With the Government Geologist's Compliments.

1910.

WESTERN AUSTRALIA.

ANNUAL PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

FOR THE YEAR 1909.

WITH FOUR MAPS AND THREE FIGURES.

PERTH:
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1910.

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ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY FOR THE YEAR 1909.

The Secretary for Mines.

Geological Survey Office,
Perth, 28th February, 1910.

A summary report on the operations of the Geological Survey for the calendar year 1909 is submitted herewith for the information of the Hon. The Minister for Mines.

The report, which has been arranged approximately on the lines of that usually adopted, contains a succinct account of the work carried out by the various members of the survey staff.

THE STAFF.

The official work of the Department has been carried out during the year 1909 by 15 officers.

Some changes have taken place in the personnel during the period under review.

Mr. W. D. Campbell, the Senior Assistant Geologist, retired on the 21st August, by virtue of the age limit laid down in the Public Service Act, whilst Mr. J. S. Brooking, Assistant Mineralogist and Assayer, severed his connection with the Department at the end of December to improve his position by engaging in private practice. In filling the vacant appointments it is to be hoped that such salaries are offered as will enable the Department to not only secure but retain the services of properly qualified and efficient officers; failing this course, the proper class of man will not be attracted to the service, which will always be in danger of losing its effective officers with the inevitable result of a decrease in efficiency.

As at present constituted the strength of the staff is hardly capable of efficiently meeting the requirements of the day, and it is to be hoped the Government will see its way to sanction the addition to the staff of an officer skilled in modern methods of petrography.

FIELD WORK.

The field work during the year under review has been carried out in various portions of the State, such as the exigencies of the public requirements demanded.

A. Gibb Maitland.—I returned from England on the 2nd of February, where I had been representing the mining interests of the State at the Franco-British Exhibition, and resumed my ordinary official duties on the 8th of the month. From that date the greater portion of the year was devoted to that multifarious administrative work inseparable from an office of this nature. A good deal of my time has been taken up in the reading and revision of manuscript reports and maps, and other editorial work. The tenth Annual Meeting of the Australian Institute of Mining Engineers was held at Kalgoorlie in the month of May, and afforded me an opportunity, in company with Mr. Gibson, of attending and taking part in the proceedings. Short visits were paid by myself to Leonora, Greenbushes, Donnybrook, and Collie in connection with various departmental matters, to which reference is made later on.

H. P. Woodward.—During the year 1909 the Assistant Government Geologist spent 224 days in the field, 127 at the head office, and 14 days on leave. From the 1st of January to the 2nd of February this officer's time was devoted to acting as my deputy, and in the preparing of the summary report for the calendar year 1908. About the middle of February a visit was paid to Collie with the object of carrying on certain investigations with regard to the liability of Collie Coal to ignite spontaneously. These investigations unfortunately could not be concluded owing to the fact that tests under similar conditions to those which exist in ships' holds and bunkers could not be carried out unless at considerable expense. In the month of March a visit was paid to Mount Morgans in connection with the State-aided boring operations being carried out at that centre. On April the 13th that officer left for Roebourne with the object of making a reasonably detailed geological examination of the West Pilbara Goldfields and a traverse from there via the Ophthalmia Range to Peak Hill. While in the West Pilbara Goldfield Mr. Woodward was instructed to proceed to Wodgina to report upon an application from the owners of the Cassiterite mine for State aid in connection with a water supply. The examination of West Pilbara, including the trip to Wodgina, occupied Mr. Woodward up to the 31st of August; whilst the traverse to Peak Hill was not completed until the 13th of October. A short time was devoted to an examination of the ore deposits of Meekatharra, and an investigation into the supposed faulting in the lower levels of the Great Fingall mine at Day Dawn. The remainder of the year, *i.e.*, from the 13th of November, upon which date Mr. Woodward returned to headquarters, was devoted to office work connected with his late journey.

W. D. Campbell.—This officer left Perth for Mingenew on the 18th of February to complete his survey of the Irwin River District, and returned to Perth on the 17th of May, having been absent in the field 89 days. This officer retired from the service on the 21st of August.

Chas. G. Gibson.—Up to the 5th of April this officer was at headquarters engaged in the preparation of his work in connection with the report on the geology of the Trans-Continental Railway Survey route, to which reference was made in last year's Annual Report. A short visit was paid to York in April in connection with a supposed silver find in the locality. On the 4th of May Mr. Gibson proceeded to Kalgoorlie to assist in carrying out some geological work at that

centre, which employed him until the 26th of November. This officer was engaged in field work 210 days in the year.

H. W. B. TALBOT.—From the 1st of January to the 1st of August, 1909, this officer was temporarily attached to the party under the command of Mr. Inspecting-Surveyor Canning, which was engaged in sinking wells on the Wiluna-Kimberley stock route. On the 1st of August Mr. Talbot left the well-sinking party and proceeded to Hall's Creek, where telegraphic instructions had been sent to him to visit the recently discovered gold-mining centre of Tanami in the Northern Territory and endeavour to trace the extension of the mineral belt into Western Australia. Hall's Creek was left on the 13th of August, and after visiting Tanami and district Mr. Talbot found himself again at Hall's Creek on the 13th of September. Up to the 11th of October this officer was travelling to Wyndham, where he caught the s.s. "Koombana," which arrived at Fremantle on the 25th of October, having been engaged during the year 297 days in the field, or, including that in 1908, 426 days on this special expedition.

LUDWIG GLAUERT.—During the month of January this officer was at headquarters, engaged, *inter alia,* in identifying the Mesozoic and Post Tertiary fossils collected by Mr. Campbell during his investigations on the Irwin River field, and in describing a number of rock slides prepared from material collected in the district in illustration of Mr. Campbell's report and maps. Towards the end of January and early in February this officer was engaged in the preparation of material for a forthcoming Palæontological Bulletin, and arranging specimens in the Geological Gallery of the Museum. Three weeks' leave of absence was granted to Mr. Glauert to enable him to conduct and superintend excavations in the Mammoth Cave near the Margaret River, some few miles from Cape Leeuwin. A large number of fossil bones were collected, and are being described by Mr. Glauert. Up to the end of May this officer rendered assistance in the office in many ways, and amongst other things examined and reported on numerous bore cores from various portions of the State, and prepared a report upon the suitability for railway ballast of a number of samples collected on the proposed route of the Transcontinental Railway. Eighteen days in June were devoted to an examination of the so-called Chalk at Gingin. Between the 28th of July and the 3rd of November Mr. Glauert was at Kalgoorlie, assisting Mr. Gibson in his work at that centre. During 1909 this officer spent 154 days in field work.

LABORATORY WORK.

Mr. E. S. Simpson has, as usual, continued in charge of the Survey Laboratory, where all the chemical and other analytical work, etc., required by the Department is carried out. During the year 1909 the total number of determinations made in the Laboratory amounted to 2,755 as against 2,504 in 1908. The whole of the assay work required by the State Battery Branch is carried out in the Survey Laboratory, and by an officer, Mr. Murray, whose salary becomes a charge upon the State Battery estimates: the total number of assays performed in this connection is included in the table showing the routine work performed during the year.

Table showing the Routine Work of the Geological Survey Laboratory during 1909.

	Public.		Official.		Unclassified. (*b*)	Total.
	Pay.	Free.	Geol. Surv. (*a*)	Other Depts.		
Total samples dealt with	122	310	176	1,572	128	2,308
Assays for Gold	72	141	35	1,527	53	1,828
Silver	5	55	30	15	19	124
Copper	2	40	9	6	21	78
Tin	4	29	10	3	8	54
Lead	3	10	3	6	6	28
Zinc	1	..	1	..	..	2
Iron	1	3	2	1	5	12
Nickel	..	3	3	..	..	6
Cobalt	..	2	3	..	..	5
Manganese	..	2	..	1	..	3
Chromium	..	1	3	..	..	4
Vanadium	..	..	3	..	..	3
Thorium	..	1	4	..	..	5
Cerium and rare earths	..	..	4	..	..	4
Tantalum	4	5	..	..	..	9
Niobium	4	..	..	..	..	4
Tungsten	..	6	1	1	..	8
Bismuth	..	5	1	..	..	6
Antimony	..	3	..	..	..	3
Lime	8	..	..	3	..	11
Phosphoric oxide	22	12	2	..	..	36
Analyses complete	..	3	34	5	..	42
Do. partial	7	2	8	1	..	18
Do. proximate	2	6	9	8	9	34
Determinations of rocks and minerals	2	151	59	29	63	304
Petrographical descriptions	..	..	17	..	..	17
Calorific values	2	4	9	6	8	29
Valuation of gold specimens	..	..	15	4	..	19
Miscellaneous	10	6	28	14	1	59
Totals	149	490	293	1,630	193	2,755

(*a.*) The results under this column only include work done for field officers of the Survey actually entered in the Laboratory books. It does not include all those determinations necessarily made in connection with the National Mineral Collection, or petrographical work, the results of which were given by word of mouth, nor does it give any idea of the time expended on Geological Survey work incapable of tabulation.

(*b.*) Samples received through Head Office without any information as to source.

Reporting upon the work carried out under his more immediate supervision in the Laboratory, Mr. Simpson remarks:—

I regret that during the year two members of the staff have resigned owing to the inadequate salaries fixed for the professional officers. So long as the value to the State of the services rendered by these officers remains unrecognised by the authorities and the maximum salaries to which they may hope to attain remain so low it will be impossible to retain in the Service officers of the necessary professional qualifications, and, having lost them, to replace them satisfactorily. Better results would be attained by means of a smaller staff of more highly qualified officers, remunerated at a rate befitting their qualifications. Much time is lost in filling vacancies, and yet the volume of material submitted for examination steadily increases. The only way out of such an impasse has been to devote less time to each examination and issue in consequence less detailed and therefore less valuable reports.

The Survey Laboratory is rightly looked to to carry out (in addition to the routine work for field officers of the Survey and others, inseparable from it) research work destined to enlarge the available information with regard to the State's mineral resources, and to assist in applying them to useful purposes to the advantage of the community. Avenues for research abound, and would doubtless, if followed, lead in some instances at least to results of far-reaching effect upon the State. As an example I need only instance the large deposits of phosphates of iron, aluminium, and lime in the Dandarragan District, which, once a suitable method has been discovered for rendering the phosphoric oxide available, should form the basis for supplying cheap fertiliser to the whole of the agricultural districts. A second field for research which would amply repay the time devoted to it is the granites of the State, of which at least three types occur, one seemingly always barren of minerals of value, the second associated with ores of tin and tantalum, the third with ores of gold and copper. Under the conditions, however, outlined above, it has been found impossible to do almost any research other than to bring to a temporary conclusion the detailed examination of the Collie coals commenced in the previous year, and to resume as opportunity offered a critical examination of the ores and rocks of Kalgoorlie. In going into the commercial importance of the deposits of monazite in the Pilbarra Goldfield information as to mode of occurrence of thoria in this mineral and the methods of estimating it, was found to be both meagre and contradictory. An endeavour was made to go into this matter somewhat fully and first results were encouraging, but increase of other work combined with the resignation of a member of the staff effectually put an end to the investigation.

The Laboratory continues to undertake all of the check and umpire assays required by the State Batteries Branch, this work being done at a very low cost to that Branch and the Government generally.

One of the most important functions of the Laboratory is the authoritative determination and commercial valuation of new finds of minerals made by prospectors throughout the country. The finders are supplied within a few days with information which enables them to decide whether a discovery is of any value or not, and in the former case (when required) in what form the material should be put upon the market, and where markets are to be found. This work is of growing importance at the present time when the mineral industry shows a tendency to decline. On the other hand the Geological Survey obtains at the same time valuable information as to the distribution of minerals in the State which would be otherwise perhaps wholly lost to it, or which at least would take many years to acquire. A large proportion of the mineral specimens (other than gold) at present in the Geological Collection have been obtained also by this means.

Details of the samples received under the Government Assays Regulations are shown in the accompanying table. The total fees received in connection therewith amounted to £124 4s. 3d., which includes £10 10s. received through the Batteries Branch from August to November.

It was hoped to inaugurate during this year a card system of keeping the Laboratory records. This would facilitate reference to past work, show at a glance what was pending, and be an improvement in many other ways. The lack of the necessary funds has, however, prevented this.

PETROGRAPHICAL WORK.

During the year a good deal of petrographical work has been carried out in connection with the field operations of the various officers, details of which will be found included in their different reports, and to which no reference need be made in this place. The total number of rock sections cut during the year amounted to 222, bringing the total number up to 1,060.

One of the most important contributions is that from the pen of Mr. J. Allan Thomson, B.A., B.Sc., F.G.S., which has been included in Bulletin No. 33. Mr. Thomson's observations make by far the most important contribution to the petrology of the fundamental rocks of the State which has yet been issued, and will doubtless prove of more than mere local importance.

Messrs. Simpson and Glauert have also contributed petrological notes on many of the specimens acquired during the field work of Mr. W. D. Campbell in the Irwin River district, which will be given *in extenso* in Bulletin 38, which is now ready for press.

There are so many practical problems requiring special investigation in connection with the rocks of the Auriferous Series of the State, that it has now become essential that a specially trained petrographer should be added to the strength of the staff, who, amongst other things, will undertake the whole of the microscopic work required in connection with the field operations upon which latter the field geologists can always be most profitably employed.

PALÆONTOLOGICAL WORK.

As in past years Mr. Robert Etheridge, the Curator of the Australian Museum, continues to act in an honorary capacity as Consulting Palæontologist to the Survey and from time to time consignments of fossils have been despatched to him for determination and description. He has furnished a description of the Oolitic Fossils collected by Mr. W. D. Campbell in the Greenough River District, which will be published in Bulletin 36, which is ready for the printer.

Dr. Geo. J. Hinde, F.R.S., contributes a detailed report on the sponge spicules in a rock from the Deep Lead (?) at Princess Royal Township, Norseman. The rock in which the sponge spicules are contained is white and silicious and consists almost entirely of the spicular remains of silicious sponges, and neither radiolaria nor datoms were detected. In addition to the spicules which resemble those of existing sponges, there are many similar to those dredged from a depth of 3,000 fathoms off the south-west coast of Australia, and similar to the eocene fossil sponges in the deposit at Oamaru, in New Zealand. Dr. Hinde concludes that the Norseman sponge rock is not merely a local deposit, but that it was formed in the open ocean, and probably at a considerable depth, and that its age is newer than the Cretaceous, but there are no data to indicate the particular periods of the Tertiary and Post Tertiary in which it may have been formed.

Mr. E. A. Newell Arber, M.A., F.L.S., F.G.S., of Trinity College, Cambridge, furnished a report upon some fossil plants collected in the course of Mr. Campbell's field work in the Irwin River District, and concludes that the beds are of Jurassic Age, and may be correlated with the Jurassic plants beds of Queensland, viz., of Talgai, the Darling Downs, and Rosewood, West of Rockhampton.

Mr. L. Glauert has described a new species of *Sthenurus, S. occidentalis*, from the Mammoth Cave, in the Margaret River. This officer has also prepared a list of Western Australian Fossils, stratigraphically and zoologically arranged, in order to facilitate the field work of the Department, on account of the new Devonian fossils from the Barker Gorge, Napier Range, in the Kimberley Division; and some notes on the geological age and organic remains of the Gingin Chalk.

These various reports will be embodied in Bulletin 36, which is now ready for press.

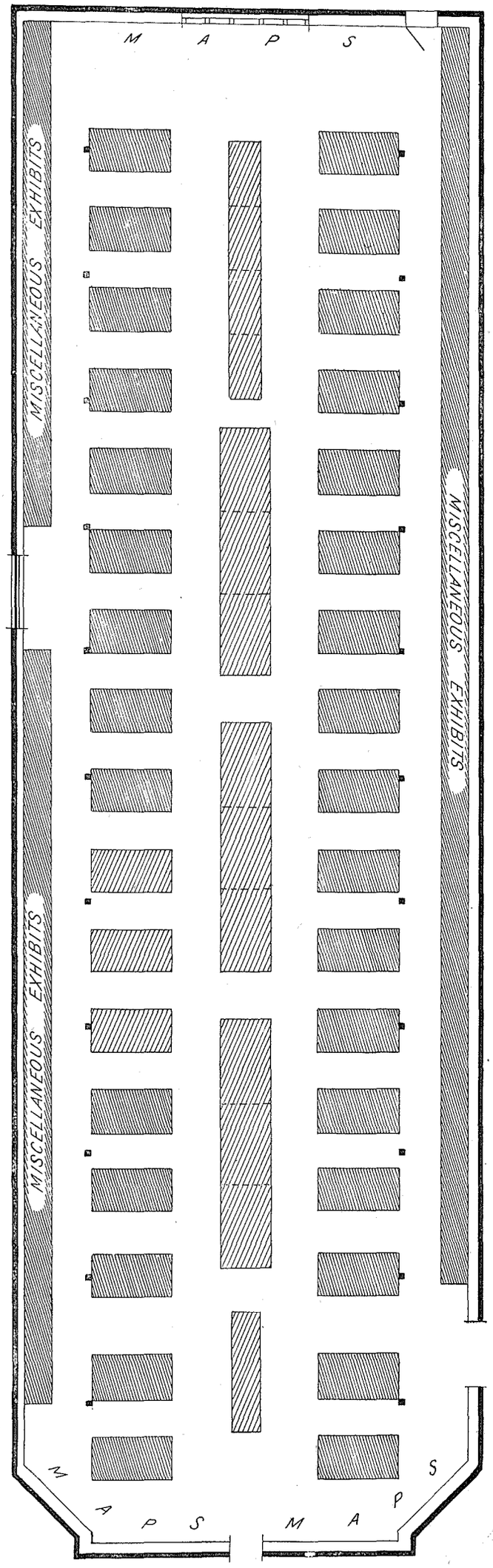
The following is a list of the type fossils in the Geological Survey Collection drawn up by Mr. Glauert.

"A 'type' is the identical individual specimen from which a species (or variety) has been described." Palmer, Index Gen., Mamm., page 20 (1904).

The figures in brackets [10035] correspond to the number in the Department's Museum Register.

