1903.

WESTERN AUSTRALIA.

ANNUAL

PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

FOR THE YEAR

1902.

(WITH ONE PLATE AND EIGHT FIGURES.)

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Annual Progress Report of the Geological Survey for the Year 1902.

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Annual Progress Report of the Geological Survey for the Year 1902.

The Hon. Henry Gregory, M.L.A., Minister for Mines, Perth.

Geological Survey Office, the Museum,

SIR, Perth, 24th April, 1903.

I have the honour to submit, for your information, the Report of the Geological Survey for the Calendar Year 1902. For the delay in the presentation of this report, I alone am responsible, having been practically continuously engaged since the close of the year upon field work and other multifarious duties appertaining to the office.

The arrangement of the different matters dealt with is somewhat similar to that followed in the previous reports.

During the year 1902 the work of the Department proceeded practically on the lines of previous years. A very large portion of the time of the staff has been devoted to inquiries connected with the Mines Development Act, recently passed by the Legislature. The newly created appointment of State Mining Engineer having been filled, it is hoped that the Geological Staff will not in future be required to any very great extent in connection with the administration of the Mines Development Act, and that their services will be available for the systematic examination of the various auriferous formations of the State, a class of work upon which the officers can always be most profitably employed.

It is highly desirable that the lesser known portions of the State be systematically examined, with the view of ascertaining how far their geological characteristics are likely to affect their possibilities as mineral-bearing country, and this information be made available to the public, under Government authority, through the medium of official reports and maps. This important class of work should, whenever possible, be carried out in advance of the occupation of the country for mining and other industrial purposes.

The extensive tract of country lying between Laverton and the South Australian Border, and that between Peak Hill and Nullagine, may be especially noted as areas which it is essential should receive early examination at the hands of geologists specially trained for the work.

In this connection it may be noted that since the Department was instituted on its present basis, it has not been found possible to examine and report upon more than about 50,000 square miles out of a possible 975,920. The work already done has been chiefly the detailed examination and mapping of important mining centres.

During the year twenty-three reports connected with the alienation of mineral lands were made; some of these entailed special visits to the districts in which the land occurred; others it was possible to deal with by the information contained in the Geological Maps already prepared by the Department.

THE STAFF.

During the year the work of the office has been carried out by eleven officers. The only changes in the *personnel* of the staff have been the appointment of Mr. H. B. Talbot to the position of Field Assistant, rendered vacant by the resignation of Mr. J. H. Brooking. Mr. Talbot's appointment dated from the 1st of February, 1902.

FIELD WORK.

The field work of the year 1902 has been, as in previous years, distributed over such portions of the State as the exigencies of the public requirements necessitated.

A. GIBB MAITLAND: The latter part of February, and the early portion of March, found me engaged in an examination of the valleys of the Warren and Donnelly, with the view of reporting upon the reputed occurrence of petroleum in the district. From the 1st to the 22nd of April I was absent from Perth on leave. The latter end of that month and the early part of May I was at Bulong in connection with an application for State aid towards the development of mining. On the 17th of June I left Perth for the Murchison, and was engaged in an examination of Cue, Lennonville, and Yalgoo, returning to Perth on the 6th of August, after having called in at Arrino to examine a copper mine in the vicinity. The latter end of September found me at Broad Arrow, dealing with a general application

for boring for reefs and alluvial deposits at Paddington and Broad Arrow. Two days towards the close of October were devoted to an examination of the valley of the Helena River in connection with a claim against the Government. From the 7th of November until the 17th of December my time was devoted to an examination of the country between Niagara and Edjudina, on the North Coolgardie Goldfield.

W. D. CAMPBELL: During the year this officer was employed in the field 127 days. In the months of March and April, Mr. Campbell was engaged in the valley of the Helena River for the purpose of acquiring certain information dealing with the foundations of possible sites for supplementary reservoirs, in connection with the Coolgardie Water Scheme, at the instance of the Department of Public Works. May and June found Mr. Campbell on the Murchison engaged on the preparation of a map of the auriferous reefs of Cue and Day Dawn, in connection with a proposal to test the reefs at a depth by means of the diamond drill. Donnybrook was visited by him in August in connection with an application for State aid towards gold mining; and Brunswick Junction respecting a water supply. Portions of September and October were devoted to the examination of the Coastal Plain within the Metropolitan Area, in connection with the water supply of Perth and Fremantle. Several visits were paid to Northampton during the months of June and October, in connection with the State boring carried out in that district.

C. C. GIBSON: In the month of June, Mr. Gibson joined his colleague, Mr. Campbell, at Cue, assisting him in the field work in that district. The latter part of June and a portion of July were devoted by this officer to assisting me in Leonnville. The month of September found Mr. Gibson at Broad Arrow engaged upon duties in connection with a proposal to carry out boring operations under the provisions of the Mines Development Act. From October the 14th up to the 19th of December this officer was engaged upon an examination of the auriferous formations of Boogardie and Mt. Magnet. Mr. Gibson was employed 82 days in the field during the year.

LABORATORY WORK.

The work in the laboratory was carried out during the year under the immediate supervision of Mr. E. S. Simpson, the Mineralogist and Assayer.

The new laboratory in Museum Street, alluded to in the Annual Report of last year, was completed, and the staff entered into possession in the month of September. The building provides ample accommodation for all needs in the immediate future; unfortunately, owing to the structure of the building, the heat is a source of discomfort to the staff during the summer months, the temperature in the coolest part of the building having already exceeded 100° on several occasions. This high temperature is also a great disadvantage to the storage of chemicals, and in some cases of analysis.

