ore is not easily identified, and may be taken for lodestuff in the calc schist. For the most part it is a pale brownish to pale gray felsitic rock with a somewhat resinous lustre. At 380 feet in the No. 3 Bore minute glistening plagioclase phenocrysts may be seen. The rock is pyritic throughout.

Under the microscope it is a more or less turbid mass made up of somewhat kaolinised, carbonated and sericitised plagioclase surrounded by carbonated material. Quartz is quite subordinate. Carbonate and some quartz veinlets are not uncommon. The pyrites is apparently for the most part of secondary origin, introduced contemporaneously with the gold-bearing solutions.

B. *Chemical and mineralogical constitution of ore in the East Lode.*—The lodestuff in the quartz dolerite greenstone is made up of the following minerals: Quartz, felspar (plagioclase), carbonates (calcite and dolomite), sericite (secondary mica), leucoxene, some chlorite, a little apatite, iron pyrites, mispickel, and very rarely free gold.

The following table has been prepared from interesting analyses of Dr. E. S. Simpson, Government Mineralogist and Analyst, coupled with petrological examination:—

Depth in bore (in feet).	Gold contents (per ton).	Percentage of iron pyrites	Percentage of mispickel.
Lodestuff in quartz dolerite greenstone—			
400′ 2″—402′ 2″	40dwt. 23gr.	3·89	2·06
406′ 2″—410′ 2″	206dwt. 20gr.	1·46	·89
434′—440′	5dwt. 8gr.	2·77	1·22
442′—446′	6dwt. 12gr.	4·82	3·50
Average ...	...	3·23	1·92
Lodestuff in calc schist—			
472′—478′	9dwt. 21gr.	3·09	2·47
500′—508′	3dwt. 5gr.	2·88	·93
512′—522′	4dwt. 21gr.	4·13	2·56
Average ...	...	3·37	1·98

These tables reveal the interesting fact that the percentages of iron pyrites and of mispickel are about the same in both quartz dolerite greenstone and calc schist.

Dr. Simpson submitted the following analysis—evidently of lodestuff in the calc schist—of ore taken from the No. 2 Bore between 472 and 478 feet.

SiO_2	49·92
Al_2O_3	4·98
Fe_2O_3	3·26
FeO	7·04
MnO	·23
MgO	7·90
CaO	6·50
Na_2O	1·66
K_2O	·50
H_2O —	·28
H_2O + ...	2·25
TiO_2	·48
CO_2	9·46
P_2O_5	·08
Fe	2·32
Cu	traces
Sb	*Nil*
As	1·14
S	2·14
	100·14

Gold, 9 dwt. 21gr. per ton.
Mispickel (FeSAs), 2·48.
Iron pyrites (Fe S_2), 3·09

There is considerable resemblance between the above analysis and the analysis of ore from the Oroya shoot at Kalgoorlie. The magnesia is certainly higher, and potash considerably lower—owing to the much smaller amount of secondary sericite in the Wiluna ore—than the Kalgoorlie calc schist ore. The absence of antimony is satisfactory.

C. *Origin of the Lodestuff*:

The ore, both in the quartz dolerite greenstone and in the calc schist, has been formed by a process of metasomatic replacement, *i.e.*, a gradual molecular substitution of one complex substance (calc schist) or heterogenous aggregate of minerals (quartz dolerite greenstone) for another, viz., ore.

The auriferous sulphide-bearing solutions penetrated these rocks along a contact zone of shattering. Every line of weakness—such as pores, joints, cracks, small shear and other tracks, and lines of sheeting—were taken to advantage of as a starting point of attack for the processes of replacement (metasomatism), and the subsequent growth of lodestuff, by the coalescence of particles of ore as they formed.

The greater the coalescence, the greater the integral mass, and consequently the size of the ore body. In auriferous zones of this nature, many factors might interfere with the growth of the ore. The process of replacement might be arrested at any stage, either through lack of further supply of solutions or through the final neutralisation of all the chemically active agents present in the circulating waters. But structural features were probably the determining factors in controlling the amount of ore formed, rather than lack of auriferous solutions.

The mode of origin just described accounts well for the observed facts regarding the distribution of values and their rapid variation from point to point. Nevertheless, this mode of origin has much to do with controlling the tonnage of payable ore available. Consequently, too much attention cannot be paid to the structural features in the ore channel, particularly in so far as they affect the distribution of values, for information of this kind will facilitate bulking of the ore and treatment of the lowest grade that will show a profit, so as to enable advantage to be taken of the enormous tonnages available in these auriferous zones.

D. *General Remarks and comparison with gold deposits at Kalgoorlie*: In so far as mode of origin by processes of metasomatic replacement is concerned, there is very little difference between the ore at Wiluna and the ore from the large mines at Kalgoorlie.

The ultimate chemical composition after replacement, as shown by the analysis quoted, is very similar to the lodestuff in the calc schist at Kalgoorlie. The Kalgoorlie ore has no arsenic, and the Wiluna ore has no tellurium. The tables showing values and percentages of sulphides in the lodestuff indicate that the ore in the calc schist, along its line of contact with the quartz dolerite greenstone, is just as rich as the ore in the quartz dolerite greenstone. It remains to be seen how the lodes in the calc schist (*e.g.*, the western lode) behave in depth away from the line of contact.

The chief rocks replaced at Wiluna were quartz dolerite greenstone and calc schist. Both these rocks belong to the same family as those at Kalgoorlie, but the quartz dolerite greenstone is not quite the same.

It cannot so far be said that the wonderful vein systems, sheeting, shearing, and in places schisting, that are features at Kalgoorlie, are present at Wiluna.

7. Summary of Petrographical Investigations:

The detailed petrographical, mineralogical and physical investigations have thrown much light on the rock formations and the nature, origin, occurrence, and economic aspect of the ore bodies on Leases 6J and 7J, held by the Wiluna Development Syndicate. A general summary of these investigations may be set down as follows:—

1. Petrographical investigations into the origin of the ore, coupled with a study of the distribution of the gold, indicate that the inherent nature of the rock, and its physical and mineralogical contents, determined its ability to bring about such metasomatic replacement and segregation as caused the formation of areas, patches, lenses, or zones of ore.