Registered Number.	List of Types.
	CŒLENTERATA.
	ANTHOZOA (ACTINOZOA).
	Tetracoralla.
[(?) 10035]	*Amplexus pustulosus*, W. H. Hudleston, Q.J.G.S., Vol. XXXIX. (1883), p. 591, Pl. XXIII., figs. 1a, 1b, 1c. Carboniferous. Fossil Range N. and S. of the Lyons River, Gascoyne R. Collected by Sir John Forrest.
[10039]	*Cyathophyllum depressum*, G. J. Hinde, Geol. Mag. Dec. III., Vol. VII. (1890), p. 195, Pl. VIII, figs. 2a and 2b. Devonian (?) Gascoyne River. Collected by Mr. H. P. Woodward.
[10038]	*Cyathophyllum virgatum*, G. J. Hinde, Geol. Mag., Dec. III., Vol. VII. (1890), p. 194, pl. VIII., figs. 1a and 1b. Devonian (?), Gascoyne River. Collected by Mr. H. P. Woodward.
(10019] and [10040]	*Pleurophyllum Australe*, G. J. Hinde, Geol. Mag., Dec. III., Vol. VII. (1890), p. 196, pl. VIIIa. figs. 1a–1f. Carboniferous. Gascoyne R. and Irwin River. Collected by Mr. H. P. Woodward.
[10023] and [10041]	*Pleurophyllum sulcatum*, G. J. Hinde, Geol. Mag., Dec. III., Vol. VII. (1890). p. 197, pl. VIIIa, figs. 2 and 2a. Carboniferous. Irwin River. Collected by Mr. H. P. Woodward.
	Hexacoralla.
(10016c]	*Hexagonella (Evactinopora) crucialis*, W. H. Hudleston, Q. J. G. S., Vol. XXXIX. (1883), p. 593, pl. XXIII., figs. 2a, 2b, 2c. Carboniferous. Fossil Range, North of the Lyons River, Gascoyne R. Collected by Sir John Forrest.
[10016b]	*Hexagonella (Evactinopora) dendroidea*, W. H. Hudleston, Q. J. G. S., Vol. XXXIX. (1883), p. 594., pl. XXIII., figs. 3a–3d. Carboniferous. Fossil Range North of the Lyons River, Gascoyne. Collected by Sir John Forrest.
[10054]	*Syringopora reticulata* var. *petula*, G. J. Hinde, Geol. Mag., Dec. III., Vol. VII. (1890), p. 198, pl. VIII., fig. 4. Devonian or Carboniferous. Gascoyne R. Collected by Mr. H. P. Woodward.
	MOLLUSCOIDEA.
	BRYOZOA.
	Polypora Australis, G. J. Hinde, Geol. Mag., Dec. III., Vol. VII. (1890), p. 199, Pl. VIIIa., figs. 3 and 3a. Carboniferous, Gascoyne River. Collected by Mr. H. P. Woodward.
	Rhombopora tenuis, G. J. Hinde, Geol. Mag., Dec. III., Vol. VII. (1890), p. 203, Pl. VIIIa., figs. 4 and 4a. Carboniferous, Gascoyne River. Collected by Mr. H. P. Woodward.
	BRACHIOPODA.
	Protremata.
[4760] (*F*178)	*Aulosteges Baracoodensis*, R. Etheridge, jun., Geol. Surv., Bulletin 10 (1903), p. 22, Pl. II., figs. 1–2a. Carboniferous. Baracooda Pool, Arthur River. Collected by Mr. A. Gibb Maitland, Government Geologist.
[4732] (*F*156)	*Productus tenuistriatus* var. *Foordi*, R. Etheridge jun., Geol Surv. Bulletin 10 (1903), p. 19, Pl. III., fig. 22. Carboniferous. Fossil Hill, Wyndham River Collected by Mr. A. Gibb Maitland, Government Geologist.
	Telotremata.
[4764] (*F*179)	*Cleiothyris Macleayana* var. *Baracoodensis* R. Etheridge, jun., Geol. Surv. Bulletin 10 (1903), p. 17, Pl. III., figs. 5–9. Carboniferous. Baracooda Pool, Arthur River. Collected by Mr. A. Gibb Maitland, Government Geologist.
[4946] (*F*229)	*Dielasma nobilis*, R. Etheridge, jun., Geol. Surv. Bulletin 27 (1907), p. 19, Pl. IV., figs. 2–4, and Pl. VI., figs. 1 and 2. Permo-Carboniferous. Mingenew. Collected by Mr. E. S. Simpson.
[10031]	*Spirifera Hardmani*, A. H. Foord, Geol. Mag., Dec. III., Vol. VII. (1890), p. 146, Pl. VII., figs. 1 and 1a. Carboniferous. Gascoyne River. Collected by Mr. H. P. Woodward.
[10077]	*Spirifera Kimberleyensis*, A. H. Foord, Geol. Mag., Dec. III., Vol. VII. (1890), p. 105, Pl. V., fig. 11. Carboniferous. Collected by Mr. H. P. Woodward.
[10078]	*Spirifera Musakheylensis* var. *Australis*, A. H. Foord, Geol. Mag. Dec. III., Vol. VII. (1890), p. 147, Pl. VII., fig. 2, and Pl. V., fig 12 (?). Carboniferous. Gascoyne River. Collected by Mr. H. P. Woodward.
	MOLLUSCA.
	PELECYPODA.
[4927] (*F*220)	*Myalina* (?) *Mingenewensis*, R. Etheridge, jun., Geol. Surv. Bulletin 27 (1907), p. 24, Pl. V., fig. 4, and Pl. VI., figs. 3 and 4. Permo-Carboniferous. Mingenew. Collected by Mr. E. S. Simpson.
	GASTROPODA.
[4960] (*F*438)	*Ptychomphalina Maitlandi*, R. Etheridge, jun., Geol. Surv. Bulletin 10 (1903), p. 24, Pl. I., figs. 13–15. Carboniferous. Wandagee Station, Minilya River. Collected by A. Gibb Maitland, Government Geologist.
[5714] (*F*275)	*Gastriocoras Jacksoni*, R. Etheridge, jun., Geol. Surv. Bulletin 27 (1907), p. 36, Pl. IX., figs. 1–3. Carboniferous. Irwin River. Collected by Mr. C. F. V. Jackson.
	PISCES.
	Selachii.
	Edestus Davisii, Henry Woodward, Geol. Mag., Dec. III., Vol. III. (1886), p. 1, Pl. I. Carboniferous. Arthur River, Gascoyne River. Collected by Mr. Davis.

Fig. 1.



PLAN OF GEOLOGICAL SURVEY MUSEUM.

MISCELLANEOUS MINERAL NOTES.

Many interesting and important mineral discoveries were noted during the year. Mr. Simpson refers to these as follows:—

Tin ores.—Cassiterite (tin oxide) at Poona Walloo Hill, Bullabulling, and Londonderry. In this connection it is interesting to note that in 1902 I wrote in Bulletin VI. the following:—

> "Silicates containing lithium and fluorine are so frequently associated with tin ores that it is interesting to note that topaz and lepidolite occur in large quantities at the mica mine near Londonderry; and lepidolite, tourmaline, and spodumene near Ravensthorpe. Tin ore has not up to the present been detected at either of these localities, though the presence of these minerals would point to the probability of its occurrence there."

Tantalum ores.—Manganotantalite (tantalite of manganese) and Manganocolumbite (niobate of manganese) in alluvial deposits with cassiterite at Poona and Londonderry. Manganixiolite (tantalate and stannate of manganese) at Londonderry.

Bismuth ores.—Bismutite (hydrated carbonate of bismuth) with gold at Salgash and North Pole (Pilbara G.F.). Samples of lodestuff from the latter assayed bismuth 7.58 per cent. and 14.83 per cent.

Tungsten ores.—Wolfram (tungstate of iron and manganese) at Collie's Soak, Murchison G.F. Scheelite (tungstate of calcium) at Poona.

Chrome ore.—Chromite (oxide of iron and chromium) at Cooglegong and 10 miles east of Buningonia Spring, N.E. Coolgardie G.F.

Miscellaneous.—Rutile (oxide of titanium) at Balbarrup. Cerargyrite (chloride of silver) at North Pole. A sample of quartz assayed:—

> Silver, 242ozs. 14dwts. per ton.
> Gold, 15dwts per ton.
> Bismuth, 7.58 per cent.

Symplesite (hydrous arsenae of iron) at Kundip. Monazite (phosphate of cerium, thorium, etc.) at Poona. Cobalitite (sulpharsenide of cobalt) at Kundip. Beryl (silicate of Beryllium) at Poona, Greenbushes, and Ravensthorpe. Pickeringite (magnesia alum) and Copiapite (hydrous iron sulphate) at Glen Ross, Upper Ashburton. Andradite (calcium-iron garnet) at Cooglegong. Meteoric iron at Lake Giles (approx. loc.).

Coal.—Lignite at Point Cloates. Brown coal at Donnybrook. Hydrous-bituminous coal in seams up to ½ inch in a bore at Liverynga Station, West Kimberley.

GEOLOGICAL MUSEUM.

In last year's annual report reference was made to the decision of the Government in connection with the transfer of the National Geological Collection to the Geological Survey. Owing, however, to reasons for which the Survey is in no way responsible, no effective work has been possible.

A very large part of the Survey Collection was thoroughly overhauled in 1908, and during the year under review 826 new specimens were added thereto, bringing the total number at present registered up to 10,912. These included the valuable specimens purchased from the Western Australian Commissions for the sum of £2,497 12s. 2d.

Of microslides there have been added 222, bringing the total number up to 1,060. The officers of the Department have in the ordinary course of their duties taken 145 photographs of geological and mining subjects, bringing the total number registered up to 593.

In the general scheme which it is proposed to ultimately adopt in connection with the arrangements of the geological collections I have decided upon a plan which seems to me to meet the requirements of four totally distinct classes of visitors to the Department, viz.: (a) the general public; (b) the average student; (c) the practical man, prospectors, miners, engineers, etc., etc., and (d) the scientific enquirer.

Naturally in a Geological Museum in such an important mining country as Western Australia, the guiding principle should be that of illustrating the geological structure, mineral resources, underground water supplies of the State, in addition to the application of geology to various industrial pursuits as well as the more systematic treatment of the science of geology in general. Limitations of space under present conditions naturally preclude undue prominence being given to much else than the above.

The arrangement of the show cases in the Geological Gallery is as is shown in the plan which forms Fig. I. The upright cases which are arranged along the walls of the gallery are occupied with Zoological, Art, and other specimens. It is essential, if the Gallery is to be made at all representative, that steps should be taken to place the whole of the room at the disposal of the Department.

To this end the minerals, rocks, and fossils of Western Australia will be properly displayed, and as far as space will admit an endeavour will be made to display specimens which are specially characteristic of Australasia and elsewhere. The fossils which have been almost entirely collected by the Survey Staff in the ordinary course of their duties, from the different geological formations in the State, will be displayed and arranged primarily in stratigraphical and secondly in zoological sequence; these in conjunction with the geological maps of the district from which they were obtained will be designed to illustrate the coal-bearing strata, the artesian water-bearing beds, the phosphatic deposits and other economic products.

The rock specimens will be systematically arranged in such a way as to illustrate the geological and mining maps of the various districts of the State.

The minerals and metallic ores will be primarily arranged on a metallic basis in such a way as to illustrate the type, mode of occurrence, and geographical distribution of the mineral resources of Western Australia. In the case of metallic ores and minerals typical specimens of nearly uniform size will be arranged, with illustrative maps, plans, diagrams, and photographs, such being of much greater scientific, commercial, and educational value than large trophies or bulk samples from individual mines or districts.

In all cases care will be taken to preserve and exhibit only such specimens as are of permanent and real value. Carried out on these lines the Geological Museum will then be, as it ought to be, primarily a collection illustrating in its widest sense the geological structure of Western Australia, in its relation to geological science in general.

PUBLICATIONS.

During the year the following official publications have been issued:—

Annual Progress Report for the year 1908.

Bulletin 33: Geological Investigations in the Country lying between 21deg. 30min. and 25deg. 30min. S. Lat. and 113deg. 30min. and 118deg. 30 min. E. Long., embracing parts of the Gascoyne, Ashburton, and West Pilbara Goldfields.

Bulletin 35: Geological Report upon the Gold and Copper Deposits of the Phillips River Goldfield.

Bulletin 37: The Geological Features of the Country lying along the route of the Proposed Transcontinental Railway in Western Australia.

Whilst Bulletin 38: The Irwin River Coalfield and the adjacent districts from Arrino to Northampton; and

Bulletin 36: Palaeontological Contributions to the Geology of Western Australia, III., are ready for the printer.

In addition—Bulletin 39: The Country between Wiluna, Hall's Creek, and Tanami,

Bulletin 41: The West Pilbara Goldfield, and

Bulletin 42: Kalgoorlie, Its Geology, Ore Deposits, and Mines, are in course of preparation and rapidly approaching completion.

LIBRARY.

The library of the Geological Survey consists of 4,294 volumes on geology, mining, and cognate subjects, having been increased during the year by 603 presentations, whilst 45 were acquired by purchase.

As opportunity offers and the state of the Survey Vote permits, efforts are being made to make the geological library as complete and representative as possible in respect to the official publications of Geological Surveys and kindred institutions of other countries. The library is at the disposal of the scientific and professional public, a privilege which has been largely availed of in the past.

One hundred geological maps issued by the Geological Survey of the United States of America; thirty of the Geological Surveys of Great Britain and Ireland; twenty by the Geological Survey of Canada, and ten from the Geological Survey of Japan have been added to the collection of Geological Maps already in the possession of the Department.

GEOLOGICAL MAP OF WESTERN AUSTRALIA.

The preparation of a geological map of Western Australia has been steadily kept in view for a number of years past. Several important traverses have been made in hitherto (geologically) unknown portions of the State, and afford the means of connecting the work which has been carried out during recent years in the Northern district, and that of the Central and Eastern Goldfields, thus tending to bridge over many important gaps.

Much of this information has been gained when engaged on other work in different and widely separated portions of the State, and has added considerably to our knowledge of the geological features of Western Australia.

All this information it is contemplated embodying in the Geological Sketch Map which will be based upon the four sheet map of the State, issued by the Department of Lands and Surveys on the scale of 25 miles to the inch.

Unless anything unforeseen happens it is hoped that the much-needed Geological Sketch Map of the State will be available for the lithographer at the close of the year 1910.

It is contemplated issuing in conjunction with it a special bulletin on the geology and economic resources of the State, which will summarise the information which the Department has acquired during the last twenty years.

PRINCIPAL RESULTS OF THE FIELD OPERATIONS.

A general review of the principal results of the field work during the year shows that a considerable advance has been made in our knowledge of wide tracts of country, more especially in the portion of the State lying north of the latitude of Wiluna; whilst considerable progress has been made with the detailed investigations in connection with the geological structure, ore deposits and mines of Kalgoorlie.

The following reports by the different field officers give a brief *aperçu* of the work each has been carrying out.

A. Gibb Maitland, Government Geologist.

(1.) *Occurrence of Coal Measures near Perth.*

The possibility of the occurrence of coal measures within 20 miles of the metropolis having been brought under the notice of the Government, the evidence as to the probability of such was investigated and the following report submitted to the Minister in November last:—

In 1872, Mr. H. Y. L. Brown in his report to His Excellency the Governor on the Geological Exploration of Western Australia* refers to the Carboniferous rocks in the vicinity of Perth as follows:—

Again at the Canning River, a few miles south-east of Perth and close to the foot of the Darling Range, strata composed of black shale (containing fragments of coal and much iron pyrites), sandstone, grit, etc., have been found by sinking through the deposit of sand, clay, and gravel which overlies it. As the occurrence of this shale indicates the presence of a formation previously unknown in the district, I consider it probable that there may be a large area of the same deposit, extending westwards below the sea level, and also that it may possibly contain beds of coal at a greater depth. Boring operations were undertaken a few months ago, and a depth of 171 feet attained about a quarter of a mile westward of the spot where the shale was first observed.

The following is a description of the material brought up from time to time, as determined by Mr. Brown:—

Canning River Bore.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Sand, gravel, sandy clay, and small boulders of igneous rocks, clay containing pyrites	16 0	..	"The sand and gravel in the above list, with the exception of that near the surface, must be considered mostly as coming from beds of sandstone and conglomerate which have been worked up by the actions of the boring tools. In the same way the black and blue clay, when *in situ*, existed as shale. It is more than probable again that the rounded fragments brought up from certain depths had previously fallen down from a higher position."* Artesian water is still flowing from this bore.
Rounded granite pebbles, and gravel, grit, blue clay and shale containing carbonised matter	25 0	16 0	
Gravel, sand, and pieces of quartz and granite; black clay with pyrites	23 0	41 0	
Rounded quartz, granite, grit, quartzite, and black clay with pyrites	29 0	64 0	
Rounded pieces of granite, and igneous rocks, gravel, sand, quartz, etc., with fragments of lignite	33 0	93 0	
Rounded fragments of igneous rocks, sand, etc.; yellow sandstone at 139 feet; coarse grit and sand at 171 feet	45 0	126 0	
Total	171 0	171 0	

* General Report on a Geological Exploration of that Portion of the Colony of Western Australia lying Southward of the Murchison River and Westward of Esperance Bay. Perth: By Authority, 1873, pp. 10-11.

In the year 1903 a specimen of black carbonaceous shale [4517] containing what are believed to be the rootlets of *Glossopteris* was presented to the Departmental Museum, with an intimation that it came from "17 miles north of Midland, not far from Bullsbrook."

This specimen was duly forwarded to Mr. Robert Etheridge of Sydney, who acts as Hon. Consulting Paleontologist to the Geological Survey of Western Australia, and in 1907 reported on it as follows:—

The presence of that peculiar semi-jointed organism known as *Vertebraria* at the fourth locality (near Bullsbrook) is interesting. The plant remains known under this name are constantly associated in our Eastern Coal Measures with the leaves of *Glossopteris*.*

The importance of this specimen [4517] in regard to the possible occurrence of Carboniferous Rocks (possibly containing coal seams) in the vicinity of Perth is very great. A recent re-examination of it indicates quite clearly that it could not have been derived from the outcrop of any strata which had been exposed to the weather, but must have been obtained from material exposed in shaft sinking, etc., at some distance from the surface. No shales of the kind are, so far as I am aware, found to occur anywhere near Bullsbrook, nor do I know of any wells, etc., in that locality which passed through strata of a similar kind.

Unfortunately the history of the specimen was never furnished to the Department and all that is known about it is that it was labelled as coming from Bullsbrook. If the locality is authentic, the probability of Coal Measures occurring in the district is more than probable, but in the light of all the information available to me I am inclined to disregard the important evidence which the specimen would otherwise afford on the grounds that it has been obtained from a locality which is at present unidentifiable.

The specimen is totally unlike any occurring in any of the Western Australian Coal Measures known to me, but has more of the characteristics of those associated with the measures in Eastern Australia.

During the last few months I have received verbal intimation that on Mr. Gibbs' Location 832, on the Canning River, fragments of coal were found in a ploughed field over 25 years ago. A very small fragment of coal said to have been obtained from the same locality was recently shown to me, but its characteristics indicated clearly that it could not have been exposed to the weather; it resembled in its essential characteristics some of the coals which are used on the Government Railways. This location is that upon which the auriferous quartz reef at Gosnells occurs, and is in close proximity to the bore put down in 1872, under the supervision of the then Government Geologist alluded to above.

The Irwin River Coal Measures which outcrop on the Coastal Plain to the north plunge beneath the Jurassic and more recent strata in the neighbourhood of Yandanooka, and do not, so far as is yet known, reappear at the surface.

In a geological map (a copy of which is to be seen in the Geological Museum) issued in 1860, by Mr. Gregory, Carboniferous rocks are shown as occurring in the vicinity of Gingin, an observation which, if capable of substantiation, is of the utmost importance.

The Irwin River beds are arranged in a series of folds of such a nature as might be expected to bring them near the surface at some points beneath the Coastal Plain, but in any of the bores put down within the Metropolitan area in the search for Artesian water, no sign has yet been met with of Carboniferous Rocks.

In the light of all the evidence now available I am inclined to regard the term Carboniferous used both by Mr. Gregory and Mr. Brown in this connection as being of mineralogical rather than of geological significance.

So far as any data at present go it does not yet appear that the occurrence of strata of Carboniferous, and possibly coal-bearing, age within 20 miles of Perth has any very sound geological reasons for its belief.