Stock was taken, as usual, at the end of the financial year, viz., 30th June, and it was found that the total cost of upkeep of the laboratory for the year 1901-2, was £703 11s. 8d., which amount includes the salaries of the staff.

Reporting on the work performed by the laboratory staff during the year 1902, the Mineralogist and Assayer informs me that 897 assays, analyses, and other determinations were made. The following table shows a detailed statement of the analytical work carried out during the period covered by this report:—

Table showing details of Assays, etc., made in the Geological Laboratory during 1902.

Classification.	Public.		Official.		Totals.
	Pay.	Free.	Geological Survey.	Other Departments.	
Total samples dealt with ...	68	170	126	242	606
Determinations	1	22	2	17	42
Assays for Gold	48	125	18	202	393
„ Silver	3	40	15	54	112
„ Platinum	...	1	...	...	1
„ Mercury	...	...	...	1	1
„ Copper	9	12	7	50	78
„ Nickel	...	3	2	...	5
„ Cobalt	...	9	2	1	12
„ Tin	3	6	1	8	18
„ Lead	2	3	3	3	11
„ Iron	...	2	1	...	3
„ Antimony	...	..	3	...	3
Chemical Analyses, complete ...	2	3	26	10	41
„ „ proximate ...	1	...	4	4	7
„ „ partial ...	2	2	4	21	29
Sections	...	2	109	...	111
Miscellaneous	2	4	5	19	30
Total of Assays, etc. ...	73	234	200	390	897

The routine work of the laboratory has included assays and analyses for the general public of various substances, including metallic ores, rocks, boiler water, etc., for a small proportion of which fees are charged. A considerable amount of information has been given by word of mouth to various applicants. In addition, many assays of tailings and ores, and some analyses of boiler waters, etc., have been made in the interests of the Superintendent of Public Batteries, and towards the end of the year for the State Mining Engineer. A number of rock sections were cut and examined, and many analyses, assays, and other determinations for the guidance of the field staff, with a view to rendering available further information on the minerals and rocks of the State.

During my necessarily frequent absences in the field, Mr. Simpson's time has been considerably encroached upon by his having to take general control of the office; despite this, in addition to the usual laboratory routine, this officer found time for the investigation of several matters of both scientific and economic interest.

Application having been made to the Government, in connection with the Friedrich process of pug treatment, at the request of the patentees for an investigation to be carried out, officially, Ministerial instructions were given to have the tests carried out in the laboratory.

Mr. Simpson reports that "it is as well to state at the outset the difficulties hitherto encountered in treating this material (which is composed mainly of a very fine grained clay):—

(1.) Owing to its very sticky nature when wetted, it is practically impossible to crush it in a battery in the ordinary wet way.

(2.) If crushed dry it breaks up into an extremely fine powder, which requires an excessive quantity of water and careful mixing to produce a pulp suitable for amalgamation.

(3.) When attempts have been made to cyanide it, it is found to settle in the vats into a solid sticky mass, which absolutely refuses to allow the solutions to pass through it.

(4.) A considerable proportion of the gold in it is in a very fine state of division.

In short, this ore presents, in an exaggerated degree, all the difficulties met with in the treatment of battery slimes.

Friederich's process aims at securing a complete breaking up of the ore and conversion into an even pulp in a rapid and thorough manner, followed by the concentration of the gold in a small proportion of the slimy ore, or in the still smaller amount of gritty material in the ore, from which the gold is then recovered by amalgamation or other means. The breaking up of the pug is effected by adding caustic soda to the coarsely broken ore and then pouring in boiling water, and allowing to stand for some time. The lumps of ore under the influence of the hot caustic solution disintegrate, and, on the addition of further hot water, followed by agitation, the whole mass becomes converted into a thin pulp, free from lumps. The disintegration of the ore is accompanied by a separation of gold and quartz grit from the fine clay, and, when the pulp is allowed to stand for a short time, these for the most part sink to the bottom of the pulp, whilst very little of the fine-clay settles. At this stage about two-thirds of it are run to waste off the top of the mixture. The remainder containing most of the gold can then, after slight dilution, be run over plates to amalgamate the gold, or can be further concentrated by repeated mixing with water, settling, and decanting, until nothing remains but quartz-grit and gold, which latter can then be recovered by amalgamation or otherwise.

The success of the process will depend upon the percentage of gold which it is possible to extract in this way, and upon the cost of extraction. The former is a matter which can be very closely ascertained in the laboratory, but the latter depends upon many questions which cannot be settled there.

Several experiments were made with the process in order to determine the quantity of water and soda needed to obtain the best results, as well as the time taken in treating the ore. In each instance one pound of ore was used. The size of the ore particles was such that whilst the whole of it would pass a one-inch screen, less than ten per cent. would pass a ten-mesh screen. The ore assayed 1oz. 19dwts. 4grs. per ton.

