1923.

WESTERN AUSTRALIA.

ANNUAL PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

FOR THE

YEAR 1922.

PERTH:
BY AUTHORITY: FRED. WM. SIMPSON, GOVERNMENT PRINTER.

1923.

P11713/23.

TABLE OF CONTENTS.

Annual Progress Report of the Geological Survey for the Year 1922.

OWING to important alterations in the constitution of the Geological Survey, its operations in certain directions have been even more restricted than had previously been referred to in the report upon the work carried out during the year 1921.

THE STAFF.

The work of the year has been carried out by six classified officers. An amalgamation was effected in the month of March of the Geological Survey Laboratory with that of the Government Analyst, the combined institution being designated the Government Chemical Laboratory, and placed in charge of Dr. E. S. Simpson, and its direct connection with the Geological Survey severed. In connection with the amalgamation of the two laboratories it ought not to be lost sight of that mineralogy is part of the functions of the Geological Survey. The Mineralogist should of necessity be an officer of the Geological Survey because (a) mineralogical work is a necessary part of its functions, (b) the geological field staff need constantly to refer to the mineralogist and *vice versa* in carrying out their respective duties, and (c) the mineralogist must be in constant touch with the Geological Survey museum and collections.

Mr. R. A. Farquharson, the Petrologist, having been appointed temporarily as Geologist to the Somaliland Protectorate, relinquished his duties in the Geological Survey on the 30th of October. The Government, in taking steps to fill the position thus rendered vacant, decided to have the petrological work carried out by Mr. C. O. G. Larcombe at the School of Mines, Kalgoorlie, where he occupies the position of Lecturer in Geology. The departmental arrangements made by the Public Service Commissioner were that the petrological work required by the Geological Survey was to be performed in Mr. Larcombe's spare time, without any addition being made to the staff of the school. This officer formally assumed his duties as Acting Petrologist on the 16th of November; it remains, however, to be seen to what extent this arrangement proves workable, for there are obviously very serious disadvantages in having this important part of the Survey's activities carried out anywhere else than at head-quarters.

Mr. T. Blatchford having been placed at the disposal of the Freney Oil Company for work in the Kimberley Division, arrangements were made whereby the field staff could be kept up to its normal strength during his absence by the appointment of Mr. A. G. D. Esson, M.A., a graduate of the University of Aberdeen.

ADMINISTRATIVE AND OTHER DUTIES OF THE GOVERNMENT GEOLOGIST.

A very large and ever-increasing portion of my time during the year 1922 was devoted to work in the office and completing the comprehensive descriptive report upon The Gold Deposits of Western Australia which forms Section I. of Chapter II.—"The Economic Geology and Mineral Resources of Western Australia"—of The Mining Handbook. In the account of the gold deposits no attempt has, for obvious reasons, been made to give any details of mining or metallurgical processes. The report has been put into type and copies should shortly be available for distribution.

Owing to the numerous calls on my time very little opportunity was afforded of personal investigations in the field during the year, the only field work it was possible to undertake being an inspection of the geological survey work carried out by Mr. Feldtmann at Youanmi on the East Murchison Goldfield. This inspection having been completed, a traverse was made between Youanmi and Merredin along the Rabbit-proof Fence, with the object of enlarging my knowledge of the geology of the State and filling in certain blanks existing on the geological map. This work occupied my time between the 15th of November and the 19th December.

During the year an effort was made by means of public lectures to give a more or less popular representation of the results of some of the activities of the Survey and the bearing of geological facts upon matters attracting a measure of public attention.

These addresses included:—

(a) The Distribution of Petroliferous Deposits in relation to Earth Movements and their Political and Commercial Significance.

In this address attention was directed to the facts that in the solid, liquid, and gaseous forms petroliferous deposits were the most widely distributed of all substances, though their occurrence in exploitable quantities was restricted; the world's supply of rock oil was limited, and a natural reservoir of petroleum having been depleted it could not be replenished; and the discovery of any fresh oil field depended on accurate deductions resulting from detailed geological surveys, coupled with well directed investigations into all the conditions which rendered the formation, migration, retention and accessibility of petroliferous deposits possible.

(b) The Mineral Wealth of the Kimberley and North-West Divisions.

During the course of this address it was pointed out, *inter alia*, how mineral deposits have at all times played and are still destined to play a very important part in the economy and industrial development of the country. Emphasis was also laid upon the fact that no country was self-sufficient in its supply of all minerals, and owing to this important and often over-looked reason that mineral commodities entered so largely into international trade. Assuming a food supply, modern industry was more fully dependent upon mineral deposits than upon any other natural group. When viewed in the light of its structural geology, coupled with the variety of its mineral deposits, these northern divisions rank amongst the most remarkable of the mineral regions on the Australian Continent. Their actual and potential mineral wealth deserves to rank amongst the most important of its industries, whilst their fertile and

healthy uplands are capable of supporting a considerable population on their agricultural and pastoral merits alone. Over £17,000,000 worth of mineral products were won from the portion of the State referred to; these served not only as the basis of manufacturing industries, but also for purposes of exchange. Whenever mining settles down to a steady industry as distinct from a feverish quest for rapid wealth there will probably not be very much necessity for looking beyond this portion of Western Australia for more than a very few mineral products.

(c) The Later Mesozoic and Tertiary Geological History of the Southern Portion of Western Australia and some of its Problems.