It may be noticed in this connection that in the bores put down on the Royal Agricultural Show Ground, and the Hospital for the Insane, at Claremont, a considerable thickness of solid crystalline limestone associated with glauconitic sands or sandstones was encountered. Lithologically these limestones bear a close resemblance to those occurring in the Lower Carboniferous strata of the Irwin River valley; their stratigraphical position, however, is not favourable to the occurrence of coal seams.

2. *Coal on Prospecting Area 155H, Donnybrook.*

On the 11th of June, 1909, Mr. O'Grady called at this office and handed in a sample of brown coal for analysis, coupled with the statement that the specimen did not represent a fair average of the whole seam, but was merely a piece from one portion, and was not particularly good.

According to the information furnished in an official memo. of the 2nd of June, the coal was obtained from the 70ft. level in the shaft in the prospecting area 155H, of 3,000 acres. About 25 feet of driving is said to have been done at that level. This seam, from Mr. O'Grady's information, was 4ft. 10in. in thickness, and made up of three bands of coal—top band 6in., middle band 1ft. 6in. to 2ft., and bottom band 7in.

This sample proved to be a brown coal of no particular value, and the Laboratory report (3441c) showed it to be of low calorific value, and to contain over 52 per cent. of ash and moisture.

Analysis 3441c.

	Per cent.
Moisture	26.95
Volatile Hydrocarbons	25.46
Fixed Carbon	21.98
Ash	25.61
	100.00

Calorific Value, 5,710 B.T.U.

On the 15th of last month Mr. O'Grady again called at this office and handed in a sample of bright bituminous coal for analysis.

According to the information supplied to me by Mr. O'Grady the coal was stated to have been obtained from the same seam as that from which his previous sample was obtained, and was made up as follows:—

Shale.	(Roof).
A. Brown Coal	1 foot. Analysis 3441c.
B. Bituminous Coal ..	1 foot (about). Analysis 4108c.
C. Brown Coal ..	6 to 8 inches.
D. Coal (said to resemble B.)	5 inches.
E. Inferior Coal ..	1 foot (about).
Thickness, 4 feet 2 inches.	

* Palæontological Contributions to the Geology of Western Australia, II. (a.) Plant Remains from the Collie Coalfield. R. Etheridge. Geol. Surv. Bull. 27, p. 8.

The sample submitted for analysis is stated to have been obtained from band (B).

The Analysis 4108c of this sample is as follows:—

	Per cent.
Moisture	2.75
Volatile Hydrocarbons	41.01
Fixed Carbon	47.03
Ash	9.21
	100.00

Calorific Value, 13,120 B.T.U.

It was deemed advisable for the Inspector of Mines to visit the locality for the purpose of sampling the seam, and on the 3rd instant he gave the following particulars regarding it:—

Sample 1. Ligneous Coal or brown carbonaceous shale, 8in., claimed by Mr. O'Grady to burn well.

Sample 2. Black hydrous Coal with a brown streak, 5in. Turns brownish on exposure and on being crushed.

Clayshale, 12in.

Sample 3. Black Hydrous Coal similar to 2, 3in.

Shale, 16in.

Thickness, 3ft. 8in.

The Inspector states that

"All these samples were taken from the face of the drive. Samples 2 and 3 were mixed together as they are very similar. Sample No. 4 was taken from the top coal of the drive but near to the bottom of the shaft. I have four pieces of the hard black bituminous coal of splendid quality, which I took from the floor of the drive and the log on the surface, which I state are foreign to the locality."

The samples collected by Mr. Briggs have been analysed with the results given below:—

		No. 4169. %
No. 4169—Donnybrook No. 1 ..	Moisture	31·34
	Volatile hydrocarbons	28·43
	Fixed carbon ..	24·37
	Ash	15·86
		100·00
	B.T.U. ..	6315.
No. 4170—Donnybrook 2 and 3 mixed	Moisture	31·28
	Volatile hydrocarbons	31·57
	Fixed carbon ..	26·12
	Ash	11·03
		100·00
	B.T.U. ..	6928.
No. 4171—Donnybrook No. 4 ..	Moisture	35·00
	Volatile hydrocarbons	28·60
	Fixed carbon ..	24·70
	Ash	11·70
		100·00
	B.T.U. ..	6429.

These samples were all non-caking brown coal.

These figures demonstrate perfectly clearly that the coal handed in by Mr. O'Grady on the 15th of last month differs very materially from that collected by Mr. Inspector Briggs; the former bears a marked resemblance to that of some of the New South Wales coal.

A special visit to Donnybrook and a portion of the period between the 23rd and the 25th of October were devoted to investigations in connection with the authenticity of the find of high-class bituminous coal reported by Mr. O'Grady on the 15th of September.

The coal in question was said to have been obtained from the seam exposed in the drive in a shaft, No. 1, 210ft. deep, better known as Murphy's Shaft.

In September, 1906, Mr. Campbell visited the locality and reported the strata exposed therein as follows:—

	From	to
Gravel and laterite	0′	8′
Pipeclay (? Shale)	8′	23′
Grey clay (? Shale)	23′	33′
Dark grey clay (? Shale)	33′	73′
Lignite	73′	77′
Clays (? Shales) and sandy grits with pyriteous lignite	77′	180′
Sandstone	180′	190′
Loose sandy grit	190′	202′

A bore was put down from the bottom of the shaft to a depth of 18 feet and passed through nothing but sandy grit.

3. This shaft was not accessible to me below the depth at which a drive had been put in on the seam of brown coal referred to in the above table.

4. A few feet from the shaft a fault of unknown downthrow exposes a thin seam of brown coal, associated with very earthy brown coal or carbonaceous shale.

An analysis (4302) of this brown coal yielded the following results:—

Moisture	36.28
Volatile hydrocarbons ..	27.67
Fixed carbon	22.60
Ash	13.45
	100.00
Calorific value	6072 B.T.U.

5. On the western side of the fault is the seam from which Mr. O'Grady claimed to have obtained the sample of high grade bituminous coal, submitted for analysis; and from which Mr. Inspector Briggs obtained the samples on the 3rd of October.

The section of this seam as showing at the face of the drive is given in my report of the 8th of last month and need not be repeated.

Owing to the foul air it was impossible for me to get access to the face on the two occasions upon which I visited the shaft.

A sample of the brown coal forming the upper portion of the seam was carefully taken from a freshly broken face and an analysis of it (4303) gave the following figures:—

Moisture	33.48
Volatile hydrocarbons ..	29.12
Fixed carbon	22.66
Ash	14.74
	100.00
Calorific value	6364 B.T.U.

This analysis is practically identical with that of the sample obtained by Mr. Briggs, and better than

that (3441c) of the original sample received from Mr. O'Grady in June last.

Careful search was made to find any traces of the high grade coal, fragments of which were picked up from the floor of the drive and a log on the surface by Mr. Briggs, but none could be found.

According to the tenour of a telegram received by myself while at Donnybrook from the Department, it appears that Mr. O'Grady still asserts that he can point out the seam from which he obtained the coal (4108c) handed in on the 15th of September.

From a knowledge of the geological constitution of the district I am hardly of opinion that he can do so, because the coal in question is obviously of foreign origin and came from a distant source.

(3.) *Subsidised Boring Operations at Leonora.*

In June, 1908, a limited liability company was formed for the purpose of prospecting the country around Leonora, by means of a diamond drill.

On the first of June, 1908, a deputation waited on the Minister for Mines in connection with the project, and the latter intimated that the Government Geologist or the State Mining Engineer would be specially instructed to visit the district and point out sites where boring operations would have reasonable prospects of success, and that the Government would pay three-fifths of the expenditure.

In December, 1908, the State Mining Engineer visited Leonora, and selected the site of three bores referred to in his report of the 7th December, 1908, and shown on the plan attached. (*Not reproduced.*)

Operations were carried out at sites 1 and 3, and were uniformly unsuccessful.

On the 28th of April, 1909, the syndicate again approached the Government with the view to geological advice being obtained before any further operations were undertaken.

The geological features of the auriferous deposits of Leonora had been investigated by Mr. Jackson in 1903, and his results embodied in Bulletin No. 13, thus rendering assistance in this direction comparatively easy.

A reference to the Geological Map of Leonora shows that practically the auriferous belts are two in number; the westernmost being that along the contact between the granitic rocks and the schists, and includes the Tower Hill, the Main Reef and Trump groups; whilst the easternmost includes what may be called the Gwalia group. All the auriferous deposits of the latter group are in schist country intersected by massive greenstone.

The massive greenstone contains crush lines, which in many cases carry quartz veins, but so far none of these have proved sufficiently rich in gold to warrant any serious attention being paid to them.

The site of No. 1 bore hole (of the State Mining Engineer) is as may be seen in the massive greenstone, and was designed to intersect a crush line ("schist lode") underlying easterly at about 65deg., and having an average strike of about north 10deg. west. The bore was put down to the westward inclined at an angle of 45deg. at a spot about 165 feet east of the outcrop of the crush line, and was continued to a depth of 470 feet. The bore pierced nothing but massive greenstone, with a thin vein of ferruginous quartz at about 133 feet, and another at 317 feet; neither, however, proved to be auriferous. So far as may be judged from the cores up to a depth of about 223 feet the hole was carried down through more or less weathered rock.

From 223 feet to the end Mr. Glauert gives the following details of the cores he examined:—

Throughout this section the rock seems to be very hard and compact, differing in this respect from No. 1 Bore, where a great deal of broken material was encountered. The rock is a typical greenstone which has undergone a certain amount of metamorphism; chloritic, talcose, and micaceous bands are common though the rock does not split readily along the lines of schistosity.

At 228ft. occasional veins of calcite and quartz are met with, generally only of limited thickness. The calcite becomes more and more plentiful though it seems to be confined to the veins and is not disseminated throughout the rock (240ft.).

At 261ft. the nature is brittle, for an abundance of planes of chlorite and silvery mica is quite striking. A few feet further on the schistose structure vanishes, and we again have many small veins of quartz and principally calcite.

In the neighbourhood of 317ft. a quartz vein of some size is struck, which, however, showed no visible traces of gold.

Soon after this the rock loses much of its schistose structure, becoming almost an amphibolite with long slender crystals of hornblende at 337ft. A thin band of chloritic and micaceous rock is encountered, but the amphibolite type is again present at 341ft. The mass then becomes finely and evenly grained, is very compact and solid, and shows very small traces of effervescence when treated with acid. Quartz veins are rare, though the mineral is present as a constituent of the rock. Gradually the rock becomes increasingly chloritic and micaceous, changing at 365ft. into a somewhat darker tint with an absence of the chloritic and micaceous planes. It gradually gains in quartz and pale or white felspar until the normal colour is once more attained. This fine-grained and evenly-grained type persists to the end of the bore, a variation in the size and number of the calcite and quartz veins being the only changes to be noticed with the naked eye.

Pyrites in small masses and crystals more or less abundant throughout.

It would seem that the rock is an "amphibolite" which has undergone various changes owing to weathering, pressure, etc., etc.

The cores were carefully sampled, 49 assays being made, of these two gave 13grs. of gold per ton, 10 "traces," whilst the remaining 37 were barren.

The intermediate, or No. 2 hole, was not bored, but the third hole passed through nothing but more or less massive greenstone, traversed at 70 feet by a band of more or less shattered rock, which may possibly represent a crush line ("schist lode"). A trace of gold was found on assay at this depth.

An examination of the cores showed:—

At the surface the rock is ferruginous and weathered; it contains a fair amount of chlorite and occasional veins of secondary calcite.

At 27ft. it becomes more solid, but is still very ironstained, calcite being present.

At 54ft. it is very massive and has lost practically every trace of ironstaining; the calcite veins are now slightly more numerous.

At 70ft. is a dislocation or fault, the rock is very much shattered for two or three feet.

At 110ft. the character of the rock changes somewhat. It becomes micaceous and has very frequent and abundant narrow veins of calcite (⅛in.-¼in.) running through it at distances of ⅝in. or ½in. apart. In consequence of the abundant mica the rock is very schistose.

At 156ft. a vein of white quartz is met with; it is only an inch or two in thickness.

At 174ft. the character of the rock again changes to a chloritic greenstone, the mica is practically absent. The calcite veins, etc., are less frequent but of greater size.

At 316ft. (odd) another quartz vein is met with which is of rather greater extent, being several inches in thickness.

At 340ft. to 370ft. we have alternations of rock with numerous fine veins or bands of calcite and rock with fewer but thicker veins of the same secondary mineral.

370ft. to 414ft. consists entirely of greenstone with coarse veins of calcite.

The last section of the bore, 414ft. to 470ft., calls for little comment. It is a solid greenstone with veins of calcite and occasional ones of quartz. At 425ft. the rock becomes somewhat more schistose, and shows greater development of chlorite, etc., along the lines of schistosity.

"Traces" of gold were found at seven depths; "minute traces" at two others, whilst the other 24 assays gave negative results.

After an examination of the localities, I cannot see much evidence to warrant the drilling of the second bore hole.

Should it be ultimately decided to continue operations, I would advise a series of bores along the line selected by the State Mining Engineer, but on the western side of the railway line; boring in this locality would be expected to intersect the Harbour Lights and other groups in the schist belt along the western contact of the granite.

In the event of anything of value being struck in any hole, it would be better to bore north and south at right angles to the line of bores, with the object of testing the deposit at three localities before proceeding with active exploitation.

Boring operations, however, should not, under any circumstances, be carried out in the massive greenstone belt, for experience has shown that the payable lodes are practically confined to the foliated rocks.

(4.) *Leonora Gold Blocks,* G.M.L. 195.

During recent visit to Leonora (October, 1909), a visit was paid to the mine for the purpose of inquiring into the question of the subsidy (or bonus) asked for by Mr. Cale, in his communication to the Government of the 14th August.

Mr. Cale originally (22nd May, 1909) applied for a subsidy of £3,800, under Part 6 of the Mining Development Act, but investigations showed that there is a debt of £3,000 on the mine to the Western Australian Bank. On being asked to make an application for an advance for pioneer mining, as laid down in Part 2 of the Mining Development Act, Mr. Cale replied (31st July, 1909) that such would not result in success, and that he did not want a loan.

On the 14th of August, Mr. Cale communicated further with the Government, and asks for £750 as a subsidy or bonus for the purpose of sinking the main (No. 1) incline shaft a further depth of 100 feet, and such to be continued to a depth of 500 feet if the developments in the first 100 feet so warranted. Mr. Cale, however, does not clearly state whether his company is prepared to bear any portion of the cost of the exploratory work he outlines, though his letter makes it quite evident that a subsidy or bonus is required and not a loan.

A full description of the essential geological features of the mine has already been given by Mr. Jackson, in Bulletin No. 13, pp. 33-35, and need not be repeated. The work done since that time has added little, if anything, new to the facts already accumulated.

There are, however, no scientific reasons for the belief that either the reefs or the values in the mine will not continue if judiciously followed.

An initial expenditure of about £500 would be required to put the mine in proper order before the sinking of the main (No. 1) incline shaft, as proposed by Mr. Cale, could be commenced, and it does not seem to me to be quite equitable to expect the State to bear any portion of the expense other than that actually involved in continuing the shaft from its present depth.

On the whole the application is not one which commends itself to my judgment, whilst the fact that a subsidy or bonus of £750 is wanted, and not a loan under Part 2, should, I think, preclude the proposition now put forward being entertained.

(5.) *Notes on the Geology of Leonora.*

A full account of the geology of Leonora was given by Mr. C. F. V. Jackson in Bulletin No. 13. In that report it was shown that the district consisted of a complex of crystalline schists, which comprised both basic and acidic rocks.

The acid schists, on the evidence available at the time, were assumed to have owed their origin to the transmutation of granitic rocks. A reinvestigation of the salient features of the field, during a short stay at that locality in August, 1909, showed that Mount Leonora, the highest and most conspicuous summit in the field, is made up of distinctly bedded rocks—quartz schists [**10880, 10883**], dipping at a fairly high angle 552 to the west. These beds are well exposed to the south of Mount Leonora, where they have been quarried for road-making, etc.

The field evidence seems to point conclusively to the Mount Leonora quartz schists being of sedimentary origin and not metamorphosed granite.

A chemical analysis of a sample of this "crushed granite" [**5084**], is quoted by Mr. Jackson on page 19 of the Bulletin in question: the figures seem rather to be those of a metamorphosed sediment than of a granite. The quartz schists, etc., of the Mount Leonora type extend without any interruption as far north as Mount George, and form a very important feature in the geology of the field, as well as being of some considerable economic importance.

The mapping in the neighbourhood of the Harbour Lights property requires a little modification: the two lodes, which are about 100 feet apart, are not in greenstone schists, but appear to be along shear-zones in crushed granite (?) or quartz schists.

To the west of Leonora Gold Blocks is a prospecting shaft 51 feet in depth; the shaft was put down through cement (laterite), which was worked in the hope of it being a deep lead. The shaft, however, was not carried deep enough to reach bed-rock.

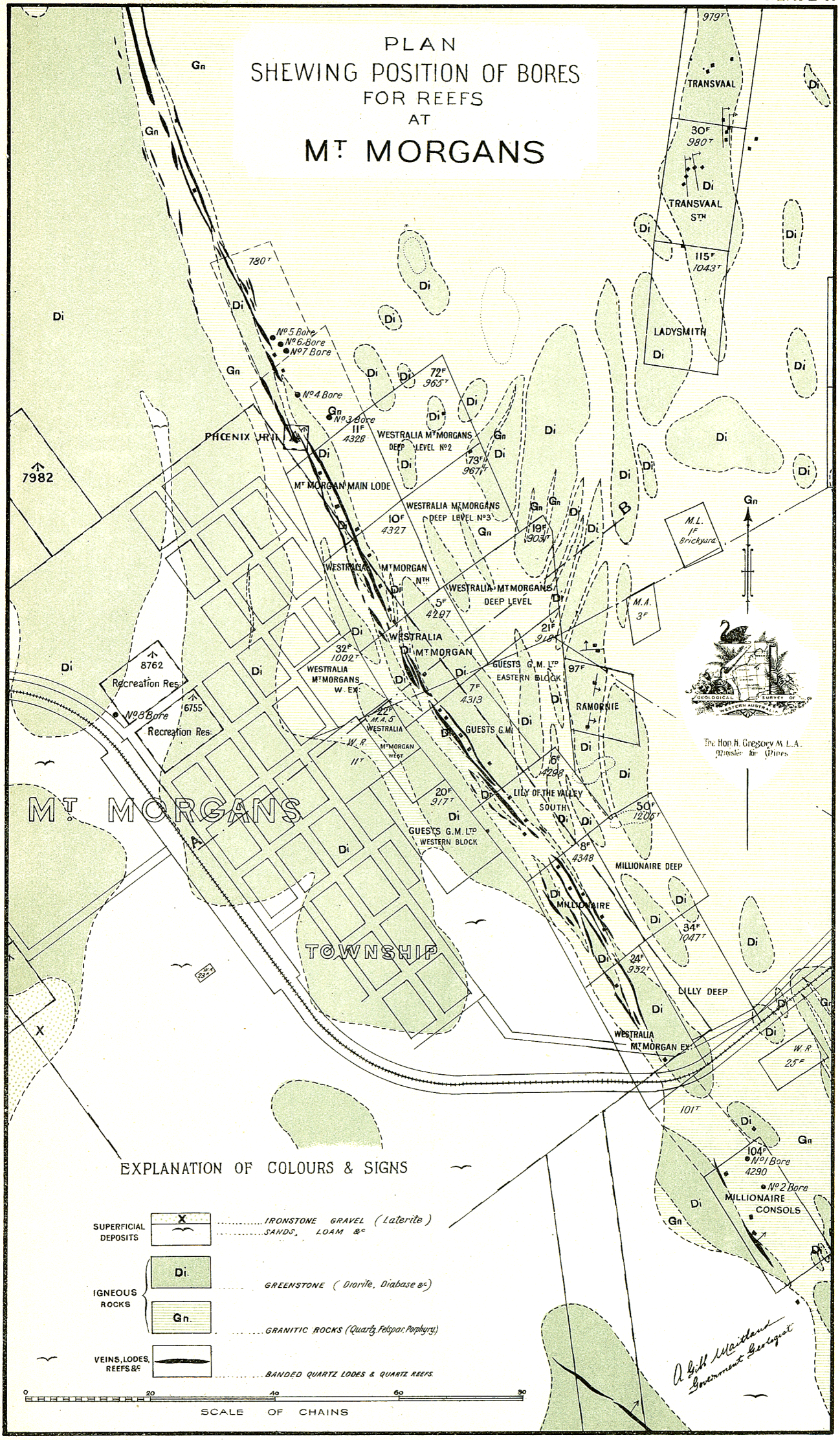
Adjoining the Leonora Main Reefs, and near the main shaft, are some workings in an auriferous wash, 35 feet below the surface. The wash, which is made up of white quartz boulders in a clayey matrix, is said to have been highly auriferous, and is reached by an incline shaft. The wash is covered by a greater or less thickness of cement (laterite). The mutual relationship of this deposit to that in the 51 feet shaft previously mentioned has not yet been clearly established.