2. The growth of the ore was further controlled by (a) the main line of contact and weakness between the quartz dolerite, greenstone and the calc schist; (b) the position of the main shear track or tracks; and (c) the distribution of lines of sheeting, and the extent of fracturing and shattering.

3. An examination of Figs. 2, 4, and 6 of Plate VI. will show that the factors mentioned in (1) and (2) determined the distribution of payable values. These figures indicate clearly (a) the rapid change in values from point to point, (b) the dependence of enrichment on small shear lines, fractures and other physical features, and (c) the great width of the auriferous zones, throughout which values are quite erratically distributed.

4. The ore formed by processes of metasomatism under great difficulties, viz., mainly by the spread of siliceous replacement, carbonation, and pyritification, through the medium of very minute pores, fractures, sheeted lines, joints, and small shear tracks.

5. In consequence of its peculiar mode of origin, and the absence of more open spaces of discission or control lines, the payable ore was of necessity very erratically distributed in lenses, zones, streaks, and patches, the extent of which cannot yet be determined.

6. There is evidence of strong shear lines at considerable depth. Strong shear lines and distinct indications of shattering were noticed in the middle of dense calc schist in the core from the No. 1 Bore at

depths of 808 and 810 feet along the incline (about 620 feet vertical depth). This is a hopeful sign, more particularly as the line of weakness along the junction of the quartz dolerite greenstone and calc schists should be prone to shearing and shattering at great depths.

7. Petrographical study, coupled with an examination of the distribution of values, indicates an important feature in the ore occurrence at Wiluna, viz., the great width of the auriferous zone over which gold has been distributed.

The auriferous zone in the eastern lode at a vertical depth of 290 feet is 78 feet wide, as indicated by the No. 2 New Bore. On account of the inclination of the bore (51½ degrees depression) the thickness of rock passed through was 122 feet, but about half of it (60 feet) is split up into four zones of 4, 26, 8, and 22 feet respectively, each of which assayed less than 1 dwt. of gold per ton, as shown in Fig 4, Plate VI. Eight hundred and forty-five (845) feet south, as indicated in No. 3 Bore, the maximum horizontal width at the same vertical depth (290 feet), inclusive of 18 feet of the felsite dyke, is 65 feet. The thickness of rock passed through along the inclination (50 degrees) of the bore was 100 feet, but here again 80 feet out of the 100 is split up into six zones of 14, 27, 7, 8, 2, and 28 feet respectively, each of which assayed less than 4 dwts. per ton. It will thus be seen that the values over the greater width of these auriferous zones are low (less than 4 dwt.) rather than high.

8. Petrographical investigation of No. 1 New Bore gives somewhat vague information about the western lode. It is difficult to say, until a survey has been made, where this bore is at an inclined depth of 1,002 feet (vertical 767) and whether it has passed completely through the western lode, though the presence of porphyrite at the bottom suggests that it has. This bore appears to have been commenced too far to the eastward. Microscopic examination proved the No. 1 New Bore to be entirely in calc schist, with the exception of 32 feet of porphyrite at the bottom. Only three lodes, 3, 4, and 4 feet wide respectively, were met with at inclined depths of 801, 810 and 898 feet. As shown in Fig. 2, Plate VI., not one of these three lodes averaged more than 40s. per ton.

9. The microscope revealed the presence of a large dyke (18 feet wide) of felsite on the western side of the eastern lode at 280 feet in vertical depth, as shown in Fig. 5, Plate VI. This dyke was not met with in the other two bores, and its strike and disposition are therefore indefinite. The felsite is older than the lodes, and, though impregnated with iron pyrites, its physical features make it doubtful whether it will pay to mine it as ore.

8. Conclusions and Recommendations.

The general result of the examination indicates that the ore bodies on Leases 6J and 7J are large low-grade deposits, with no specific signs of secondary enrichment such as prevailed at Kalgoorlie. The wonderful series of vein systems, sheeting, shearing, and in places schisting, that form a feature of the Kalgoorlie goldfield are absent at Wiluna.

Figures 1 to 6 on Plate VI. show clearly the remarkable and rapid change in values from point to point, and the intermixing of wide patches of rock assaying only traces, with ore worth about 40 shillings per ton.

The mode of origin of the ore, and the absence of prominent spaces of discission, make it appear as if it will be an uphill fight all the time to bulk the ore to an average payable value and to make profitable use of the large tonnages available in these wide auriferous zones.

Notwithstanding the numerous low-grade zones, totalling 60 feet, assaying less than 1 dwt. per ton, out of 122 feet of rock passed through in the No. 2 New Bore, and 80 feet assaying less than 4 dwt. per ton out of 100 feet of rock passed through in the No. 3 Bore, the Company sank the new shaft 290 feet and put out a cross-cut which passed through ore that they estimate to be worth 39s. 6d. per ton over a width of 42 feet.

For this reason alone it is essential, and of the greatest importance, that the 290ft. level should be opened up in a southerly direction in order to gain more definite information regarding what width of rock can safely be bulked and a profit made from the 850 feet of rock between the new shaft and the south shaft. The extension of the lode could also be tested in a northerly direction. In this way valuable information would be gained as to the nature of the lenses and the possible position and number of sheeted or sheared tracks that caused in places the increased values. A certain amount of winzing would also be helpful.

The information so far gained about the western *lode is not encouraging. Only three small lodes,* each less than three feet wide, and not one of them averaging more than 40s. per ton, were met with between 800 and 902 feet. Two of these three lodes are separated by 54 feet of unpayable rock.

It may be the fault of the No. 1 Bore; if not, then the indications are that there has been a considerable splitting up of the western lode inside a vertical depth of less than 700 feet.