This address, which was delivered to the members of the University Natural History Society, dealt with the geological features and history of that portion of Western Australia which, owing to the valuable and varied nature of its mineral deposits as well as its animal and vegetable life, has long aroused the keenest interest amongst geologists and naturalists of all nations. An endeavour was made in the course of the lecture, by taking the southern portion of Western Australia as an example, to show that geological science, one of the very best grounds for training the faculty of observation and the power of reasoning, was essentially a history of the earth, and how such was of importance because the events in its history shaped its subsequent career, and how a thorough investigation of the rocky framework was a matter of considerable importance in a State such as Western Australia where science, the inspiring muse of industry, was slowly but surely making its influence felt. Especial attention was directed to the volcanic activity which took place in Miocene Tertiary times, the evidences of which are to be found in the western portion of the South-West Division. The basic lavas, with their original horizontality of bedding but slightly disturbed, covering an area of about 3,000 square miles, remain as a fragment of the enormous flows which spread over the extreme south-west portion of Western Australia and probably over a much larger portion now buried under the Indian Ocean and the sea along the South Coast. Until these lava flows have been dissected by the weather there is very little visible evidence of the masses of basic rocks which almost certainly lie below the surface and constitute the magma from which the basalts emanated. Dykes have been noticed traversing the Tertiary sediments near Albany, and it is likely that some of those scattered veins and dykes of very fresh dolerite occurring at Norseman and elsewhere may represent the intrusive phase of these eruptions. The newest igneous rock on the Dundas Goldfield is the remarkably fresh intrusive norite which has been followed across country for a distance of at least 12 miles in an east and west direction. The Norseman norite and its congeners may possibly belong to the same period of Tertiary igneous activity as the basaltic lavas. A suggestive feature in connection with this norite dyke is that its southern margin on the western side of Lake Cowan has changed towards a peridotite. In the country at the northern end of Lake Cowan there are olivine-dolerite dykes in a remarkably good state of preservation, which may also represent smaller satellitic intrusions related to the Norseman norite, which has been found to extend to the northern end of the Frazer's Range. Serpentines, the alteration products of peridotites, are of frequent occurrence in the country surrounding the area occupied by the Miocene sedimentaries; the serpentines contain veins and masses of dazzling white magnesite and chalcedonic silica. It has already been pointed out that one of the outstanding features in the geology of Western Australia is the great similarity both in structure and constitution to that of India and the countries bordering the Indian Ocean, and it is quite possible that the suggested connection between the Western Australian Tertiary basaltic lavas and those olivine-dolerite dykes and masses of serpentinised magnesite-bearing peridotites may find their parallel in the ultra-basic relatives of those basic lavas which constitute such an important feature in Indian geology. In India, besides those great lava flows, known collectively as the Deccan Traps, there are other intrusive and extrusive basic and ultra-basic rocks of late Tertiary age, some of which now remain as conspicuous masses of serpentine containing magnesite and the valuable mineral jade.

FIELD WORK.

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

Table showing the Distribution of Field Work during the Year 1922.

Goldfield or Land Division.	F. R. Feldtmann.		A. G. D. Esson.	
	No. of days in the field.	Percentage of working days.	No. of days in the field.	Percentage of working days.
South-West Division	...	...	43	14·1
Yalgoo Goldfield	...	...	102	33·4
East Murchison Goldfield	201	55·0	46	15·1
Total	201	55·0	191	62·6*

Mr. T. Blatchford, Assistant Geologist, having been employed as geologist to the Freney Oil Exploration Company, was not available for departmental geological survey work, neither was Mr. R. C. Wilson, Field Geologist, who was deputed to act as Assistant to the State Mining Engineer, a position for which his qualifications and subsequent experience in active practical mining operations fitted him.

F. R. Feldtmann, Field Geologist.

The early portion of the year up to the 18th of May was devoted by Mr. Feldtmann to multifarious office work connected with the report on the mining centre of Gibraltar on the Coolgardie Goldfield, which, *inter alia*, included the preparation of the geological maps, underground plans, and sections in illustration of the text. The period intervening between the 25th of May and the 10th of December was spent in a detailed geological examination and survey of the gold deposits and their surroundings of the mining centre of Youanmi, on the East Murchison Goldfield. Mr. Feldtmann spent 201 days in the field, all of which were in the East Murchison Goldfield.

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

Mr. Esson joined the staff of the Geological Survey of Western Australia early in the year and commenced duty on the 2nd of March as Temporary Field Geologist. During his term of service in 1922 Mr. Esson was engaged in examining and reporting upon various districts throughout the State, viz.:—

1. Alluvium and laterite in the vicinity of the Helena River.

* Represents percentage of a possible 305 working days, Mr. Esson having been appointed on 2nd of March, 1922.

2. An investigation into the basic dykes, Wongong Brook Weir Site.
3. Field work at Melville (Noongal), Yalgoo, and Mugga Mugga, Yalgoo Goldfields.

On 20th July Mr. Esson proceeded to Yalgoo to await my arrival, during which time an examination in a broad and general way of the country in the vicinity of Yalgoo was made.

Acting upon instructions Mr. Esson proceeded to Noongal (Melville), 14 miles north of Yalgoo, for the purpose of completing the work and filling in the blanks on the maps begun by Mr. E. de C. Clarke, late Field Geologist in the Geological Survey of Western Australia, and referred to in the Annual Report for the year 1919. On 27th October, in accordance with instructions, Mr. Esson left Melville for Youanmi, where he collaborated with Mr. Feldtmann in his work at that centre. During his stay at Youanmi a preliminary reconnaissance was made of the country south of Youanmi to Curran's, which lies about 14 miles distant. In the main, the country is greenstone intruded by granite and obscured by alluvium. In some of the shafts at Curran's shearing has taken place and, broadly, the geology is very similar to that at Youanmi. Probably they both form part of the same belt of disturbance. On 1st December Mr. Esson left Youanmi in the company of the Government Geologist upon a trip by horse from Youanmi to Merredin, going first to the 206-mile post on Rabbit-proof Fence No. 1, thence along the fence southwards to the 49-mile post, and thence to Merredin by Muckinbuddin and Nungarin. Altogether during the year 1922 191 days were spent in the field out of a possible 305 days, *i.e.*, 62.6 per cent. In the interim, whilst at the head office, Mr. Esson was engaged preparing maps and plans and collecting information connected with the various reports, as well as compiling the several reports themselves. In addition he carried out various duties deputed to him.

PRINCIPAL RESULTS OF THE YEAR'S FIELD OPERATIONS.

1.—THE YOUANMI GOLD-MINING CENTRE, EAST MURCHISON GOLDFIELD.

(F. R. Feldtmann.)

Geography.

