1918.

WESTERN AUSTRALIA.

ANNUAL PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

For the Year 1917.

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Annual Progress Report of the Geological Survey for the Year 1917.

Compared with previous years, a greater proportion of the Staff's time for the calendar year 1917 was devoted to writing reports rather than field work. This was due mainly to the accumulation of information, which had been previously collected, assuming such proportions that it was found necessary to write it up ready for the printer before a fresh programme could be undertaken.

The results are evidenced by the fact that during the year six new publications have been issued; two are complete for the printer, and eight more are in hand and mostly completed.

Throughout the year the work has been carried out on similar lines to those adopted in previous years. More attention, however, is being given to the study of the occurrences of base metals and minerals of economic value. In conjunction with the latter, experiments are being carried on in the Laboratory with regard to our Clays, Potash minerals, etc., the results of which will be felt in the near future, and which should be of great value to intending manufacturers.

An increase in the Chemical Staff and a more extensive Laboratory would greatly augment this section of the work, and no doubt tend to establishment of industries at present non-existent in the State.

THE STAFF.

In the early part of the year the Survey met with a serious loss in its Staff by the death, after a very brief illness, of Harry Page Woodward, the Assistant Government Geologist. As one of our pioneer geologists, Mr. Woodward possessed a personal knowledge of the greater portion of the State such as few men, if any, possess, and though many of his writings will continue to stand out in bold relief, by his death the State loses one of its leading geologists and a source of information difficult to replace.

C. S. Honman is now on the Western Front doing his bit "for us" and his country. We congratulate him in being one of three to pass all examinations before leaving for a Commission in the Engineers.

There has been no other change in the personnel of the permanent Staff.

FIELD WORK.

Owing to Mr. Woodward's demise, the field work of the South-Western Division was suspended, but his notes and maps are in the hands of the Director of the Survey, and being prepared by him for publication.

The Director of the Survey was also engaged for portions of the year on field work in the Yalgoo Goldfield, which he had commenced in the previous year.

Otherwise he was engaged in compiling a Mining Handbook and other publications enumerated in the list accompanying this report, and in the ordinary administrative work of the office. For the remainder of the field Staff the enclosed list sets out the district in which each officer worked, also the number of days occupied in each district.

The following brief description of the work done by each officer, with the short reports and *résumés* of Bulletins written during the year, shows clearly the work accomplished for the period under review, and needs no further comment on my part.

Lists of publications issued, ready for printer, or in progress, together with a description of Specimens donated, are appended.

Table showing the Distribution of Field Work for the Year 1917.

Goldfield or Land Division.	T. Blatchford.		J. T. Jutson.		H. W. B. Talbot.		E. de C. Clarke.		F. R. Feldtmann.	
	No. of days in the field.	Percentage of working days.	No. of days in the field.	Percentage of working days.	No. of days in the field.	Percentage of working days.	No. of days in the field.	Percentage of working days.	No. of days in the field.	Percentage of working days.
Northam	3	·82		...	...	...	...	...	...	...
Esperance District	23	6·3	...	...	...	...	...	...	...	...
Gingin	4	1·09	...	...	...	...	...	...	...	...
Northampton	9	2·46	...	...	...	...	...	...	...	...
Katanning	3	·82	...	...	...	...	...	...	...	...
Cue	8	2·1	...	...	...	...	...	...	...	...
Yilgarn and Phillips River...	5	1·37	...	...	...	...	...	...	...	...
North Coolgardie Goldfield	...	...	151	41·4	...	...	...	...	...	...
South-West Division ...	...	...	...	...	17	4·65	...	...	...	...
Yalgoo Goldfield	...	...	...	...	34	9·31	...	...	...	...
Mt. Margaret Goldfield ...	...	...	...	...	...	...	184	50·41	...	...
East Murchison Goldfield ...	...	...	...	...	...	...	14	3·83	...	...
East Coolgardie Goldfield ...	...	...	...	...	...	...	...	...	13	3·56
North-East Coolgardie Goldfield	...	...	...	...	...	...	...	...	17	4·66
Totals	56	15·06	151	41·4	51	13·96	198	54·29	30	8·22

ANNUAL REPORT.

T. Blatchford, Assistant Geologist:

The first two months of the year were occupied in completing Bulletin 71. This work was materially hampered by a severe illness. In April an inspection was made of a discovery of wolfram at Grass Valley, five miles east of Northam. A short report has been supplied relative to this occurrence.

Portions of the months of May and June were taken up by an inspection of the graphite deposits at Munglinup, in the Eucla division. During this trip he was accompanied by Mr. H. P. Herbert, the representative of the Morgan's Battersea Crucible Co. The sampling of the various graphite veins was undertaken conjointly, and on our return to Perth the samples were treated in accordance with modern commercial methods. Through the courtesy of Mr. Herbert much useful knowledge was obtained in this direction, and since his departure a small separation plant designed by him has been erected in the Chemical Laboratory attached to the Geological Survey Department for treating subsequent samples. The results of the sampling and an interim report on the graphite deposits at Munglinup are embodied in Bulletin 73.

During July two short visits were made to Gingin in connection with the Phosphatic lime deposits on Molecap Hill. During those inspections the workings were sampled and a report and the results of the sampling have been furnished.

An endeavour was made in September to inspect several reported graphite deposits at Northampton, but owing to the inclement weather this work had to be temporarily abandoned. One outcrop, however, some three or four miles north of the Murchison River, opposite Mr. Glass's Station-house, showed graphite flake of a very promising nature, and since my visit the ground has been applied for and is now being prospected.

An inspection of a reputed deposit at Katanning containing coarse graphite was made, with disappointing results. There is certainly graphite at Katanning, but lodes containing payable quantities have yet to be found.

The new centre, Tuckabianna, five miles north of Pinnacles in the Cue district, was visited in November and a report furnished.

Owing to the sampling of the Munglinup graphite deposits in May and June, a syndicate was formed to thoroughly prospect the property. In December an attempt was made to take a hurried trip down to see the latest developments, but this was frustrated by heavy rain when *en route*.

In addition to the field work above mentioned a considerable amount of time was spent in the office in connection with the various reports and publications as well as attending to the administrative duties of the Government Geologist during his absence in the field.

J. T. Jutson, Field Geologist:

Returning from annual leave on 8th January, Mr. Jutson was engaged on various office matters, including the preparation of a Progress report on Comet Vale, correction of proofs, and obtaining further data for Comet Vale and Goongarrie work, until the 20th January, when he left for Comet Vale, and from that date until the 7th June he was engaged on the detailed survey of Comet Vale and Goongarrie. He then returned to Perth on account of illness, and from the middle of June until July was engaged on various office work, including the plotting of maps, correction of proofs, and bringing up to date the article for the Mining Handbook, on the relation of the Law to prospecting and mining in Western Australia. During the month he returned to Goongarrie and completed the detailed geological survey of Goongarrie and Comet Vale, returning to Perth on the 30th July. From this date, until the commencement of his annual leave, on the 17th December, he was engaged on the multifarious matters connected with the maps and reports of the Niagara-Kookynie-Tampa District, and the Comet Vale-Goongarrie District, as well as correction of proofs for the printer, the bringing up to date the article for the Mining Handbook by Mr. P. J. Atkins, late Clerk-in-Charge, on Assistance to Prospecting and Mining Development; and also the preparation, in conjunction with Mr. Farquharson, and with the aid of Messrs. Simpson and Blatchford, of a Glossary of field and mining geology terms for the Mining Handbook.

Attached is an epitome of the results of the geological survey of Goongarrie, and some further notes on Comet Vale.

During the year Mr. Jutson spent 151 days in the field.

H. W. B. Talbot, Field Geologist:

On his return from annual leave on the 8th January, and until the end of the month, Mr. Talbot's time was occupied, in collaboration with Mr. Clarke, on the completion of the report on the expedition to the South Australian border. Work was then commenced on the maps, sections, and reports of his three years (1911-14) in the North-West, Central, and Eastern Divisions of the State. With a few interruptions, this work occupied his time until November.

From the 26th February to the 3rd March, Mr. Talbot made a short trip to the Darling Range to map the laterite in the vicinity of Swan River; and from the 11th to 21st April he was engaged running a section across Toolbrunup, in Stirling Range.

From the 15th November to 18th December, Mr Talbot accompanied the Government Geologist on an examination of several centres in the southern portion of the Yalgoo Goldfield.

The total number of days spent on work in the field amounted to 51.

E. de C. Clarke, Field Geologist:

Mr. Clarke was engaged from January to June in correcting the final proofs and making the Index of Bulletin 68 and preparing plans, figures, and text of Bulletin 75.

The remainder of the year was occupied in field work in the South-West parts of the Mt. Margaret Goldfield.

Mr. Clarke was engaged on field work during the year under review 198 days.

F. R. Feldtmann, Field Geologist:

On his return from annual leave, and the completion of the Annual Report for 1916, Mr. Feldtmann spent the greater part of the year at head-quarters on the reports on the centres at Quinn's and Jasper Hill, in the Murchison Goldfield, and in the preparation of maps and diagrams thereon.

In addition to work on the above reports, a good deal of time was spent during the earlier part of the year in the revision of proofs of Bulletin 69, since published.

On the 7th November Mr. Feldtmann left Perth for Kalgoorlie to examine the Hidden Secret Mine, and the 14th of the same month proceeded to Bulong to inspect the magnesite deposits there, returning to Kalgoorlie on the 1st December to examine the magnesite-bearing country west of Hannan's Lake.

The remainder of the year was spent in the preparation of the report on the Hidden Secret Mine and other work connected with the trip.

The number of days spent on work in the field amounted to 30.

THE RINGING BELL COPPER LODE, TWIN PEAKS.

(A. GIBB MAITLAND.)

The Ringing Bell Copper Lode is situated not far from the head station at Twin Peaks, on the Malgoo Goldfield.

The lode, which lies in close proximity to a well-defined pegmatite, or porphyry dyke, can be followed continuously for about 1,300 feet on an average bearing of north 5 degrees east, has a high underlay to the east of between 80 and 90 degrees. At both ends of the outcrop the lode gradually tapers out into the enclosing country rock.

The ore-carrying matrix is a more or less siliceous ironstone passing in places into an almost pure quartz; it contains small quantities of malachite and chrysocolla.

The lode has been opened out in five localities. Mining operations, however, have been confined to the central portion of the outcrop, where a vertical shaft has been put down to a depth of 35 feet. The lode, as seen, varies from 6 to 18 inches in thickness. A drive from the foot of the shaft has been put in from the north along the ore channed for a distance of about 10 or 12 feet, but there is very little ore showing in it. The owners had raised about 3 tons of ore, which yielded 16 per cent. of copper, and were just despatching (22nd October, 1917) to the coast a further parcel of 3 tons, obtained from the shoot in the main shaft. An average sample, taken by myself from the 3 tons, yielded on assay in the Survey Laboratory, copper 15.54 per cent.; iron 28.64, and of silica 21.41 per cent., in addition to 1oz. 11dwts. 23grs. per ton of silver, and of gold a trace. The ore would appear to be self-fluxing.

Some distance to the north of the main shaft the lode, which is two feet wide, has been opened up to a depth of 3 feet, and at this point consists of a mass of magnetite in a siliceous limonite matrix. The northernmost end of the outcrop, where it had been opened up, was found to consist of quartz stained with green carbonate of copper but destitute of other minerals. The southernmost extremity of the outcrop showed merely copper stains over a width of about 5 feet.

The richest portion of the lode seems to be that upon which the deepest workings are situated, and it does not appear at all likely that the deposit is capable of yielding any large quantity of copper ore.

The total quantity of copper raised from the abandoned copper lode, situated about a mile and a half to the south, and which was worked during 1907-08, amounted to 19½ tons; this, with the 8 tons from the Ringing Bell Lode, brings the total yield of the district up to 27½ tons of copper.

INTERIM REPORT ON THE OCCURRENCE OF GRAPHITE IN THE KATANNING DISTRICT.

(T. BLATCHFORD.)

For some time past samples of rock containing small quantities of graphite have been forthcoming from Katanning. As the graphite in these samples was usually of the flake variety, an inspection was made on the present trip of the more important spots where it occurred. In all, five places were examined. The following is a description of the various localities.