Much information would be gained by (a) sinking the central shaft another 100 feet to 300 feet and testing the west lode; (b) cross-cutting westward from the 200ft. level in the new shaft; or (c) cross-cutting about half-way across to the west lode from the 290ft. level of the new shaft and test by means of depressed bores the value and nature of both the east and the west lodes between 600 and 700 feet in vertical depth.

The felsite dyke cannot be regarded as payable ore. More information is required about the strike, disposition, and extent of this dyke and the possibility of it containing payable values.

There is no doubt as to the deep-seated origin and primary nature of the ore; there are also indications that the shear or fault lines will probably live below 1,000 feet. But the mode of formation of the ore, and the absence of well-defined spaces of dicission or schisting, such as are found in some ore channels, make it necessary that a lot more information must be gained by further development before it can be said that these ore bodies will make a big mine that will yield large tonnages—not less than 20,000 tons a month—of payable ore.

Through the courtesy of Mr. Vail I visited Wiluna during the year by motor car. Advantage was taken of the opportunity to make notes of the country passed through, and in this way I was able to prepare a rough geological reconnaissance of the area. As a result of these observations, a diagrammatic sketch section was drawn of the country between Menzies and Wiluna. The main geological and physical features, calling places, and time of travel are represented.

It is interesting to note that out of the 190 miles of country passed through between Leonora and Wiluna, there would be, roughly speaking, about 150 miles of greenstone as against 40 miles of granite.

As this sketch section may be of interest to travellers and others interested in the country between Leonora and Wiluna, it is submitted herewith.

II. Petrological Report on Rocks from the No. 19 Level in the Menzies Consolidated Gold Mine, Menzies Goldfield.

A suite of rocks collected from the No. 19 level in this mine proved to be of more than ordinary interest. Generally speaking, the rocks presented the appearance of greenstone schists that had been intruded by acidic granitic material which wedged itself along and between the foliation planes of the schists. The acid intrusive proved on microscopic examination not to be granite, for there was a total absence of the holocrystallinity typical of that rock. The intrusive rock is a grade of alaskite ranging from quartz porphyry through felspar porphyry to typical quartz veinlets. The rock looks so much like granite that the term "granite" will be used in macroscopic descriptions.

The "Granite."

Specimen A. 1/3880, S. 4589, is typical of the white "granite." It shows much glassy quartz, incipient schistosity, and contains an undoubted ferromagnesian constituent.

Under the microscope, in plain light, it is seen to be made up of clouded and water-clear areas, throughout which prisms and fragments of dark bluish-green hornblende and minute scales and fragments of brown biotite are distributed.

The constituents have separated out into more or less parallel bands of different degrees of crystallinity. The clear areas are made up of bands and lenses of coarse quartz mosaic. The clouded areas form a very fine-grained microcrystalline aggregate of quartz with some felspar, in which large clouded phenocrysts of orthoclase are set. The groundmass seems to have flowed round the phenocrysts, which present a type of "augen" structure. Lumps and fragments of hornblende have been broken from the greenstone schist and enclosed in the acid magma. Rods and scales of biotite appear to form accessory constituents.

The rock is a sheared, slightly biotitic orthoclase porphyry (alaskite), the schistosity being in part due to "flowing" and in part due to dynamic effects. Specimen C, 1/3882, S. 4591, is another phase of the alaskite porphyry. In hand specimens it has the appearance of a pure white siliceous "granite."

Under the microscope it is strongly porphyritic. It contains two kinds of phenocrysts—(1) felspar, and (2) quartz. The felspar is orthoclase, and it occurs as large irregular-shaped clouded (kaolinised and party carbonated) phenocrysts. The quartz separated out as occasional single homogeneous individuals, but in nearly all places it formed mosaic aggregates that may be rounded, lens-shaped, lenticular, or even in bands. The quartz is, nevertheless, for the most part phenocrystal in habit.

The texture is at once curious, but it seems to be a feasible possibility in the crystallisation and consolidation of these thin residues of alaskitic magma. The groundmass is a very fine-grained cryptocrystalline quartz-felspar mosaic, which may in places become quite coarse in grain. Minute strips of brown biotite are common, and the axes of this mineral are arranged in parallel direction. A little chlorite and occasional patches of calcite may be seen. The rock is a somewhat sheared *biotitic quartz orchoclase porphyry* of alaskitic origin.

The greenstone schist.

Specimen D, 1/883, S. 4592, is typical. It is a beautiful hornblende schist with biotite-quartz mosaics squeezed along the foliation planes. The development of biotite is considerable. The rock is a hornblende-biotite schist.

Specimen B, 1/3881, S. 4590, is from a part of the hornblende schist traversed by thin siliceous streaks no wider than one-fifth of an inch, evidently of granitic origin, and thus pointing to the extreme tenuity of the invading solutions.

Under the microscope it is a beautiful hornblende schist, with coarse and fine-grained mosaics of quartz and of groundmass material from the acid intrusive—squeezed along and between the foliation planes.

The bands of hornblende alternate with (a) bands of coarse quartz mosaic of igneous origin, (b) bands of fine mosaic made up of a cryptocrystalline aggregate of quartz with some felspar, remnants of shapeless orthoclase phenocrysts, and (c) bands of coarse quartz-calcite mosaics.

Specimen F, 1/3885, S. 4594, is a piece of greenstone schist about an inch from a thin wedge of intrusive "granite."

Under the microscope the rock is a typical hornblende schist. The spaces between the hornblende plates—the axes of which are arranged in parallel direction—present the appearance of "gutters" of water-clear material that may be resolved into a fine-grained mosaic consisting of quartz with little rods and wisps of biotite. The mosaic is evidently a product of the residual alaskitic or acid porphyry solution.

In places the schist presents the appearance of having been saturated with the siliceous solutions forced into it from the acid intrusive.

The Contact Rock.

Specimen E, 1/3884, S. 4593, was taken from the junction of the "granite" with the hornblende schist for one-fifth of an inch on each side of the line of contact.