Location.—The Youanmi gold-mining centre is situated in the Black Range District of the East Murchison Goldfield, approximately 52 miles SSW. of Sandstone, the centre of the district, and about 19 miles E. of No. 1 Rabbit-proof Fence, which forms the western boundary of the goldfield. It is 71 miles (79 miles by road) SE. of Mount Magnet on the Geraldton-Meekatharra Railway. A mail motor-car runs twice a week between Mount Magnet and Youanmi.

The main mining area is situated from three-quarters of a mile E. to a mile N. of the township. Two other small groups of leases, the Commonwealth and Golden Crown, are situated respectively 1½ miles NNW. and about three-quarters of a mile S. of the township.

Topography.—The country north and west of Youanmi is undulating, but the area is one of comparatively low relief, there being no hills of any size near the town. The most conspicuous hill in the district is Trig. or Bald Hill, a conical shaped hill about 5½ miles E. of Youanmi.

West of the town, a succession of small laterite hills and breakaways mark the level of the former plateau. Of these, the nearest and one of the most prominent is an abrupt little hill on the Rifle Range Reserve. North of the town are a number of low ridges, the backbones of which are formed by jaspers.

The chief drainage channel of the centre is a broad ill-defined creek, which runs in a southeasterly direction between the town and the mining area, passing to the south of the Youanmi Mine, whence it runs slightly south of east.

Geology.

The rocks of this area are much obscured both by weathering and by superficial deposits. In common with most mining centres of the goldfields the auriferous area lies in a belt of greenstones enclosed by granite, the greenstones near the margin being cut by numerous tongues of granite which run in from the main mass.

The full extent of the greenstone belt has not yet been determined, but it is probably more than 20 miles in length, extending for some miles north of Youanmi and beyond Curran's Find, 14 miles south.

The greenstones are separable into three main types including: (a) a very fine-grained schistose rock, representing a fine-grained doleritic epidiorite, now largely chloritised and in places carbonated, which forms the main country rock of the lodes; (b) a medium to coarse-grained epidiorite from a gabbro or coarse dolerite; and (c) a very fine-grained massive amphibolite or epidiorite, with scattered hornblende phenocrysts and occasional small areas of a pegmatitic facies with hornblende crystals up to three inches in length.

But little information is available as to the relative age and relationships of these three types. What appears to be a dyke of the coarser-grained type occurs, however, in the fine-grained schistose rocks in G.M.L. 731B, near the northern end of the main group of leases, both rocks being cut by granite dykes, and it is probable that the fine-grained schistose rocks correspond to the Older Greenstones of Kalgoorlie, the coarser gabbroid rocks to the Younger Greenstones.

The fine-grained massive amphibolites of type (c) may represent a still later doleritic intrusion. They are, however, cut by acid dykes and therefore do not belong to the youngest series of basic dykes found on the goldfields.

The older schistose rocks occupy the eastern portion of the belt. Outcrops of these rocks are, with but few exceptions, completely weathered, and much of the area occupied by them is covered by detrital deposits. The gabbroid rocks appear to occupy a large part of the western portion of the belt; a few outcrops are found to the west of the Cemetery.

The only occurrence observed of the fine-grained massive amphibolites was at a point about a quarter of a mile west of the Anketell telegraph line, and about four miles north of Youanmi, where they form a small, low knoll.

The granite mass east of the mining area is composed of rock differing from the normal biotite granite of the goldfields. Biotite is almost absent, the rock consisting of quartz, felspar—probably a soda-bearing variety—and muscovite. In grain the rock ranges from coarse to fine.

The margin of the granite forming the eastern boundary of the greenstones runs in a general north-northwesterly direction, through the main group of

leases, a little to the east of the lode channels, but is very irregular, and, as stated, numerous tongues run from it into the greenstones. North of the mining area, the boundary, so far as examined—a distance of about four miles—is approximately parallel to, and a short distance east of, the telegraph line to Anketell Siding.

The dykes running from the main granite mass into the greenstones are composed, for the most part, of rock very similar to that of the main mass. In a few, however, biotite is present in fair amounts. The smaller dykes are usually fine in grain, and in some a gneissic structure, probably original, is present.

The strike ranges from northwest to northnorthwest and the dip, as a rule, is southwest at angles ranging from 65 deg. to 75 deg. From their marked parallelism and the very acute angle they make with the margin, the dykes evidently occupy lines of shearing in the greenstones, formed prior to or during the intrusion of those rocks by the granite. The dykes are older than the lodes, but cause a certain amount of deflection and impoverishment in them.

A series of dykes somewhat different from those mentioned occurs in the main workings of the Yuanmi Mine at the Nos. 5 and 7 levels. These are usually of a pinkish or reddish colour and range in texture from fine-grained, almost felsitic, to coarse pegmatitic, with large pink or pale-red orthoclase crystals. Fluorite, in small quantities, and small veins of red and white carbonates are associated with these dykes.

Jaspers are not so well represented in this as in most other centres of the Murchison and East Murchison Goldfields. A number of bars, mostly of no great length, occur along a general line which runs in a northnorthwesterly direction through the Golden Crown and Commonwealth groups of leases, respectively south and northnorthwest of the town, and extends for some miles to the north. In the main group of leases, only a few short bars, mostly striking eastnortheast, occur. A few of these penetrate the granite for a short distance, but most stop short at the margin. Owing to subsequent intense shearing, including that immediately preceding ore deposition, several of these bars are now represented only by a few disconnected short lenses.

In the Commonwealth group, the ore bodies, which appear to be very short, are closely associated with the jaspers, which have evidently influenced the deposition of the gold.

The principal lodes of this centre occur in the greenstone schists as a series of elongated lenses in a comparatively narrow zone of highly sheared rock along the margin of the granite. They strike approximately parallel to, or, if anything, slightly more northerly than the general strike of the margin, but as that is very irregular, run into the granite in places to die out a short distance from the margin. So far, auriferous bodies have been found to occur in the contact zone over a length of about 1¼ miles, but a number have not proved to be payable for any length. The average strike of the lodes is a few degrees west of north; the dip ranges from about 55 deg. W. to vertical.