Block 299.—On this block four shafts have been sunk of varying depths, from 47 to 10 feet.

Of these, the most northern, 47 feet in depth, was sunk in decomposed granite. At the surface, nodules of ironstone had been broken which showed fine graphite flake. Small specks of graphite were also found in much of the granite intersected in the shaft, but definite veins were absent.

As most of the surface ironstone nodules containing graphite were to the west of the shaft, it is likely the prospectors will put in a crosscut to the westward in the hope of intersecting veins in that direction.

East of this shaft is another shaft some 25 feet deep, sunk on the east side of an ironstone hill. A little graphite is also showing in some of the stone here.

The main shaft, 47 feet deep, in the southern end of the block had fallen in.

A shallow shaft to the west of the main shaft showed a little graphite in the rock, and an indefinite irregular vein containing slightly more flake was cut at the bottom of the shaft. The dip of this vein was apparently to the south-east. These workings are in a highly oxidised and decomposed kaolin rock, probably of granitic origin.

Further to the west, on the same block, a shallow shaft has been sunk in a coarse-grained granitic rock, probably a pegmatite.

Scattered over the surface near these shafts graphite may be found in the ferruginous laterite.

In the adjoining block to the north (block 362) two shafts have been sunk to vertical depths of 47 and 26 feet in decomposed granite.

Small specks of flake may be seen in some of the rock pierced by these shafts, but again definite veins were absent.

Small specks of flake were also visible in some quartz, probably portion of a pegmatite dyke.

To the west of these shafts graphite specks occur in a very altered basic dyke, probably a highly weathered dolerite. Practically no work has been done in this locality.

On Block 296, specks of graphite were found in a lateritic rock, but nothing definite has been exposed here.

Near the Warren Road on Block 4285, graphite has been found in the laterite and also in a very fine-grained, possibly granitic rock, too much decomposed for accurate determination.

As far as could be seen from the various workings, the country rock is granite relatively unfoliated, through which numerous basic dykes have intruded. These basic dykes have been examined and classified as quartz dolerites.

In the vicinity of the dykes, graphite occurs in the form of minute flakes disseminated through the granite and also in the dykes themselves. It seems

highly probable that the graphite is at least an original mineral in the basic dykes, and probably largely so in some of the granitic rocks (it is to be seen included in the quartz of the pegmatites).

Up to the present no graphite veins have been found, or have any definite channels in the granite been intersected. In consequence, though it is quite possible further developments may expose shear zones, etc., containing graphite deposits, there is no evidence at present of such existing.

NOTES ON THE TUCKABIANNA MINING CENTRE.

(T. Blatchford.)

Introductory.—In accordance with your verbal instructions to make a general inspection of the Tuckabianna Centre, I beg to submit the following preliminary report on that field:—

Location.—Tuckabianna lies at a distance of four to five miles north-east of the Pinnacles (Jasper Hill). The Pinnacles is situated 12 miles south-west of Cue.

Communications, etc.—A bi-weekly mail service by motor car runs between Cue and Jasper Hill, but at present none at Tuckabianna.

Geology.—In general, the geological features of Tuckabianna resemble those of the Pinnacles and Webb's Patch.

Broadly speaking, they consist of extensive well defined bands of quartz-haematite schists (locally known as jaspers or ironstone bars) in foliated greenstone, the latter being bounded on both sides by granite.

Intruding the greenstones, and possibly the quartz haematite schists, are hornblende quartz porphyries. Any available specimens of greenstones at Tuckabianna were so highly weathered as to be useless for accurate determination. It is therefore impossible at present to state definitely whether the greenstones there will link up with those of Webb's Patch or the Pinnacles. However, Webb's Patch is on the same strike as Tuckabianna. Porphyrite dykes occur both at Tuckabianna and Webb's Patch and not at the Pinnacles, so that there is a probability of the former being the case, and that Webb's Patch and Tuckabianna are the same series. Though highly weathered, the porphyrite dykes are distinguishable at Tuckabianna as white or yellowish rocks, through which are scattered numerous grains of original quartz. In several of the mines this form of rock is known as the "white footwall rock." It differs only in appearance from much of the weathered greenstone in that it is not foliated, and is gritty to the touch on account of the quartz grains.

Quartz-Haematite Schists.—There is a large development of this class of rock at Tuckabianna. It occurs as parallel bands of varying thickness in the greenstones. Some of the bands have a thickness of at least 60 feet, possibly more. They vary in composition from a siliceous ironstone to one almost wholly quartz. The gold occurs in certain portions of the quartz-haematite schists, and not in quartz reefs. There are two geological features closely associated with the occurrence of the gold which are worthy of special notice.

1. The bands in which the gold occurs are much contorted or even brecciated. This is particularly noticeable in the Italians claim (G.M.L. 1931).

2. Porphyrite dykes occur as one of the walls of the gold-bearing band, *e.g.*, the Blue Streak (G.M.L. 1928) and Cameron and Wards (G.M.L. 1929). These dykes are locally known as the "white footwall."

It is not evident whether porphyrite dykes occur in the Italians claim or Faherty's, for up to the present time there has not been any crosscutting in either of these mines into the footwall.

There seems little doubt that the higher grade ore occurs in pipes or shoots with a dip to the north, but as the greater portion of the surface is more or less obscured by an over-burden of surface detritus, and as up to date there has been very little driving along the course of any of the lodes, the extent of the payable portions is not determinable.

It is evident, however, that highly payable ore has been mined at several points along an extended line, and that there is still ample room for further prospecting. That payable ore will be found only in narrow shoots, though probable, is still problematical, and there is ample good ore opened up to encourage further development. Many of the prospectors now in the field seemed anxious to know how the "jasper bars" were running, and at present have no map of any kind to guide them. For this reason the present appears to be a case in which a thorough survey should be made at an early date, as no doubt such would be of considerable value, saving the sinking of shafts in disadvantageous portions and preventing much crosscutting in wrong directions.

The following is a list of the crushings compiled from official records. As in some cases almost half the gold contents pass into tailings, the assay value of the tailings, where known, has been added in a footnote.

Name of Mine.	G.M.L.	Tons crushed.	Gold in fine ozs.
Blue Streak	1928	70·00	44·73
Gold Streak	1939	13·00	3·13
Nigel	1926	39·00	182·44*
Tosiana	1931	385·00	849·76†
Tuckabianna North ...	1929	32·50	33·54
Triplicate (Syndicate) ...	1914	439·00	116·71

* Gold in tailings, 126ozs. † Gold in tailings, 877ozs.

DISCOVERY OF WOLFRAM AT GRASS VALLEY.

Near Northam, South-West Division.

(T. Blatchford.)

Location.—The wolfram found at Grass Valley occurred as "floaters" in a ploughed field on Location 2809‡, situated some three miles due north of the township of Grass Valley. Grass Valley lies on the Great Eastern Railway some few miles east of Northam.

Geology.—The principal rock of the Grass Valley district is undoubtedly granite. There are, however, a network of apparently recent (?) dolerite dykes occurring in the granite mass. The fertility of the district is due to the weathering of these more basic rocks. Except on the crest of the hills, outcrops are rare. The nature of the underlying rocks can, however, be fairly well determined by the soils, the

‡ Lands Department 40-chain litho., 27C.

granitic portions being very sandy and light coloured as compared with red or chocolate loam derived from the dolerites.

In the immediate vicinity of where the wolfram was picked up, both the granite and dolerite outcrop, and, in addition, the surface is covered with broken fragments of rock which are not too weathered to prevent an accurate determination of their origin. It was impossible, however, to map the various rocks or ascertain definitely their relationship, for the surface is almost invariably covered with surface débris, varying in thickness from a few inches on the crest of the hill to several feet in the valleys.

From the evidence obtainable, however, it was found that though there are only two main classes of rock, both have several representatives. Thus the granites vary in composition from normal microcline biotite to a true hornblendic form, with minor modifications, due to the presence of garnets and tourmaline. In structure all gradations from massive to gneissic granite may be seen. Pegmatites are common and, as a rule, are coarse in grain. They are inclined to be felspathic rather than quartzose. In one instance minute traces of the green chrome-mica, fuchsite, were detected. Some of the quartz derived from one of these dykes was also stained green with chromium.

The dolerites vary very much in structure, some being extremely coarse-grained, whilst others are of the fine-grained basaltic variety. These have not yet been examined petrologically.

Wolfram.—Nothing definite is known about the occurrence of the wolfram except that numerous pieces were picked upon the slope of a hill, the area covered having a length of some 30 to 40 yards, and that one piece at least was attached to a fragment of granitic rock, which is probably a piece of the matrix. However, as a system of trenching is in process, there is a possibility of the source being discovered at an early date. As wolfram has been commonly found in Western Australia associated with granitic rocks, more particularly pegmatites, and that a rock of this nature has probably been found associated with the wolfram here, it is more than probable that if the matrix be discovered it will turn out to be a pegmatite. The prospectors were apprised of these conclusions, and should be able to recognise the different forms of rock from our conversation on the spot.

COMET VALE.

(J. T. JUTSON.)

A progress report of the uncompleted survey of Comet Vale appeared in the Annual Report for 1916. As the field work has now been completed, and the rocks have been microscopically examined by the Petrologist, a more complete account of the general geology of the district can now be stated than was given in the 1916 Report. The description of the topography, vegetation, water supply, and lodes comprised in such report needs no amplification here, except to mention as regards water supply, that samples of the underground waters of the Sand Queen and Happy Jack mines have been analysed, and that they show over 11 and 25 per cent. total solids respectively, of which common salt forms nearly 8 per cent. and over 20 per cent. respectively. The Happy Jack mine water is therefore a particularly saline one.

General Geology.—The rocks of the district may be divided into two great groups, the basic and ultra-basic, and the acid, the acid rocks being younger than the basic and ultra-basic.

I. Basic and Ultra-basic Rocks.—These comprise (1) fine-grained epidiorites and amphibolites, (2) fine-grained hornblende schists and associated rocks, (3) a grey serpentine, (4) amphibolites, hornblendites and altered peridotites, (5) talc-chlorite schists.

(1) The fine-grained epidiorites and amphibolites comprise the belt of greenstones covered mostly by ironstone wash and sand, in which the principal line of lode (the Sand Queen-Gladsome) of the district is situated. On account of the superficial covering, the northern, southern, and western boundaries of this belt have not been determined, but it abuts on the east of the grey serpentine presently referred to. These epidiorites and amphibolites are dense, fine-grained, and mostly massive rocks, and at the present time are the most important economic group on the field.

(2) The fine-grained hornblende schists form the chief rocks of the north-west trending line of reefs, known as the Lady Margaret line, which lies to the west of the town and the railway. They are tough, dense, fine-grained rocks, and are associated with some amphibolites or epidiorites.

(3) The grey serpentine occurs to the east of the fine-grained epidiorites and amphibolites. Outcrops are scarce, as the surface of the ground is almost completely covered by ferruginous laterite, which has been derived from the underlying serpentine. The latter occupies but a narrow belt, trending north-north-west. The rock is very distinctive both in its fresh and in its weathered appearance. In places it has been altered into a talc-schist. The Happy Jack lode occurs in the serpentine. The lode is a lode-formation, and is probably merely the country rock (grey serpentine) changed to a schist and otherwise much altered, in which gold has been deposited from solution. Chromate of lead occurs in the Happy Jack lode, and chromium has been found by analysis in the serpentine and in the overlying laterite.

(4) The amphibolites, hornblendites, and altered peridotites form a north-north-west trending belt of rocks between the grey serpentine and the western shores of Lake Goongarrie. Without defining the actual boundaries, this group of rocks can be divided into three main groups—(a) actinolitic hornblendites which form the main belt of rocks along the west-north-west trending Tunnel line of reefs, (b) serpentines and actinolitic amphibolites forming a belt south-east of the Tunnel line of reefs, and along the western shore of Lake Goongarrie, and (c) talc-chlorite carbonate rocks derived from peridotites or hornblendites in an area south of (a) and west of (b). The actinolitic hornblendites (a) are of some economic value as the reefs of the Tunnel line occur in them, but (b) and (c) are, so far, of practically no value.