It is proposed, when opportunity offers, having a reinvestigation made into the Leonora District, when many of the things which are not yet clear may be definitely set at rest.

(6.) *The Condition of Mining on the Greenbushes Tinfield.*

In the years 1899 and 1900, the condition of mining in, and the future prospects of, the Greenbushes Tinfield were fully set out in two reports by myself, and

PLAN SHEWING POSITION OF BORES FOR REEFS AT Mt MORGANS



EXPLANATION OF COLOURS & SIGNS

SUPERFICIAL DEPOSITS	X	IRONSTONE GRAVEL (Laterite)
		SANDS, LOAM &c
IGNEOUS ROCKS	Di.	GREENSTONE (Diorite, Diabase &c)
	Gn.	GRANITIC ROCKS (Quartz, Felspar, Porphyry)
VEINS, LODES, REEFS &c		BANDED QUARTZ LODES & QUARTZ REEFS.

0 20 40 60 80

SCALE OF CHAINS

H.J. Pether, Government Lithographer, Perth, W.A.

it was then pointed out that the tin ores fell into two distinct categories:—

(1.) Superficial deposits—
  (*a.*) Alluvial deposits,
  (*b.*) Residual deposits.

(2.) Deposits in country rock—
  (*a.*) Tin-bearing granites,
  (*b.*) Tin-bearing dykes,

and that the future of the field, after the exhaustion of the superficial deposits, would depend upon the economical working of the deposits occurring in the country rock.

This report was followed by a very voluminous one, prepared by Mr. H. P. Woodward in the year 1908, which, in addition to his own observations, summarised all the information prepared by previous geologists.

The Greenbushes field is the oldest tinfield of the State, having turned out, up to the close of 1909, 7,318.2 tons of black tin, valued at £510,682. The principal source of the tin ore raised at Greenbushes is the alluvial deposits, which are fairly widespread, having been worked in many of the gullies which traverse the field. These are divided into the deep leads and the alluvial of the existing water channels. In the latter the tin wash often lies at depths varying from 10 to 40 feet beneath the present stream bottoms; whilst the deep leads have been found to reach at least 100 feet in depth.

The residual deposits, which contain sharp, angular tin, very little removed from the position in which it was originally deposited, are of minor importance.

At the time of my visit to the field there were eight dredging and sluicing plants at work on the alluvial deposits, and there was still a good deal of alluvial and residual ground to be exploited.

On M.L. 460, Mount Jones, was a patch of residual sands, about 170 feet above the junction of Jones's Creek and the main watercourse which was being hydraulic sluiced. There was very little "over-burden," which was only about 3 or 4 feet thick, the tin-bearing was "free," being practically pure sand. The tin was very fine and angular, and obviously could not have travelled very far from its parent source: it very likely owes its origin to the decomposition of a granite *in situ*. The sand patch is hemmed in by granite.

All deposits of this nature naturally become depleted in course of time, and after their exhaustion, the future of the field must perforce depend upon the possibility of the deposits in Class 2 being able to be worked in bulk. As far as any work has at present been carried it appears that, when viewed on the whole these deposits are too low grade, and of such an irregular nature, to be followed by systematic mining.

H. P. Woodward, Assistant Government Geologist.

(7.) *Discovery of New Minerals on the Phillips River Goldfield.*

I have very great pleasure in reporting the discovery of certain new minerals near Kundip, upon the Phillips River Goldfield, which may, in the near future, prove to be of considerable value to this State.

The facts are briefly as follow:—Whilst engaged upon the recent examination of this field I was struck by the appearance of certain minerals in the ore from the Alice Mary, M.L. 99, owned by Mr. Ellis, which were supposed to be Cuprite and Azurite, but did not answer to the description of these minerals. I therefore collected as many as I could carry, and upon my return to Perth submitted these to Mr. Simpson for determination, when they proved to be Olivenite (hydrated arsenate of copper) and Erythrite (hydrous arsenate of cobalt); he also detected the presence of another mineral, but the quantity was too small for determination. I therefore communicated with Mr. Ellis, who kindly furinshed me with a further supply, which has now been examined in the Departmental Laboratory, the following report upon which has been handed in by Mr. Simpson:—

"Some little time ago Mr. Woodward brought to Perth some samples of ore from this lease which contained streaks of a pink mineral which proved to be Erythrite (hydrous arsenate of cobalt). Associated with it was a green copper mineral which was found to be Olivenite (hydrated arsenate of copper). Both these minerals being new to the State a further supply of ore was obtained from the mine. In this second lot of ore two more minerals hitherto unrecorded in this State have been detected, viz.: Symplesite (hydrous arsenate of iron) and Cobaltite (sulphuresnide of cobalt). The two latter minerals are in intimate admixture in the form of veins and nodules of massive black or dark green Symplesite impregnated with finely granular Cobaltite and occasionally Arsenopyrite. A sample made up of a number of lumps of ore showing much Symplesite gave the following assay results (undried):—

Insoluble	5·08 per cent.
Lime and magnesia ...	Strong traces
Manganese oxide	Trace
Iron...	14·98 per cent.
Copper	4·76
Cobalt	0·95
Nickel	Slight trace
Silver	1oz. 12dwts. 21grs. per ton
Gold	6dwts. 13grs. per ton

"The iron in this sample was equal to 53 per cent. of Symplesite ($Fe_4As_2O_8 + 8\ H_2O$). One lump of ore not included in this sample appeared to consist of about equal proportions of Cobaltite and Symplesite and may therefore be expected to assay over 10 per cent. of cobalt. In view of the high price of cobalt and its increasing use in the arts, the Mineral Industry for 1907 speaks of an American ore assaying 6 per cent. of copper and 3 per cent. of nickel and cobalt as 'obviously a high grade of ore.'"

Cobalt is put on the market in the form of oxide, which has recently been quoted at from 6s. to 10s. per lb. White arsenic which would be produced in treating such an ore is at present quoted in Europe at about 1½d. to 2d. per lb.

From this it will be noticed that it is a Cobalt ore of high grade and therefore should it prove to occur in any appreciable quantity it will be of very considerable value, the only reason for regret is that this mineral was not detected sooner, for some eight tons of this ore have been disposed of to the local smelting works as copper ore, the metallic contents of which were only valued at £10 per ton.

The discovery is, however, of considerable importance for even should no large quantity exist in this particular lode the presence of cobalt having been proved in this district may lead to further discoveries of even greater value.

(8.) *The Mount Morgans District of the Mount Margaret Goldfield.*

The mines of this district are situated for the most part along one of the razor-backed ridges consisting of typical banded ferruginous quartzites so common upon the Murchison and Yilgarn Goldfields. This ridge stretches for 4½ miles in a north-westerly direction following the contact of the greenstones upon the west with the granites upon the east. The greenstones as far as visible are of the usual highly-

weathered and altered schistose character, whilst in the granite area the rocks consist mostly of felspar porphyry with dykes of hornblendic porphyry in places near the contact.

These acidic rocks are clearly of igneous origin, their intrusion taking place subsequently to the laying down of the greenstone, the origin of which is obscure. This deduction is arrived at from the fact that a considerable number of greenstone masses have become entangled within the acidic magna, these being particularly numerous near the contact, whilst further a few acidic minor dykes are met with in the greenstone area, but no basic ones were observed in the granite, the whole of the rocks of this class clearly being only entangled masses.

The main fissure line does not consist of one continuous reef but of a large number of lenticular bodies which apparently follow a fault or shearing plane, they vary considerably in character from pure white quartz, various banded highly siliceous rocks having a quartzite texture, banded jaspers to ferruginous gossans, the latter of which, according to the local authorities are the only ones that are auriferous.

An inspection of the working plans of the W. A. Mt. Morgans mine reveals the fact that a series of these bodies have been worked, and they were of a lens or pipe-like character with a pitch at a low angle to the south. With depth, the number of these parallel lenses decreased as did also their horizontal extent, their maximum development occurring at about the 200-feet level.

These ore bodies have apparently been intersected horizontally by tabular porphyritic dykes, thus indicating that the mineralisation of this fracture zone took place prior to the final efforts of vulcanism, possibly due to contraction and fissuring allowing of the flow from the still molten magma to the east.

With the exception of this one mine no payable auriferous shoots have been discovered upon this line, and since the highest values in it occurred between the surface and a depth of 200 feet, testing by boring upon this line with the object of cutting possible pipes or ore at a depth presents very slight prospects of success.

It will be noticed (see Map, Bulletin No. XVIII.) that the fracture zone does not consistently follow the contact of the two rocks, but in the central portion, where the principal mine is situated, it follows a line of inclusions of schist within the granite area which at this point are in great number and extend in a northerly direction to the Transvaal mine, which is situated entirely within one of these bodies.

Upon the Ramornie, which may be said to lie at the juncture of the north and south belt of enclosure with the main fissure line, the gold occurred in fracture dyke composed of crushed rock fragments. This carried good value in places, but was very patchy.

Without an exhaustive examination of the only mine worked to a depth it would be impossible to attempt to draw any conclusion, whilst this examination is of very considerable importance as this is one of the solitary instances in which lodes of considerable size and richness have been worked to a depth in these banded quartzites, therefore the opportunity should be seized if this Company is successfully reconstructed to make an inspection when the lower levels are unwatered.

(9.) *Boring for Reefs at Mt. Morgans.*
(With a Plan, Plate I.)

Upon receipt of instructions I proceeded to Mt. Morgans on the 2nd of March, and made a general examination of the auriferous belt at that centre, with the object of selecting further sites for bores which were being put down in this locality by a local syndicate with State assistance. Upon my arrival I found that three bores had already been completed, viz., Nos. 1 and 2 upon the Millionaire Consols at the south end of the line, and No. 3 near the Phoenix trig. at the north end, whilst No. 4 in the same locality was approaching completion (See plan).

These bores had all been put down at an angle upon the east or hanging wall side of the lode with the object of intersecting it at a depth of about 400 feet but, owing to the distance of Nos. 1 and 2 from it, it is extremely doubtful whether either of them cut the reef.

No. 1 bore was down a depth of 564 feet and from it 18 core samples had been assayed, the highest of which yielded gold at the rate of 1dwt. 2grs. per ton, whilst from No. 2, down 493 feet, none of the 23 samples assayed more than a trace.

The plant was then removed to the north end of the line and No. 3 bore put down to a depth of 496 feet (?) from which 28 samples were assayed, none of which exceeded a trace, whilst from No. 4 bore, which was 832 feet in depth, 94 assays were made of the various reefs passed through, the highest of which was only 7 grains.

I then selected sites for Nos. 5 and 6 at a point a little further south where good values were said to have been obtained near the surface, fixing the positions closer to the reef outcrop with the object of intersecting it at a depth of between 200 to 250 feet, since at this level the other mines upon this line had obtained their highest values.

No. 5 bore was sunk to a depth of 303 feet and 34 assays made from the various ore bodies encountered, the highest of which only yielded gold at the rate of 2dwts. 4grs. to the ton; therefore the plant was removed to site No. 6 and the bore put down 310 feet. In this several low-grade ore bodies were cut from which 34 samples were taken, one of which gave the results of 9dwts. 10grs. for 12 inches in thickness.

No. 7 bore hole was then put down between Nos. 6 and 4 to a depth of 310 feet and from it out of the 25 samples tested the highest return was only 4dwts. 22grs.

The unsatisfactory result obtained both at the north and south end of the line caused the syndicate to abandon further idea of prospecting it, therefore the plant was removed about three-quarters of a mile in a south-easterly direction to a position between the railway and recreation Reserve No. 8762, when at last their enterprise was rewarded by the discovery of a formation, 15 feet in thickness, at a depth of 218 feet, which averaged 9dwts. 4grs. of gold per ton. A total of 18 assays were made from this bore, but with the exception of the seven from the before-mentioned lode, they were of low value.

It is most satisfactory to note this result, for not only has a very considerable sum of money been expended by the local people, but an equal amount has been granted by the Government, who, in addition, made 275 assays free of cost.

PLATE II.

PLAN & SECTIONS OF

THE CASSITERITE TIN MINE

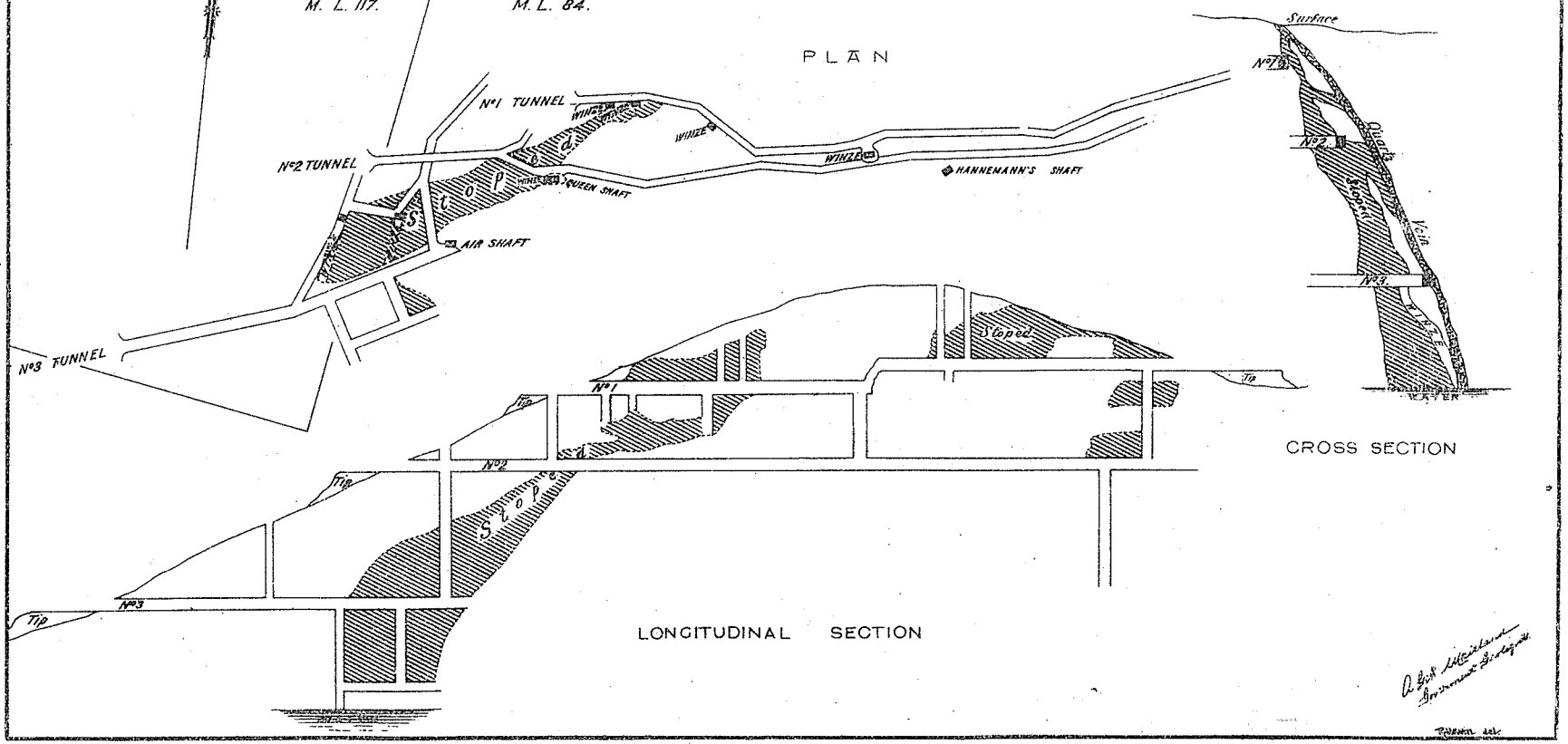
WODGINA PILBARA G. F.

0' 25' 50' 75' 100' 125' 150'

Scale of Feet.

TO ACCOMPANY ANNUAL PROGRESS. REPORT OF THE GEOLOGICAL SURVEY FOR 1903.

The Hon.ble Gregory M.L.A. Chamber for Mines



H.J. Pether, Government Lithographer, Perth, W.A.

(10.) *Wodgina Tin-mining Centre.*

(With a plan Plate II.)

Physical Features.—Wodgina is situated in a hilly triangular-shaped tract of country the apex of which points southward and, being the highest point (about 350 feet above the surrounding plain), is marked by a cairn locally known as Mt. Kettle. The two ranges are in the form of a V, the western of which runs roughly speaking north and south, whilst the eastern has a more north-easterly course. The former of these ranges runs for a distance of about five miles, gradually rising in altitude and terminating in a series of broken ridges, whilst the latter maintains its general altitude for a distance of four miles and terminates abruptly.

Between these ranges is a rough, broken valley traversed by a main watercourse and its branches, which flow in a north-easterly direction to the Turner River.

*Geology.**—The rocks forming these ranges are schistose greenstones (dolerites?) of a highly siliceous and ferruginous character, much contorted, plicated, and faulted, the detrital matter from which and also the surface are extremely hard whilst a few feet below and down to the water-level they are comparatively soft, consisting of a folii of a weathered argillaceous rock and siliceous hematite. The western of these ridges is capped by a ferruginous conglomerate, probably a portion of the Nullagine Series.

In the western side of this valley the rocks are soft highly calcareous schists covered by shallow travertine deposits and intersected by quartz reefs, but in the centre and eastern portion there is an intrusive mass of the older volcanic series consisting of dolerites, vesicular lavas, and amygdaloids often foliated but extremely hard.