Auriferous reefs of any size are not common in this area, but numerous small quartz veins of a granitic type and carrying little or no gold are common in the sheared zone, along the granite margin. There are a fair number of buck reefs, mostly in the granite. Most of these strike approximately east, the dip, so far as could be determined, being to the south at a steep angle.

In addition to the older lines of shearing occupied by the granite dykes, jaspers, and lodes, there is evidence of intense shearing at several periods subsequent to gold deposition. Shear zones and planes belonging to several series younger than the lodes occur in the contact zone. These have shattered or faulted the lodes in places, seriously affecting the continuity of the ore shoots.

At least three series of these later shear zones have been recognised in the Yuanmi Mine, namely:—(a) One striking a few degrees east of north and dipping west at angles ranging from about 45 deg. to 55 deg.; (b) One striking approximately parallel to the lodes, but, as a rule, straighter and also steeper, the dip ranging from 64 deg. W. to vertical, and averaging between 70 deg. and 80 deg.—the shear zones of this series are said to be highly carbonated in places and to contain barren sulphides, and in the oxidised zone may easily be mistaken for true lodes; and (c) a third striking approximately N. 60 deg. W. and dipping SW. at about 70 deg.

A large proportion of the shear zones belonging to these series are said to occur in portions of the main workings of the Yuanmi Mine, which were inaccessible during my survey, and the information as to their occurrence was supplied by Mr. L. B. Williams, until recently manager of the Yuanmi Gold Mines Ltd. With the exception of those of group (c), which appear to be confined to a small area at the southern end of G.M.L. 863B, where the workings were inaccessible, my observations in those portions of the mine which were accessible, and along the belt north of the Yuanmi Mine, confirm those of Mr. Williams.

Of the three series (a) appears to be the oldest—it is best represented at the northern end of the Yuanmi Mine. The relative age of (c) is uncertain; Mr. Williams is inclined to regard it as younger than (a), but its relationship to (b) is obscure.

In addition to the above, a number of fault planes, striking approximately N. 30°—40° W. and dipping southwest at a shallow angle, affecting the granite dykes and quartz veins, were observed in the east crosscut off the south drive from Prospect Shaft.

There is not much evidence of transverse faulting in this area, the only place where it appears to have taken place being along a large buck reef, striking a few degrees north of east, at the southern end of G.M.L. 770B, Hill End. Along this reef the granite boundary, which here strikes about northnorthwest, shows an apparent horizontal displacement of 160 feet—the displacement being to the west, going north. About 140 feet farther NNW. along the granite boundary is what appears to be a subsidiary parallel fault, a small jasper being displaced for a horizontal distance of about 12 feet. In this case, however, the faulting may be due to a northward-striking shear zone.

The Lodes.

As stated, the main ore bodies of this centre occur in a zone of highly sheared rock along the margin of the granite forming the eastern boundary of the greenstones. Although auriferous deposits occur over a length of about one and a quarter miles in this zone, only those in the southern portion have proved payable for any length, the continuity of the ore bodies being much affected by granite dykes and by later shear zones.

Mineral composition.—Owing to the inaccessibility of the deeper workings of the Yuanmi Mine it is

impossible to give a detailed description of the lodes in the sulphide zone. Representing zones of intense shearing in the greenstones, they are highly schistose, but in places the schistosity is partly obscured by silicification. The ore contains much finely granular pyrite, but some of the densest pyrite seems to be associated with the steeper series of later shear zones and is therefore barren. The presence of stibnite and arsenopyrite in large quantities in the Yuanmi main lode has greatly increased the difficulty and cost of treatment. In the P Shaft Lode stibnite is present but arsenopyrite is said to be practically absent. According to Mr. Williams there is some evidence for regarding the stibnite as associated with the steeper shear zones. As a general rule carbonates appear to be absent from the lode or present only in small quantities, their occurrence being associated with the steeper shear zones and the pink granite. The Yuanmi mine is also characterised by the presence of very finely granular magnetite in large quantities, usually outside the lode channel; it appears to have been formed prior to ore deposition and is possibly connected with the jaspers.

Occurrence.—The most important lodes in this area are those of the Yuanmi Mine, which includes G.M.Ls. 863B, 864B, 865B, and 866B—the outcrops of the lodes so far discovered being confined to the first two leases—and those of G.M.L. 886M, United, and G.M.L. 770B, Hill End.

The lodes of the Yuanmi Mine include the Main Lode, West Lode, East Lode, Prospect Shaft Lode, and P (Pollard) Shaft Lode. Of these the most important is the Main Lode which has been proved for nearly a length of 1,000 feet—extending from a point a little north of No. 1 Shaft, about 420 feet from the northern boundary of G.M.L. 863B, to the southern end of a large open cut, about 150 feet north of the south boundary of the same lease. The lode has been proved to a depth of 778 feet (No. 7 level) below the collar of the main shaft. The ore shoots, however, were not by any means continuous over this distance, being broken by the later shears, and by poor zones where the lode shear cut through granite dykes, into a series of lenses of varying length. The greatest length of ore in the sulphide zone occurred at the 558 feet and 657 feet levels. At the 778 feet level the ore body was much broken owing to the presence both of shear zones of series (a) and (b) and of granite dykes. The average dip of the lode is stated by Mr. Williams to be 58°. The average width was about 4½ feet.

It has been generally assumed on the mine that the main lode has been faulted transversely at a point about 100 feet north of the southern boundary of G.M.L. 863B and that Prospect Shaft Lode was the faulted portion.

Other than a small eastward-striking quartz vein, of which a trace is visible at the surface, no sign of any transverse line of weakness was seen, and, moreover, so far as can be judged, the granite boundary to the east has not been faulted, at any rate to any appreciable extent. I am, therefore, inclined to regard the trace of lode matter cut at the junction of the northeast crosscut from V shaft with the southwest crosscut from Prospect Shaft as the southerly continuation of the Main Lode.