Under the microscope the acid intrusive at its contact with the hornblende schist is powerfully porphyritic. Large rounded and irregular-shaped phenocrysts of quartz (and a few of orthoclase) are set in a very fine-grained mosaic or cryptocrystalline aggregate of quartz and felspar. The rock is a quartz felspar porphyry of alaskitic origin.

The acid magma evidently forced its way along the foliation planes in the hornblende schist, and portions of the hornblende became detached and settled in the siliceous solution that constituted the magma. The edge of the magma was very siliceous, because lenses of a coarse quartz mosaic may be seen immediately inside the first layer of hornblende in the schist. Fine mosaics (evidently from the groundmass of the acid eruptive) with distinct lumps of phenocrysts of felspar and patches of calcite are common

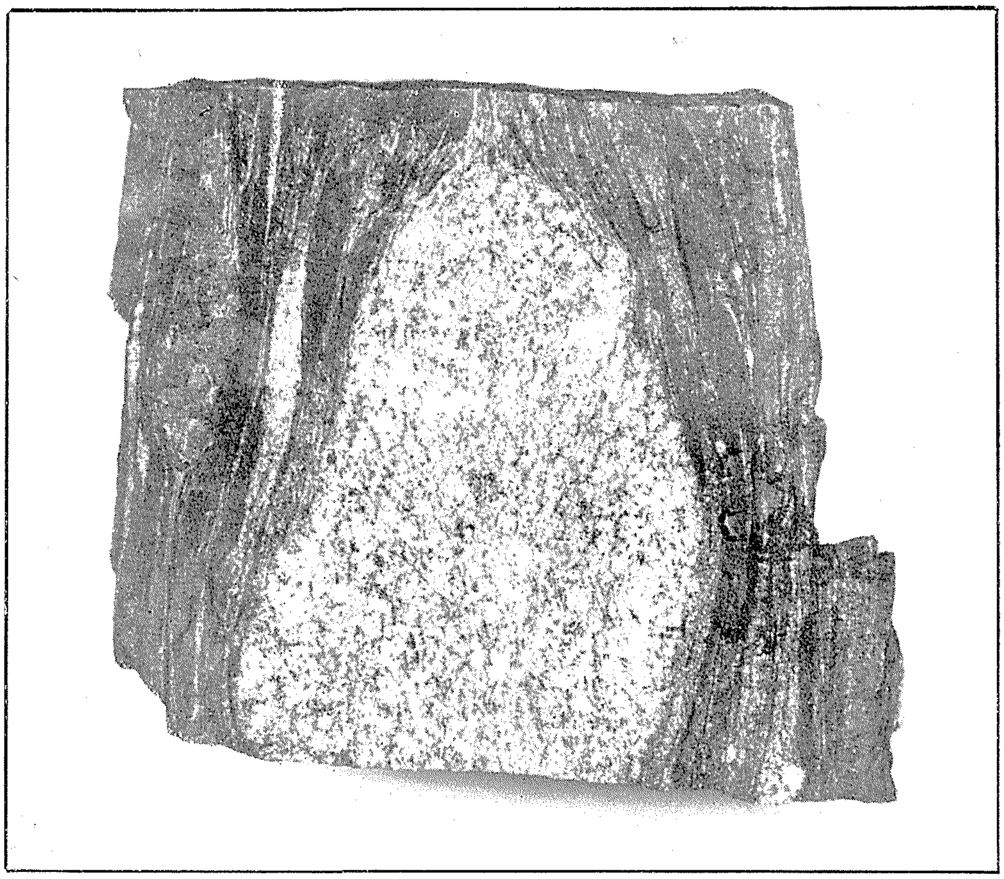

Figure I.
Alaskite intruding hornblende schists.
(Menzies Consolidated Gold Mine, Menzies Goldfield.)

between the foliation planes and along the planes of schistosity.

General Remarks.

The occurrence of these acid alaskitic intrusions into hornblende schist at the No. 19 level in the Menzies Consolidated Mine, is of considerable interest. The microscopic examination enables one to gain an insight into (1) the textural changes, (2) the mineralogical changes, (3) the changes in viscosity of the magma, and (4) finally the metamorphic effects along the contact zones, where the magma intruded itself.

The textural changes range from powerfully porphyritic patches to felsitic zones and fine and coarse mosaics of quartz; the mineralogical changes range from quartz porphyry and orthoclase porphyry to quartz veins; and studies in viscosity indicate extreme tenuousness for the solutions along the immediate contacts.

The hornblende schists were intruded by a highly siliceous alaskitic magma. From this magma crystallised a porphyritic rock with a base ranging from a fine-grained quartz-felspar mosaic to a mixture of quartz-felspar and quartz mosaic exhibiting a tendency to "flow." The consolidation of the felspar in general preceded that of the quartz. It is probable that crystallisation took place under great pressure and subsequent to injection. This crystallisation, however, was slow, so that the residual quartz was, before its final consolidation, in part drawn off and injected into the schists, and so could play the role of an independent intrusion, so proving a process of magmatic differentiation by partial crystallisation. That the lenses are the fillings of cavities which were present in the schists, does not seem likely. The parallelism of the schistosity with the curving walls of the lenses shows that the intrusion filled spaces which it itself created.

The form of the quartz and alaskitic lenses is compatible with the normal one for attenuated, aqueous, but still viscous, granitic material injected into the schists. The alaskitic fluid must have been much the same as that of the quartz, being less fluid than that which has formed the true granite which must exist somewhere in the area. The rock probably crystallised at a relatively lower temperature, when compared with that of less siliceous igneous rocks, and remained mobile below the fusing point of most of the granitic constituents, on account of the intermixture of water, which was one of the most abundand and efficient factors in the process of crystallisation. More knowledge is required about the quantity of water a magma can contain.