The following are the figures for the most successful experiment:—

One pound of ore was taken and caustic soda added, at the rate of 40lbs. per ton. Boiling water, at the rate of 440 gallons per ton, was poured on and the ore allowed to stand for 15 minutes, during which the lumps disintegrated under the influence of the soda, aided by a slight agitation. (N.B.—In practice this agitation, as well as the boiling of the water, will be effected by passing steam through the pulp.) More boiling water, at the rate of 880 gallons per ton, was then added and the mixture boiled for 15 minutes; after which the ore was found to be completely broken up and mixed with the water in an even pulp. This state, it appeared, could not be reached with less soda or water. The pulp was then allowed to settle for 15 minutes, and a considerable portion of it decanted off. This decanted portion may be called First Tailings. The balance was repeatedly washed with water, the tailings (Second Tailings) being saved, until finally a small quantity of gritty concentrates remained. The following are the quantities of each product, with the distribution of gold therein:—

1st Tailings,	70	per cent.	of ore	contained	28	per cent.	of total gold.
2nd „	29	„	„	„	4	„	„	„
Concentrates	1	„	„	„	68	„	„	„

The experiment showed, therefore, that it is possible to extract 68 per cent. of the gold in this manner in about one hour's time. Mr. Frederich's experiment, made in my presence, gave an apparent extraction

of 69 per cent. With such an ore this result would appear very satisfactory, and might possibly be improved upon in practice by perfecting the details of the process.

I am not in a position to give an estimate of the cost of labour, water, heating, etc. The soda at 35s. per cwt. would cost 12s. 6d. per ton of ore.

MINERAL COLLECTION.

New specimens, to the number of 1,189, were added to the collection during the year, bringing the total number registered up to 4,390. By far the greater part of these were collected by the officers of the staff in the ordinary course of their duties, and designed to illustrate their reports and maps.

Diatomite (variously known as diatom earth, diatomaceous earth, infusorial earth, kieselguhr, etc.) was the only new mineral recorded during the year. This mineral is used for a variety of purposes in Europe and America, but it is doubtful whether it would pay to export. Diatomaceous earth is chiefly employed in the manufacture of dynamite, disinfectants, heat-proof paints and packings, and metal polish. The deposit, which appears to be extensive, occurs at Lake Gnangara or Nangerup, in the Wanneroo district.

PRINCIPAL RESULTS OF THE YEAR'S FIELD OPERATIONS.

Mineral Resources.

The following reports on the mineral resources of various portions of the State were prepared during the year:—

Iron Deposits of Western Australia.—In the month of September the Chairman of the Select Committee of the House of Representatives of the Commonwealth Parliament on the Bonuses for Manufacturing Bill approached the Government for a report on the iron ores of the State. Information was especially required as to the extent of the deposits, their locality, distance from the sea coast, means of transit, analyses of the ore, together with data bearing on the possibility of obtaining coal in the State for smelting purposes. In response to the request of the Minister for Mines, the following report was supplied:—

General.—The ores of iron are extremely widely distributed throughout Western Australia, but, with one or two exceptions, the area in which the exploitation of such deposits is actively prosecuted is very limited, such areas being at present confined to localities where ore used as a flux can be obtained in considerable quantities. Some of the richest and most extensive deposits are absolutely valueless, owing to their geographical position. The iron deposits of the State so far examined, can be broadly separated into two main divisions—(*a*) the ores associated with the crystalline schists and other allied rocks; and (*b*) the superficial deposits of limonite (laterite ore), which occupy extensive areas in many and widely separated portions of the State, and the soft porous deposits of hydrated oxide of iron (bog ore) of comparatively recent origin.

Extent and Locality of Deposits.—The important ores associated with the crystalline schists are developed most extensively in the watershed of the Murchison River, more especially between 25 degrees and 28 degrees of South Latitude, and 116 degrees and 119 degrees East Longitude. The most important localities are Horseshoe, Peak Hill, Mount Gould, and Mount No Name, Peak Hill; and Mount Hale, Weld Range (Wilgie Myah), Munara Hills, and Mount Narryer, Murchison. Less important deposits of this nature occur at Marble Bar, Pilbarra; Kilalo Well, Murchison; Wiluna, Mount Townsend, and Mount Marion, East Murchison; Bardoc, Broad Arrow; Mount Jackson, Yilgarn; and Jennapullin, Blackboy Hill, and Greenhills, Avon District.

These deposits consist of highly inclined beds, bands, and lenses of almost pure hematite (occasionally magnetite) or admixtures in all proportions of hematite and quartz, interbedded with and sometimes replacing quartzites, and quartz schists.

No detailed geological survey of any of these important deposits having yet been made, it is impossible to give even a rough approximate estimate of the minimum quantity of ore in sight in any one of them. That quantity of ore must be large as is evidenced by the following descriptions:—

Mounts Hale, Taylor, etc.—The sigma-shaped range of hills on the West side of the Murchison, of which Mounts Taylor, Hale, Matthew, Yarrameedie and Erawandoo form the most prominent summits, is remarkably prolific in iron-bearing schists. The summit of Mount Hale is formed of contorted quartz schists with bands of hematite, which occur in lenticular masses; some bands are often as thin as a sheet of paper, whilst others widen out to considerable dimensions. One band measured 70 feet across and outcropped for over a quarter of a mile, but varied in thickness in different parts. There were similar bands parallel to it and equally persistent along the strike. Just under the Western summit of Mount Hale the quartzite is replaced by a great bed of hematite, several huge monoliths of which stand out prominently on the range. This hematite can be followed along the range to a point just South of the summit of Mount Matthew. A partial analysis of a sample of this bed yielded, in the Official Laboratory, the following in parts per hundred:—

Ferric oxide, Fe_2O_3	94·05 per cent.
Ferrous oxide, FeO	0·97 ,,

The outcrop of a bed of ironstone forms a conspicuous feature on the surface at the foot of the Mount Narryer Range. The bed, which is vertical, attains a thickness of eight or nine feet, and rises about two feet above the ground.