(5) Talc-chlorite schists occur as thin bands associated with, and derived from, various basic and ultra-basic rocks.

At present there is no evidence available to indicate the relative ages of groups (1) to (5) to one another, but they are all apparently older than the acid rocks now to be described.

II. Acid Rocks.—These consist of a quartz porphyry, an aplite, and a hornblende, and a biotite granite.

(6) The quartz porphyry occurs as a series of dykes in the various rocks of group I. It is found both massive and foliated, and is associated with the principal lodes of the field, i.e., the Sand Queen-Gladsome line, the Lady Margaret line, the Happy Jack, and the Tunnel line. At the Sand Queen mine it is considered that where it abuts the reef, values become poor, but elsewhere this effect has not been noticed.

(7) The aplite is usually a fine-grained rock, but has in places a pegmatitic phase. It occurs as small dykes and veins in the rocks of group I. and in the porphyry.

(8) The granite occurs as small dykes and masses. Along the Tunnel line a hornblende granite outcrops as thin dykes, while to the north and west of Comet Vale a biotite granite is occasionally found. There is evidently a larger belt of it, but the country outside the mining area has not yet been mapped. The granites are of no economic value, except that a very decomposed one is quarried at the northern end of the town for building purposes.

GOONGARRIE.

(J. T. JUTSON.)

The following is a brief statement of the mining geology of Goongarrie:—

Area.—The area surveyed in detail represents the long and narrow mining field of Goongarrie, the length being about five miles and its width one mile.

Position.—Goongarrie is 55 miles north of Kalgoorlie on the main railway line from Kalgoorlie to Laverton, and was formerly known as the "90-Mile," 90 miles being in the early days the estimated distance of the field from Coolgardie. The mining belt lies immediately to the east of the railway.

Topography.—The topographical features may be summarised as follows:—(1) Three small isolated belts of high land arranged in a north-north-west direction, all three belts being deeply dissected by steep narrow valleys. (2) Intermediate areas of either gently sloping or flat land, broken by isolated hills and ridges of quartz and other rocks. (3) To the west of (1) and (2) is a somewhat elevated belt of country. In the centre of the field this belt has a gentle unbroken slope to the west, and cliffs facing the east, these cliffs being broken by short gullies trending eastward; the western gentle slope is covered in part by a thin (about six inches or less in places) deposit of sand, which in places has been blown over the brow of the slope into the heads of the small eastward-trending gullies just referred to. At the southern end of the field this elevated country is practically a tableland, whilst at the northern end it is broken into ridges and valleys. (4) To the east of (1) and (2) lies Lake Goongarrie (including the "lake country" and lake proper) with numerous low sand ridges and rock floors. Many quartz reefs and "blows" rise from these floors, forming conspicuous objects in the landscape; and their *débris* often so litters the ground that in places the latter is entirely covered by fragmental white quartz, producing "stone fields" and "desert pavements." Silts of various thickness occur on the eastern side of the lake. The lake is bounded on the east by sand ridges and low sandy country, and on the west in places by cliffs of hard rock at the foot of which rest the rock floors referred to above. The wind has played an important part in the shaping of the form of the land here.

There is hardly any drainage to the west on account of the sandy nature of the country. Almost all the drainage which in the upper portions of the valleys of the dissected isolated high lands flows—broadly speaking—north and south, ultimately finds its way eastward to the lake, which is the lowest portion of the country.

A study of the physiography shows that in the dissected isolated high lands, the longitudinal valleys are almost always in and running parallel to the belt of schists, whilst the separating ridges are steep and composed of hard unweathered rocks. Most of the quartz reefs are also in the schists, so that here there is a clear illustration of the relation of geological structure to surface relief, and to the occurrence of lodes.

Vegetation.—The vegetation is mostly stunted "mulga" with a few oaks, dwarf eucalypts, and some salt bush and samphire flats.

Water Supply.—A large dam has been built by the Government about two miles north of the township of Goongarrie and just to the east of the railway line. The water is pumped from the dam to a tank close to the town, erected at a high point, and from here it is distributed to various places, including the New Boddington Gold Mine. Surface water has to be entirely depended upon, as the underground water is extremely salt.

General Geology.—The rocks of the district may be divided into three groups, (1) Basic and ultra-basic, (2) Altered sediments associated with thin acid dykes, and (3) Other acid dykes. The determination of the individual specimens is the work of the Petrologist.

I. *Basic and Ultra-basic Rocks.*—These comprise a great group of greenstones which are divided into fine-grained epidiorite, porphyritic epidiorite, hornblendite and serpentine associated together, three types of amphibolised quartz dolerite, quartz carbonate-chlorite schist, and a porphyritic quartz epidiorite.

The fine-grained epidiorite forms a considerable portion of the isolated belts of high land already referred to; and also forms a north and south-trending band of rock at the northern end of the field. The rock is a fine-grained, dense, and generally massive rock, but with a rough schistosity developed through it in many places. It is of little economic value, as, although a moderate number of reefs occur in it, they appear not to be payably auriferous.

The porphyritic epidiorite extends as a long narrow tapering band of rock to the east of and abutting the fine-grained epidiorite and the schists to be presently described. The rock has large cream-coloured phenocrysts of felspar in a fine-grained grey ground mass. It is roughly schistose or cleaved in most places, but would not be classed as a schist. It abuts on its eastern boundary the great belt of altered sediments later described. There are a moderate number of mostly small quartz reefs in this rock, but they have hitherto not been proved to be of much economic value.

The hornblendite and serpentine form a long broad band to the west of the town and of the schists to be presently described; and they constitute the somewhat elevated country already referred to. As the rock apparently possesses no economic possibilities (beyond the occurrence of some asbestos) no attempt has been made to separate the hornblendite and the serpentine.

The amphibolised quartz dolerites outcrop as bold ridges and small knobs and bands associated with the fine-grained epidiorite and the quartz-carbonate-chlorite schists. The dolerites appear to be intrusive into the epidiorite and some of the schists, and occur as long masses roughly parallel to the general strike of the schists, and of the field generally, that is, a few degrees to the west of north. The outcrops vary from three or four feet to seven or eight chains in width. The rocks are usually hard and massive, but are occasionally roughly schistose. A few quartz reefs, which are apparently non-auriferous, occur in them, and the rocks may be said to be of no economic value. The amphibolised dolerites have been divided into three series, which are very similar to one another in mode of occurrence and mineralogical composition. They probably represent a series of intrusives from one magna, such intrusions taking place perhaps either simultaneously as differentiated products or at very short intervals of time.

The quartz-carbonate-chlorite schists are, economically, the most important rocks in the field. The New Boddington reefs and most others that have been worked to any extent, occur in these rocks. They form a practically continuous narrow belt through the whole length of the field, are mainly between the fine-grained epidiorite and the hornblendite-serpentine area, and generally occupy low ground on account of their easily weathered nature. The strike of the rocks is usually a few degrees to the west of north, but in places is more to the west, and occasionally in other directions. The dip is high and to the west or south-west. The rocks are mostly fine-grained, but some are medium and coarse-grained. The field relations of the various rocks suggest that the schists have been derived by dynamic metamorphism chiefly from the fine-grained epidiorite, but partly by one or other of the amphibolised quartz dolerites.

The porphyritic quartz epidiorite occurs as thin dykes in the porphyritic epidiorite.

II. *Altered Sediments and Associated Rocks.*—A great series of altered sediments with which are associated some (apparently numerous) thin acid dykes, forms a second main group of rocks. They occur on the floor of Lake Goongarrie, and probably have a width across their strike of about two miles or more. They consist of shales, grits and conglomerates, all more or less soft and considerably decomposed. Many of the conglomerate pebbles, which are mostly quartz porphyries, have been so stretched by dynamic metamorphism that they are now very lenticular. In addition to the true aqueous conglomerates, it is probable that crush conglomerates also occur. The strike of the sediments is usually a few degrees to the west of north, although some outcrops show local contortion. The dip is high and to the west. Thus the sediments generally conform both in strike and dip to the strike and dip of the schists above described.

At their western margin numerous quartz reefs and "blows," usually conforming in strike and dip to the sediments, occur. Some work has been done, but on the whole these reefs do not appear to have been payable, many of the "blows" being, as usual, "buck" quartz reefs.

Associated with the sediments and evidently intrusive into them either as dykes or sills are thin bands of acid rocks, some of which are foliated quartz porphyries. At the junction of the porphyritic epidiorite and altered sediments a long but thin (up to 10 or 12 inches) and broken band (or two or three bands in places) of siliceous ironstone outcrops.

III. *Acid Intrusions in the Basic and Ultra-basic Rocks.*—The third group of rocks comprise a series of acid intrusions, which are associated with the basic and ultra-basic rocks. They are divided into two types, a quartz porphyry and a hornblende-felspar porphyry. The quartz porphyry is foliated in places and forms a rather long, narrow, north and south-trending band at the northern end of the field, intrusive into the fine-grained epidiorite. It contains several small quartz reefs, but they do not seem to be payably auriferous, as practically no work has been done on them. The hornblende-felspar porphyry occurs as a series of thin short dykes in the hornblendite-serpentine area close to the junction of the latter with the quartz-carbonate-chlorite schists.

IV. *Recent Superficial Deposits.*—These require but brief mention. The most important from an economic standpoint are the alluvial deposits in the beds of the creeks and gullies in portions of the high lands, which have been a good deal worked for gold with apparently in some cases excellent results.

Ferruginous laterite caps some of the hills at the southern end and western side of the field, but throughout the main mining belt it is absent. In places a ferruginous "quartzite" occurs in small patches. Clays occur on the flats, and low sand ridges on the lake floor. On the latter at the foot of some of the quartz reefs and "blows" some alluvial gold was found in the early days.

The Lodes.—The auriferous lodes are almost entirely quartz reefs. Gold has been found in places in the soft decomposed schists adjacent to the reefs, but lode-formations practically do not exist. The quartz reefs are very abundant through the whole field, but unfortunately many of them appear to be quite barren. Many are large quartz "blows" or hills which form prominent features in the landscape. These "blows" are usually non-auriferous, except that occasionally a thin band may carry payable gold.

The strike varies, as the reefs trend in all directions, but the greatest number bear between north and south and north-west and south-east. Some are parallel to, and some cut across, the strike of the schists. The direction of underlie varies considerably.

In thickness the quartz reefs and veins range from an inch or less to "blows" up to 14 feet thick, but no average thickness can be stated. Some reefs are many chains in length, but many are very short.

The quartz contains as a rule but few minerals, pyrites being the most abundant.

The reefs occur in most of the rocks in the field but most abundantly in the quartz-carbonate-chlorite schists, and the altered sediments above described, and it is to these rocks, and especially to the schists, that the gold-bearing reefs are almost wholly confined.

The most important reefs of the present time are those being worked by the New Boddington G.M. Co. There are two reefs, roughly parallel to one another, Kearman's and the Boddington. Kearman's is the more easterly reef. There are numerous other reefs that have been more or less worked, but the workings are mostly inaccessible. One of the principal lines appears to have been the series of reefs about 10 chains to the east of the New Boddington, known as Hicks's line. At Gull's Blow, a prominent quartz outcrop to the south-east of the town, a long tunnel was driven under the hill, but apparently with no satisfactory results. Shallow workings exist on various reefs around the hill. To the west of Gull's Blow in the valley of the gully running southward from the Boddington mine some shallow sinking has recently been done and some good specimen gold was said to have been obtained.

A copper lode occurs to the north-east of the township at the old workings in the old Providence lease. Several shafts and open cuts have been sunk and apparently a moderate amount of ore raised, but no work has been done for some time. So far as could be seen in the workings, from the surface, the ore, which is chiefly the common green carbonate, (malachite), occurs in a band of ironstone from six to 18 inches thick, standing nearly vertical, in and conformable to soft gray schists which are also slightly impregnated with the ore at their junction with the ironstone. The writer was told that the latter had much thickened below in some places, but whether for any distance or not is unknown.

An asbestos lode associated with magnesite and dolerite occurs a little over two miles to the north of the town and nearly half a mile west of the railway. Where a face can be seen the lode is 18 inches thick and occurs in fibrous serpentine rock. An open cut about 50 feet long, 7 feet deep and 10 feet wide, has been excavated, and some of the asbestos has apparently been disposed of. It is only, however, of the actinolitic type.