The microscopic evidence favours slow and interrupted crystallisation, because two distinct periods or generations of crystals are frequently represented, though there was only one generation in that portion of the magma that possessed sufficient mobility to be injected into the schist. It would appear as if the quartz is younger than the felspar. The quartz was segregated into chains, lenticles, and the patches of perfectly allotriomorphic grains that constitute the mosaics. In those places where physical conditions permitted of more free growth, the grain-size of the quartz increased. The interstices and spaces between the foliation planes of schist were filled with the residual fluid under great pressure. The available evidence indicates further that as crystallisation progressed the residue left became finer in grain and more aqueous. A convenient expression would be "magmatic quartz" for the silica that was forced through, permeated and saturated the hornblende schist along its contact with the alaskitic magma.

Alaskite is a general term, without regard to texture, applied to siliceous end products consisting essentially of quartz and alkali felspar from granitic magmas. Holmes, in his "Nomenclature of Petrology,'' refers to alaskite as "A leucocratic granite, containing quartz and alkali-felspars, with only traces of other minerals."

The rock from the Menzies Consolidated Gold Mine quite agrees with Holmes' description in that it consists of quartz and alkali felspars with traces of biotite. However, the alaskites so far examined by me from Western Australia, viz., those at Balgarrie (G.S. W.A. 113/22) and at Menzies, exhibited a powerful porhpyritic tendency, and in this respect resemble the dyke rocks from Forth Mile Creek, Alaska, which have been described by J. E. Spurr (A.I.M.E., 1913, p. 273) as follows: "One remarkable phase (of alaskite, C.O.G.L.) studied is a porphyritic dike rock, whose groundmass consists entirely of quartz in small interlocking grains, giving, both in hand specimen and under the microscope, the appearance of quartzite. Yet this rock contains scattered, but regularly distributed, porphyritic crystals of felspar. It is thus not only related by the closest ties to similar slightly less siliceous alaskites of the same district, but it is only removed by its scattered porphyhritic crystals from being a true quartz vein." In the specimens from the Menzies Consolidated Gold Mine the quartz porphyry, felspar porphyry, cryptocrystalline aggregates of quartz and felspar, and pure quartz veins may all be seen within the space of four square inches.

Figure 1 is a photograph of the hornblende schist with intrusive alaskite.

III. Petrological Examination of Two Bores put down at Wiluna by the Mararoa Gold Mining Company.

During the year a detailed examination was made of material received from two bores—No. 1 and No. 2—put down by the Mararoa Gold Mining Company.

No. 1 Bore.

This bore was put down to a depth of 500 feet. The angle of depression was 40 degrees. The amount of core obtained from every hundred feet of boring was as follows:—

Depth of Bore.	Core obtained.	
feet.	ft.	in.
0—100	19	10
100—200	33	0
200—300	56	6
301—400	82	11
400—500	83	0
	275	3

A general and careful petrographic examination of the core shows that with slight textural variations and changes in degree of chemical and mineralogical alteration—especially in the vicinity of the lode—the rock throughout the whole 500 feet is the same, viz., a dense fine-grained amphibolite.

From Surface to 150 *feet.*

The zone of oxidation ends about 253 feet 6 inches, which shows that the agencies of weathering have long been at work in this region. In the zone of oxidation the rock consisted of ironstained weathered greenstone with very ferruginous patches. Down to 150 feet the rock did not show sufficient shearing or evidence of silicification to warrant assays being made. A little quartz was noted between the depths of 26 feet to 31 feet.

From 150 *feet to* 253 *feet* 6 *inches.*

From 150 feet to 253 feet 6 inches, the bottom of the zone of weathering, the rock was a little harder, but still consisted of weathered fine-grained greenstone, dirty pale-greenish in colour, and traversed by numerous cracks, many of which were filled with little seams of ironstone, and, in places, quartz.

In view of (1) the glassy quartz veins, (2) the evidence of shearing, (3) the fracturing, and (4) other evidences of dynamic pressure between 150 feet and 253 feet 6 inches, five samples were selected and assays made of core from the following depths: 182ft. 4 in. to 187ft.; 195 ft. to 195ft. 8in.; 202ft. 9in. to 205ft. 6in.; 220ft. 4in. to 222ft. 8in.; and 231ft. 5in. to 234ft. 8in. The highest assay was 5 grains of gold per ton.

From 253 *feet* 6 *inches to* 395 *feet.*

The rock between these depths consisted of dense fine-grained greenstone, in some places brecciated or crushed, in others slightly sheared. Quartz and calcite veinlets and a little gypsum were noted. At 391 feet the rock was slightly pyritic and carbonated. In consequence of the facts several assays were made of core from the following depths: 298ft. 6in. to 299ft. 6in.; 344ft. 6in. to 345ft. 6in.; and 391ft. to 392ft. The results were unfortunately negative, nothing higher than traces of gold being recorded.

From 395 *feet to* 430 *feet.*

Between these depths the country rock is still the same, viz., dense fine-grained greenstone. But at about 396 feet the rock becomes highly altered and more or less sheared. At 400 feet the rock is slightly pyritic with quartz veinlets parallel to the planes of schistosity. From 400 feet 11 inches to 401 feet 11 inches the rock is heavily impregnated with very fine-grained pyrites. Between 401 feet 11 inches and 404 feet 6 inches the rock becomes more siliceous and schistose, with fine-grained pyrites along the foliation planes. Between 404 feet 6 inches and 407 feet 9 inches the core consisted of heavily impregnated dark pyritic siliceous ore. The rock contained no values between 411 feet and 423 feet. From 423 feet to 430 feet the core consisted of pyritic mottled greenstone with patches of siliceous pyritic lodestuff.

In view of the foregoing evidences of lodestuff nine assays were made of core taken between depths of 398 feet 5 inches and 413 feet. The highest assay was 11 dwt. 20 grains of gold per ton from rock between 404 feet and 406 feet 2½ inches. Between depths of 423 feet and 430 feet four assays were made: the highest return for gold was 3 dwts. 4 grains per ton.