The following are complete analyses by Dr. F. S. Earp, in the Official Laboratory, of two ores of this description :—

—	No. 338, Mount Narryer.	No. 342, Mount Hale.
Water, H_2O, etc.	4·82	1·08
Alumina, Al_2O_3	·60	.94
Manganese sesquioxide, Mn_2O_3	Trace	·55
Iron peroxide	82·07	92·66
Iron protoxide, FeO	Trace	·97
Lime, CaO	3·32	·11
Magnesia, MgO	*Nil*	·55
Titanium dioxide, TiO_2	·53	1·09
Silica, SiO_2	9·33	3·14
Sulphuric anhydride, SO_3	·32	·09
Phosphoric anhydride, P_2O_5	Trace	·17
	100·99	101·35

In the Weld Range, at the head of Roderick River, is the Wilgie Myah, said to be one of the richest iron lodes in the world. * This deposit was worked by the natives before the white invasion of Western Australia, and the ore (used as war paint) was traded for great distances. It has been opened up by them to a depth of over 100 feet, and at the bottom of the excavation to a width of 50 yards. The deposit is a banded hematite, the soft, red clayey bands being those to which the natives only devoted any attention. An official analysis of the massive hematite variety of the deposit yielded 61·91 per cent. of metallic iron, and the hard, red Wilgie gave 34·17 per cent. of iron. A deposit of the enormous size of the Wilgie Myah from 150 to 200 feet in width naturally varies in its chemical composition, but at the time this deposit was visited in 1900, it was not found possible to adequately sample the whole width of the lode.

The following table shows the results of the assays of the iron-bearing schists as made in the Departmental Laboratory :—

Assays of Iron-bearing Schists.

Locality.	Description.	Metallic Iron.	Silica.	Water hydroscopic.	Water combined.
		per cent.	per cent.	per cent.	per cent.
Mt. No Name, Peak Hill ...	Banded limonite ...	50·33	7·30	·38	11·45
Munara Hills, Murchison ...	Massive hematite ...	63·7	?	?	?
Mt. Hale, Murchison	Do. ...	65·62	*Vide*	analysis	above.
Wilgie Myah, Murchison ...	Do. ...	61·91	1·13	·13	3·97
Do. do.	Hard red "Wilgi" ...	34·17	21·93	1·11	11·51
Wiluna, East Murchison ...	Argillaceous limonite ...	35·5	?	?	?
Mt. Narryer, North-West ...	Hematite quartz schist	57·45	*Vide*	analysis	above.
Mt. Jackson, Yilgarn	Fibrous limonite ...	60·20	1·62	·39	14·79
Bardoc, Broad Arrow	Siliceous hematite ...	55·5	?	?	?
Pinyalling Range, Yalgoo ...	Massive hematite† ...	66·55	·91		

† Also Phosphoric Anhydride, P_2O_5, ·13.
Sulphuric Anhydride, SO_3, ·24.

Deposits of very pure magnetite have been found in the ferruginous dyke-rocks of the Darling Ranges, at Serpentine and the Collie Rivers. Similar deposits exist in the neighbourhood of Ravensthorpe, Phillips River, but their extent is at present unknown. A recent analysis of the Magnetite ore, from a locality 12 miles north of Collie, yielded at the hands of the assayer —

Metallic iron	52·87 per cent.
Silica, SiO_2	·45 ,,
Titanium dioxide, TiO_2	14·13 ,,

The following table shows the position of the Murchison deposits with reference to the nearest coalfield on the Irwin River, and the means of transport thereto :—

Deposit.	Distance from nearest seaport by rail and road.	Distance from railway line.	Distance to nearest coalfield by road and rail.
Mt. Hale	362 miles, Geraldton ...	100 miles, Cue... ...	441 miles, Irwin River
Mt. Narryer ...	362 ,, ,, ...	100 ,, ,, ...	441 ,, ,,
Wilgie Myah ...	312 ,, ,, ...	50 ,, ,, ...	391 ,, ,,

The superficial deposits comprise the Laterite ores and the Bog Iron ores. The Laterite ores, together with the gravel resulting from their denudation, are the most widely distributed ores in the State; they vary very much in their composition. The ores are most largely developed on the tops of hills or ranges; in depth they pass gradually, without any distinct line of demarcation, into the rock upon which they lie. These deposits owe their origin to the concentration of the ferric oxide by the action of atmospheric changes. Nowhere do any of these ores attain any great thickness. The ores of this class have been principally used for fluxing purposes, to which end 45,772 tons have been raised up to the end of 1901.

* H. P. Woodward. The Murchison Goldfield. Perth: By Authority, 1893, p. 20.

The following table gives the results of the assays of the laterite ores as made in the Official Laboratory by Mr. E. S. Simpson :—

Assays of Laterite Iron Ores.