Surrounding this entire tract is an extensive granitic area. As a rule these rocks at the surface are much weathered and soft, presenting a gneissic structure, but in places bold masses of a porphyritic character rise from the plain forming bold low ridges or peaks.

A series of pegmatite dykes offshoot from the main granite mass intersecting the range to the eastward and north of Mt. Kettle, traversing the schists in a north-easterly direction but terminating abruptly upon encountering the solid greenstones, at which point they form large massive bodies of irregular shapes; whilst in the greenstone area itself another series of similar dykes suddenly make their appearance, starting abruptly from the point of contact with the schists traversing the rocks in a northerly direction almost continuously for a distance of some three or four miles. These have apparently no connection with the series met with in the schists, although it is possible that they may be a continuation of the same displaced by faulting. The composition of these pegmatite dykes varies considerably from felspar to almost pure quartz, whilst offshoots from them are often composed almost entirely of mica.

In the greenstone area these dykes carry ores of tantalum in large bunches or splashes, the tantalite having apparently crystallised out subsequently to the felspar, since the former presents surfaces showing the casts of the laminii of the latter. This point is of particular interest owing to the fact that the lumps of tantalite derived from what is practically a quartz reef exhibit the same characteristics, therefore conclusively proving that the quartz is a secondary mineral replacing the felspar with which the ore in other portions of the dyke is solely associated.

It may be mentioned here that these dykes only contain ores of tantalum in appreciable quantities near the contact zone of the greenstones with the schists.

Upon the other side of the contact or in the schistose area these dykes do not contain tantalite, which mineral was supposed to be replaced by tin, since large and rich deposits of this mineral were discovered at the surface intimately associated with pegmatite fragments; the development of these bodies has, however, demonstrated the fact that although the stanniferous veins are not pegmatitic although often occupying the same fissure as they do or intersect them they are of entirely independent and more recent origin, whilst their course, although occasionally identical, is more irregular and has generally a tendency to depart from them below the surface, striking away to the northward with an underlay to the west. It would therefore appear that they are in reality a series of cross fissures which have been deflected from their true course upon encountering the pegmatite or quartz vein; at the same time it is an undoubted fact that this encounter of the two series of veins has had a considerable influence upon the deposition of cassiterite in the lodes, for so far it is only within some 30 or 40 feet of this intersection that the veins have proved to be of sufficient value to work, whilst the pegmatite veins themselves have to a small degree occasionally been enriched near the contact.

These tin-bearing veins, which consist of mica, quartz, tourmaline, and cassiterite, are small but often extremely rich in the last-named mineral, which may occur in masses up to 100lbs. in weight of great purity which need only breaking and hand-sorting before bagging.

The Cassiterite Mine.—This mine is situated upon the face of the range near the apex of the V-shaped valley, and upon the area held four tunnels or adit levels have been driven into the hill upon two of the quartz-pegmatite dykes. Of these, three have been driven upon the vein one below the other, thus forming a series of levels which test a considerable extent of the so-called lode both vertically and horizontally.

The uppermost of these has been driven completely through a spur of the range, whilst the other two have also been driven for a considerable distance and connected by winzes (see plan).

At one point of the outcrop at the top of the hill and following its outcrop down the face of the hill the rich tin-bearing vein was exposed and from it a small ravine called Ogilvie's Gully was enriched to such a considerable extent that a great many tons of tin ore were obtained by dry-blowing or hand-picking.

The rich vein of ore was at first supposed to form the footwall of the dyke, but upon development it was found only to follow the dyke for a short distance from the face of the hill; however, work was proceeded with and was rewarded farther on by another make of ore, which, however, was of much lower grade.

The vein was then followed and was found to branch off to the northward, it being small, varying from one to three feet in thickness, and was extremely rich in places. It was then stoped and the rich stone thus won beaten up, hand-picked, and then screened, the result, black tin, being bagged, whilst the valueless lode matter was tipped in one dump and the screenings containing fine tin into another.

In this manner the rich pipe of ore, which is 40ft. long at its greatest length, was worked out down to

* *See* Bulletin No. 23, Mineral Resources of the Pilbara G.F., by A. Gibb Maitland, Government Geologist.

the water-level, whilst payable portions of the main dyke at the point of contact were also worked.

Upon the other or middle dyke another tunnel was also driven where the occurrence of the ore was found to be similar, and was worked in the same manner but not so extensively.

The lessees having in this manner obtained all the available ore without the aid of machinery sold the property to the present owners, who have erected a very complete tin-dressing plant upon the mine consisting of rock-breaker, Huntington mill, May jigs, and Wiffley tables driven by a powerful oil engine which also works a dynamo, the latter being connected by cable with a motor at the water shaft.

In January last this plant started to crush and dress, when it was found that the available water supply was insufficient to enable continuous crushing to be carried on, whilst after pumping for some time the supply so considerably diminished as to preclude the possibility of working more than about five shifts per week, but in spite of this fact the plant was of such a capacity that since its inception it has been able to handle all the ore dumps with the exception of some three or four weeks' supply, and since no development work has been carried on by the present owners the mill must necessarily come to a standstill for want of ore.

Although undoubtedly the present water supply is quite inadequate to the requirements of this large plant, even with the greatest of care, for a period of 8 hours per day, the question which naturally arises in one's mind is whether it is not a question of the plant being too large for the mine rather than the scarcity of water supply, for if this plant with its present limited supply can handle the ore accumulations of several years in about five months, cannot it continue to keep pace with the ore raised day by day from developments?

Water Supply.—The underground water supply in this elevated tract of country is necessarily limited, whilst owing to the character of its surface (as previously described), even given a considerable rainfall (which it has not), little would find its way down into the interstices of these solid rocks, whilst situated as it is at the head of the valley there is little catchment to drain.

The water-level, too, is considerably above the level of the surrounding plains, and since the foliation of the rocks follows the valley they admit of a free drainage northward.

The first well sunk was by the Government in the township near the contact of the massive greenstones with the schists, but the supply obtained was so limited that it was supplemented by a second well a few chains farther south in the same zone; thus between the two the requirements of the inhabitants were met. Later on, however, the company sank a well a little south of the last-mentioned but still in the same belt; failing to obtain sufficient water, a bore hole was put down in its bottom by the Government, by which means a fair supply was struck, but upon this being heavily drawn upon by the electric pump both Government wells were drained.

With a view to obtaining a further supply, the Government are now boring in the calcareous schists at a point about half a mile west upon the other side of the greenstone at a very likely looking spot, whilst another was selected farther to the northward. When first put down wells at these points will in all probability yield a comparatively good supply but will eventually reduce to something like 2,000 gallons per day, whilst the company state they require 10,000 gallons, which supply can only be obtained by sinking upon the granite area over the range to the southward, which will necessitate about 1¼ miles of piping and power to raise water 350ft. in vertical height, whilst even upon this side of the range it is very doubtful whether this supply can be obtained from less than two wells although good sites have been selected.

Conclusion.—Since absolutely no development work upon this property demonstrates ore reserves it would, I consider, be premature upon the part of the Government to trouble about obtaining a larger water supply for this mine, since the existing supply is ample to treat all the ore that can be obtained whilst this development is taking place.

It would of course be premature to express a definite opinion with regard to the value of this property until further development has taken place, but all indications point to the existence of a small or series of small rich veins of very limited extent, which if carefully handled may pay handsomely in a small way, but there is nothing to encourage the idea that a mountain of tin exists, nor even a low-grade lode of great size.

(11.) *Preliminary Report upon the Mining Centres of the West Pilbara Goldfield.*

Whim Creek.—At this centre the Old Whim Well Copper Mine is still being actively worked; it is situated upon Loc. 71, a freehold property acquired about 20 years ago by a local syndicate who first worked this mine and later on formed it into a company. Up to the end of 1901 this company and syndicate had produced 9,097 tons of ore from this mine which averaged close on 17 per cent. Then for a period of five years the mine was closed down until it was taken over by the present company in 1907, who have since that date raised 3,638 tons of ore* up to the end of 1908.

The lode as has been mentioned in previous reports lies upon the side of a hill, its dip corresponding with that of the slope, and in consequence it was only covered by rock at those points at which spurs strike off, and is exposed in the beds of each of the intervening valleys.

The outcrop of this lode can be traced upon the top of the Slate Hill ridge for a distance of three-quarters of a mile in a north-westerly direction from the cairn, whilst to the south-east of this point it is cut off by a quartzite bar along which lode-matter with patches of rich ore can be traced in a north-easterly direction for a distance of 60 chains.

The main section of this lode that has been worked is about 30 chains in length in which large but more or less lenticular masses of ore dip in a northerly or north-easterly direction which have been followed down on the face of the slope for a distance of 12 chains or to a point which allows of the delivery of the ore to the dressing plant which discharges into the trucks upon the tram line which connects with Balla.

Owing to the lenticular character of these ore bodies the original company came to the conclusion that all the ore of a sufficient value for shipment had been worked out. This, however, has proved not to be the case, since the present company by prospecting have discovered others of equal richness only a few feet above or below those previously worked. With the object of testing this lode at a

* The percentage of the ore is not indicated in the official statistics. A. G. M.

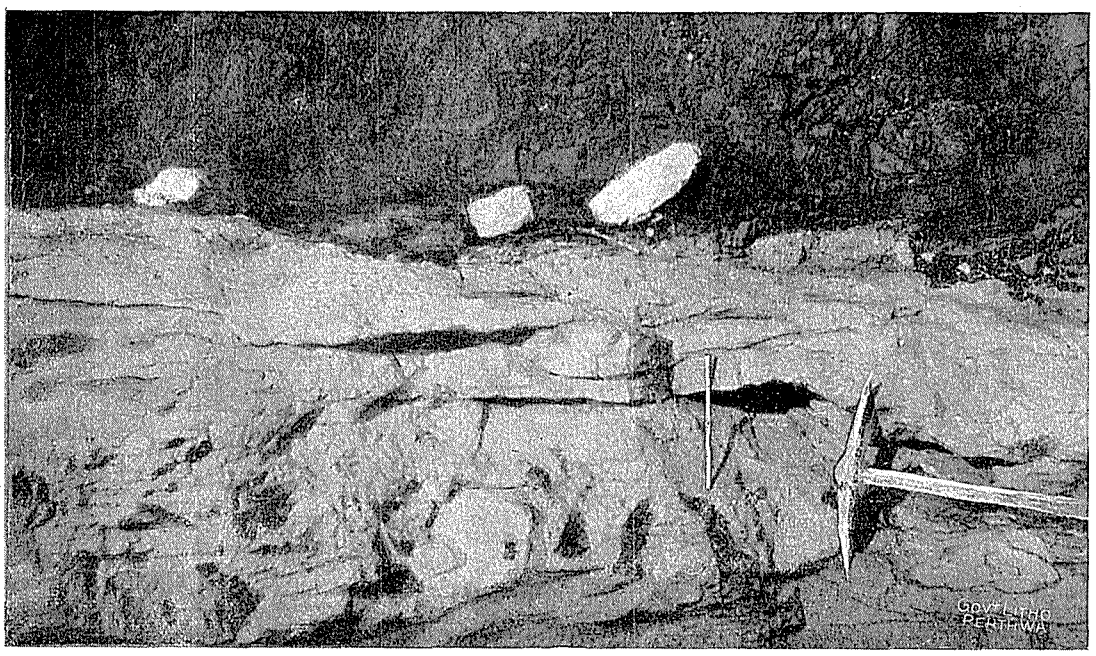


Photo., H. P. Woodward.

THE OCCURRENCE OF TANTALITE IN ALBITE, WODGINA, PILBARA G.F.

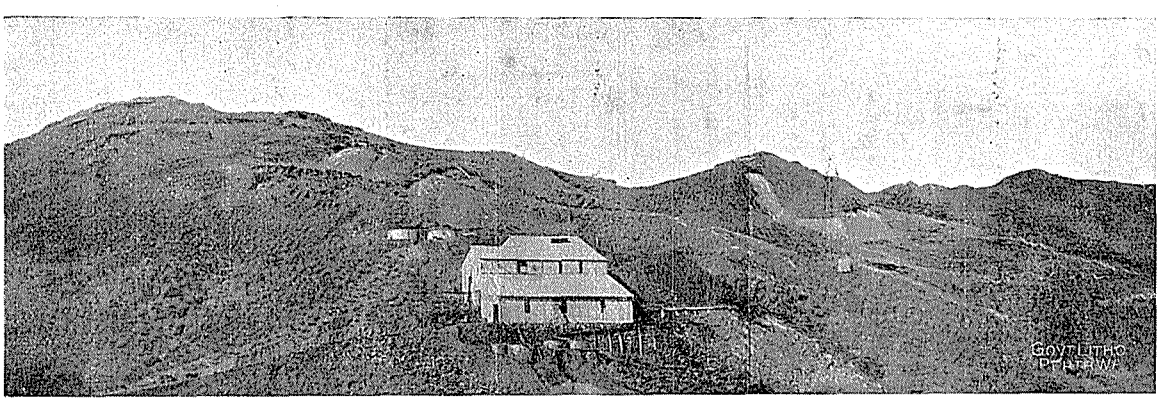


Photo., H. P. Woodward.

THE MT. CASSITERITE MINE, WODGINA, PILBARA G.F.

depth a vertical shaft was sunk some time ago on the flat at a distance of about 10 chains from the lowest workings; this cut a well-formed body of ore 6 feet in thickness and assaying 10 per cent. at the water level which is here about 80 feet in vertical depth. This lode was risen on in a northerly direction until connection was made with some prospecting work carried out by the original company which had proved unsatisfactory owing to the fact that the winze had followed a branch vein of little value.

For some reason further development from this shaft has been discontinued and the entire energy concentrated in scratching ore from the old upper workings upon the system which would be expected of a party of tributers who have no interest in the future of the mine.

Lately, however, a diamond drill has been purchased with the object of testing the lode at a depth and one bore already put down discloses that at the point where cut at a depth of some 270 feet the ore channel is about 50 feet in thickness, consisting of silicified slate with small veins of marcasite and chalcopyrite; it also discloses the fact that the formation has taken a steeper dip, for had the existing angle of dip been continuous it should have been cut at a depth of from 150 to 200 feet.

This bore hole is so far satisfactory since it not only proves the character of the lode in the sulphide zone but also sets at rest the question as to whether or no this lode will continue downwards.

Diamond drilling for lodes is at the best of times most unsatisfactory, and particularly when the ore occurs in this lenticular form, for even had a large body of rich ore been cut the extent of it would have been uncertain, whilst in this instance it is quite possible that such a body may have been missed by only a few feet.

By far the most satisfactory method of testing this lode would be by a drive at the water level from the 80-feet shaft which would have made available a 10 chain section of the lode lying between it and the existing workings which could have been worked by stopes and passes, and since it is all situated in the oxidised zone there is little reason to doubt but that as rich bunches of ore will be discovered in it as in the section already worked, added to which it could be more systematically worked and the ore more economically handled.

From this level also the ore body below the water level could be tested by winzes which would demonstrate its character in the sulphide zone and the direction of the shoots, thus enabling the management to select the most advantageous site for the permanent main shaft.

So far this lode has proved to be the largest and richest ore body as yet discovered in Western Australia in the oxidised zone, whilst to judge from its promising appearance at the water level there is every prospect of it proving to be a good lode in the sulphide zone.

The section to be worked between the water level and the existing workings will probably prove to contain ore in lenticular masses of high grade consisting largely of copper glance with some oxides and possibly metallic copper due to secondary enrichment, whilst below the water level, owing to the impervious character of the country it will in most probability pass almost directly into primary sulphides of considerably lower value which will require dressing but will be eventually useful if local smelting is undertaken.

The ore below the water level as proved by the bore will consist of a cupriferous zone of considerable thickness in which sulphides of copper and iron will occur in veins and bunches in a slate formation which has been hardened by the permeation of silicious solutions, but there will probably be but little quartz.

It will be noted from the above that the prospects before this mine are encouraging but still problematic until the development suggested has been carried out.

It is quite distressing to see such a fine ore body being worked in the present manner (which is the only possible manner in which it can be made to pay owing to the want of facilities), which consists of discarding all ore that will not assay 16 per cent.; this does not mean merely discarding some three tons of every four raised, but it represents about one-tenth of what could be raised if a 5 per cent. ore could be handled (which is considered a high grade in America). This, however, is impossible until smelting works are established either at Balla or preferably at the mine itself, for it would be more economical to haul the fuel with a return loading of matte or bar than to convey a bulk of low grade ore to the works, particularly as flux will not necessarily have to be conveyed from the coast. Another point also of importance is that with the inauguration of smelting works many other copper mines will be worked in this district, and since all of these lie inland the cartage from there will be shorter than to Balla.

In the vicinity of the Whim Creek there are several other small but promising lodes that have been partially developed, but now abandoned owing to the fact that only ores of a value between 20 and 30 per cent. will pay to work upon a small scale at the present market price of copper.

Mons Cupri.—About four miles south in a direct line is situated this remarkable deposit, which consists of a large hill riddled with copper veins, two of the largest of which have, one upon the north and the other upon the south side, been considerably developed, and from these workings some 1,600 tons of 8 per cent. ore have been raised, a portion of which was treated on the spot in a small blast furnace.

The ore dumps and lodes have recently been tested by the Whim Well Company, who estimate them at something like 5 per cent., but of rather a siliceous character in the upper levels, but below the water level, in a winze, sulphide ore was cut that should smelt well after concentration.

If an ore of this grade could be smelted locally at a profit, there is a large quantity available upon this property, which can be easily won since a large section of the lode can be worked from the adits already driven.

Mallina.—There are several abandoned gold mines here, upon two of which batteries were at one time worked, but there are no reliable records of the result of the early crushings. One of these lodes most recently worked contains a large quantity of antimony, dumps of which of high grade are still at grass, whilst some is stated to have been shipped.

Peewah Creek.—There are some old antimony mines upon the Peewah Creek, about four miles south-

easterly of Mallina, around which a good deal of ore of good quality is still lying; they are said to have been abandoned on account of the low price of antimony and the low gold values contained.

EGINA.—This centre is deserted with the exception of about three dryblowers. It has been a purely alluvial field, and judging by the character of the country, I should conclude that the gold was derived from the disintegrating of the Nullagine beds which, at one time, overlaid it, since there are no indications of auriferous veins, the country being solid clay slates without quartz reefs.

There is an old copper mine about one mile to the westward of the well which has yielded some 500 tons—19½ per cent. ore. The lode can be traced for a considerable distance at the surface, and upon it a large amount of development work has been done, but the ore marketed has evidently been raised from a large opencut, about three chains in length, from which it must have been of high grade as spoil heaps are too small to indicate much dressing.

Some samples raised from one of the deep shafts indicate that the ore is passing into the sulphide zone, but no stoping appears to have been done at the lower levels.

There is a large heap of very good ore still left on the surface, from which a good number of tons of 20 per cent. ore could be picked since it consists largely of lumps of malachite, but cartage and other charges would be too great for even this to pay at the present price of copper.

HONGKONG AND ANNIE'S GAP.—There are several old abandoned gold mines at these centres, some of which have had batteries and other machinery upon them, but proved to be of insufficient size and value to pay companies; they would, however, probably pay a working party with their own small plant to work for a time.