From 430 *feet to* 450 *feet.*

Between these depths the rock consisted mostly of dense fine-grained greenstone. Between 439 feet and 441 feet there was some poor lodestuff consisting of dense pale greenstone, somewhat pyritic and siliceous with glassy quartz and calcite veins. Two assays were made. The highest gold return was 3 dwt. 16 grs. per ton. Each assay showed 8 grains of silver per ton.

From 450 *feet to* 500 *feet.*

From 450 feet to the bottom of the bore (500 feet) the rock consisted of the usual dense grayish fine-grained amphibolite, in part bleached and for the most part slightly pyritic with occasional quartz and calcite veins. There was not sufficient shearing, silicification, or mineralisation between 450 feet and 500 feet to warrant assays being made. The rock from 500 feet was a calc schisty gray greenstone showing no mineralisation or shearing whatever.

Conclusions.

The petrological investigations indicate that the rock through which the No. 1 Bore passed was one homogeneous mass, changed only by various degrees of alteration (carbonation, etc.) and in places disturbed by earth forces that were sufficiently powerful to produce a certain amount of shearing as a result of the elongation of the rock particles in one definite direction.

The lode formation evidently started at a depth of 398 feet, and continued to 411 feet—a total distance of 13 feet. From 411 feet to 423 feet the mineralisation was not sufficient to class the rock as ore. Values came in again at 423 feet and continued to 428 feet 4 inches, making a total width of 5 feet 4 inches of very poor lodestuff. Two feet of poor ore was noted at 439 feet.

The assay results and petrographic investigation indicate that the bore passed through about 13 feet of low-grade lodestuff between 398 feet and 411 feet; 5 feet 4 inches of still lower grade ore between 423 feet and 428 feet 4 inches. The two feet of lodestuff at 439 feet is negligible.

The lodestuff was evidently formed by metasomatic or replacement processes that proceeded from poorly defined sheared lines. By this means sulphides were introduced into the fine-grained greenstones.

It is unfortunate that where the bore penetrated this lode there was not greater shearing and concentration of gold contents. The shear lines at this point were evidently not powerful enough, and the gold contents not sufficient, to enable the whole of the massive rock between 398 feet and 428 feet 4 inches to be replaced to a sufficient extent to bring the grade up to a value that would admit of profitable extraction by bulking the ore.

No. 2 *Bore.*

This bore was put down to an angle of 60 degrees to a depth of 350 feet 6 inches. Detailed petrographic investigations indicated that the country rock passed through in this bore was the same as that met with in the No. 1 Bore, viz., fine-grained amphibolite (1/3819), with similar textural, chemical, and physical alterations.

The depth of the zone of oxidation was about 250 feet. Some siliceous ironstone with glassy quartz was met with in the first three feet of core, but the assay gave negative results.

General Remarks.

Judging from the amount of core obtained in boring, attention is called to the great necessity for carefully examining the oxidised ground. From 34 feet to 52 feet 6 inches there was no core, and this distance is quite enough to contain a large lode. Again between 250 feet and 253 feet only five inches of core were obtained. At 250 feet there is a silicified zone that might have been auriferous; but five inches of core does not leave much to work on.

The rock from the No. 2 Bore, taken as a whole, did not exhibit much evidence of lodestuff or shearing. At various depths between 228 feet and 287 feet 9 inches it was thought that there might have been some values, but the assays were disappointing.

IV. Petrology: Leonard Range, Eastern Division.

The late Mr. F. Hann, during his explorations in the vicinity of the South Australian border in 1902-03, collected some interesting rocks. These have been examined with a view to correlating them with rocks from auriferous areas in Western Australia. They consist of acid porphyries, greenstones, and epidote-quartz rock. The following is a brief description of the specimens submitted:—

Ophitic quartz dolerite (now quartz dolerite greenstone). (5115.)

A dark green, medium-grained (doleritic) rock, apparently consisting of felspar and a ferromagnesian constituent.

Under the microscope the rock is seen to contain the following minerals:—augite, felspar, epidote, uralite, chlorite, quartz, ilmenite, leucoxene, and a little apatite. Some of the augite is quite fresh, and cores of it are surrounded by epidote, uralite, and chlorite. The pyroxene has been converted into pseudomorphs of fibrous uralite and chlorite. The felspars seem to have changed into an indefinite mixture of albite, saussurite, and epidote. Ophitic texture is strongly in evidence. Most of the ilmenite has been leucoxenised. A little clear quartz was noted.

This rock was originally made up of augite, plagioclase, quartz, and ilmenite. By processes of pressure and other metamorphism, such as one usually meets with in epidiorites on the goldfields, the plagioclase has been completely albitised, epidotised, partly saussuritised, and partly sericitised; while the augite was converted for the most part into aggregates of chlorite and feathery uralite in about equal proportions.

Epidote-quartz rock (5116).

A dense, more or less pistachio-coloured rock with an uneven fracture. Only two constituents—epidote and quartz—are visible macroscopically.

Under the microscope the rock is seen to be a mass of shapeless quartz and irregular-shaped plates of epidote associated with some water-clear material. Small rods of apatite were noted.

This rock has probably been regenerated from an epidiorite by contact metamorphism, or in any event a type of metamorphism accompanied by siliceous solutions.

Acid felsitic orthoclase porphyry (5118).

A siliceous, dark, felsitic (almost flinty-looking) and somewhat banded or streaky rock. The "streakiness" or "pseudo-flow" structure is due to the alternation of imperfect dark, almost black bands and flesh-coloured bands. Hand specimens show distinct evidence of small rectangular cleavable phenocrysts of felspar with all the appearance of orthoclase.

Under the microscope the rock is seen to consist of microcrystalline to cryptocrystalline aggregates of quartz and felspar. The banding is due to an alternation of fine and mediumly coarse-grained mosaics of quartz. Felspar may be seen distinctly in the coarser grained mosaics, which are in places (a) arranged in parallel lines as a result of dynamic stress, (b) aggregated in patches suggestive of crushed phenocrysts, and (c) gradually merging into the finer microcrystalline groundmass.