Locality.	Description of Ore.	Metallic Iron.	Silica.	Water (hygroscopic).	Water (combined).
		%	%	%	%
Mt. Baker, South-West	Nodular laterite	51·33	4·44	?	?
Do. do.	do.	50·54	5·49	?	?
Darling Range, South-West	do.	34·73	19·44	?	?
Do. do.	do.	45·00	9·88	?	?
Do. do.	do.	41·60	11·33	?	?
Do. do.	do.	59·63	1·59	?	?
Do. do.	do.	52·57	?	?	?
Serpentine do.	do.	29·95	9·71	·81	14·26
Greenbushes do.	Turgite nodule	62·47	?	?	?
Do. do.	Laterite	52·43	(1·52)*	?	?
Do. do.	Loose pebbles from laterite ...	38·88	(23·26)*	?	?
Murrin Murrin, Mt. Margaret ...	Compact ironstone	52·55	2·55	·57	9·00
Kalgoorlie, East Coolgardie	Dark, slightly cellular laterite	57·63	1·53	·52	8·10
Do. do.	Mottled laterite	47·42	4·07	·63	10·84
Coolgardie, Coolgardie	Cellular laterite	25·13	?	?	?

* Total insoluble matter.

The ores of this type already worked all occur either close to or at no great distance from the Railway Line.

The Bog Iron ores consist of soft porous deposits of hydrated oxide of iron: these occur at different points along the Southern and Western Coast Line. Up to the present, however, deposits of this class have not been exploited.

Two samples, only, of this class of ore have been examined, with the following results:—

Assays of Bog Iron Ores.

—	2582 Herdsman's Lake.	2341 Wanneroo.
	%	%
Water lost at 100°	3·17	...
Water and organic matter lost at a red heat	11·93	...
Metallic iron	51·75	48·61
Silica	2·82	8·52

The following table shows the production of Iron Ore in Western Australia up to the end of August, 1902:—

The Production of Iron Ore in Western Australia.

Year.	Locality.	Ore raised.	Estimated value.	Remarks.
		tons.	£	
Previous to 1899	West Pilbarra	100·00	300·00	
1899 ...	Clackline	1,540·00	1,071·00	
1899 ...	Coate's Siding	4,712·00	3,277·00	
1899 ...	Greenbushes	2,000·00	1,391·00	
1899 ...	Werribee	4,600·00	3,200·00	Used as a flux
1900 ...	Avon	12,251·00	9,258·00	
1901 ...	Avon	9,972·00	6,983·00	
1901 ...	Greenbushes	2,725·00	2,086·00	
1901 ...	Clackline	7,422·00	3,930·00	
1901 ...	Boulder	450·00	247·00	
1902 ...	State generally	4,800·00	2,040·00	Up to 31st August, 1902
	Total	50,572·00	33,783·00	

Coal for Smelting Purposes: Collie River Field.—The only coalfield at present opened up in the State to any extent is the Collie River Field. The coalfield embraces an area of about 50 square miles, and is connected by rail with the main railway system of the State. A considerable number of workable seams have been proved by mining and boring to exist in the basin. All these seams are practically identical in character, being hydrous, non-caking, bituminous coals, varying noticeably in the proportion of ash present. The inability of the coal to yield coke, and the fragility, low calorific value, and relatively high percentage of ash, prohibits its use in smelting.

Irwin River.—The Irwin Coalfield is embraced by the area drained by the eastern branches of the Irwin River. The field, however, has not yet been sufficiently explored to pronounce any definite opinion as to whether any coal suitable for smelting purposes is likely to be discovered. The area covered by the coal-bearing series, however, is very great. Having in view the delimitation of the geological area of the coalfield, two bores were put down by the Government at Dongarra and Yardarino, but, owing to an

accident to the boring rods, operations were stopped in both cases without having unequivocally reached the base of the Coal Measures.

Gascoyne River.—Undoubted Carboniferous Rocks being known to exist on the Gascoyne River, the possibility of the occurrence of commercial coals associated therewith is apparent. In view of the utility of such in connection with the exploitation of the Murchison iron ores, the Government are putting down a bore on the coast at Carnarvon. This bore has now attained the depth of over 2,000ft.,* and, after piercing a considerable thickness of Tertiary Rocks, entered the Carboniferous Series at about 1,200 feet. The bore is now in progress, and it is contemplated continuing it until the base of the formation has been unequivocally reached, when the question of the occurrence of coal seams will be definitely settled.

Summary.—The ores of iron are very widely distributed in Western Australia. The deposits of the Murchison stand out prominently before any of the others yet reported upon, but, owing to their geographical position, they are practically valueless under present conditions. Although practically neglected at present, they are destined to form a very important State asset. No detailed geological surveys of any of the Murchison deposits having yet been made, an approximate estimate of the minimum quantities of ore in sight in any one of these deposits cannot be made. No coal suitable for smelting has yet been found in the State.

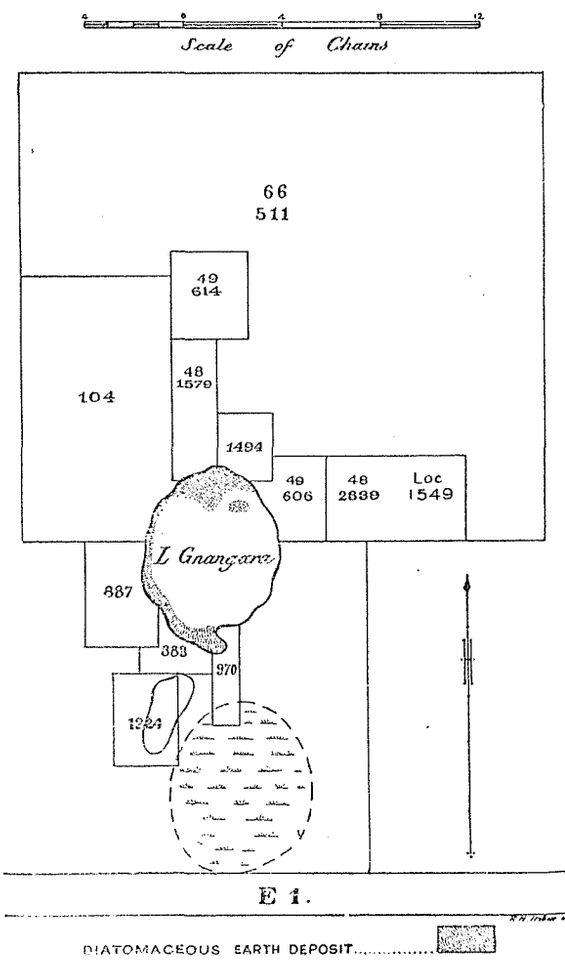
Diatomaceous Earth, Wanneroo.—The discovery of an extensive deposit of Diatomaceous earth at Lake Gnangara, in the Wanneroo district, formed the subject of the following report by Mr. Simpson:—