PILBARA.—There are a few men working here, the largest number being upon stream tin, which occurs along the granite contact with the schists country upon the south edge of the belt, which runs easterly and westerly. The tin-bearing zone is followed by the auriferous, in which there are a number of large hungry-looking quartz reefs in which the gold occurs in very rich veins, dabs and splashes, the balance being absolutely barren, they have therefore absolutely failed so far as companies are concerned, although batteries have been erected upon two or three occasions.

Upon the north side of the gold belt there is a line of cupriferous country in which, at one or two points which have been opened, some nice ore is visible, but its distance from port precludes the possibility of its paying to work at present.

STATION PEAK.—Upon the mine here the tailings are being treated by cyanide, but no mining is being carried on.

The lode, which is a large one, has been worked from the surface by means of an adit to a level convenient for tramming to the battery, the stone proving to be of high value. A winze has been sunk upon it to water level from which a sample the owner, Mr. Bull, informs me, was taken that assayed 16 dwts., but contained a large quantity of pyrites.

CROYDON.—The mine here was flooded at the time of my visit, so only the surface could be examined upon which the outcrop can be traced for about 1½ miles as a ferruginous lode, pits here and there disclosing good carbonate of copper at a shallow depth.

The lode has been followed down in the mine to a depth of somewhere about 90 feet, where it contained so much blende that the company stopped work. Captain Piper then entered into an arrangement with them, and he is now working the rich secondary sulphides at the 60 feet level.

It is a pity that the work of sinking was discontinued, as it would probably have passed through the zinc which might possibly have only been a bunch.

The shoot now being worked is very rich, and it is extremely probable that others will be discovered along the lode when further prospecting has been carried on.

The ore at present is carted to Point Sampson by camel teams, a distance of about 60 miles, so that it requires to be of high standard.

SHERLOCK.—There is an old antimony mine upon the Croydon Road, crossing the lode in which outcrops for a distance of two or three chains along which a series of pits and trenches have been opened, from which some 10 tons or more of high-class ore have been raised, and bagged, but not carted.

TOWRANNA.—There are two old abandoned mines at this centre upon which, at one time, there were batteries; they did not, however, prove remunerative under company management, but might possibly by parties of working men, if the values continued down in the hard country.

WEERIANNA.—Upon this field, which is only about two miles from Roebourne, a line of small lenticular quartz bodies have been worked for a length of about 1½ miles in a north-easterly direction.

A short time ago a local company was formed, which with State aid erected a battery, but not making a success of things they surrendered the leases and plant to the Government. A party of working miners is now in treaty with the Minister regarding a lease of the mill; they propose to work one lease and to crush at a low rate for other working parties. They estimate that 10dwts. stone will pay them well. If this proves to be the case, this field should give employment to a fair number of men, it will also be an inducement to miners in other centres, such as Pilbara, Hong Kong, and Towranna, to work low-grade shows upon similar lines.

ROEBOURNE CENTRE.—These mines, which lie in the rough, hilly country immediately south of Weerianna, were all worked for copper, but are now abandoned; on the Lily Blanche there appears to be a good lode of yellow sulphide. From this about 1,000 tons of 17¾ per cent. ore have been shipped, and as the workings are of very limited extent this lode must be of considerable promise.

There are many other smaller but promising lodes which have been opened, but which did not pay to work under the existing conditions.

GLENROEBOURNE.—At this centre, which lies about 7 miles to the westward of Roebourne, are a number of copper lodes, which were originally worked over 30 years ago, since which time they have been abandoned and taken up again on three occasions. At the present time three properties are being worked, viz., the old Carlow Castle by Shaw and party, upon which some fine grade glance ore, carrying a fair quantity of gold, is being raised from the lode at the north-west corner of the lease, which is of a good size and very promising appearance. Whilst examining the other lodes upon this lease I discovered cobalt ore upon the dump of the old water shaft, also what

I take to be nickel and cobalt ore, samples of which have been assayed, with the following results:—

	Cobalt Ore, Smallpage. 4403	Cobalt Ore, Carlow Castle. 4404	Cobalt Ore, Carlow Castle. 4405
	%	%	%
Copper	12·80	4·24	4·00
Nickel	·13	·67	·45
Cobalt	1·63	1·00	1·87
Arsenic	·86	2·76	7·35

The Carlow Castle North is held by Smallpage and party, who are working the northern extension of the same lode as worked in the Carlow Castle. They have carried down an underlay shaft from 20 to 60 feet, from which they have raised and shipped some high class glance, carrying a considerable quantity of gold. The ore is of such high grade that this work has paid handsomely. In this lode there are also traces of cobalt ore, a sample of which has been forwarded for assay.

The old Glen Roebourne is now held as a six-acre lease, and a little ore raised from near the surface. This has the appearance of a fine lode from which, to judge by the extent of the workings, a very considerable quantity of ore must have been raised in the past.

There are numerous other lodes in this district that have been worked, but are now abandoned since it takes a very high-grade ore to pay when worked upon a small scale.

Upon the whole this belt and the Weerianna, which are only three miles apart, are extremely promising, and there is little doubt but that at some future time this will become an important copper-mining centre when smelting can be done on the spot.

The Nicol Centre.—The reefs in this locality are the best defined in the district, being most regular in course for great distances, and they are contained between well-defined walls, having been worked from open-cuts to a depth of 20 to 30 feet, from which the stone has been mostly crushed. The Ninety-nine leases are now being worked, and the small three-head mill put in working order, with the object of testing the lode in bulk as development at a greater depth proceeds. Judging from general appearance this is a promising lode, but no examination could be made as the workings were full of water.

General.—Wherever the crystalline schists or slates outcrop in this district the country is of a highly metalliferous character, not strikingly auriferous, but more favourable for the baser metals associated with gold in the oxidised zone. Of these baser metals not only indications but actual discoveries prove it to be distinctly copper country in the highest degree, for not only are there large and rich lodes which pay to work under about the most unfavourable conditions in the world, but there are numerous others that cannot be worked at present, whilst extensive belts of slaty country are intersected by ferruginous outcrops of a distinctly cupriferous character, which may in the future prove to be copper lodes of greater value even than those now being profitably worked.

It is only necessary to refer to the report of the State Mining Engineer to see that it costs £10 per ton to realize upon ore from the Whim Well mine, which is worked upon a larger scale than the others, and is only 15 miles from a port, with which it is connected by tramway, and, therefore, at the present market value of this metal it would be impossible to make even a 20 per cent. ore pay when worked upon a small scale without the gold contents are exceptionally high.

(12.) *Deep Boring for Minerals and other Deposits in the Roebourne and Onslow Districts.*

Prospecting for lodes by the means of a diamond drill has proved to be most unsatisfactory and unreliable, for the following reasons:—

(*a.*) Owing to the fact that payable ore deposits extend over such an infinitesimal portion of the total mineral-bearing area in any district, the chances are something like one million to one against a bore intersecting any value-carrying stone.

(*b.*) Since ore usually occurs in more or less lenticular concentrations the chances of cutting a valuable ore body, even when boring is conducted along a line of proved lode are so extremely remote that one would hesitate to recommend this method of prospecting without the work could be carried out in a thoroughly systematic manner by a series of bores at a cost of many thousands of pounds.

(*c.*) It may also be stated that the results obtained by boring for lodes may be most misleading: for instance, a small, rich vein or bunch may be cut and followed for several feet, which upon development may prove to have no size or extent.

(*d.*) It follows, therefore, that any attempt to thoroughly prospect the extensive mineral-bearing areas of the Roebourne and Onslow districts by means of deep boring would, unless unlimited means were available, be absolutely useless.

(*e.*) Water and horizontally-bedded deposits like coal may be prospected for by boring, since they both cover a considerable horizontal area, whilst the drill has also been successfully employed in mines in the place of cross-cutting to prove the existence of parallel ore bodies.

Being fairly thoroughly acquainted with the districts referred to, and knowing the extent covered by mineral deposits I cannot recommend this method of prospecting these districts since limited sums of money expended in this direction would, I consider, be absolutely wasted.

(13.) *The Country between Roebourne and Peak Hill.*

From Glen Roebourne I proceeded to the Upper Nicol, traversing a granite belt, upon the south-western side of which near the river schists again outcrop, and in these are some large quartz reefs upon which a considerable quantity of work was done some years ago. These reefs strike in an east and west direction, and are stated to have prospected well, but owing to the large volume of water encountered in sinking work was abandoned.

To the southward of this schistose belt a considerable area of granitic rocks is exposed, intersected by a large gabbro dyke, which often attains an elevation of 100 feet sheer up above the surrounding country. This dyke may be traced for a distance of some 20 miles running in a north-easterly direction.

To the northward of this dyke the bold cliff-like edge of the tableland may be observed in the distance, the rocks of which belong to the Nullagine Series, but differ from those previously examined farther to the eastward, in that the flaggy quartzites which overlie the volcanic rocks are much more largely developed.

Following down the course of the Maitland River to Karratha a belt of granite country is traversed, which

at the last-named place has been thrown up into a series of rough hills by the intrusion of a gabbro dyke, which strikes in a north-westerly direction. This dyke forms a bold hill ridge some eight miles in length, the core of which is gabbro, whilst flanking it upon either side are piled masses of granite, which have clearly been thrown up by it.

Westward of Karratha for a distance of 10 miles are extensive alluvial flats flanked to the southward in the distance by the Tableland (Nullagine) Series. Near Mt. Wilke, on the edge of the tableland, and between it and the telegraph line, is a belt of schistose country, which gives place to granite at the Eramurra Pool, and this belt is of a promising character for mineral deposits.

Between this point and the Fortescue River a low range is crossed, the rocks of which consist of ferruginous quartzites striking north and south, with a dip to the westward. Some samples of lignite, similar in character to those of Fly Brook and Depôt Hill, upon the Irwin River, were brought to me, said to have been discovered in this neighbourhood, but I was unable to visit the locality. The rocks are lithologically identical with the tableland section of the Nullagine Series, so largely developed along the upper course of the Fortescue River.

This series of rocks extends continuously in a southerly direction up the Fortescue River past Balmoral Station, as far as Munderoo Pool, at which point the volcanic series of vesicular lavas again make their appearance from beneath them.

From this point onwards in an easterly direction to Gregory's Gorge the volcanic series have been cut through by the river, which flows in a cañon-like channel, in the bed of which at one point an exposure of granitic rocks is visible underlying the eruptive series.

Upon emerging from the defile, which is about 100 miles in length, the river flows over a wide, rich alluvial flat, flanked upon the north by low, flat-topped hills of ferruginous quartzites and argillaceous flags and upon the south by the precipitous face of the Hamersley Range.

Near this point the fine springs, known as the Mill Stream, break out, the large flow of water being due to the rise of the impervious eruptive rocks, which prevent its further subterranean passage towards the coast.

Between the Mill Stream and Middle Creek Police Station extensive alluvial flats are crossed, but upon nearing the latter place broken, hilly country is entered, the rocks of which consist of flags and ferruginous quartzites. Mt. Billroth, near Tamberry Station, is a flat-topped hill, 1,371 feet above the sea level. On account, however, of the great elevation of the surrounding country it presents quite an insignificant appearance, as also does Mt. Florence, which attains nearly the same altitude.

From Mt. Florence to the Goodiarrie Hills the road crosses the alluvial plains of the Fortescue River, flanked to the northward by the low quartzite ridges, which form the dividing range between the watersheds of the streams which flow to the north coast and those which feed the Fortescue to the south.

The Goodiarrie Hills consist of rocks of ferruginous quartzites of the Nullagine Series, which at this point close in upon and cross the river, forming a bar above which the waters from the upper courses of the Fortescue are impounded in a large salt marsh some 50 miles in length and 12 miles in width. This salt marsh only overflows into the lower courses of the river in very exceptional seasons, therefore this range of hills constitutes practically the head of the Lower Fortescue, the main tributaries of which take their rise in the Hamersley Range to the southward.

Upon the south side of this large salt marsh the Hamersley Ranges turn to the south-east in the direction of Ophthalmia Range, which latter is in reality the eastern extension of the former, and consists of the same series of rocks which have been classified by the Government Geologist as belonging to the Nullagine Series.

Roy Hill and Battle Hill are two isolated peaks of quartzose sandstone, which rise from the plain, whilst in this locality the granitic rocks are, apparently, not far below the surface, since the soil is composed of a red sand with a considerable quantity of mica.

From Roy Hill the Ethel Creek, which is the main branch of the Upper Fortescue, was followed in a south-westerly direction over an extensive plain to the base of the Ophthalmia Range, at which point volcanic rocks outcrop overlaid by ferruginous, flaggy quartzite, which constitute the main range and are similar lithologically to the upper section of the Nullagine Series.

About 12 miles from the range, in a south-westerly direction a belt of schistose country of a promising auriferous character is encountered; this belt has a north-easterly trend towards Coobina Soak, some 30 miles distant, at which point colours of gold are reported to have been discovered. This belt is intersected in places to the eastward of the route traversed by granitic intrusions, and it is in the vicinity of some of these that a good deal of prospecting has been done.

The dividing ridge between the watersheds of the Fortescue and Ashburton Rivers is a low cement (laterite) capped range of hills, whilst judging from the character of the surface and the quantity of strewn fragments of quartz and ironstone, the schists are not far beneath the surface.

Upon the south side of this ridge upon Goldfields Creek, one of the branches of the Ashburton, a considerable tract of kaolinised schists, containing large quantities of quartz, is exposed, which, at a point about eight miles north-east of Deadman's Hill, proved to be auriferous. A considerable extent of country here has been prospected, and a large amount of dry-blowing has been done, the gold being said to occur attached to quartz fragments (specimens), but there does not appear to be any record of the actual quantity won.

The character of the gold caused the prospectors to do a considerable amount of trenching over the worked-out patches, with the object of discovering the leaders from which it was shed, but so far success has not attended their efforts, and this field is now abandoned.

From this point south to within 20 miles of Peak Hill a belt of what would appear to be Lower Carboniferous rocks is crossed; these rocks consist of shales, sandstones, quartzites, and dolomitic limestones. They are nearly horizontally bedded and form flat-topped hills, which rise abruptly from the plains, and from the tops of which the same class of country stretches as far as can be seen with field glasses. To the eastward, however, I am informed upon good authority, the predominating rocks are sandstone.

Upon the south side of the Gascoyne River the crystalline schists again make their appearance; they mostly belong to the acidic group, in which the quartz veins are usually small, and occur in the form of a network through a kaolinised belt. These rocks may

possibly be altered sediments, but this question can only be determined by tracing them in a westerly direction down the river.

Upon the whole, the journey from Roebourne to Peak Hill disclosed little of value from a mining point of view, but at the same time added considerably to our knowledge of the geology of the State, since it formed an important link between the work carried on by the Government Geologist to the westward and that by Mr. Talbot, who accompanied the Canning Expedition; thus it enables us to delineate upon our maps those areas which in our opinion are likely to prove metalliferous, thus being the means of saving considerable time and money to prospectors. But although of a general negative character from a mining point of view it has revealed the fact that the auriferous belt worked at Bangemall and upon the Ashburton River extends in this direction, thus indicating the possibility that between the last-mentioned place and Goldfields Creek other rich patches may be discovered.

Between Peak Hill and Meekatharra, with the exception of a small patch of auriferous country at Abbots, the rocks where they outcrop appear to mostly belong to the granitic series, but since they are mostly covered by a layer of cement (laterite?) their true nature cannot be determined until a more detailed examination is possible.

From Peak Hill I travelled to Meekatharra and made a cursory geological examination of the district and the principal mine; from this I arrived at the conclusion that this centre was of very considerable promise and well deserved a detailed survey.

Owing to the fact that the surface of this belt of country is covered by cement (laterite?), and also to the decomposed nature of the rocks exposed in the shallow workings it was found impossible in so short a time as was then at my disposal to attempt an examination in anything like detail; this I should very much like to undertake at a future date.

(14). *Preliminary Report upon the Ore Bodies of Meekatharra.*

Meekatharra is situated upon the northern end of the Nannine auriferous belt, the intervening space between which two centres is becoming rapidly covered by scattered groups of leases.

The rocks of this belt consist for the most part of schistose greenstones much hydrated, intersected by dolerite, felspar, porphyry, and granitic dykes, and traversed parallel to the lines of banded ferruginous quartzites which evidently represent main lines of shearing, whilst upon the western side is a ridge of broken granitic hills.

The greater portion of this area is covered by cement (laterite ?) of variable thickness, the surface of which is often thickly strewn with quartz. Prospecting, therefore, consists in first testing these floaters (strewn quartz fragments) when, if they prove rich in gold, trenching or sinking for the reef is resorted to, but owing to the tough nature of the cement it is usually found to be more economical to sink shallow shafts and crosscut in the soft schists.

In this tract of country the banded quartz rocks are practically the only ones that outcrop, forming low stony ridges which run in a general north and south direction, and in consequence the careful mapping of these should be of considerable value in the elucidation of the faulting which has apparently played an important part in dislocating the auriferous formations.

Until a detailed geological survey is made, however, it would be premature to draw conclusions as to the origin of these formations which differ considerably from any other of the auriferous deposits of the State, but it may be assumed with perfect safety that their origin is closely associated with the occurrence of the intrusive dykes, but whether the basic or acidic it is impossible to say, although evidence tends to point to the latter whilst the former are possibly the disturbing influence.

The gold occurs in what are generally known as lode formations but which in this instance would be more correctly described as stockworks since they consist (as far as worked) of belts of highly talcose and altered rocks intersected by numerous quartz veins of variable size, and it is these veins which carry the gold, the enclosing rock (formation) being absolutely barren although often pyritic.

The quartz may occur in the form of a perfect network of minute intersecting veins, in which case the whole mass of the formation is treated, or upon the other hand, as in the Fenian mine, these individual veins may be of sufficient size to be worked alone.

These formations are enclosed between well defined boundaries called walls, but which will prove in all probability when development has proceeded at a great depth to be only boundaries between the included matter (called formation) and the adjoining rock mass (called country).

These bodies have a more or less north and south trend with a dip to the eastward, whilst the so-called shoots pitch to the northward.

The general character of these formations points to the conclusion that they represent shatter rather than shear zones since, although the general trend of the quartz veins is north and south, they have the habit of darting across the body from wall to wall in an easterly and westerly direction upon those joint planes which dip north whilst the southerly inclined joints do not carry quartz but often veins of dolomite.

This erratic behaviour is very noticeable in the larger veins, which after crossing the ore channel abruptly gradually work back diagonally across the formation towards the other wall to be suddenly thrown back again, and so on time after time. The small veins behave in a similar manner to the larger but in them it is not so observable since the individual vein is not followed by the workings.

The occurrence of these areas of enrichment in a series of shoots, or more correctly speaking pitch zones, is in all probability brought about by a compressing force applied in the direction of the schistosity (north and south) such as would be caused by the intrusion of a mass of granite, whilst the meteoric waters find passage down these, the intervening belts being usually so impervious that the workings in one of these auriferous areas may be perfectly dry even though it is below another which is quite wet.