The West Lode outcrops a few feet east of the Main Shaft but has not been worked at the surface for any distance. It has been driven on at the 66 feet, 162 feet, and 300 feet levels, the greatest length of driving being at the 162 feet level where the lode was followed for about 400 feet. The drives, however, disclosed but little payable ore. From the direction of the southern end of the drive at the 162 feet level and the low assay values, it is possible that the lode was disturbed by a shear zone of series (a). The formation followed for a short distance from V shaft is possibly the southerly continuation of this lode.

The East Lode outcrops about 160 feet east of the northern portion of the Main Lode and is only a few feet from the granite boundary, horses of granite being enclosed in the lode in places. It has only been followed for short distances at the 40 feet and 100 feet levels from two small shafts. At a shallow shaft a little to the south of those mentioned, the lode is affected by a shallow-dipping shear zone.

The East Lode is on the same line as Prospect Shaft Lode and the two may prove to be continuous, but owing to the proximity of the granite, any intervening ore shoots are likely to be of no great length.

The Prospect Shaft Lode has only been followed for 130 feet north of that shaft by a drive at a vertical depth of 50 feet—the face of the drive was said to be in granite. South of the shaft it is disturbed by two large and several small granite dykes and apparently also by one of the shallow-dipping shear zones. The probable southerly continuation of this lode was cut in the east crosscut off the south drive from Prospect Shaft, but at this point it cuts a small granite dyke.

The most important lode in the southern portion of the mine is the P Shaft Lode. This lode has been worked for a total length of about 900 feet and to a vertical depth of about 300 feet. The ore shoots are somewhat broken owing to the presence of granite dykes, including one very large dyke in which the north drive at the 300 feet level ends, and to faulting by nearly vertical shear zones. At the upper levels the lode appears to split on reaching the large dyke and to continue northwards as two bodies, of which the more westerly, which has not been followed for any distance, appears to be on the line of Prospect Shaft Lode, of which it may be the southerly continuation. At the surface P Shaft Lode appears as a series of detached lenses, of which the southernmost has a marked easterly dip, and as a whole this lode dips more steeply than the Main Lode. The best shoot in this lode extended from about co-ordinate 1,050 feet south (the main shaft being taken as the datum) to about 1,250 feet south, but was somewhat patchy.

Two lodes have been worked in the United and Hill End leases, which are north of the Yuanmi Mine, but separated from it by G.M.L. 873B. The more easterly lode of the two outcrops in the Hill End lease approximately parallel to, and about 50 feet east of, the western boundary, the strike being nearly due north. The lode has been worked in an open cut close to the southern end of the lease and from shafts in the United lease, into which it dips, and G.M.L. 873B to the south. It has not been worked to any extent below water-level, the flow of water being too great for the prospectors to handle, but a considerable tonnage of oxidised ore has been extracted. At its southern end the lode is much disturbed and has apparently been faulted along the westerly continuation of the large buck reef previously mentioned as occurring at the southern end of the Hill End. At its northern

end the lode runs into the main granite mass and dies out close to the margin.

The second lode is situated in the northern portion of the United lease. It strikes approximately north-northwest. At the surface it is separated into two portions by a long wedge of granite which has been dragged back along the lode channel. The western branch consists mainly of greenstone schist, the eastern in part of granitic material.

The lode has been worked for a length of about 280 feet, chiefly from a large but shallow open cut and from a shaft about 140 feet deep, 350 feet southwest of the northeast corner of the lease. At the southern end of the open cut the lode appears to be narrowing. The lode probably dies out to the north, in granite, near the northern boundary of the lease. As with the previously mentioned lode a fair amount of oxidised ore has been extracted, but little work has been done below water-level, which is said to be at about 100 feet in the shaft.

Summary and Conclusions.

The Yuanmi mining centre is situated near the eastern margin of an extensive greenstone belt, enclosed by granite, and comprising rocks of three types and of two, possibly three, ages.

The eastern portion of the belt consists of fine-grained schistose epidiorites, largely chloritised, probably corresponding in age to the older fine-grained greenstones of Kalgoorlie; the western of coarse-grained gabbroid or doleritic epidiorites similar in appearance to certain of the younger Kalgoorlie greenstones. The third type, which is possibly younger than either, is a massive fine-grained amphibolite occurring about four miles north of Youanmi.

The eastern portion of the belt is cut by numerous granite dykes.

The principal ore bodies are situated in a comparatively narrow zone of intense shearing in the older fine-grained greenstones along the granite margin. They include the lodes of the Yuanmi Mine, of which the most important are the Main Lode in G.M.L. 863B and P Shaft Lode in G.M.L. 864B, and those of the United and Hill End leases.

The continuity of the ore shoots is much affected by the presence of numerous granite dykes, causing impoverishment at the point of intersection, and by a number of later shear zones of several series, which have shattered and dissipated the ore bodies in places. Of these the most serious are the steeply-dipping shear zones owing to their strike being practically identical with that of the lodes and to their great width in places.

The Yuanmi Main Lode has been worked to a depth of 778 feet, the P Shaft Lode to a depth of about 300 feet. That payable ore bodies occur below these depths there is little doubt, but to predict the positions of such ore bodies at any given depth, accurate projections of the dykes and shear zones encountered at the levels above would be necessary. At a level put in from the main shaft at a depth of 880 feet the Main Lode would probably be free from the steeper shear zones that affected it at the 778 feet level, but would be affected at intervals by those of the flatter series—a less serious matter—and to some extent by granite dykes.

2.—ALLUVIAL AND LATERITE DEPOSITS OF THE HELENA RIVER, BETWEEN DARLINGTON, BOYA, ZIG-ZAG, EAST GUILDFORD, SOUTH-WEST DIVISION.

(Alex. G. D. Esson, M.A.)

Upon March 9th, 10th, 20th and 23rd, 1922, a reconnaissance was made of the valley of the Helena River for the purpose of plotting the Helena alluvial deposits from a point on the river bearing about 207 deg. from Darlington Station, down to East Guildford, where Morrison's bridge crosses the river. I also made an examination of the laterite deposits at Boya and near to the Zig-Zag, on the Canning Jarrah Timber Company's railway line.