"The first sample of this material was sent to the laboratory, through the medium of the Hon. the Minister for Mines, by Mr. W. B. Gordon, M.L.A. It was marked "clay," and a report was desired as to its value and possible applications. It has been partly calcined, and a preliminary examination revealed its extreme lightness, and also that it was composed mainly of silica (78·26 %), alumina (9·44 %), and water. This pointed to the probability of the material being a silicious infusorial earth, and a subsequent examination proved that it was composed almost entirely of the skeletons of the minute algæ known as Diatoms, and of equally minute fresh-water sponges (Spongilla).

Through the courtesy of Mr. Gordon and Mr. McLeod, the owner of the land adjacent to the main deposit, I have been able to inspect the deposit *in situ*. It occupies the northern and western edges of Lake Gnangara, a permanent fresh-water lake eleven miles due north from Perth, and about four miles north-east of Wanneroo.

PLAN OF
LAKE GNANGARRA — SWAN DISTRICT

SHEWING PROBABLE EXTENT OF DIATOMACEOUS EARTH DEPOSIT



* On the 8th of June, 1903, the depth reached was 2,611 feet.

At the time of my visit (October, 1902), the main deposit was found to form a quaking bog, with a smooth surface starting immediately at the foot of the sandy banks on the northern shore of the lake at a height of a few inches above water level, and sloping gradually towards the lake, beneath the surface of which it passes. The whole deposit is covered with a scanty growth of reeds, and, from all appearances, is still in process of formation. Opposite blocks 48/1579 and 10/357 these reed beds are seen to extend out into the lake for about 10 chains, and may be taken as a rough indication of the extent of the deposit. On the shore side it passes under the sand banks for some little distance, as evidenced by the quaking nature of the latter close to the lake on the north side.

Towards the east the reed beds gradually become narrowed, and finally disappear near the boundary of blocks 10/357 and 49/606, where they give place to a beach of fine, white sand, mixed with small pebbles of dried diatom-earth. Towards the west, also, the deposit narrows, but does not disappear altogether, continuing as a narrow edging to the lake, more or less obscured by drift sand, etc., all along the west side and possibly also (judging by the reeds) the extreme south side.

It was found that for a few yards from the shore on the north side the deposit had dried sufficiently on the surface to support the weight of a man, though not that of a horse or other beast. The surface quaked considerably with each step, and was composed of moist earth, dark brown in colour, and somewhat sun-cracked, on the top of which were scattered small, dry flakes of the same earth, almost white in colour. These latter floated readily when thrown into water. The earth could be easily dug out with a spade in large blocks, resembling sticky, dark-brown clay, the hole subsequently filling in with water. By means of a short pole, a hard bottom was felt in one place at a depth of five feet; in other places bottom was not reached at that depth.

It was impossible to visit the south-western corner of the lake, where the reeds widen out somewhat; whilst the existence of any notable quantity of the earth along the western shore is more or less hypothetical. Owing to the deposit dipping under water at a short distance from the shore on the northern side, the extent southwards of this, the main deposit, can only be conjectured. Assuming it to have an area of at least 15 acres, with an average depth of five feet, there would be about 75,000 cubic yards of the moist earth available. This would yield (as shown by experiment) 45,000 cubic yards of calcined earth, weighing, roughly, 8,000 tons.

The deposit is saturated with water, and very rich in organic matter. When dug up and exposed to the sun and air, it dries to a tenaceous mass of a dirty white colour on the outside and a light brown within. In this condition it floats readily on water, and, on being thrown into a fire, will smoulder until all organic matter is burnt out of it, leaving an extremely porous mass, which is somewhat tender to handle. During air-drying and calcination, a shrinkage occurs from 100 volumes of crude wet earth to 66 in the first process, and still further to 60 in the second.

The following is the analysis of the partly calcined earth submitted by Mr. Gordon:—

Water and Organic Matter lost at 100°	5·63	per cent.
Water and Organic Matter lost on ignition	16·69	,,
Silica, SiO_2	67·72	,,
Alumina, Al_2O_3	9·98	,,
Iron protoxide, FeO	Trace	
Lime, CaO	·22	,,
Magnesia, MgO	Trace	
	100·24	
Silica in calcined earth	86·91	per cent.

Several samples of the crude earth were collected by myself at Lake Gnangara, and the following results were obtained from an examination of a sample from about 12 inches below the surface of the deposit on the north side of the lake. The detailed analysis was made on the air-dried sample, and the other analyses calculated therefrom.