So far as can be gathered by a comparatively cursory examination, the primary force which is responsible for the shearing in the Marmont, Fenian, and Ingliston Consols is a large intrusive mass of felspar porphyry at the south-east end of the first-mentioned mine. This mass is an igneous acid intrusion, in part a felspar porphyry consisting prin-

cipally of albite and quartz, whilst the balance which covers the larger area is a soft kaolinized rock containing quartz and sericite, probably an hydrated form of the first-mentioned rock.

This latter class of rock appears to be fairly common upon this field, its occurrence being usually accepted as an indication of a barren zone although the adjoining country to the northwards may be rich.

There are also basic intrusions which consist of mica hornblende dolerite (diabase) that may possibly have influenced the enrichment of certain of the lodes, but this problem requires further investigation.

The depth to which these bodies in the main group will prove to be auriferous will depend upon that to which the shatter zones extend, since it is only in these that the concentration and deposition of gold have taken place. This, however, will probably be considerable since the lodes if anything show increased values and size in the lowest levels worked.

In the Ingliston Extended, which has no connection with the main groups before referred to, this zone of enrichment was of considerable thickness at the surface but gradually tapered downwards, then bifurcated, whilst below this point it rapidly decreased in size until both legs pinched out in the solid rock below.

In this mine a basic dyke was encountered upon the hanging wall side of the ore body; it is composed of a solid crystalline mica hornblende dolerite in the main mass, but adjoining the lode it has been considerably altered and sheared and loses all crystalline structure. Recently further developments were made in this mine by the discovery of an auriferous quartz reef lying to the north-westward of the main body; it had an underlay to the westward or in the opposite direction to that first worked and is apparently considerably dislocated, whilst at the northern end it runs into a kaolinized granite mass where it loses values.

It is not necessary to enter into a detailed description of the various mines in this preliminary synoptical report, but it may be mentioned that the Yaloginda lodes, so far as can be judged from the limited workings present very similar characters to those of Meekatharra.

(15.) *Supposed faulting in the Great Fingall Mine, Day Dawn.*

(With Plan and Section, Plates III. and IV.)

In response to instructions I visited Day Dawn on November 11th and devoted the following day to a re-examination of the lower levels of the Great Fingall Mine in the endeavour to ascertain if it were possible that the lode had been dislocated by faulting at its northern and southern ends.

The theory that this lode was cut off by a fault at its northern end is by no means new since as far back as 1902 Mr. Campbell, formerly of this Department, delineated it upon his plan of the Auriferous Reefs of Cue and Day Dawn, which accompanied Bulletin No. 7.

This fault theory probably originated in the fact that at the surface the main line of lode presents a massive outcrop having a general north-westerly course to a point at which the character of the schistose country rock changes into a massive greenstone.

An inspection of the plan referred to above reveals the fact that the reef terminates abruptly at a point near the north end of the workings, G.M.L. 2d, but that a large outcrop occurs a few chains to the eastward in G.M.L. 189d, which was supposed to be the faulted continuation of it. It will also be observed that another body following practically the same course of the main reef outcrops a few chains to the northward of the point at which it was lost.

A more recent and detailed examination* of this district reveals the fact that no apparent dislocation has taken place at the surface but that at the point of contact between the chloritic schists and the massive greenstones the fissure has probably bifurcated, one branch of which first strikes in a north-easterly direction along the contact line for a distance of a few chains and then turns sharply in a northerly direction entering the massive greenstones. The other branch apparently follows the general direction of the main fissure but does not show at the surface for some few chains.

This bifurcation of the lode may be observed at its northern end in almost all the levels of the mine, but all attempts to trace the continuity of the fissure further in this direction has so far failed.

A considerable amount of prospecting with this object has been carried on at the No. 7 (524ft.) level which was driven upon the course of the lode into the solid greenstone country until another quartz body was cut that clearly proved to be the eastern branch described previously since this had been followed down in the Great Fingall North mine to a depth of 300 feet.

Two crosscuts also driven in a westerly direction from this level intersected another reef which is apparently the western branch seen at the surface.

Neither of these two quartz bodies carries any gold values nor have they any connection with the main reef, but it is quite clear that they represent the downward extension of the two branches which were previously described as outcropping at the surface.

A tracing of the outcrop when placed upon the top of the plan of this level practically coincides with the reefs cut in it, thus clearly proving that portions only of the two branches visible at the surface continue downwards, since at this depth the workings clearly disclose the fact that they have no connection by fissure with the main lode.

At a point about 150 feet to the northward of the bifurcation where the reef is ultimately lost a belt of highly fissile black schists is encountered, the cleavage planes in which strike in a north-easterly direction, or in other words at a considerable angle to the general direction of the lode channel, and this is supposed to be the fault plane.

Where penetrated in the No. 13 level this belt proves to consist of 37ft. of graphitic slate, 26ft. of chloritic schist or lode country, 47ft. graphitic schist, 11ft. country, 4ft. graphitic schist followed by massive greenstones (carbonated saussuritised dolerite); they therefore form the contact rocks between the chloritic schists in which the quartz reefs carry high values in gold and the massive greenstones in which the reefs so far have proved to carry it in patches only to a depth of about 100ft.

It is by no means easy to arrive at the origin of these graphitic rocks, but since this phenomenon is by no means uncommon at points where contact metamorphism has taken place (many instances of

* Bulletin No. 29, Geology of Cue and Day Dawn.

THE HON. H. GREGORY M.L.A.
Minister for Mines.

PLAN OF

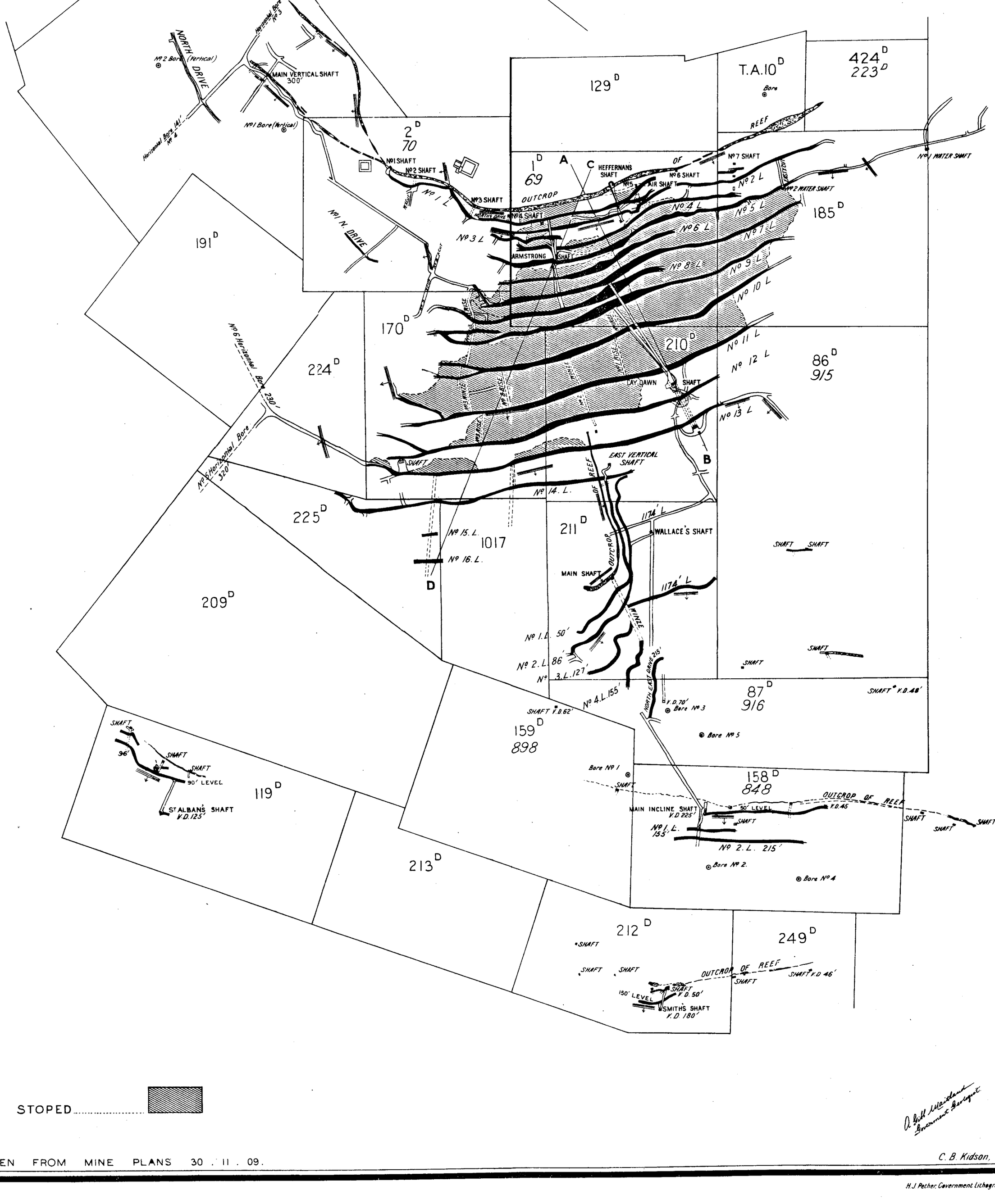
THE GREAT FINGALL CONSOLIDATED LTD GROUP.

DAY DAWN

MURCHISON G. F.

Scale. 300 Feet to One Inch.

TO ACCOMPANY ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY FOR 1909



STOPED.....

TAKEN FROM MINE PLANS 30 . 11 . 09.

A. Gibb Maitland
Government Geologist.

C. B. Kidson, del.

H.J. Pether, Government Lithographer, Perth, W.A.

PLATE IV.

SECTIONS OF

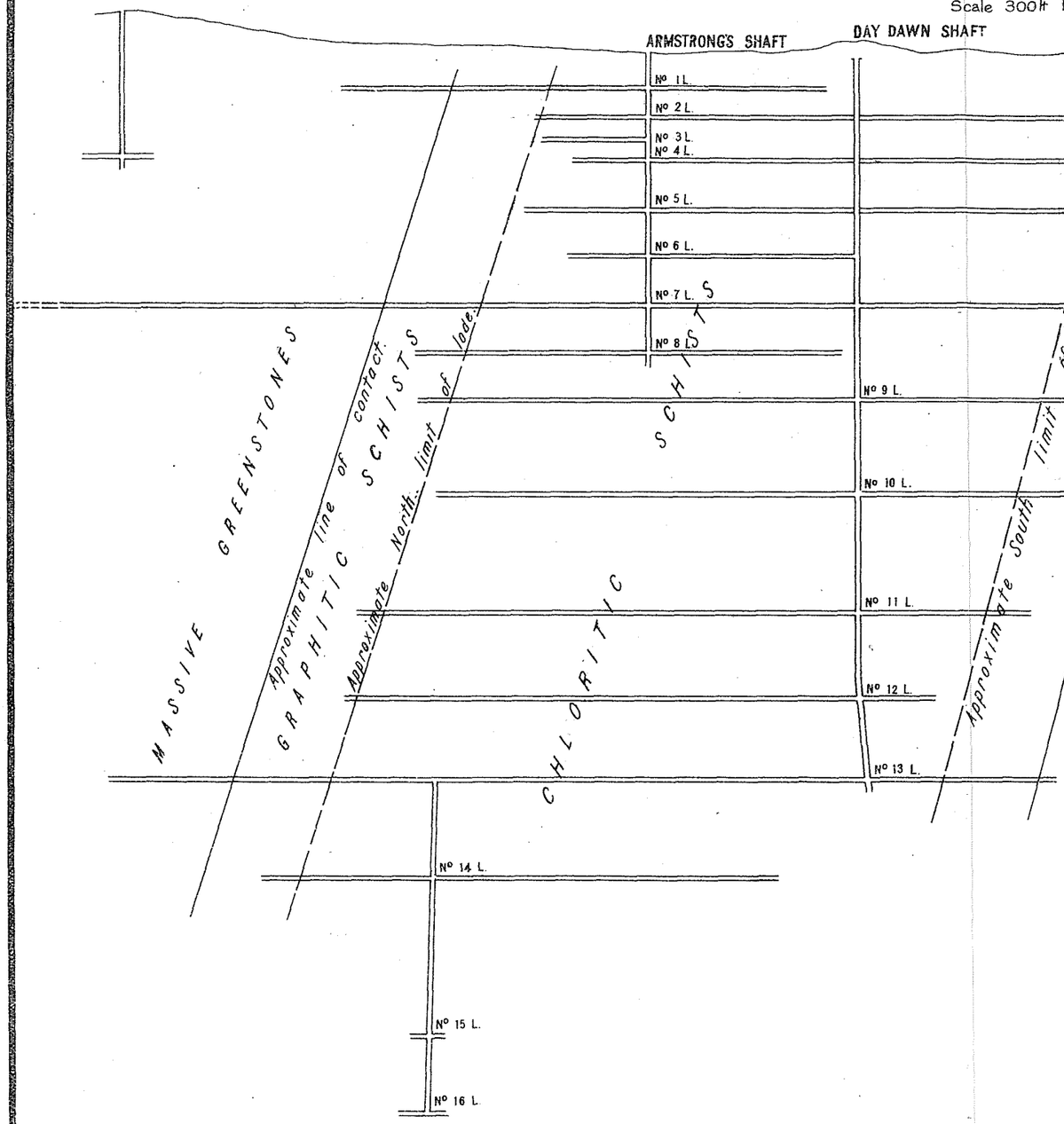
THE GREAT FINGALL CONSOLIDATED LTD.

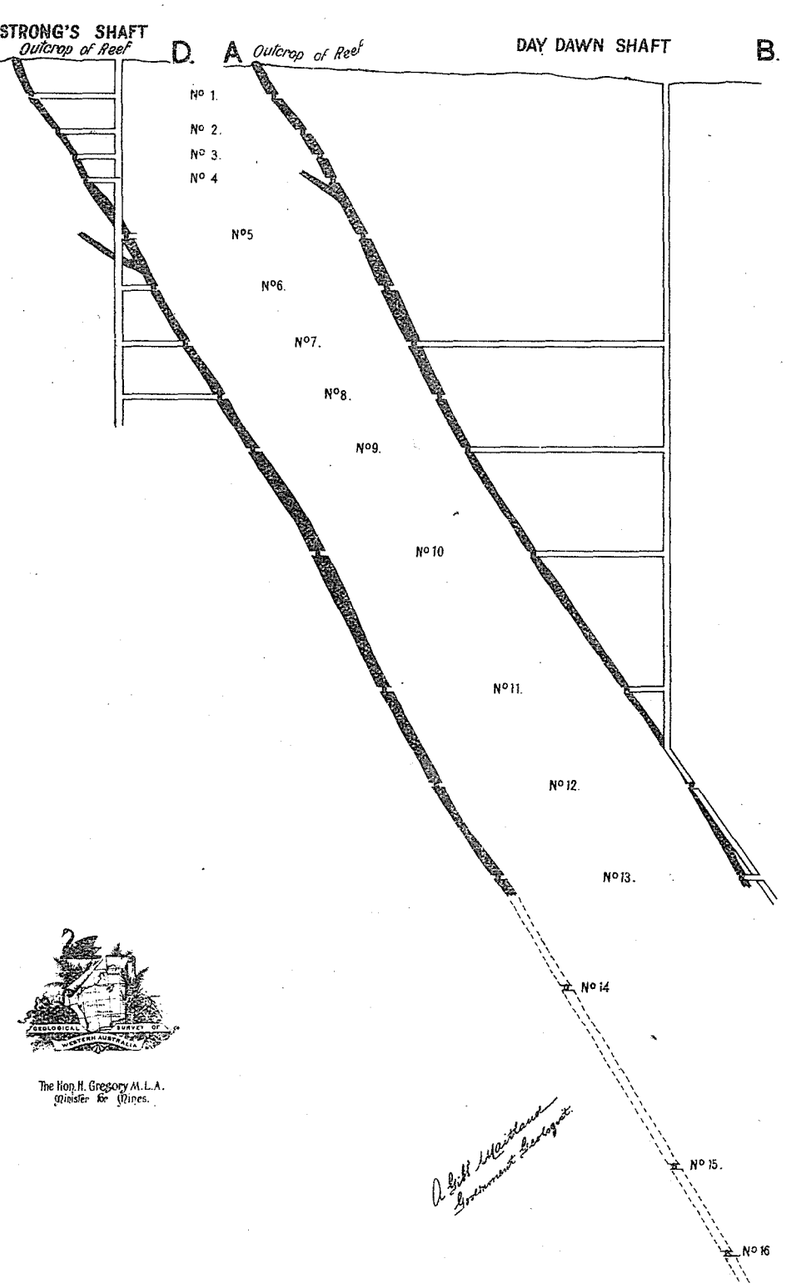
DAY DAWN

MURCHISON G. F.

TO ACCOMPANY ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY FOR 1909

Scale 300ft to One Inch.





The Hon. H. Gregory M.L.A.
Minister for Mines.

A. Gibb Maitland
Government Geologist.

H.J Pether. Government Lithographer. Perth. W.A.

which occur at Kalgoorlie), it is not necessary to theorise upon this question particularly as they have apparently exercised no direct influence upon the enrichment or otherwise of the lode.

A reference to the geological map which accompanied my report upon this district published in 1907 as Bulletin No. 29, will demonstrate that the direction of the cleavage planes of these schists, which are north-easterly, follows that of the contact as mapped in at the surface, whilst those of chloritic schists which follow the north-westerly course of the lode lie at right angles to it. (See plan).

From the plan that accompanies this report it will also be noticed that at the southern end at the point where the lode is lost in both the Nos. 5 and 13 levels, massive greenstones are again encountered, the cleavage planes of which strike in a similar direction to the same rocks at the north end of the lode. Thus the entire length of the lode is contained in the chloritic schists, whilst the fissure, except at the surface, does not penetrate the massive rocks at either end in which the quartz bodies, although apparently following the same course, are not connected in any way and are barren.

After a careful study of this question I can see no evidence in support of the dislocation theory of the lode by faults at the ends, but I consider that very strong evidence exists which points to the conclusion that the Great Fingall lode itself occupies a faulted fissure plane which crosses the belt of chloritic schists from side to side terminating upon coming in contact with the massive greenstone belt at either. Whilst the shearing strains generated by the ascending or descending mass would be great enough to cause parallel schistosity in the rocks upon either side of the fault for a considerable distance.

Another point in favour of this fault fissure theory rests upon the fact that the West Fingall reef which overlies the lower workings of the Great Fingall follows the normal cleavage planes of the rocks or at right angles to the main lode (see plan).

The sedimentary origin or otherwise of these rocks has, to my mind, little value, for allowing that they were originally sediments they have since been melted and in consequence become igneous rocks quite as much as lavas poured out of volcanic craters. The great point of interest, however, appears to centre around the question of which class of rocks is likely to contain payable lodes at a depth, and this question seems pretty clearly answered in this district by not only experience gained in the Great Fingall Mine itself but in the other mines in the neighbourhood.

With regard to the continuity of values at a depth Mr. Hoover, who is an undoubted authority upon such matters, lays down as a general rule in his Principles of Mining that a lode maintaining its size and character to a depth equal to the length of its outcrop may be depended upon to extend for a further distance of half that length, but probably of diminished size; this would, under ordinary circumstances, give the Great Fingall a life to 1,800 feet; as, however, he further qualifies this rule in the case of fault planes, should my theory prove to be the correct one this reef may extend to a very considerable depth, whilst gold values, although recently found to steadily diminish level by level are so subjected to fluctuations that at any time it is quite possible a great improvement may be met with.