1. *Helena Valley Alluvium*:

It is to be noted that the term alluvium has two applications. It may be applied to river deposits, which, in the case of the Helena, would be largely flood deposits or flood plains. On account of the economic importance of these, I have taken this application of the term in making this report.

Alluvium is deposited on the old worn-out valley of the Helena, a valley cut out when the river was much younger and probably flowed faster. In places a difference of eight or ten feet in the height of the two banks was noticed. This could probably be explained as being due to the fact that the river when younger deposited an alluvial plain consisting largely of sand and clay. The river then cut into this plain, forming a fairly wide, new bed, upon one side of which it again deposited alluvium at a much lower level than the older plain. In some places a difference in the deposits on either bank can be seen, although both are distinctly alluvial.

In no case does the alluvium extend to more than ten or twelve chains from the river, and in places lateritic ironstone and granitic rocks border the present bed of the river.

Economically, these alluvial flats are of great importance, on account of their depth and productiveness, especially in connection with intensive agriculture or market gardening. I am informed by a resident of one of the flats that the depth of alluvium varies from twenty-seven or thirty feet in the middle of the valley to nothing on the extreme edge. The alluvium is largely good loam, very finely divided. In places, however, it seems to be composed mostly of clay.

In some places it is possible that the deposit is covered by æolian deposits of dune sand and in such a case, in the short time available, it was impossible to estimate exact boundaries.

(2.)—*Laterite Deposits*:

It was impossible to make more than a superficial examination of these. I examined them:

(a) *On Greenmount Hill, from Boya Siding.*—Here the deposits seem to begin at a height of forty feet or less from the summit and extend all over the hill top. They are highly ferruginous.

A distinct difference in the character of the vegetation on and off the laterite deposits was noticed.

Lower down the hillside, the rock was more or less weathered granite, while, lower down still, everything was covered with the detritus from this weathering.

(b) *Boya Quarries.*—Granite and diorite are quarried here from the sides of small spurs of Greenmount Hill. The diorite seems to be intrusive into the

granite and is used with the granite for road-making material. The granite is a grey, close-grained variety and should make excellent building stone. Near the surface the lateritic weatherings were observed, but in this case they differed from those on top of the hill in being kaolinised and stained with ferruginous matter.

(c) *Ironstone Deposit on Canning Railway, running from Ridge Hill to the Helena.*—This seems to be a concretionary stone, which is probably lateritic. It is ferruginous and is economically of no value, further than in road making. It is a fairly extensive deposit, which crosses the Helena Valley, and on the opposite side of the river from the Canning Railway, it has been weathered to produce a heavy, rusty, clayey loam.

3.—THE BASIC ROCKS OF THE WONGONG BROOK WEIR SITE, SOUTH-WEST DIVISION.

(Alex. G. D. Esson, M.A.)

In accordance with official instructions, a visit was paid to Wongong Brook, a tributary of the Canning River, and a geological survey of the surroundings of the proposed weir site and of the basic dyke system in its vicinity made. A map (21 A.1), showing the geological relations was prepared and a series of photographs (1770-3) taken of the dyke, through which the centre line of the proposed weir site passes.

Geology.—In this report the geology is briefly dealt with: (1) generally, and (2) particularly—in regard to its bearing upon the proposed weir.

The geological relations are somewhat obscured by débris and floaters, but field investigations show that the country is of igneous origin and consists of granite, threaded by fairly wide greenstone dykes. These greenstone dykes are joined to each other by narrow stringers and also by fairly wide dykes.

The greenstone is a hard epidiorite, which ranges in grain from fine to medium. It is younger than the granite, which is of the biotite-microcline variety, ranging from a medium to a coarse grain. In some places the granite becomes so coarse in texture as to resemble a pegmatite. The rock is largely decomposed on the surface and to some depth below, as we can see from the fact that one shaft had to be dug 40 feet before coming on to granite that was solid.

It is to be noted that although there has been a certain amount of metamorphism in the granite, in only two places has there been found evidence of fissuring, caused, probably, by the intrusion of the greenstone. In most cases the changes are due to weathering.

It may be concluded that the greenstone is intrusive and younger than the granite. There is no evidence of sills. Hence the surface of the original greenstone may have been much weathered in turn and worn down to its present levels. There is thus to be seen on the surface to-day what is probably a section of the old dyke system.

The soil produced by the weathering of the greenstone is a heavy clay loam which is extremely productive and admirably suited for intense horticulture. This, mixed with greenstone floaters, covers the lower slopes and obscures the geological relations.

The greenstone dykes can be divided into two main groups: (a) *main parallel dykes,* and (b) *connecting dykes.*

(a) These main dykes form the crests of the ridges and are more than 250 feet in width. They run roughly parallel to each other in a north and south direction.

(b) The connecting dykes join the main dykes and seem to run along any transverse line of fracture. They vary in direction but they run roughly east and west.

At present it is not at all clear whether the two types of dykes are of the same or of different geological ages, a point that is extremely difficult to determine especially as geological relations are by no means absolutely clear. It is generally recognised that when one dyke crosses another, that which has its fine-grained edge unbroken is younger than the other. Unfortunately, definite evidence of this kind was unobtainable.

All the dykes observed seemed to be of the same composition. In some cases the grain was finer than in others, but in the same dyke could be found both fine and coarse grained material quite close to each other. It was observed that the broader and longer a dyke, the coarser the grain.

In places inclusions of the felsitic material from the surrounding granite was found incorporated with the greenstone. This occurred near the edge of a dyke usually when the adjacent granite was found not to be much decomposed.

In shaft "f" the granite was found running up the side of the nearest dyke and giving evidence of being subjected to pressure from below.

The site marked out for the proposed weir is situated in a gorge, forming part of the valley of Wongong Brook and having very steep sides. On account of the steepness the bed of the brook is littered with loose boulders of granite and greenstone.