Analysis.	Crude wet.	Air-dried.	Calcined.
	per cent.	per cent.	per cent.
Moisture and organic lost on air drying	77·88	*Nil*	*Nil*
,, ,, ,, at 100°	2·48	11·20	*Nil*
,, ,, ,, on ignition	7·93	35·79	*Nil*
Silica, SiO_2	10·89	49·08	92·96
Alumina, Al_2O_3	·78	3·51	6·65
Iron protoxide, FeO	Trace	Trace	Trace
Lime, CaO	·03	·16	·30
Magnesia, MgO	·01	·05	·09
	100·00	99·79	100·00
Bulk specific gravity	1·145	·383	·232
Relative change in weight	100·0	22·1	12·2
Relative change in bulk	100·0	66·1	60·2

Under the microscope, the earth is seen to be composed of a felted mass of siliceous spicules, in which are embedded numerous diatom frustules, of perfect form. They belong mainly to the groups of Naviculeæ and Eunotieæ, a very large species of Pinnularia being especially noticeable. The genus Bacillaria, which is said to yield the best dynamite, is apparently entirely absent.

Diatom-earth (called also infusorial earth, diatomaceous earth, tripoli and kieselguhr) has been put to a great many uses, owing to its lightness, its abrasive power, its great absorbent power, and its low conductivity for heat. Foremost of its uses is that of an absorbent for nitro-glycerine, the resulting mixture being known as dynamite. The Wanneroo earth would not appear to be well suited for this purpose, owing to the high percentage of alumina in it, and also owing to the forms of the diatoms present in it. It is eminently suited for the manufacture of disinfectants by the absorption of phenol, etc., as well as for lining cold storage rooms, and railway wagons, and as an ingredient for refrigerating paint. Owing to the extremely small percentage of iron and other mineral impurity present, it would be an excellent source of silica for the manufacture of soluble and other glass. It could be used as an ingredient of metal-polishing powders and soaps. For all these purposes it would require to be calcined and crushed."

The Reputed Petroliferous Deposits of the Warren and the Donnelly Rivers.—Considerable attention having been directed to the reputed occurrence of petroleum in the country drained by the lower reaches of the Warren and the Donnelly Rivers, it has been considered desirable, owing to the fact that the conditions governing the occurrence of petroleum depend upon considerations of geological structure, that an examination of the locality should be made with a view of determining how far the conditions prevailing on the Warren and the Donnelly had any bearing on the future of the district.

The structure of the country drained by the Warren and the Donnelly is of extreme simplicity, as can be seen by a reference to the two sketch sections following, which may be regarded as typical of the country in this district.

A large quantity of bitumen is reported to be washed up and left by the receding waves all along the South Coast of the State, but more especially in that portion between Cape Leeuwin and Point D'Entrecasteaux, into which the Warren and the Donnelly Rivers empty themselves.* No trace, however, was seen by me of asphalt anywhere along the beach. Somewhat similar material has been reported as being found on the beach at many different localities round the shore of the Great Australian Bight. These fragments are washed up from sources at present unknown.

The formations exposed consist of:—

(*a.*) *Superficial deposits*, comprising sand dunes, alluvial deposits, etc.
(*b.*) *Basaltic lavas.*
(*c.*) A series of *sandstones, grits, clay shales,* and *coal seams,* and
(*d.*) *Crystalline rocks,* which form the floor upon which the other formations were laid down.

The Warren River.—The Warren River flows over the hilly country, composed of crystalline rocks, until within a short distance of the coast, when it eats its way gradually to the sea through the sand dunes and peaty swamps which extend for about five miles from the coast.

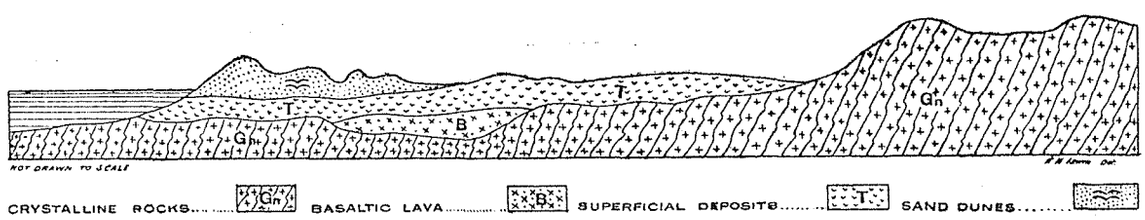
Emerging from the somewhat constricted valley in the hills, the river is flanked on either side by variable width of alluvial deposits. The full thickness of the deposits was not exposed in any single section. In several localities, within a mile or two of the coast, the section in the river exposes at one or two places a deposit of cement, discoloured by vegetable matter—in reality a carbonaceous sandstone. The cement, which rests upon a floor of clay of somewhat variable character, is of not great thickness.

It having been pointed out that this cement yielded mineral oil to such an extent as to warrant its being designated "petroleum rock," two analyses were made in the Departmental Laboratory of the deposit, without any trace of petroleum or asphalt (oxidised petroleum residue) being obtained. It, of course, is conceivable, from the fact that the deposit is exposed at the surface, coupled with the relatively high temperature prevailing during the summer months, that some at any rate of any oil stored therein might evaporate; any such loss would be comparatively insignificant.

The underlying peaty clay ("bituminous clay") also yielded, on analyses in the Departmental Laboratory, no trace of either petroleum or asphalt. Neither of the two deposits can in any sense be regarded as petroliferous.