Mode of occurrence of Gold.—There seems to be a tendency throughout the field for the gold to occur in very rich pockets or small shoots in the main lodes and for some small leaders to be prolific gold bearers. Apart from these features, the gold is apparently rather sparingly distributed.

Nature of the Field.—As the field is an old one, and the reefs mostly outcrop at the surface, its future will depend on deep workings, and payable concerns of this character have not yet been proved. If the New Boddington mine should be payable at depth, an impetus will be given to test other reefs at depth, and capital will no doubt be forthcoming for this purpose. It does not, however, necessarily follow should the New Boddington reefs not be payable at depth that other reefs are also unpayable. The main mining belt has been disturbed by intrusions, with the result that the reefs are frequently irregular, short, and probably of no great depth. Still there can be no doubt that many will live to a reasonable mining depth, although there will probably be considerable difficulty in places in picking up the reefs at various depths. In this district particularly, it is advisable to keep to the reefs as closely as possible, by means of winzes. Nothing definite can be said as to the probable gold contents.

E. DE C. CLARKE.

From the 3rd January to 4th June I was engaged in correcting the final proofs and making the index of Bulletin 68, and (in collaboration with Mr. H. W. B. Talbot) in preparing plans, figures and text of Bulletin 75, on the country between Laverton and the South Australian border.

The rest of the year till 18th December, when I returned to Perth to take annual leave, which began on 21st December, was occupied with broad field work in the south-west parts of the Mt. Magnet Goldfield and in the east part of the East Murchison Goldfield, the object being to map on a scale of 4 miles to the inch a block of country about 13,000 square miles in area covered by the Lands Department map 43/300 and by the south part of 52/300. This work, when complete, will link up similar surveys by H. W. B. Talbot to the north, and by C. S. Honman to the south.

Of this block of 13,000 square miles about half has already been examined, therefore the work should be completed during the 1918 season.

In the area under review there are at present six or eight centres in which mining is active. There are, in addition, a very large number of abandoned mining camps.

A revival of mining in the district may be confidently expected, and a detailed account both of the workings and history of these centres of former activity would be of value to those who prefer modern to antiquated methods of prospecting, but such a detailed examination is beyond the scope of the survey at present in progress, which has as its object the broad geological mapping of the country, so that the various belts which should be further searched for valuable minerals may be clearly indicated, and the general trend and character of known ore-bodies may be briefly stated. No attempt at prospecting likely localities could be undertaken during the course of the present survey.

In a report such as this, which is not illustrated by maps, any but the most general remarks on the distribution of the various formations would be unintelligible. The following statement, sufficient for present purposes, may have to be modified when the survey has been completed.

The oldest rocks are sediments, highly altered near Leonora, where they constitute Mt. Leonora and most of the country for 8 or 10 miles to the east, highly altered also much farther north, near Duketon, less changed from their original state near Pyke Hill, just west of Lake Carey. Whether or not these two lots (highly altered and less altered) of sediments are of the same age has not yet been proved.

Next in age are the greenstones, which vary a good deal in structure, composition and general appearance in the southern part of the country under review, but seen, farther north, to be very uniformly of the fine-grained type usually described as "diorite." Intrusions of greenstones into the sedimentary rocks already described are seen in a few places, proving that the former are younger than the latter.

On the other hand, granitic rocks frequently intrude the greenstones, and are therefore of later age than the greenstones.

In the greenstones are long lines of "Jasper Bars," such as those running from Leonora through Mounts George and Davis, from Mt. Margaret through Mt. Morgans to Mt. Zephyr, and those running north from the neighbourhood of Laverton.

As in other parts of the State the greenstones with their Jasper Bars are the chief auriferous formation, nevertheless, considerable quantities of gold have been got from granite, as at Wilson's Patch, Mt. Stirling, and the "Linger and Die," and a galena-bearing vein near the Teutonic Well. Further search for valuable minerals other than gold is to be recommended in the granite country near Mt. Waite, on Erlistoun Creek.

Until official records have been examined it would be unsafe to particularise, but the impression gained in conversation with prospectors is that many mines at present closed down will, when capital is available, be profitably re-opened. Moreover, much of the country near famous rich "shows," such as the "Victory" and Wilson's Patch, has yet to be systematically prospected.

RECENT DEVELOPMENTS AT THE MAGNESITE DEPOSITS OF BULONG.

(F. R. Feldtmann.)

The magnesite deposits at Bulong were examined and mapped early in 1915, and a description of them together with a brief account of the general geology of the area was given in the Annual Report for 1915. The deposits were visited in November, 1917, to examine the progress made in working them since my previous visit. This is described in the following report which is supplementary to that given in the Annual Report for 1915.

General Geology.—As stated in the previous report, the town of Bulong is situated in a greenstone complex composed mainly of serpentine—from augite-peridotite-gabbro and amphibolites derived therefrom, with local development of talcose rocks; this complex extends to the extreme western edge of Lake Yindarlgooda, 2½ miles to the east. The eastern part of the greenstone area is more ultrabasic in character than that round Bulong itself, and it is in this eastern part, near the lake and composed almost wholly of serpentine, that the magnesite deposits occur.

Intruding the greenstones are several large dykes of hornblende-porphyrite with north-south strike, and some smaller dykes of somewhat similar rock with east-west strike.

East of the main greenstone area is a belt of schists and sheared conglomerates, also striking north-south. This belt is much wider to the north than to the south; east of the northern end of the magnesite area it is fully two miles, and probably more in width, and a couple of miles further south is apparently only three-eighths of a mile wide.

Underlying the flat south of the Government Tank is another area of schistose rock, probably also of clastic origin. Owing to lack of sufficient data, they were not mentioned in the present report. These rocks are almost entirely obscured by superficial deposits and the few outcrops are too much weathered for determination in the field. Part of the western boundary of these schists can be mapped with some degree of accuracy, but the eastern is entirely obscured and their full extent cannot be ascertained with any certainty.

East of the main area of schists and sheared conglomerates, and forming the country round Mt. Yindarlgooda is another greenstone area somewhat less basic in composition than the rocks of the magnesite area; this greenstone belt has also been intruded by numerous small dykes of porphyry or porphyrite.

The Magnesite Deposits and Workings.—The work done since my previous visit confirms the occurrence of the magnesite as comparatively short and very irregular veins in the serpentine rock, which is much decomposed where the veins are numerous. In places the veins are so numerous as to form, roughly, about one-sixth of the whole mass of the rock. None of the veins approach those of the Grecian and Californian deposits in size, rarely reaching two feet in width, and the majority being under a foot and usually only a few inches.

As stated in the previous report the magnesite occurs in places, in particular immediately south of the main or "Magnesite" creek, running eastward through M^{l}. C^{m}. 1^{Y}. to the lake, as a surface deposit; this may be in part due to its formation as a "cement" comparable to the travertine associated with decomposed amphibolitic rocks, but is probably largely due in the first place to the occurrence of large flat veins of the mineral. This surface covering of magnesite is, in a few places, over a foot thick.

Since my previous visit, two mineral claims, Nos. 1^{Y} and 2^{Y}, of 300 and 150 acres respectively, have been taken up by the Permasite Manufacturing Co.; these cover the greater part of the northern half of the magnesite area and include the best of the deposits.

Several trial holes a few feet in depth have been sunk on the deposit, particularly to the south of Magnesite Creek; most of these were sunk during my previous visit, but three or four others have since been sunk near the southern end of M^{l}. C^{m}. 1^{Y}., veins of magnesite being cut in each.

There are now three quarries on M^{l}. C^{m}. 1^{Y}. of which one, 300 feet north of the main creek and east of a large watercourse running into it, is over 40 feet in length by about 25 in width, and varies from 10 to 15 feet in depth. The other two quarries are from about 80 to 220 feet south of the creek, the easternmost and largest being about 1,000 feet south-west of the north-east corner of the claim; this quarry is 140 feet long by an average width of 26 feet and reaches 20 feet in depth at its southern end. The third quarry, about 90 feet west of the last, is about 55 feet long by 15 feet wide, on the average, and is 12 feet deep at the southern end.

According to the estimate of the company's manager at Bulong, the magnesite "at grass" is as follows:—

7 tons of "firsts" bagged and ready for carting.
496 tons of "firsts" broken and stacked at quarries, and
70 tons of "seconds" broken and stacked at quarries.

In addition 688½ tons were quarried and exported in 1915 and 10½ in 1916. In 1917 73 tons were sent away from Bulong, of which some 20 were treated in Western Australia.

The value of the mineral is estimated at £1 per ton on the ground, the export value being estimated at a trifle under £4 per ton.

Magnesite in the Vicinity of Hannan's Lake.—During my recent visit to Kalgoorlie a brief examination was made of the western shore of Hannan's Lake, where the occurrence of magnesite was known. In this locality the mineral occurs only as a few small and scattered veins in the low hills near "Serpentine Bay," about 4½ miles S.S.E. of Boulder City, and a mile east of Mt. Hunt. The country here bears a general resemblance to that of the Bulong deposits, and the rock is serpentine, in which a few veins of asbestos occur in places. The veins of magnesite appear to be too small and sparsely distributed to be of any commercial value.

NOTES ON RECENT MINING AT THE NORTH END, KALGOORLIE.

(F. R. Feldtmann.)

A request having been made by the owners of the Hidden Secret Mine at the "North End," Kalgoorlie, for a geological examination, having in view the possibilities of picking up another shoot of payable ore, I was instructed to visit the mine on my way to Bulong; these instructions were carried out in November. Advantage was also taken of the visit to Kalgoorlie to examine briefly recent developments on other mines at the North End.

Hidden Secret G.M.L. 4001E.

At the time of my previous survey of this mine, carried out during the general examination of the "North End," a drive was being put in to the south at the 404ft. level; this drive had then reached a point approximately 180 feet south of the crosscut from the main shaft.

The drive has since been carried another 20 feet to the south, but has left the main lode channel, which should lie about 12 feet farther east from the face. At the end of the drive a vertical winze has been sunk in the hopes of cutting the lode near the downward continuation of a small patch, carrying good values, in the face of the south drive at 436 feet, from the winze 50 feet north. The hanging wall of the lode was cut at about 20 feet below the 404ft. level, the winze being then continued through the main lode and the "green" or fuchsite lode, on the footwall side of the former, to a depth of 42 feet below the level; thence the winze was continued on a dip of 47°, along the footwall of the "green" lode for a distance of 35 feet. From this point, at a depth of 473 feet from the surface, a somewhat tortuous drive was put in to the south for about 90 feet; this drive is partly in the main lode, partly in the fuchsite lode, the face being in the hanging wall side of the main lode.

Owing to the low values obtained, some doubt arose as to whether the formations cut in the winze and followed in the drive were the main and "green" lodes—the latter not being so well defined at this level—or whether these should not be farther east.

A crosscut was therefore driven to the north-east for 59 feet, but with the exception of a small seam carrying low values, which was cut at 48 feet and driven on for 26 feet to the south, with unsatisfactory results, this crosscut is entirely in dolerite greenstone country.

A drive was then put in to the north-west for about 40 feet, from a point in the south drive about 16 feet south from the bottom of the winze from the 404ft. level. At a point in this drive, about 24 feet from the south drive, samples assaying about 2 dwts. were obtained from the footwall of the main lode, at its junction with the fuchsite lode. A winze was then sunk to a depth of 52 feet on a dip of 56°, the bottom of this winze being approximately 516 feet below the level of the surface at the main shaft; this winze has followed the dip of the lode, and not the values, which pitch to the south, and leave the winze at about 10 feet below the level. A drive south from the bottom of the winze should cut this shoot at about 12 feet.

The main points on which the members of the syndicate desired information were:—

(1) Whether the formation cut in the winze from the 404ft. level and followed in the south and north-west drives at the 473ft. level are the main and "green" lodes, or whether these should lie to the east of the present workings.

(2) What are the possibilities regarding the existence of another shoot, and

(3) If such is likely to exist, in what direction it should be sought.

(1) From the results of my survey I consider that the formations cut in these workings are the main and "green" lodes, which, however, are not too well defined at the 473ft. level, particularly at the southern end.