The rock is an acid eruptive in which the psuedo-flow structure or streakiness was caused by dynamic stress during the process of consolidation. It bears a strong resemblance to some of the acid porphyries of the Warburton Range, described by Mr. Farquharson on pages 124-125 of Bulletin 75.

Comparison of specimens from Leonard Range with rocks described in Bulletin 75, G.S.W.A.:

It would appear as if these three rocks (5115, 5116 and 5118), bear a strong resemblance to certain rocks described by Messrs. Talbot, Clarke, and Farquharson in Bulletin 75, "A Geological Reconnaissance in the Country between Laverton and the South Australian Border (near Latitude 26 degrees)."

The Acid Porphyhies: Mr. Farquharson, when describing (page 124) the acid porphyries between the Warburton and Barrow Ranges, strongly emphasised "their extremely fine-grained felsitic and flinty nature." He also referred to the black and pinkish tints, as well as to pinkish orthoclase phenocrysts.

There are many points of analogy between specimen 5118 and the acid porphyries described by Mr. Farquharson, *e.g.*—

1. Their extremely fine grained and flinty nature.
2. Their blackish and pinkish tints.
3. The presence of pinkish orthoclase phenocrysts.
4. The microcrystalline nature of the base, and
5. The streakiness or pseudo-flow structure.

The Greenstone: Messrs. Talbot and Clarke, when describing the country between Laverton and the South Australian border, divided the greenstones into four belts. Nos. 5115 and 5116 appear to belong to the greenstones of the third belt, which extends from Elder Creek to the south end of Barrow Range. No. 5115 may be classed with the greenstones—medium to fine-grained fibrous epidiorites and amphibolites that have been derived from dolerites and gabbros—extending eastward from the Warburton Range, described by Mr. Farquharson on page 131, No. 1/1044, a greenstone near the intrusion, has been described as "a rather fine-grained zoisitised and chloritised dolerite." In the neighbourhood of Muller Hill, there is a highly epidotic rock—1/1046.

Correlation with rocks from the auriferous areas of Western Australia: The opinion has been formed that all these rocks (5115, 5116 and 5118), could come from goldfields areas in Western Australia. The ophitic chloritised epidiorite (5115) is quite analogous to the greenstones of the goldfields, and epidotic products such as 5116 could occur.

Acid eruptives are not uncommon on the goldfields, but I am not acquainted with banded and streaky felsitic orthoclase porphyries like 5118, though Mr. Farquharson says that the acid porphyry facies may be represented at Niagara and in the Kookynie district.

There is no geological reason why auriferous deposits may not be found in such rocks as 5115, because its microscopic features indicate that along suitable lines, and in the presence of auriferous solutions, this rock would be amendable to replacement.

The contact areas between Elder Creek and Mount Squires, though not of great areal extent, may yet prove to be auriferous.

V. Boring for Oil, Boddington, South-West Division.

In March a series of samples was submitted from a bore put down in search of oil at Boddington, in the South-West Division. The following is a description of the samples received:—

Depth in Bore.	Nature of material.
feet.	
2—18	Ironstained rotten granite.
18—24	Small lumps of a glassy, ice-like quartz.
24—69	Kaolinised clayey material with quartz grains. Evidently rotten granite.
69—88	Broken up quartz and felspar—evidently from granite.
89—100	A very acid type of granite.
Bottom (Mar. 16)	Solid and slightly kaolinised granite.

The whole of the material from this bore is represented by phases of granite, an acid igneous crystalline rock, that could not possibly hold oil. On March 23 the Government Geologist wrote to say the bore was down 154 feet and still in solid granite. It is really unfortunate that money should be wasted in boring for oil in this type of country, when there are sedimentary areas in which boring may be justified.

VI. Determinations and Reports for other Departments, as well as for the General Public.

The following are synoptical notes of some of the more important investigations:

(a) *Graphite from Wagin*: A sample was received from Wagin. It consisted of a holocrystalline admixture of glassy quartz, dark green plates of hornblende, and flakes of black lustrous graphite. The graphite is of commercial type, and should be amenable to concentration. If this material occurs in any quantity, it should be further examined, with a view to determining (a) the percentage of graphite present, (b) the percentage possible by concentration, and (c) the commercial value of the stone.

(b) *Granite from a Quarry at Parkerville.*—This sample was obtained from Messrs. Wilson, Gray, & Coy.'s quarry. It is understood that this granite after being dressed and polished for ornamental work, developed a dirty gray-white film on the surface, which rendered it quite useless for monumental work. The sample was submitted with a view to determining whether its microstructure or mineral composition might throw any light on the matter.

The rock is a normal biotite granite. The minerals observed were: Quartz, orthoclase, microcline, plagioclase, biotite, kaolin, sericite, and epidote.

Features in this rock that may be detrimental to its use for ornamental work are as follow.—

1. The rock contains a large proportion of dark brown biotite. Microscopic investigation indicates that this mineral formed prior to the felspar, in which it is included as small scaly plates that might fall out or be pulled out in polishing. The larger part of the biotite is very ragged around its edges. Processes of weathering may take some of the iron oxide into solution and in this way produce a stain.

2. Although the rock looks fresh, much of the felspar has been considerably altered. The microcline seems to resist the weathering, and it is practically unchanged. In the orthoclase there is considerable sericitisation and some kaolinsation; but the plagioclase (and in part the orthoclase), which makes up a large part of the rock, has suffered considerable epidotisation, the epidote taking the form of almost colourless and exceedingly small grains. It is conceivable that this microscopic epidotisation may, in the surface zones, and under the action of meteoric waters, give rise to solutions that could produce staining.

3. The rock has apparently been taken from near the surface, and with increase in depth it is not unreasonable to suggest that the defects referred to may be remedied—unless, of course, the biotite is the absolute or main cause of the trouble.