Upon arriving at the site of the proposed weir it was found that a number of shafts had been made under the direction of the Engineers of the Metropolitan Water Supply Department. Each of these shafts was carefully examined, and where necessary a number of them were extended and deepened on to solid bottom. In addition a few more shafts were sunk with the object of discovering any fissures which might be a danger to the weir or which might contribute to loss of water by seepage. Each shaft has been designated by a letter, thus, a, b, . . . z, and a description is dealt with in proper order.

Shaft

a. 5 feet deep on solid greenstone.
b. In this shaft there is a junction of the granite and greenstone. The edge of the latter seems to run at about 85 deg. from the horizontal. Here the granite shows slight indications of fissuring.
c. 22 feet deep on to a solid greenstone lying almost level.
d. This consists of a series of shafts lying in line and bearing 351 deg. and connected by drives, etc. All give granite at the bottom at about a depth of 12 feet.
e. 17 feet deep on to solid granite. Costeening has been commenced towards the solid greenstone dyke which outcrops solidly on the surface 35 feet from the edge of this shaft.
f. This consists of a long open cut, 13 feet deep. At 16 feet from the 100 foot peg there is a junction between the greenstone and the granite. Here the granite seems to have been subjected to some pressure and it runs up the side of the greenstone somewhat.
g. 10 feet 6 inches deep on solid granite. At the bottom there is a drive towards the south to the greenstone reef and this it meets at 7 feet from the shaft.

h. 9 feet 6 inches deep on to granite.
i. 12 feet deep on to granite.
j. 11 feet deep on decomposed granite. Work was discontinued here on account of the incoming of water.
k. 5 feet deep on greenstone.
l. 7 feet deep on greenstone.
m. Obtuse angle trench with dyke crossing it in two arms of the trench.
n. 2 feet 6 inches to 5 feet deep. At its south end the greenstone and granite meet.
o. 12 feet deep on granite.
p. 11 feet 6 inches deep on greenstone.
q. 9 feet 6 inches deep on granite. There is a junction here on the north end of the shaft.
r. 6 feet deep on solid granite.
s. 7 feet deep on granite.
t. 23 feet deep on granite dipping about 45 deg.
u. 10 feet 6 inches deep on granite. There is a junction on the north side of the shaft.
v. 17 feet deep on to granite.
w. 23 feet deep on to solid granite dipping 45 deg.
x. 35 feet deep on to solid granite.
y. 40 feet deep on to granite wash. This and "z" are old shafts.
z. Old shaft on to decomposed granite.

In most cases the shafts bottoming on granite have had the granite covered up with greenstone floaters and pug. In shafts "b" and "f" there is slight evidence of fissuring.

The centre line of the proposed weir passes through various portions of a narrow winding dyke connecting up two main dykes which form the crests of the ridges making the watershed at that point.

Conclusions.—Observations have shown that in this district there is a somewhat complicated system of greenstone dykes which intrude the much older granitic rocks. On the higher slopes at about 700 or 750 feet above sea-level we find the laterite commencing and obscuring the dyke systems. On the lower slopes alluvial soil has been deposited, and this, when formed from greenstone, is very productive, and less so when formed from granite. Soil formed from the laterite generally consists of an ironstone gravel which is of little value in growing crops.

Although no evidence of the occurrence of gold and other useful minerals was detected, it is understood that they have been found in the district.

I am much indebted to Mr. Lawson, the Engineer for Metropolitan Water Supply, and the late Mr. Hillman, his assistant, for their courtesy and assistance in supplying maps and in lending me two of their most capable miners, McGuigan and Sandercott.

4.—NOTES ON YALGOO, NOONGAL AND MUGGA MUGGA, YALGOO GOLDFIELD.

(Alex. G. D. Esson, M.A.)

Yalgoo.—In the main the country to the south of Yalgoo is obscured by recent superficial deposits. In places there are outcrops of the underlying rocks and these, combined with other observations, lead one to conclude that in this district there is a junction between the acid granite rocks and the basic greenstones.

In the area examined—from Yalgoo about 9 miles south and about 3 miles on either side of Rabbit-proof Fence No. 2—practically the same main types of rocks were found as at Melville later on. From Morrissey Creek, which runs south in a line somewhat west of the town of Yalgoo, crush-quartzite specimens [1/3452] were obtained forming the bed of the creek. A quarter of a mile eastwards of the creek shearing was again observed. It is probable that the creeks follow zones of shearing in this district.

No indications of metalliferous deposits were noted, although gold has been found farther southeast at the Joker, a prominent hill southeast of Yalgoo, where (*vide* Woodward, Appendix 2, Annual Report, Department of Mines, 1895) "A series of rich veins strike off from a large dyke." This working was abandoned by the company and apparently did not prove of any great value.

Noongal.—Noongal is one of the earlier abandoned mining centres of the Yalgoo Goldfield. A draw well with a good supply of fair water is located in the townsite near to the hotel, but otherwise potable water is hard to obtain except in a good season.

Up to December, 1921, the total amount of gold produced was 2,146.54 ounces, which includes alluvial, dollied and specimen gold, and the total tonnage of ore treated up to that date was 3,380.70 tons (of 2,240 lbs.). A slight revival occurred in 1921. A small 5-head battery has been established by Messrs. Neville and it is probable that this action may induce more prospectors to go to the district. The highest gold output is 571 ounces in the year 1897 and the bulk of that came from the Victorian United vein. Between 1915 and 1918, 1,932½ lbs. of bismuth, of a value of £472, were produced and marketed.

Generally, it can be said that Noongal lies upon an extremely rugged junction of acid and basic rocks. In the north, the acid intrusives have caught up large fragments of greenstone and occasionally have in part assimilated these. In the south the granites have intruded into the greenstones in the form of dykes and veins. In addition in the south there are many jasper bars which also have been intruded by porphyries. The whole centre then is a zone of contact between the acid and basic rocks and this zone constitutes the basis of deposition of gold and other minerals such as pyrites, molybdenite, scheelite, and bismuth.

The gold deposits, as would be expected, are patchy and do not seem to have any great continuity, but, where found, they seem to give fair values.