(2) There appear to be no reasons why another shoot of payable ore should not be found, but it is impossible to say at what distance below the present workings it might occur. I doubt, however, whether anything so rich as the previous shoot is likely to be found.

(3) Though experience has shown that the ore shoots of the Kalgoorlie field occur irregularly, I think the best general direction to follow is the downword projection of the pitch of the rich shoot; that values are likely to occur along this line is shown by the occurrences in the south drive at 436 feet, and at the top of the winze from the 473ft. level.

In future operations I consider it advisable to follow the gold, when found, rather than sink a vertical winze or one in the direction of the dip of the lode, in order to avoid unnecessary driving and crosscutting. For example, a winze from the small patch at the 436ft. level, approximately following the direction of pitch of the shoot, would have cut the patch at the 473ft. level and saved most of the work at the latter level.

Creswick G.M.L. 4585E.—The present lease on this ground covers the south-western part of the former Creswick G.M.L. 454E and the western part of the original lease 547E (later 4515E).

At the time of the general survey of the "North End," Messrs. Nelson Bros., the holders of G.M.L. 4515E, were working on a formation striking north-west and running into the main N.-S. lode (*vide* Bull. 69, p. 61 *et seq.*) from the south-east about a chain south-east of the south corner of the present Fair Play G.M.L 4609E; this formation was being worked from an open-cut close to the junction of the two formations.

Since taking up the present lease, the holders, Messrs. Bennet and party, have done a good deal of work on a new formation parallel to and a few

feet north of that worked by Nelson Bros. The new lode appears to be similar in character to Nelson's lode, and probably connects the N.-S. lode with the Isabel west lode; it should thus cut the junction of the fine-grained and the quartz-dolerite greenstones.

Though usually yielding good patches of ore near their junction with the N.-S. lode, these cross formations are seldom payable for any great distance from it.

The discovery of other patches of this nature was anticipated on p. 63 and elsewhere in Bulletin 69.

Official returns up to the end of November, 1917, show a total for G.M.L. 4585E of 88 tons of ore treated for a return of 78.65 fine ounces; from G.M.L. 4545E, 58 tons were treated for 107.59 fine ounces, an additional 30.89 fine ounces being obtained by dollying.

FAIR PLAY G.M.L. 4609E.—This lease covers the whole of the former Fair Play G.M.L. 4052E, as well as the greater portion of G.M.L. 4063E, Fair Play Extended. The holders, Messrs. McPherson and Rae, have been following a narrow cross formation or shear zone between the surface and the 107ft. level; this formation is apparently parallel to and, roughly, some 20 feet south of the green shear zone shown on Fig. 16 of Bulletin 69; it had not been worked by the previous holders of the ground. A small parcel from the present shoot has given an average of over 3¾ ounces to the ton, but payable values do not seem to extend for any distance where the formation cuts the main lode channel, the ore body thus forming a small irregular pipe at the junction of the two formations.

As the work on the new "make" of ore has been confined to the oxidised zone, it is impossible to say how much of the gold content is due to secondary deposition.

This formation or shear zone is probably subsidiary to the green shear zone which formed the southern limit of the shoots previously worked on this mine.

Official returns for G.M.L. 4609E, to the end of November, show 16.60 tons treated for 62.56 fine ounces.

RISING SUN G.M.L. 455E.—The present lease covers the same ground as former G.M.L. 4039E, of the same name. The holders are working the downward continuation of the formation discovered by Messrs. Regan and Lowe, from which a small parcel of particularly rich oxidised ore was obtained. As stated on page 135 of Bulletin 69, this formation is probably a spur joining the southerly continuation of the Westralia Limited lode, the patch being of a similar nature to those of the Creswick lease.

Since the mine was previously visited a good deal of work has been done from the bottom (d. 94 feet) of the vertical shaft and the party has connected through to the east crosscut at the 96ft. level from the old "Sunrise" shaft.

The workings, which are entirely in the oxidised zone, must be near the junction of the dolerite greenstones with the fine-grained greenstone; the exact position of the junction in this lease is, however, uncertain, owing to lack of exposures below the oxidised zone.

From G.M.L. 4559E, according to official returns, a total of 102 tons has been treated for 63.80 fine ounces,

P.A. 955E.—This ground, which formed that part of former G.M.L. 4293E, Milanese, south of the Great Western Railway, is held by a local syndicate, who are at present sinking a shaft to cut the easternmost of the four lodes running through the western part of G.M.L. 4293E; this shaft is a short distance south-east of the 125ft. shaft on the same lode (p. 91, Bulletin 69).

Although fair prospects are said to have been obtained from this lode in the 125ft. shaft, only very poor prospects were obtained in the drives from the same shaft, and I do not think that any great quantity of payable ore is likely to be obtained along this line, although, oxidation having extended to a very considerable depth, there should be a fair body of easily treated material.

As may be seen by a reference to Bulletin 69, one of the most likely places for the occurrence of a payable ore-body in this vicinity is along the eastern edge of the large albite-porphyrite dyke. This dyke is, unfortunately, entirely obscured in this ground, but its eastern edge should cross the northern boundary about 4 chains west of the northern corner of G.M.L. 4293E.

THE OCCURRENCE OF ASBESTOS AT BULONG.

(F. R. FELDTMANN.)

Asbestos is found near Bulong occurring sporadically in short veins and lenses, mainly in the serpentine rocks which, with the derivatives of gabbros and allied rocks, make up the greenstone complex. Both the hornblende and serpentine (chrysotile) varieties are present, but the latter has so far only been found as minute veinlets, usually less than one-eighth of an inch in width, in the massive serpentine. A little work has been done on an occurrence of this nature, on a low ridge about half-a-mile south-east of the south-west corner of Mineral Claim 1Y, and about 2¾ miles east-south-east of the town, in the hopes of striking larger veins of the mineral, but nothing encouraging was found and it is not considered likely that payable veins of the chrysotile occur.

Only a few veins of the hornblende asbestos, of any size, have been found up to the present. One, two or three inches in width, was seen by the writer about 18 chains south-west by west from the south-east corner of Mineral Claim 1Y. The asbestos forming this vein was soft and silky and apparently of fair quality at the surface; the vein was tried by the holders of the above mineral claim, but at a very shallow depth the asbestos became much harder and enclosed many impurities and the work was therefore discontinued.

The only vein of hornblende asbestos which has been given a serious trial was found to the north of the town, about 36 chains east-north-east of the north-west corner of Reid and Colin Streets. This is probably within the area covered by former P.As. 515Y and 516Y, although the position of these areas as given in the description do not exactly coincide with that of the vein as fixed by the writer; no other workings were, however, seen in the neighbourhood. The vein has been tried in three shallow shafts, of which the middle and deepest shaft is about 10 feet; the second shaft is about 30 feet south-west, and the third 50 feet north-east of the first shaft.

The asbestos vein has been cut in all three and has therefore been proved over a length of 80 feet, but it appears to be pinching in the north-eastern shaft; it is about three inches wide in the middle shaft. The strike is about 52° and the dip north-west at about 60°.

The most marked feature is the length of the fibre, some of which reach three feet. The fibres strike with instead of across the vein, and pitch north-east at about 47° in the plane of the vein. The asbestos is hard and stiff and appears to be practically useless for commercial purposes, and there is but little chance of the quality improving at depth. The rock in the vicinity appears to be serpentine.

To sum up, none of the asbestos veins of any size have so far proved of sufficiently good quality for commercial purposes, and it is doubtful whether such are likely to occur.

LABORATORY REPORT, 1917.

During the past year the routine work of the Laboratory, as indicated in the accompanying table, has consisted largely in classifying and valuing minerals, in making assays for the commercially important constituents of various ores, and in making physical and metallurgical tests and analyses of minerals, rocks, and ores. The total number of samples registered was 1,671, being an increase of 20 per cent. on those received during the previous twelve months. Included in these figures are the assays made for the State Batteries Branch, which keep one member of the staff almost fully occupied in determining the values of tailings, etc. An increasing amount of laboratory work is required by the State Mining Engineer in connection with the State advances against base metal ore in transit to smelters. This and other matters submitted by this officer occupy almost the whole time of a second member of the staff. The work done free for prospectors and others continues to increase in volume, and should have a very beneficial effect in helping to locate new mineral deposits and to bring to the productive stage other previously known deposits. Without this system, to a certain extent, only the most obvious deposits and those of whose value there is plainly no uncertainty would be opened up, whilst many valuable minerals, whose appearance is not generally known, would be overlooked altogether.

The main objects of the Geological Survey Laboratory are to stimulate and extend in already established directions the commercial utilisation of the minerals of the State, and to endeavour to open up new lines of economic application for minerals at present lying unused, as well as to discover and keep records of deposits of all minerals now valueless but likely to be of value in the future.

These objects are attained by several interdependent methods:—

(1.) Collections of minerals are made in every part of the State by all the officers of the Survey, and are systematically catalogued and kept for reference.

(2.) Notes are kept of the approximate quantity of such minerals in sight, and their availability in regard to transport, etc.

(3.) Examinations and working tests are made with a view to determining their chemical and physical properties and their applicability to industrial purposes, the best means of separating them from their worthless associates, as well as their beneficial or deleterious effect upon existing processes.

(4.) Contact is established between manufacturers requiring various crude minerals and individuals in a position to supply their wants from local sources.

With the increasing price and greater scarcity of many common materials necessary to the every day life of the community, efforts have been redoubled to assist in the substitution of local minerals and mineral products for imported ones. Amongst such substances which are so plentiful in Western Australia and so accessible that there is no excuse for importing either the crude minerals or their more readily manufactured products, may be mentioned many pigments, such as red and yellow ochre, raw and burnt sienna and barium white (barite). Ground chalk has been imported in large quantities in the past and used for whitewashing or distempering and putty making; for the former purpose any of the several pure white and fine-grained local clays makes an excellent substitute, and for the latter certain local marls are well suited. Both are now undergoing commercial trials. Heat insulating materials have been brought to this country over thousands of miles of ocean, whilst within a few miles of Perth one can get in large quantities one of the best insulators known, viz., a pure diatomite. Abrasive materials of many grades of hardness are plentiful in the State, ranging from the fine and soft infusorial earths (diatomite and spongolite), through felspar, quartz, and garnet to corundum, as well as sandstones suitable for grindstones, and "oilstones" of the quality of Turkey Stone suitable for making whetstones for the finest edged tools.

Large quantities of crude arsenious oxide and other arsenic compounds are imported for use as sheep dips, insecticides, etc., at the same time as hundreds of tons of the same oxide are wasted in the fume from roasting furnaces in various parts of the country, or lost for the want of a simple roasting and condensing. The information available in this Laboratory regarding arsenic ores was so complete that during the year inquirers for arsenic deposits for the production of commercial compounds were enabled to locate suitable supplies of ore, and take over leases with the object of working them for this material.

For many years past experimental work has been going on in this Laboratory with a view to testing the value of local clays for industrial uses. Preliminary physical and, in some instances, chemical tests have thus been made in the past of very many clays with useful results. In order, however, to convince manufacturers of the possibilities of these clays and to induce the expenditure of capital on new or extended plants for their utilisation, something more than these preliminary tests are necessary. During the current year therefore, under the aegis of the Hon. Minister for Industries, Mr. T. Rafferty, a practical potter, who possesses personal experience of the various stages of the pottery industry, has been attached to the Laboratory temporarily with a view to further testing on practical lines the capabilities of the many and varied clays known to exist in large quantities throughout the south-western por-

tion of the State. A model kiln having been built, the co-operation of the public was invited to the extent of collecting samples of clay for testing purposes to supplement the collection already in the possession of the Department. The response met with was not too satisfactory, up to the end of the year only 41 clays representing 13 districts having been sent in. Samples are, however, still coming to hand, and it is hoped that many other districts may yet be represented, and that the services of field officers of the Survey may be utilised to obtain samples from known deposits from which no samples are at hand. From the preliminary tests made up to the present it would appear that local equivalents are available of china clay, fireclay of normal types, cornish stone, felspar, flint and terra cotta, but there may be a difficulty in obtaining a white ball clay of the highest degree of plasticity.