(c) *Unakite from Gilgarna Rock, 20 miles north-east of Kurnalpi.*

A special examination of a curious rock (1/3329) from the abovenamed locality was made for Dr. E. S. Simpson, Government Mineralogist and Analyst. The following is an account of the more important features.

Macroscopic features: In hand specimens this rock has the appearance of a coarsely crystalline granite. It is made up of large plates of pink cleavable orthoclase, which forms by far the largest part of the rock. The glassy quartz is quite subordinate. Small grains of a dark green ferromagnesian-looking mineral are scattered throughout the rock at irregular intervals, and there are occasional black cleavable flakes of biotite.

Microscopic features: Under the microscope the rock is typically holocrystalline and granitic in texture. The minerals observed were: quartz, orthoclase, microcline, epidote, biotite, sphene, calcite, and kaolinite.

Quartz shows no special features, beyond inclusions of epidote, calcite, and sphene. It is typically allotriomorphic, and, when compared with the orthoclase, is quite subordinate.

Orthoclase forms by far the largest proportion of the rock. It occurs in large plates, practically kaolinised, and in places showing carlsbad twinning with irregular composition planes. All the felspar showed a lower refractive index than quartz or balsam. A good deal of the orthoclase showed a curious submicroscopic twinning, which may be due to soda in the orthoclase. On the other hand, if the analysis does not show an appreciable quantity of soda, the submicroscopic twinning may be the result of pressure in the orthoclase.

There is evidence of strong pressure in the rock in the form of mosaic patches in and along the composition planes of the felspar. It is a known fact that microcline is mostly found in older eruptive rocks that have been subjected to pressure, and that normal orthoclase may assume the microstructure of microcline when it has experienced strong pressure. Microcline is present, but it is quite subordinate to the orthoclase.

Epidote: A curious feature in this rock is that the ferromagnesian constituent is mainly represented by epidote of a pale green colour. It is not augite because all the extinctions measured were straight and parallel to a rather well-marked cleavage, traces of the (001) cleavage showing along plates evidently parallel to the general direction of elongation (100) of the crystals. The absence of pleochroism negatives hornblende.

Biotite showing strong pleochroic colours is intimately associated with the epidote.

Calcite occurs in irregular patches, as well as in small grains replacing the orthoclase.

Kaolinisation is evident in the somewhat turbid cloudiness in parts of the felspar.

A possible order of separation of the minerals may have been: sphene, calcite, epidote, biotite, orthoclase, microcline, and quartz.

Sphene of a dark brown colour is present in granular pieces, as well as in perfect wedge-shaped crystals.

Nomenclature: This rock is a variety of alkalic granite. A granitic rock low in quartz, with considerable pink felspar and epidote, has been termed "unakite." (T. L. Watson: Am. Journ. Science, XXII., 1906, p. 248.)

This rock is of interest in that, according to the aforegoing description, it is a typical unakite.

(d) *Leucophyllite schist from Peedamulla Station, North-West Division.*

This rock was submitted by Mr. Blatchford. It is a white, finely-foliated and somewhat contorted schist. The lustre is rather dull when examined across the foliation planes, which are distinctly wrinkled and pearly lustred as a result of the development of scaly sericite.

In section the rock is seen to consist of a mass of microscopic scales of sericite less than 1/1000th of an inch in width, and all with their axes arranged in a parallel direction. The scales of sericite touch one another. Under the microscope distinct waves and folds may be seen in the schist.

A chemical examination for potash and soda by the Government Mineralogist and Analyst resulted as follows:—

Potash (K_2O) ..	..	3.66 per cent.
Soda (Na_2O) ..	..	0.42 per cent.

Judging from the small percentage of potash, it is reasonable to infer that the mineral is leucophyllite. The rock is an incipiently contorted leucophyllite schist, similar to some schists from Ofenbach, Austria.

GEOLOGICAL SURVEY MUSEUM AND COLLECTIONS.

Little or no progress has been made in connection with the re-arrangement, etc., of the Geological Survey Collections, of which they stand in need. The accessions to the Survey Collection during the year 1925 amounted to 221, thus bringing the total number registered up to 17,947. The number of micro-sections cut and registered was 74, thus making a total of 4,597 slides in the possession of the Geological Survey.

The following is a list of the minerals presented to the Departmental Collection:—

Reg. No.	Description.	Locality.	Donor.
1/3775	Pyrite Pebble	Nullagine, Pilbara Goldfield, North-West Division	F. S. Cooke.
1/3875	Tin Ore ...	Brickwooda, Tinga Tinfield, New South Wales	P. C. Larsen
1/3887	Fossil ...	21 miles east of Albany, Warriup Road, South-West Division	C. J. LeMesurier
1/3894	Meteorite	Murchison Downs Station, Kyarra District, Murchison Goldfields	— Richardson
1/3897	Stibnite ...	20-Mile Battery, Nullagine, North-West Division	L. Ives
1/3915	Sulphate of Ammonia	Flinders Range, near Wooltana Station, South Australia	— Montague
1/3916	Fossil ...	P.A. 154H, Esperance District, Eucla Division	C. Hancock

The Geological Survey collection of photographs comprises 2,138 negatives, accumulated by the officers of the Department in the ordinary course of their official duties during the last 30 years. The photographs cover a wide range of subjects and are representative of the various portions of the State in which departmental activities have extended. The complete set of photographic prints is contained in 44 special albums and placed in the Survey library. These photographs are of no inconsiderable scientific and historical value, which increases as years go by.

LIBRARY.

The Library of the Survey was enriched during 1925 by 745 publications from cognate institutions throughout the world, including all the newly created Geological Surveys, and in addition 47 volumes were added by purchase.

The distribution of the official publications issued by the Geological Survey during 1925 amounted to well over 1,000. These were transmitted to the addresses on the regular exchange list and to others in response to requests for specially named reports, bulletins, or maps.

A. Gibb Maitland

Government Geologist.

Geological Survey Office,
Perth, 8th June, 1926.

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