There is another point worthy of noting which is that the lode will probably carry values to such a depth as the country rocks in its immediate vicinity are metasomatically altered.

With the object of arriving at some definite conclusion as to the origin of the above rocks, samples were submitted to Mr. E. S. Simpson, B.E., of this department, who made an exhaustive analysis, which is as follows:—

SiO_2	62·62	F_2O	2·62
TiO_2	·16	F_2O_3	1·00
CO_2	*Nil*	Al_2O_3	18·78
P_2O_5	·29	F	·57
H_2O	2·07	S_2	·65
K_2O	3·30	C	1·60
Na_2O	3·36	H_2O	·13
CaO	·82		
Mg.O	3·09	Total	100·22
Mn.O	·16		
		Sp. Gr.	2·76

Whilst in his remarks upon it he says: "So far as the chemical composition goes, this rock may either be an altered carbonaceous shale or a much altered igneous rock to which hydro-carbons have penetrated."

A microscopic examination was also made by Mr. Glauert, also of this department, who says:—

"This is a very dense black rock showing a most distinct banded structure.

"The large amount of finely divided graphite greatly obscures the field, and renders the determination of the other minerals a matter of difficulty.

"Bands of pyrites can be seen even in the hand specimen running parallel to the foliation. The other minerals are quartz, zoisite and a little brown iron ore with a good deal of kaolinic matter.

"The rock is evidently a 'greenstone' altered by the shearing, etc., to which it has been subjected. There is no trace of any sedimentary structure."

Recently very considerable interest has been taken in the question of the origin of rocks belonging to the crystalline series, with the object of determining whether they are of altered sediments or of primary igneous origin.

In the Journal of Geology, Chicago University Press, August, 1909, under the title of "Chemical Composition as a Criterion in identifying Metamorphosed Sediments," Mr. Edson S. Bastin of the U.S. Geological Survey propounded the following rules:—

That in altered sediments the percentage of Mg.O exceeds the Ca.O and the K_2O the Na_2O, whilst the Al_2O_3 is in considerable excess over and above the | : | ratio necessary to satisfy the lime and alkalies.

Since all these conditions are fulfilled in the above analysis, it is highly probable that this rock is an altered sediment.

The general conclusions arrived at are:—

1. The Great Fingall reef has not been cut off or displaced at either end by faults.
2. Its entire length is contained in the chloritic schist belt which it crosses from side to side.
3. The reefs in this or similar belts of rocks will prove to be the only productive ones of this district.
4. The search for auriferous reefs in the hard crystalline greenstone belts is not likely to prove successful.
5. The Great Fingall reef being a cross fissure or fault may prove to be of very considerable downward extent.
6. Being a main fissure, although the valves have gradually but persistently decreased downwards, there is every possibility of zones of increased enrichment being met with at any time.

7. And therefore it would be more advisable to expend all the available energy upon the downward development of this ore body in preference to seeking for supposed dislocated continuations of the reef in country which is not likely to contain auriferous veins.

CHAS. G. GIBSON, ASSISTANT GEOLOGIST.

(16.) *The Argol Syndicate's Property at York (York Silver Mine.)*

In accordance with instructions, I visited York and examined the Argol Syndicate's claim, and also the adjoining one worked by Mr. Carter; these being situated near the west corner of Loc. Y 6, about three and three-quarter miles north of York townsite.

A large serpentine dyke runs through the "Argol" property in a roughly east and west direction, and can be followed across country for some distance, such dykes being of fairly common occurrence throughout the Darling Range district. At the surface this dyke has weathered into the usual soft ferruginous "clay," but at a depth of 50 or 60 feet is fairly hard and unaltered, the change being a very gradual one. The enclosing country rock is a slightly schistose granite, this being the type rock of the district.

A small vertical shaft has been sunk to a depth of 50 to 60 feet on the dyke, but no further work has been done on it beyond a couple of small surface cuts. Three sets of samples were taken from here, and these gave an assay in the Departmental laboratory results as follows:—

No. 1.—	Gold, nil.	Silver, nil.	Copper, nil.
No. 2.—	do.	do.	do.
No. 4.—	do.	do.	do.

The samples showed no indications of the presence of any other commercial metals.

Sample No. 1 was from the weathered portion of the dyke, taken from a surface cut.

Sample No. 2 was a "grab" sample taken from the dump at the shaft.

Sample No. 4 was surface stone (altered serpentine).

On the adjoining claim some twenty chains to the south, worked by Mr. Carter, is a low ridge trending roughly east and west, and capped with a few feet of ironstone conglomerate. On the north side of this ridge, towards its eastern extremity, a tunnel has been driven in southerly under the ironstone for a distance of 150 feet; near its end this tunnel passes through a small decomposed serpentine (?) dyke striking roughly east and west and underlying slightly to the north. This dyke apparently forms the backbone of the ridge, and it is evidently to its decomposition that the ironstone owes its existence; some of this ironstone is of very fair quality, but it cannot be looked upon as of any great value.

The country on each side of the dyke is a slightly schistose granite, considerably kaolinised, and very soft where cut through in the tunnel. At the point where the tunnel passes through the dyke a vertical winze has been sunk, on the footwall side of the dyke, to a depth of about 60 feet; in the bottom of this winze the granite is becoming pretty hard.

A sample was taken across the dyke at the point where cut by the tunnel, and this gave on assay in the Department laboratory results as follows:—

No. 3.—Gold, nil. Silver, nil. Copper, nil.

There were no indications of the presence of any other commercial metals in the sample.

The work on this property appears to have been done under the belief that the ironstone capping of the ridge is the "cap" of a sulphide lode; such, however, is not the case, the ironstone mainly owing its existence to the weathering of the serpentine dyke and the subsequent concentration at the surface of the ferric oxide thus produced. Ironstone (laterite) cappings of this description are of common occurrence throughout the Darling Ranges, and are almost invariably found in association with basic (serpentine or diorite) dykes.

In view of what I saw on the spot, and of the results of the above assays there is, in my opinion, nothing to justify further work upon these properties, and I do not think that either of them is of any value from a mining point of view.

(17.) *The Kalgoorlie Goldfield.*

The full report on the Kalgoorlie Goldfield is in preparation and will be accompanied by a geological map. The report deals only with the general structural features of the field, the ore deposits being only touched on briefly; further work must yet be done on these and a full report on them published later.

The following is a short summary of the chief features as dealt with in the present report.

The original rocks of the field were of sedimentary origin, viz., shales, soft sandstones, conglomerates, etc., with possibly interbedded lava flows—laid down horizontally in probably pre-Cambrian time—on a gneissic or granite floor; these were subsequently by earth movement tilted into their present highly inclined positions, and later on were intruded by large masses of basic and ultra-basic igneous rocks (amphibolites), diabases (porphyrites, peridotites), these in turn being intruded by a small series of acidic rocks (quartz and felspar porphyries). Further, earth movement has then taken place causing considerable shearing and faulting of the rocks, the former resulting in the formation of the lines along which the auriferous lodes occur.

The rocks of the field have been grouped under the following nine heads:—

(1.) The ancient sediments (shales, sandstones, grits, conglomerates, etc.).
(2.) The calc schists (older greenstones).
(3.) The fine-grained amphibolites (older greenstones).
(4.) The quartz diabases (newer greenstones).
(5.) The coarse-grained amphibolites (intrusive).
(6.) The peridotites (intrusive?).
(7.) The porphyrites (later intrusives).
(8.) The quartz and felspar porphyries (later intrusives).
(9.) The recent deposits (sand, loam, laterites, etc.).

The calc schists and the fine-grained amphibolites probably represent an older series of greenstones, possibly occurring originally as lava flows interbedded with the sedimentary series.

The coarse-grained amphibolites represent a somewhat later intrusion, or series of intrusions; they include both basic and acid types, some of the latter being very closely allied to the quartz-diabases, the whole series being probably originally derived from the same magma.

The quartz-diabases are by far the most important series of rocks on the field, as it is within them that all the more important ore bodies occur. Ore bodies, though, are also found in the calc schists and in cer-

tain of the coarse-grained amphibolites, but these cannot compare in importance with those in the diabases.

The peridotites possibly represent a later—or contemporaneous—intrusion of ultra-basic rocks: they are developed chiefly at the south end of the field, but even here are of comparatively limited area and of no great importance. At the north end of the field they are associated with certain of the ore deposits.

The porphyrites occupy a comparatively large area, and together with the closely related porphyries represent a later intrusion. They are of no economic importance and contain no auriferous deposits.

(18.) *Reported Tin Find near Coolgardie.*

In accordance with instructions I paid a short visit of inspection to the scene of the reported tin find near Coolgardie.

The find is situated some 12 or 13 miles south-west of Coolgardie, and claims have been pegged over two areas known respectively as Fraser's and Mercer's, the latter locality being about a mile and a half north of Fraser's, on which the original specimens were "specked."

The staple formation of the country is greenstone schist, having the general north-north-westerly strike, and this is intersected by a series of coarse-grained pegmatite dykes, the more general trend of which is roughly north and south and whose thickness is anything from a few inches up to a couple of chains.

A large one of these dykes outcrops on rising ground on Fraser's lease in a very much weathered form, and over the surface of it and on the slope of the hill down from it a small amount of tinstone (?) and tantalite has been picked up, the largest piece being stated not to exceed four ounces in weight.

On Mercer's ground a similar condition of affairs exists except that here there are several dykes, the main one of which is possibly a continuation of the one on Fraser's; here also a small amount of tinstone (?) and tantalite has been "specked," mostly in small pieces.

It has been stated that so far none of the ore has been found in the pegmatite, and I certainly in a somewhat brief examination could find none of it, although this is its natural source of origin.

No work of any description whatever has so far been done on any of the claims and no efforts made to trace a possible "run" of the ore into any of the gullies or flats; all the ore so far obtained has been "specked," and the amount so obtained has been variously estimated at from ten to twenty pounds in weight.

At the present time it is absolutely impossible to express a definite opinion as to the actual value of the find beyond saying that it is certainly worth further prospecting, and that the country, intersected as it is by pegmatite dykes similar to those prevailing on the North-West and other tinfields of Western Australia, is favourable to the occurrence of both tinstone and tantalite.

As to the necessary prospecting, this should be confined to the search for alluvial and for a possible "run" into the different gullies (on Mercer's) and on to the flats (at Fraser's), for, unless the existence of a considerable amount of alluvial, or detrital, ore can be proved, it is hardly likely that the lodes (the pegtite dykes) will give any payable return for work done on them.

Five samples of ore have been handed to you by myself for determination and report by the Departmental Mineralogist. The greater portion of all these samples were "specked" on the ground by myself, the remainder having been similarly obtained by others in my company. The sample marked No. 5 was washed by myself from a sample of "dirt"—surface soil—on Mercer's lease.

Samples of detrital tin and tantalum ore, collected at Londonderry, were examined at the Survey Laboratory by Mr. Simpson, with the results given below:—

In all such material tin occurs in two forms, viz.:—

(a) As free tin oxide (cassiterite), in which form it is marketable as a tin ore.

(b) As combined tin oxide in the tantalum-bearing materials. In these it occurs as stannate of iron or manganese in quantities varying from less than one per cent. in normal tantalite and columbite up to eight per cent. in the stanniferous tantalite known as ixiolite. The latter mineral is known to occur in the Wodgina district.

The samples collected by Mr. Gibson from Londonderry consist mainly of normal columbite (niobate and tantalate of manganese) with ixiolite and a little normal tantalite. The tantalum minerals present exhibit a very wide range of specific gravity indicating a series of specimens ranging from nearly pure tantalate of manganese through all gradation of mixtures of tantalate and niobate to nearly pure niobate of manganese. In view of this fact efforts should be made to obtain a bulk sample (say ½ cwt.) of this ore to determine whether it would not be worth putting on the market as a tantalum or niobium ore, the value of which at present considerably exceeds that of tin ore.

In the following table the results for "tantalic oxide plus niobic oxide" were obtained by precipitation; those for tantalic oxide were deduced from the mean specific gravities:—

Assay Results.	3431. I.	3432. II.	3433. III.	3434. IV.
	%	%	%	%
Tin, free	*Nil*	*Nil*	*Nil*	*Nil*
Tin, combined ..	2·79	0·40	4·06	1·82
Tantalic oxide plus niobic oxide	79·20	80·12	79·44	80·14
Tantalic oxide ..	47	47	49	32

3435, No. V. Concentrates from a dish of dirt. The total weight of these was 6.282 grammes (about one-fifth of an ounce), and their composition:—

	Grammes.
Cassiterite	.041
Tantalite and columbite	1.373
Ilmenite and garnet	1.472
Magnetite	.869
Quartz, etc., under 3.3 specific gravity	2.527
	6.282

In this sample of Mr. Gibson's there were only a few very small fragments of cassiterite. A sample forwarded to the Hon. the Minister by Mr. Frazer contanied, however, a fragment of cassiterite about one inch in diameter.

It is worth noting that in 1902 I predicted the occurrence of tin in this locality, vide Bulletin VI., page 34.

H. W. B. TALBOT, Topographical Surveyor.

(19.) *Wiluna to Hall's Creek and Tanami.*

From the 1st of January until 1st August I was attached to the party under the command of Mr. Inspecting Surveyor Canning that is engaged sinking wells on the Wiluna-Kimberley stock route.

On August 1st I left the well-sinking party and proceeded to Hall's Creek, where I received telegraphic instructions to visit Tanami and endeavour to trace the extension of the mineral belt into W.A. I left Hall's Creek on August 13th and proceeded, via Sturt Station, to Tanami. From the latter place I travelled westerly to the border between South Australia and Western Australia, and thence northerly to the Gardiner Range. From the Gardiner Range I went west-north-westerly to Sturt Creek, which I crossed near the old Dennison Homestead. From this point I followed the track to Hall's Creek, which place was reached on September 13th.

From Hall's Creek I proceeded to Wyndham, arriving on October 11th. I left Wyndham by the s.s. "Koombana" on October 14 and arrived at Fremantle on October 25th.

On my return a preliminary report, dealing with the economic aspect of the country near the South Australian border in the vicinity of Tanami, was written, and for the completion of that work a commencement was made with the writing of a detailed report covering the whole of the country visited during my 14 months absence from Perth.

The following is a short description of the broader geological features of the country along the Stock Route:—

From Wiluna greenstone schists overlain in places by sandstones and quartzites extend to a point a few miles past No. 2 Well. Granite then makes its appearance and continues really as far as Lake Nabberu. Although there are belts of 10 miles in width in which no granite can be seen there is no doubt that it underlies the sandy plains and that the sand forming these is derived from the disintegration of the granite mass.

The Frere Range runs along the north band of Lake Nabberu and is formed of Devonian shales and sandstones resting unconformably upon a series of metamorphic slates. These slates extend northwards as far as the Carnarvon Range, under which they disappear. They extend north-westward beyond the limits of my travels, and along the stock route they may be seen at intervals as far as Pierre Spring, at which place they are seen dipping under Devonian conglomerates and sandstones identical with the beds of the Carnarvon Range. The slates are not seen again to the north, but a belt about 30 miles in width extends in an east-south-easterly direction beyond the furthest point reached by me, viz., the Lee Steere Range. These metamorphic rocks do not occupy the whole of the country, as in many places they are overlain by Devonian sandstones and in some localities areas of the slates are seen surrounded by sandy plains. Wherever these metamorphic rocks can be seen they are traversed by numerous lenticular quartz reefs, the strike of which invariably coincides with that of the enclosing slates. All the quartz seen by me was of the "buck" variety and appeared to be devoid of mineral of any kind. From what I saw of this belt of country I do not think that much hope can be held out that discoveries of any economic importance will be made within its boundaries.

From Pierre Spring to a little beyond Karara native well all the hills along the stock route, excepting some elevated diabase country around Weld Spring, consist of Devonian sandstones, grits, and conglomerates. Wherever the basal stratum of this series was seen it consisted of pebble conglomerate made up of fragments of the underlying slates and rounded quartz. At their southern boundary the Devonian rocks dip to the north at angles varying from 35 to 45 degrees, but as the beds are followed northwards the dip decreases rapidly, and in a range 13 miles north of Pierre Spring the dip is only 10 degrees. From this point northwards as far as the Devonian rocks extend the beds are tilted into a series of anticlinal and synclinal folds, and in the McKay Range near the northern extremity of this series there is a very extensive fold extending for the whole length of range and eastwards from it to beyond Karara. In this anticlinal the beds on the south side of the range have a dip of as much as 65 degrees. The axis of the folds runs in an easterly and westerly direction.

A few miles north-east of Karara there is a small belt of gneissic granite traversed by numerous quartz reefs and diabase dykes, the strike of which coincides with the foliation of the granitic rock, and this is in an easterly and westerly direction. This belt of gneissic granite is bounded on the north by a ridge of Devonian sandstone and conglomerate, which dips to the north at an angle of 55 degrees. No rocks are seen to the north of this point for about 12 miles, the intervening country being occupied by high sand ridges, when a strip of granite about two miles in width is crossed. This granite belt is seen at intervals in the hollows between the sand ridges for a distance of 25 miles westward from the stock route and it again makes its appearance further westward near the Rudall River.

From No. 26 Well north-eastward along the stock route to Sturt Creek and thence as far as Flora Valley, all the hills are formed of horizontally-bedded shales and sandstones probably of Carboniferous age. Excepting the south-west tablelands, which rise to a height of from 300 to 400 feet above the level of the surrounding country, none of the hills rise to any considerable altitude, and sand ridges occupy most of the country. Occasional patches of good grazing country occur along the Sturt to the site of the old Dennison Downs Homestead, but from there to Flora Valley the country along the Sturt consists of splendid downs covered with rich soil derived from the weathering of the Carboniferous shales which can be seen in places where small creeks have cut deep channels through the soil.

The Carboniferous rocks extend along the road to Tanami as far as the Gardiner Range, when Devonian sandstones again made their appearance. On the southern face of the Gardiner Range and in places on the eastern side these Devonian beds can be seen resting unconformably upon a series of highly inclined metamorphic rocks. The metamorphic rocks are traversed by numerous quartz reefs of a different type to those seen along the stock route, and I am of opinion that this belt of country is well worth prospecting. Samples of quartz were brought back for assay but none of these yielded any high returns, the gold contents ranging from nil to 3dwts. 6grs. per ton; but the fact that these samples yielded such poor returns must not be taken as a proof that payable reefs do not exist. Breaking off pieces of quartz with

a geological hammer is not prospecting, and in a country where the reefs are almost innumerable the chances are all against the finding of payable reefs, unless systematic prospecting is gone in for. These assays prove, however, that some of the reefs do carry gold.

Southward from the Gardiner Range auriferous belt most of the country is occupied by sand plain, but metamorphic rocks with quartz reefs occur on the tops of some of the rises, and in many places the presence of a large amount of detrital quartz and pieces of the rock, similar to that associated with the quartz reefs south of the Gardiner Range, proves that the underlying rocks are at no great distance below the surface.

No country of economic importance was seen between the Gardiner Range and the Sturt along the route I followed on my return journey.

I have, etc.,

A. GIBB MAITLAND,
GOVERNMENT GEOLOGIST.

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