As opportunity occurs a series of monographs are being written giving detailed information regarding all the minerals of a particular mining district. The first of them to appear was that on the Minerals of Kalgoorlie, which was published in 1912 in Bulletin 42. In 1916 a full account of the Minerals of Meekatharra appeared in Bulletin 68. In 1917 the third of the series, "The Minerals of Westonia," was published in Bulletin 71. Westonia has proved to be unique in some respects so far as Western Australia is concerned in the mode of occurrence of gold, and further, has yielded a number of minerals of interest both economically, such as molybdenite, scheelite and wolfram, and scientifically, such as a tungsten-bearing variety of wulfenite, (molybdate of lead) and miloschite, the rare chromiferous variety of kaolinite. In continuance of this series, there is now in hand an investigation of the minerals of Comet Vale and Goongarrie, a district presenting several unusual features in regard to gold occurrence, and noted for its many interesting minerals. These investigations pave the way for a more thorough understanding of the source and distribution of the gold and other exploitable minerals, as well as for a more effective metallurgical treatment of the ores in sight.

Owing to the controversy which has arisen over the fertility of the soils in the area lying between Esperance and Norseman, a large number of these soils were handed over to the Laboratory in the early part of the year for a thorough investigation of the water soluble minerals ("salts") present in them. The details of this investigation occupied the time of a specially appointed officer for three months and yielded results not only applicable to the study of the fertility of this particular area but also to the study of the past history of this area of the State, including its geologically recent (Miocene) submergence by the sea, and also to the study of the more general question of the effect of surface solutions on the oxidation and enrichment of the upper portions of ore deposits. Evidence was given regarding this investigation to the Royal Commission on the Mallee Belt and Esperance Lands.

The unusual demand for graphite, principally for steel melting crucibles in munition plants, continues to prevail, and desultory prospecting has gone on over large areas of the State, and an unusually large number of samples have been tested to determine their value. For this work the Department now uses a plant specially designed by the Morgan Crucible Company, which, working on the principles of a full-sized commercial washing plant, gives results indicating the quantity and quality of marketable flake which is recoverable. The quality demanded for crucible making is such that the flake shall be large enough to be held on an 80-mesh (linear) screen, and shall in bulk contain not less than 80 per cent. carbon. In practice it will probably be found that ores yielding less than 10 per cent. of such flake will not pay to work. The only localities already known to yield such ore are the Munglinup River, Kendenup and the Northampton District, including an area extending from the Murchison Railway to the lower Murchison River. Amorphous (finely granular) graphite, which is valueless, is much more widely distributed throughout extra-tropical Western Australia.

A report was prepared during the year upon the utility as fertilisers of the Cretaceous chalk, coprolite and glauconite occurring in association at Gingin. The existence of these substances at Gingin has been known for many years, an hydraulic lime having been burnt from the cream-coloured chalk about 20 years ago, and attempts having been since made on several occasions to have the chalk used as a source of Portland cement. For this purpose it is too irregular in grade and too high in general average of silica percentage to be satisfactory, typical samples showing:—

Lime, CaO	39.50	42.46
Magnesia, MgO ..	1.27	1.52
Alumina, Al_2O_3 ..	3.40	1.95
Iron oxide, Fe_2O_3 ..	2.53	1.90
Silica, SiO_2	20.28	16.72
Carbonic acid, CO_2 ..	32.34	35.03
	99.32	99.58

The demand which now exists for agricultural lime has caused a new interest to be taken in this material, since such a soft rock with an average of 75 per cent. carbonates is well suited for making agricultural "ground limestone." In certain fairly extensive portions of this area the chalk is associated with an appreciable quantity of coprolite (nodular lime phosphate) averaging 23 per cent. phosphoric oxide, whilst potash in the form of glauconite is not only concentrated in an extensive bed of greensand beneath the chalk but is distributed also through both chalk and coprolite. The presence of this phosphoric oxide and potash should add to the fertilising power of the material from these beds. Very little is known of the chemistry of glauconite beyond the fact that it contains 7½ per cent. of potash, all of which is readily soluble in moderately dilute hydrochloric acid, and that while it resists weathering when surrounded by abundant calcium carbonate, in non-alkaline situations it fails to resist the action of air and rain. It seems highly probable that the potash in this mineral would be available as plant food, a most important matter in the present famine in potash for agriculture. The chemical properties of this mineral should be thoroughly investigated to ascertain if this is so and if there is any inexpensive means of concentrating the potash contained in it. Another possible source of agricultural potash, viz., Jarosite, is described below under Mineral Notes.

	Pay.	Free.	G.S., W.A.	O.D.	Totals.
Samples.	126	323	195	1,027	1,671
Gold assay	99	115	15	872	11,10
Silver assay	33	56	5	93	187
Copper assay ...	31	52	5	54	142
Tin assay	1	17	...	11	29
Lead assay	19	15	1	9	44
Bismuth assay ...	...	5	4	...	9
Antimony assay ...	1	...	...	2	3
Iron assay	...	10	1	...	11
Manganese Assay ...	...	16	...	1	17
Tungsten assay ...	...	11	3	3	17
Lime assay	...	2	5	1	8
Arsenic assay ...	...	...	...	5	5
Phos. Oxide assay ...	...	4	6	...	10
Tantalum assay ...	...	6	...	...	6
Niobium assay ...	...	6	...	...	6
Molybdenum assay ...	1	4	...	2	7
Silica assay	...	7	2	...	9
Carbon assay ...	2	...	...	...	2
Sulphur assay ...	...	...	...	4	4
Petroleum assay ...	...	10	1	...	11
Lithia assay	...	...	...	1	1
Tellurium assay ...	...	1	...	...	1
Titanium assay ...	...	...	3	...	3
Zinc assay	...	4	...	...	4
Nickel assay	...	...	1	...	1
Chromium assay ...	...	...	1	...	1
Potash assay ...	...	2	...	...	2
Sodium Chloride assay	...	...	...	17	17
Soil analyses	...	...	...	40	40
Proximate analyses ...	...	30	30	24	84
Complete analyses ...	2	3	39	1	45
Partial analyses ...	1	4	37	4	46
Determinations ...	6	184	50	37	277
Practical Clay Tests	...	5	2	39	46
Graphite Flotation Tests	...	16	6	6	28
Metallurgical Tests ...	1	...	...	4	5
Microphotos	...	...	12	...	12
Lime burning Tests ...	...	...	16	...	16
Calorific Value ...	...	...	...	11	11
Gold Valuation ...	...	...	4	...	4
Miscellaneous ...	1	9	19	7	36
Totals	198	594	268	1,248	2,308

MINERAL NOTES.

During the year several new mineral discoveries of importance were made, of which the following are brief descriptions:—

Jarosite (hydrous sulphate of potassium and iron), Northampton and Nullagine.—This mineral, only once previously recorded from Australia (hundred of Coghlin, S.A.), and but rarely from foreign localities, has been found in considerable amount in association with graphite at Northampton. In an outcrop a little to the north of the town it is in the form of firm yellow granular masses, which under the microscope are seen to consist of groups of bright yellow hexagonal crystals. The molecular ratio of potash to soda in the mineral from this lode is 4½ to 1.

During the present year the same mineral has been shown by Mr. H. Bowley, Assistant Mineralogist and Chemist, to be an important constituent of some portions of the oxidised auriferous conglomerate (banket) at Nullagine, forming no less than 11 per cent. of a large specimen which was analysed. The mineral is in microscopic crystals or granular masses of sulphur-yellow colour, scattered throughout the cementing material of the conglomerate and the more porous pebbles in it, or constituting pseudomorphs after pyrite. The molecular ration of potash to soda is about 3½ to 1.

Tests have shown that jarosite is of some metallurgical interest in gold ores, since it acts as a "latent acid" capable of interacting with alkaline solutions and decomposing alkaline cyanides. Its chief interest at the present time lies in its potash contents, which, provided the mineral could be found in sufficient quantities, could be made available for agricultural purposes at an extremely low cost.

It is quite probable that jarosite, which up till now has been looked upon as a rare mineral, may in reality be of wide distribution, since it easily escapes recognition, being in mass not unlike an ordinary yellow ochre (xanthosiderite, Fe_2O_3, $2H_2O$). It should be looked for in the outcrops of all highly pyritic lodes.

Natroalunite (hydrous sulphate of aluminium and sodium), Kalgoorlie.—This mineral belongs to the same group as jarosite and alunite, and, like them, acts as a "latent acid" towards cyanide solutions, and is therefore of interest to gold metallurgists. It has been detected in veinlets of tough granular structure, opaque and white in colour, in weathered rock on the Maritana Lease, Kalgoorlie, and between Tailings Leases 15 and 19, Boulder. In appearance it closely resembles a tough white clay, the plasticity of which, however, it lacks. Quantitative analyses and tests of its chemical and physical properties have confirmed its identity. This is the first record of its occurrence in Australia.

Apatite (Fluophosphate of calcium), Greenbushes.—The bright blue, semi-transparent variety of apatite known as "lazurapatite" has been detected in crystalline masses up to one inch (25mm.) in diameter in a somewhat fine-grained pegmatite from Greenbushes.

Molybdenite (sulphide of molybdenum), Darling Ranges.—Many years ago this now valuable mineral was discovered in a fractured grey granite one mile north of Swan View Station, in the Darling Ranges. A small open cut was made on the outcrop, but no serious attempts have ever been made to determine the average grade or extent of the deposit. (*Vide* An. Prog. Rept. G.S., W.A., for 1914, p. 23). Later, traces of molybdenite were detected at North Dandalup, about 45 miles south of Swan View (*vide* An. Prog. Rept., G.S., W.A., for 1916, p. 11), and at Clackline, 37 miles east of Swan View. Recently small quantities have been found in a pegmatite vein at Mahogany Creek, six miles south-east of Swan View, and quite encouraging prospects at Mokine, near Clackline. These numerous occurrences over an area of granite country between 40 and 50 miles square suggest the advisability of thoroughly prospecting this area for molybdenite, a mineral indispensable to our Munitions Department and at the present time quoted at an abnormally high figure, viz., £5 per unit for concentrates at point of production, equal to about 4s. 6d. per pound.

Molybdenite (sulphide of molybdenum), Mulgine (near Warriedar).—The occurrence of molybdenite in this locality was noted in my Annual Report for 1915, and a description of the deposits by the Government Geologist appears in the Annual Report of the Survey for 1916. Although only a few hundredweight of concentrates from this locality have been marketed, specimens of rich ore continue to reach Perth from it. Recently blocks of ore have been exhibited with a width not less than twelve inches

(30 cm.) and consisting of a fine white microcline granite, through which coarse flakes and rosettes of molybdenite are very evenly distributed to the extent of forming about 20 per cent. of the whole mass. These are by far the most promising specimens of molybdenum ore ever obtained in Western Australia.

Powellite (molybdate of calcium), Mahogany Creek and Mulgine.—This rare mineral has been found in both localities in pegmatite veins in the form of milk-white or pale grey pseudomorphs after molybdenite. They are soluble in strong hydrochloric acid and the solution reacts strongly for calcium and molybdenum, but not for tungsten or water.

Magnesite (carbonate of magnesium), Coolgardie and Bandimup.—About one and a half miles east of the township of Coolgardie a deposit of very high-grade magnesite has been opened up during the year. This mineral is white in colour and very dense and finely granular in structure. A bulk sample was analysed with the following results:—

	Per cent.
Magnesium carbonate, $MgCO_3$ ..	98.18
Lime, CaO	nil.
Silica, SiO_2	.63
Alumina and iron oxide, Al_2O_3, Fe_2O_3	1.04
Water, H_2O	trace.
	99.85

The magnesite from Bandimup Water Reserve, 21 miles east of Ravensthorpe, was similar in appearance and had the following composition:—

	Per cent.
Magnesia, MgO	46.63
Equal to $MgCO_3$, 97.50 per cent.	
Lime, CaO	1.34
Iron oxide, FeO	.10
Alumina, Al_2O_3	.19
Carbonic acid, CO_2	51.13
Silica, SiO_2	.28
Water and organic matter ..	.99
	100.66

The minerals from both these deposits are above average quality and are well suited for the manufacture of sorel cement, for which there is now a big demand, as well as for calcined magnesia, epsom salts, and other magnesium compounds.