The rocks of Noongal are igneous in origin in the main, but there are also a number of superficial deposits which may have been originally lateritic and which are sometimes consolidated.

The igneous rocks are subdivided into acid and basic rocks. The basic rocks can be subdivided into greenstones and gabbroids. Mr. Farquharson, commenting on the basic rocks, says that the gabbros are metamorphosed forms of either basaltic dolerites with amphibolised augite or micropegmatitic quartz epidiorites. The greenstones are:

(a) metamorphosed dolerites, quartzose, granulated or foliated;
(b) metamorphosed gabbros;
(c) tremolite chlorites.

The acid rocks are various phases of biotite microcline granite. The intrusive dykes and veins take the form of quartz porphyries, granite porphyries, pegmatites and quartz.

The whole mass of greenstones has a dip westwards, which varies from 30° to 70°, and the strike is approximately north and south.

As has already been stated the minerals found are gold, bismuth ores, molybdenite, scheelite, pyrites, and also lepidolite.

On account of the irregular patchy nature of the deposits money should only be expended in judiciously trying to pick up continuations of the rich patches, for payable results can only be expected as the result of prospecting on a moderately small scale. The lepidolite deposits may prove worthy of the consideration of prospectors on account of the lithia contents, as well as the scheelite and bismuth deposits on and around the old Harrison's Reward Lease.

That part of the area to the southwest of the townsite about two or three miles should also be worthy of investigation by prospectors, especially where porphyries intrude the jaspers.

Mugga Mugga.—Opportunity was availed of to make a short reconnaissance of Mugga Mugga, a low belt of greenstone hills lying south of Gullewa and formerly on the boundary of the Yalgoo Goldfield.

Granites form the main country rock as far as Gullewa from some miles south of Yalgoo. These granites run more or less continuously as far as Gullewa and at this point greenstones take their place, continuing southwards as far as Mugga Mugga at least. From Yalgoo south to Mugga Mugga the country is largely obscured by lateritic and superficial deposits.

At Mugga Mugga quartz veins intrude the greenstones, and seen from the tops of the hills these appear to be lying more or less parallel in an east and west direction. There is also another series lying approximately north and south. A number of these reefs were examined and in the main were found to be barren although in places indications of copper staining, probably by malachite, were noted. On the level country to the east of the hills a small pocket of fairly rich copper ore was found, but, judging from a cursory examination, this would be of no great extent. The ore was a quartz carrying malachite, and Mr. Larcombe, Acting Petrologist, commenting on it says it is somewhat brecciated white glassy quartz, siliceous iron-stained with particles of malachite. The greenstone is a medium-grained epidiorite which has been largely epidotised.

PETROLOGICAL WORK.

During the year the time of Mr. Farquharson, the Petrologist, was occupied in the multifarious petrographical work required in connection with the routine duties of the Survey.

A good deal of time was devoted to an examination of the cores from the bores which were put down at Boulder with the view to testing the possibility of the extension of the group of lodes to the south-east.

Owing to Mr. Farquharson's departure from the State for service in British Somaliland, no report upon the year's work was received from him.

GEOLOGICAL SURVEY MUSEUM AND COLLECTIONS.

No progress has been found possible in the reorganisation and expansion of the Geological Survey Collections for the reasons which have already been set out in previous Annual Reports.

The additions to the Geological Survey Collection during the year 1922 amounted to 174, bringing the total number of minerals, rocks, and fossils registered up to 17,493. The number of micro-sections prepared amounted to 351, of which 112 have not been registered, thus bringing the total number of slides entered in the books of the Department up to 4,568.

A number of photographs of special geological interest, which have been taken by the members of the Geological staff in the ordinary course of their duties, have been added to the departmental collection.

Special mention is made of the following additions to the geological collections:—

Reg. No.	Specimen.	Locality.
1/3320 to 1/3335	Asbestos ...	Pilbara and West Pilbara Goldfields.
1/3367	Bore Core, No. 2 Bore	Williams Bore, Lease 5083E, Boulder.
1/3368	Bore Core, No. 3 Bore	do. do.
1/3369	Bore Core, No. 4 Bore	do. do.
1/3371	Joadja Shale ...	New South Wales (Mr. Le Mesurier.)
1/3373	Bore Core, No. 1 Bore	Boulder (Golden Ore Channel Company).
1/3374	Bore Core, No. 2	do. do.
1/3375	Bore Core, No. 3	do. do.
1/3376	Bore Core, No. 2 Deflected Bore	do. do.
1/3413	Muscovite Mica ...	Lyons District, Morrisey Creek, N.W. Division (Mr. Buckland).
1/3415	Crocidolite ...	Robertstown, South Australia. S.A. Geological Survey.
1/3430	Impsonite ...	Oakes Find, Negri River, Kimberley Division (Mr. Strevens).
1–3431	Opals and Opalised shells	Stuart Range, South Australia (Mr. O'Neil).
1/3437	Gypsum	2m. N. of Hines Hill, Avon District, S.W. Division (Mr. W. E. Sharp).
1/3438	Anthophyllite Asbestos	Moora (Mr. Le Mesurier).
1/3446	Muscovite Mica ...	Coolgardie (Mr. McPherson).
1/3448	Bore Core ...	British Flag Lease, Boulder (Dr. Laver).
1/3452	Epidote crystals	Roebourne, West Pilbara G.F. (Mr. H. J. Watson).
1/3464	Basalt with Bitumen	Madrid, Orange Free State, South Africa (Geological Survey of South Africa).
1/3490	Breccia	Balline Station, 40m. N.W. of Northampton, Victoria District, S.W. Division (Mr. C. H. Counsell).

LIBRARY.

The Library of the Geological Survey has received by way of exchange 783 publications from other cognate institutions throughout the world, and 147 volumes were added by purchase during the year.

PUBLICATIONS.

The only publication issued during the year 1922 has been the Annual Progress Report for the year 1921.

The publications in accordance with the list on pages 59 and 60 of the Annual Report for the year 1921 yet remain to be printed.

Government Geologist.

Geological Survey Office,
Perth, 10th April, 1923.

INDEX.

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