Talc (hydrous silicate of magnesium), Kundip.—The occurrence of talc in the Phillips River District has been known for some years, but only recently has any attempt been made to put it to practical use. An analysis of a typical sample collected during the year showed its composition to be:—

	Per cent.
Silica, SiO_2	63.39
Magnesia, MgO	30.22
Ferrous oxide, FeO	1.24
Manganese oxide, MnO	nil.
Nickel oxide, NiO	.29
Lime, CaO	nil.
Ferric oxide, Fe_2O_3	.08
Alumina, Al_2O_3	nil.
Water combined, H_2O	4.56
Water hygroscopic, H_2O	.20
	99.98

Density, 2.70.

This is a pure talc possessing a coarsely foliated structure and pale green colour. It yields a dead white powder entirely free from grit, which could be used in the rubber trade, for filling in paper making, and for toilet purposes. Such material, after fine grinding, was selling in the United States at £3 to £3 15s. per ton in December, 1917, and was worth considerably more in Australia.

Fluorite (fluoride of calcium), Mulgine.—Early in the year fluorite was detected in microscopic violet-coloured granules in a rich molybdenum ore from Mulgine. The ore resembled a greisen in appearance, and was composed (in decreasing order of frequency) of yellow muscovite, microcline, oligoclase, quartz, molybdenite, pyrite, fluorite, zircon, and sphene. The fluorite granules were sometimes interstitial, sometimes embedded in the felspar. At the end of the year the Government Geologist collected some specimens of ore from the molybdenite lode on M.L. 40, which exhibited coarse cleavable masses of the same mineral up to three-quarters of an inch (20 mm.) in diameter. These also are purple in colour, mostly very deep in shade up to purplish-black, but shading off occasionally to a lighter shade of the same colour. Fluorite occurs under very similar conditions at Poona (Murchison Division), where, however, molybdenite is absent.

Prehnite (hydrous silicate of calcium and aluminium), Comet Vale and Coolgardie.—The presence of this mineral, which is related to the zeolites, in association with calcite and gypsum in the vughs of the lode of the Sand Queen Gold Mine at Comet Vale, indicate that the concluding conditions of vein-filling in this deposit were distinctly different to those which obtained in all other West Australian gold deposits of which descriptions are available, excepting the lode at Sherlaw's Mine at Coolgardie, where the same combination of minerals is found.

Chrysotile (hydrous silicate of magnesium), Hale's Well, north of Nullagine.—Asbestos of the actinolite species is widely distributed throughout the older greenstones of the State, but is unfortunately almost valueless. The commercially valuable asbestos, chrysotile, has only been known in the past at Soanesville, a most inaccessible locality in the North-West. During this year a small tonnage of high-grade chrysotile has reached Fremantle from M.L. 16, two miles south-east of Hales' Well, and about 15 miles north of Nullagine. The mineral is pale greenish-yellow in colour, and is easily divisible into fine, soft, and tough fibres. The maximum width of vein noted was 3¾ inches (9½ cm.), and the maximum length of fibre 3 inches (7½ cm.).

Sillimanite and *Andalusite* (both silicates of aluminium), Kunanoppin.—The detection of these minerals in garnetiferous mica schists, the latter with much graphite also, is of importance, since similar rocks with the same conjunction of minerals occur in association with auriferous lodes at Marvel Loch, 80 miles to the east-south-east. There is thus a possibility of gold deposits being found farther to the west and north-west of Westonia, which has hitherto been looked upon as the westerly limit of the Yilgarn auriferous area.

Coal, Irwin River.—After having been abandoned for some years, the coalfield near the head of the Irwin River has again been prospected this year by means of three shafts, and the latest sample from the seam at a depth of 42 feet showed the lowest percentage of ash yet recorded from this field, viz.,

8.76 per cent., as against a previous average of 14.52 per cent. Partly because of this low ash, but more largely because the coal, which in the seam carries about 20 per cent. of moisture, had been thoroughly aid-dried before being submitted for analysis, a record calorific value was shown by this sample, viz., 10,494 B.T.U. The sample had the following composition:—

	Per cent.
Moisture	9.48
Volatile	32.59
Fixed carbon	49.17
Ash	8.76
	100.00

Assuming the freshly mined coal to have 20 per cent. of moisture, reduced to 15 per cent. by two or three days' air-drying, the fresh coal would have a calorific value of 9,274 B.T.U., and the coal put on the market after a few days' exposure, 9,854 B.T.U. If this high grade can be maintained, the possibility of using this coal as a fuel throughout the Murchison area should be seriously considered.

Meteorite, Youanmi District. — Another large metallic meteorite was acquired by the Department during the year. This is a somewhat flattened mass of nickel-iron, deeply pitted on both sides and evidently a complete boloid. It weighs 268lbs. (121 kg.) and measures 22 inches (56 cm.) in greatest diameter and 6 inches (15 cm.) in greatest thickness. It appears to belong to the group of "medium octahedrites," which is a common type. This makes the thirteenth metallic meteorite discovered in the State, of which seven have been "medium octahedrites," three "broad octahedrites," one "broadest octahedrite," and two "finest octahedrites."

E. S. SIMPSON,
Government Mineralogist and Chemist.
Perth, 1st February, 1918.

PETROLOGICAL WORK.

(R. A. FARQUHARSON.)

The petrological work carried out during the past year may be most conveniently summarised under the following heads:—

I. Determinations and Reports for the Geological Survey Staff.
II. Determinations and Reports for mine managers, for other departments, for prospectors, and for the general public.
III. Miscellaneous.

I.—Determinations and Reports for the Geological Survey Staff.

While a number of identification and short descriptions have been made of specimens brought in by members of the staff, with the object of obtaining information that would throw light on some particular geological or mining problem, the chief work of the year has been the determination, description, and correlation of rocks collected by the officers in the field, and discussions, with the officer concerned, of the geological problems of the various districts.

The total number of sections cut during the year was 713, while 435, exclusive of many duplicates, were added to the slide collection. The suites of specimens treated include those from:—

A.—The Warburton Range and the country to the east of it so far as the South Australian Border.

The results of the examination of the rocks—which was begun in December, 1916—have proved both interesting and important, but as a general account of them with a section comprising detailed description has been given in Bulletin 75, now in the Press, only a brief resumé is called for here. The rocks have been classified as follows:—

(1) Acid Porphyries.
(2) Granites both of pink and grey colour.
(3) Granulites and gneisses of Cohn Hill and Mt. Aloysius.
(4) Greenstones.
(5) Basic plutonic and dyke rocks.
(6) Rocks of volcanic origin.
(7) Rocks of classic and sedimentary origin.

1. The acid porphyries, which include quartz porphyries, with and without quartz phenocrysts, granite porphyries, granular porphyries in some cases garnetiferous, and micropegmatite, are genetically connected, being of one rock mass, due to differences in the conditions of solidification in different portions of the mass.

2. Both pink and grey granites are usually very coarse-grained with large crystals of microcline. In some specimens greenish-brown hornblende is present, and in the grey granites not only is granular garnet frequently found, but also the evidence of the operation of severe dynamic stress in the rock. Though the similarities between the two granites are strong, there is doubt whether they are facies of one magma, and whether the pink is not younger than the grey.

3. The granulites and gneisses of Cohn Hill and Mount Aloysius are different from any rocks yet found in other parts of Western Australia. The granulites, which are hypersthene granulites, show certain marked resemblances to the acid members of the Charnockite Series in India. The gneisses are garnet-sillimanite gneiss mineralogically similar to the Saxon granulites.

4. The greenstones are, on the whole, very similar to those found in association with the auriferous deposits in different parts of the State, *e.g.,* at Meekatharra. One specimen, about the mode of occurrence of which there is some doubt, is noteworthy for the presence in it of seapolite partially replacing felspars.

5. The basic plutonic and dyke rocks include (a) plutonic intrusives or rocks of plutonic habit occurring apparently as large masses, (b) rocks of doleritic habit occurring as dykes. The former, (a), are olivine norites with the characteristic minerals in varying proportions. They are very similar both in mode of occurrence and in composition to the olivine norites from India and South Africa. The latter, (b), comprise micropegmatitic quartz-dolerites, ophitic olivine dolerites, ophitic dolerites and fine-grained amphibolised dolerites.

6. Rocks of volcanic origin. Specimens which, from the presence of vesicles are undoubtedly of volcanic origin, were obtained from a few localities, notably Mt. Herbert and Table Hill. They are all

fine-grained basaltic dolerites considerably altered by epidotisation and chloritisation.

7. The rocks of clastic and sedimentary origin include decomposed tuffs or agglomerates, grits, quartzites, conglomerates, and volcanic conglomerates, and some metamorphosed sediments of doubtful character.

As one of the objetcs of the expedition to the Warburton Range was the examination of the country for any greenstone areas likely to prove worthy of prospecting, special attention has been paid to the correlation of the greenstone specimens with those from the goldfields of the State, and the results of this have been set out in a separate chapter of the Appendix to the Bulletin. Further, the results of the investigation of the rocks collected on the expedition, together with the facts gleaned from a critical perusal of the various publications hitherto issued relating to the geology of Central Australia, have enabled a general correlation to be made of the rocks of the most important features of this little-known region, and some conclusions to be drawn as to its general geological constitution. The details of the correlation, the resultant conclusions, and a digest of the previous papers dealing with different parts of the region have been set out in another separate chapter.

B.—Parts of the North-West, Central, and Eastern Divisions between Long. 119deg. and 122 deg. E., and Lat. 22deg. and 28deg. S.

The numerous specimens collected by Mr. Talbot from this region have been fully described in Bulletin 77, which is ready for the press. They include rocks of the following type:—

1. Sedimentary rocks.
   - (a) Sandstones.
   - (b) Grits or arkoses.
   - (c) Shales and slates.
   - (d) Quartzites, haematite-quartz rocks, and quartz-schists.
   - (e) Limestones.
   - (f) Jaspers.
2. Granites and quartz-porphyries.
3. Basic igneous rocks.
   - (a) Older greenstones.
     - (i.) Quartz-amphibolites, serpentines, epidiorites, hornblendites.
     - (ii.) Older amphibolised and zoisitsed dolerites.
   - (b) Basic and doubtful acid lavas; and tuffs and agglomerates making volcanic vents.
   - (c) Basaltic dolerite sills, dykes and bosses.

Of the sedimentary rocks, the sandstones are in three localities glauconitic; the shales are in many instances indurated by contact metamorphic action of the basic sills; the limestones are in some localities magnesian and even dolomitic. The jaspers are remarkable in that they have been undoubtedly derived from sedimentary rocks by silicification. Outcrops have been found in which a gradual change can be traced from the jasperoid material to a finely banded true soft sediment.

The Basic Igneous rocks are chiefly noteworthy owing to the fact that included amongst them are not only sills and dykes but undoubted vesicular and non-vesicular lavas. The sills and dykes, which consist of basaltic dolerite and micropegmatitic quartz-dolerite, occur in some places—as in the Lofty Range—in very large numbers; and the lavas, if, as is probable, they extend as far as the coast at Roebourne, attain an enormous thickness and extent. These flow rocks are chiefly basaltic dolerite.

Associated with the lavas are small patches of volcanic agglomerates and scoriaceous tuffs, which, in two instances at least, mark the vents from which lava has issued.

C.—Goongarrie and Comet Vale.

Goongarrie.—The rocks described from this district for Mt. Jackson have been grouped as follows:—

1. Fine-grained epidiorites.
2. Porphyritic epidiorites with large zoisitised felspars.
3. Hornblendites and serpentines.
4. Amphibolised quartz-dolerites, some coarse-grained, some fine-grained, some with quartz, some without quartz.
5. Quartz-carbonate-chlorite schists.
6. Altered sediments (conglomerates, grits, and shales, with associated acid rocks).
7. Porphyries, (a) quartz porphyry, (b) Hornblende-felspar porphyry.

Comet Vale.—The rocks illustrating the district are very similar to those from Goongarrie; they have been thus classified:—

1. Fine-grained epidiorites and amphibolites.
2. Fine-grained hornblende schists and associated rocks.
3. Grey serpentine.
4. Amphibolites, hornblendites, and altered peridotites, including serpentines and talc-chlorite-carbonate rocks.
5. Talc-chlorite schists.
6. Quartz-porphyries.
7. Aplites and granites.

The above classifications are the result of discussions between Mr. Jutson and myself, discussions which were desirable owing, on the one hand, to the petrological resemblance between many of the greenstones, and, on the other, to the peculiarities of their occurrence in the field.

D.—Quinn's, Jasper Hill and Warriedar.

Quinn's.—The rocks from this locality comprise greenstones that are chiefly schistose epidiorites, microcline aplites and pegmatites, and rocks which had formerly been described as granitic schists, but which, owing to the absence of felspar, and the very large content of granular quartz, appear rather to be of clastic origin. These latter seemingly vary very considerably in composition, for some are white, others yellowish white, and others dark-green and of dioritic character. Some are much sheared, others almost massive. Apparently associated with them are finely foliated talcose chloritic schists, of which some show decomposed white knots.

Jasper Hill.—The chief rock types collected from this area are:—

Greenstones—

1. Massive epidiorites and amphibolites.
2. Sheared or foliated epidiorites and hornblende schists.
3. Fine-grained massive epidiorites or amphibolites with thin acicular felspars.
4. Finely foliated hornblende-epidote-quartz rocks.

Granites and Porphyries—

5. Granular aplites with veins of quartz and fibrous tourmaline.
6. Biotite and garnetiferous muscovite granite.
7. Chloritic quartz porphyry or porphyrite.
8. Finely foliated black tourmaline hornfels.

There is little doubt that the massive and the sheared and foliated epidiorites are genetically identical. They may have been intrusions from the same magma differing slightly in age, or the massive varieties may represent only portions of the same rock mass as the foliated rocks, that have escaped the shearing stresses. The latter now appears to be more probable.

The fine-grained massive epidiorites (3) differ so much in structure from the others, and so closely resemble the fine-grained amphibolites of Kalgoorlie, that they have been separated as a distinct group, though whether they are altered forms of an old lava or of the chilled margin of a dolerite mass is not at present clear.

Warriedar.—The country is this neighbourhood surveyed by Mr. Feldtmann consists mostly of—

1. Fine-grained fibrous amphibolite.
2. Coarse-grained amphibolite.
3. Fine-grained amphibolised ophitic dolerite or epidiorite.
4. Amphibolised ophitic gabbro.
5. Platy and prismatic hornblendites.
6. Banded zoisitised and amphibolised quartz-dolerite.
7. Quartz diorite.
8. Micacised and granulated quartz porphyry.
9. Phyllitic shale.

E.—Esperance District, in praticular the neighbourhood of the Munglinup Graphite Deposit.

These rocks, collected by Mr. Blatchford and Mr. Herbert (the representative of the Morgans Battersea Crucible Company), were submitted to me for determination, and at Mr. Herbert's request, for detailed description and investigation of the nature and origin of the lode material. The chief rocks were found to be:—

1. Foliated granular hornblende gneiss.
2. Garnetiferous hornblende gneiss.
3. Decomposed specimens mostly impregnated by graphite.

In the decomposed rocks the evidence obtained showed that—

(a) There are undoubted pegmatite veins impregnated by graphite in the zone in which the shafts occur.
(b) The lode material not only contains pegmatite veins, is in places composed of a kaolinic quartz mass derived from the alteration of a quartz-felspar intrusion.
(c) In one shaft, the graphitised material is a fine granular carbonate rock consisting largely of magnesite.

It is probable that the lode material is in part the alteration product of a granitic pegmatite, in part an extremely weathered basic rock of serpentine or gabbro character.

At Mr. Herbert's request, microphotographs were taken to show the interlamination of rock material with the graphite flakes, a phenomen which is frequently the cause of unexpectedly low results in the mechanical separation of the graphite.

F.—Kojonup, Tuckabianna, etc.

The rocks from these localities, which were mostly very decomposed, were collected only for determination and for confirmation of their relationships.

II.—Determinations and Reports for Mine Managers, for other Departments, for Prospectors, and for the general public.

During the last year or two, there has been evinced by mine managers and mining companies an increasing desire to take advantage of the facilities afforded by the Geological Survey Department for the determination of rocks and bore cores that are of importance from the point of view of mining geology. This is distinctly encouraging as an indication that the value of an accurate knowledge of the character and relation of the rocks of any mine, and the influence of these factors on the devolopment and future of the mine becoming more and more generally realised by those responsible for mining operations.

During the year examinations have been made—

1. Of two parcels of specimens from the manager of the Youanmi Mine.

The specimens were determined and their relationship to one another described. Nearly all were granites metamorphosed, to a greater or less extent, by heat and pressure.

2. Of two parcels of bore cores from the Sons of Gwalia Mine.

The first parcel consisted of cores from No. 21 level, bores No. 83 W. and No. 84 E. The facies in No. 83 were chiefly chlorite-carbonate schists and fibrous, more or less sheared epidiorites. The facies in No. 84 E. were distinctly dioritic or epidioritic rocks, carbonated, sheared and foliated epidioritic rocks, and chlorite-carbonate schists.

The second parcel comprised cores from No. 21 level, bores Nos. 91 W. and 92 E. No. 91 W. consisted of carbonate-chlorite quartz schist and sheared fibrous epidiorites, in some cases carbonated and zoisitised. No. 92 E. showed fibrous epidiorite sheared or foliated, and carbonate-chlorite-quartz rock.

3. Of specimens from the Edna May Consolidated and from the Edna May Golden Point Mine. These were examined to determine their relationship to the rocks of the Edna May Mine, Edna Central and Edna May Deep Mines.

Determinations for other departments consisted chiefly of those for the State Mining Engineer and for Wardens and Mining Registrars.

For prospectors and for the general public, 190 determinations have been made of rocks and minerals, and, when desired, the determinations have been supplemented by short notes on the value of the specimens.

III. *Miscellaneous.*—A considerable amount of time and labour has been spent in connection with the following:—

1. The preparation and despatch of collections of rocks and minerals to Mining Registrars, the Royal Military College, Duntroon, etc.

2. The correction of typed and printed proofs of the various reports for pubilcation.

3. Microphotography.

4. In conjunction with Mr. Blatchford, the preparation of a rock classification with colours, rulings

and symbols, to simplify and introduce a further degree of uniformity into the geological maps of the Survey.

5. With the assistance of Mr. Jutson, the correction and amplification of the Glossary of geological and mining terms to be issued with the Mining Handbook.

6. Reporting on the quality of specimens of asbestos.

7. Bringing up to date the registration of the rock-sections in the Survey collection. In this duty, I have been assisted by Mr. Welsh.

GEOLOGICAL SURVEY MUSEUM AND COLLECTIONS.

The addition to the Survey Collection during the year amounted to 621, bringing the total number of registered specimens in the collection at the end of the year to 15,525. In the last Annual Report the total registered was given as 15,595, but this number included duplicates and many rocks examined but not registered.

The total number of sections cut and registered was 435, and of those cut but not registered 288.

Special acknowledgment must be made of the donation to the collection of:—

1161 Graphite, from four miles north of Northampton—(H. P. Herbert);
1185 Scheelite in Auriferous Quartz, Hill End Gold Mine, Norseman—(State Mining Engineer);
1186 Coorongite, Estuary of the Pallingup River, South-West Division—(State Mining Engineer);
1219 American Pumice, Sydney—(C. Gudahy);
1247 Galena Crystals (four), from Nooka Mine, Northampton—(J. Reynolds);
1248 Collie Fossils (17), from Brown's Collieries, Collie—(Inspector McVee);
1270 Obsidianite, Preston ?—(Rev. Vaughan);
1274 Scheelite and Wolfram in Pegmatite, Edna May Deeps, Westonia—(N. Stuckey);
1322 Lepidolite, Ubini Railway Station, Coolgardie—(State Mining Engineer);
1323 Gneiss, between Kulin and Skulin Railway Stations, Kondinin Railway Line—(Wood, Railway Engineer);
1324 Quartz with Garnets, Grass Valley—(J. W. Regan);
1348 Micaceous Haematite, Mt. Gould, Peak Hill Goldfield—(J. W. Regan);
1382 Gold specimen, Kanowna, Coolgardie Goldfield—(Hopkins);
1383 Artesian Bore Cores, G. H. Gooch's Wandagee Station, *via* Carnarvon—(Davis Hankinson & Co.);
1386 Micaceous Haematite, Mt. Gould, Peak Hill Goldfield—(C. F. Connelly);
1387 Pyritic Conglomerate, Nullagine, Pilbarra Gold field—(F. S. Cooke);
1388 Plumbago—(R. Boyce & Co., Melbourne);
1390 Fossil Shell (Voluta) ? Wagin Townsite, South-West Division—(W. E. Wood);
1435 Obsidianite, Karralie, Yilgarn Goldfield—(J. McIlwraith);
1436 Meteorite, 50 miles South of Youanme—(Mines Department);
1440 Bore Cores (Artesian), Byro Station, 200 miles North of Yalgoo—(Darlot Bros.);
1484 Vesicular Basalt, Bunbury—(W. Atkins);
1511 Gold in Quartz-Haematite Schist, G.M.L. 1926, Tuckabianna, Murchison Goldfield—(T. Faherty);
1522 Coal, Irwin River—(Barnett Bros.);
1231 Ore (12 specimens), from Dutch-Sweeney Mine, California—(F. A. Moss);
1244 Fossils (29 specimens), Murrawiginn Cave, 120 miles North of Cliffs of the Bight, South Australia—(Mrs. D. Bates).

LIBRARY.

The Geological Survey Library received during the year 1917 1,690 publications from other cognate institutions throughout the world; in addition 115 volumes were added by purchase, and 16 volumes bound.

The distribution of the official publications of the Survey issued during the year amounted to 3,248 as against 3,063 of the previous year.

PUBLICATIONS.

The publications for the year have been as follows:—

Annual Progress Report for the year 1916.

Bulletin 71—The Geology and Mineral Resources of the Yilgarn Goldfield, Part III.—The Districts North of Southern Cross: by T. Blatchford and C. S. Honman.

Bulletin 71—Palæontological Contribution to the Geology of Western Australia, Series VI., Nos. XI. and XII.: by F. Chapman and R. Etheridge.

Bulletin 73—The Geology of the North Coolgarlie Goldfield, Part I.—The Yerilla District: by C. S. Honman.

Bulletin 74—Miscellaneous Reports, Series V., No. 61-68.

Bulletin 75—A Geological Reconnaissance in the country between Laverton and the South Australian border, including part of the Mount Margaret Goldfield: by H. W. B. Talbot and E. de C. Clarke.

Bulletin 76—Interim Report on the Graphite Deposits at Munglinup, Eucla Division: by Torrington Blatchford.

In addition to these, there are now ready for the Printer:—

Bulletin 70—The Western Australian Mining Handbook: by A. Gibb Maitland and Staff.

Bulletin 77—The Geology and Mineral Resources of the North-West Division, between Latitude 22deg. and 28deg. South and Longitudes 119-123: by H. W. B. Talbot.

The following are in hand:—

The Artesian Water Resources of Western Australia: by A. Gibb Maitland.

The Geology and Mineral Resources of Western Australia, with a four-sheet geological map: by A. Gibb Maitland.

The Geology and Mineral Resources of the Yalgoo Goldfield: by A. Gibb Maitland.

The South-West Division; its Geological Structure and mineral Resources: Commenced by the late H. P. Woodward, to be completed by the Government Geologist.

The Mining Geology of Niagara, Kookynie, and Tampa, North Coolgardie Goldfield: by J. T. Jutson.

The Mining Geology of Comet Vale and Goongarrie, North Coolgardie Goldfield: by J. T. Jutson.

The Mining Centres of Quinn's and Jasper Hill, Murchison Goldfield: by F. R. Feldtmann.

The Geology of Warriedar, Yalgoo Goldfield: by F. R. Feldtmann.

The Magnesite Deposits of Western Australia: by F. R. Feldtmann.

T. BLATCHFORD,
Acting Government Geologist.

30th May, 1918.

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By Authority: FRED. WM. SIMPSON, Government Printer, Perth.