The local discolouration of the sea in the vicinity has been held to be due to the escape of petroleum from those portions of the rocks which pass beneath the ocean. Owing to the state of the weather it was impossible for me to collect any of the yellowish scum appearing at intervals for analysis, but everything points to the fact that it merely owes its origin to the decomposition of seaweed and the like.

The crystalline rocks make their appearance on the beach beneath the sand hills at high-water mark, some distance to the North of Black Head, which lies to the South of the Warren River. There is every geological reason for believing that they extend Northwards and pass at a relatively shallow depth beneath that portion of the district drained by the lower reaches of Meerup Brook and the Warren River.



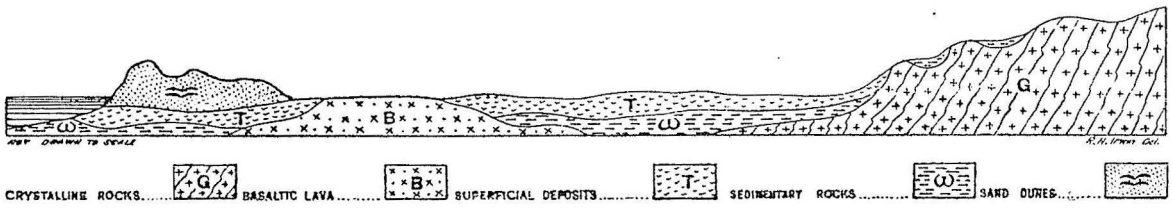
GENERALISED SECTION DOWN THE WARREN RIVER.
LENGTH OF SECTION 10 MILES

* H. P. Woodward. The South-Western portion of the Colony. Annual Report of the Department of Mines for the year 1894. Perth: By Authority, 1895, p. 9.

Owing to the fact that there are no data which will enable an idea to be formed as to the shape of the surface upon which the superficial accumulations rest, it is impossible to form any precise idea as to the actual thickness of the cover which conceals the underlying crystalline rocks and basaltic lavas; that, however, it cannot be relatively great, would appear obvious from an inspection of the ground. In close proximity to the beach, however, near the mouth of the river, the deposits would naturally be expected to be of a greater thickness than further up the valley.

The Donnelly River.—The country between the Warren and the Donnelly Rivers is of identical geological constitution to that exposed in the valley of the former.

The basaltic lava, however, rises to the surface a little to the North of Silver Mount, at a point about midway between the two rivers, and again makes its appearance in great force in that bold headland known as Black Head, some distance to the North of the mouth of the Donnelly.



GENERALISED SECTION DOWN THE DONNELLY RIVER.

LENGTH OF SECTION 15 MILES

On the tributaries of the Donnelly River, a series of sandstones, grits, and clay shales, together with one or two coal seams, are exposed. This series of strata is coterminous with that which occupies the country between the Donnelly and the Vasse. In the neighbourhood of Busselton these strata have been pierced by means of six bores, the deepest being 656 feet, at which depth the floor of granite and gneiss was encountered. At Newton, near Busselton, the base of the series was 329 feet from the surface, at which depth gneissic rocks were encountered. In these bores brown coals of variable thickness were met with in every case.

On Fly Brook, a tributary of the Donnelly, boring and shaft sinking was carried out some years ago, and a series of strata identical with that of the Vasse was encountered; seams of brown coal were met with at shallow depths, but in no case does it appear that any petroleum was encountered. The strata on Fly Brook reach a fairly considerable altitude, and have been laid down in irregular hollows of variable extent, on the surface of the underlying crystalline rocks. Owing to the configuration of the country, sections of those rocks are rarely exposed in the watercourses. Towards the coast these strata pass beneath the sand dunes, which effectually conceals them from view. There, however, is no evidence by which their thickness can even be conjectured, though all the available evidence points to the fact that these superficial deposits attain a greater thickness than in the Warren.

In the light of our knowledge of the geological structure of the valleys of the Warren and the Donnelly, it may be reasonably doubted whether the district can in any sense be regarded as being petroleum-bearing. No petroleum has been discovered in the district, nor does its geological structure seem to conform to that which regulates the occurrence of oil elsewhere.

There is nothing clearer, from all the evidence at present available, that the country is unlikely to rise to any importance as an oil-producing district.

Since this report was written, three bores have been put down in the neighbourhood, and, according to the bore journals supplied to the Government, they prove incontestably that the deposits in the valley of the Warren reach a much greater thickness than had been anticipated. The following are the details of the strata passed through in the bores, as supplied by the owners of the property:—

No. 1 Bore.

Nature of Strata.	Thickness.	Depth
	feet.	feet.
Sand and black mud	49	0
Basalt	32	49
Total	81	81

No. 2 Bore.

Nature of Strata.	Thickness.	Depth.
	feet.	feet.
Sand	504	0
Total	504	504

No core available, the boring being through loose sand.

No. 3 Bore.

Nature of Strata according to Bore Journal.	Thickness.	Depth.
	feet.	feet.
Incoherent sand	80	0
Black clay, interspersed with seams of sand	20	80
Quartz pebbles	10	100
Incoherent sand	52	110
Basalt, partly decomposed	21	162
Shale and brown coal	2	183
Bituminous sandstone	10	185
Brown coal, with particles of ashes, mud, pumice, etc.	10	195
Decomposed graphite	Thin seam only (?)	205
Scoriæ from pyrites, sand, mica, clay, artesian flow, fresh water, graphite, and small quantity of gas	60	205
Quartz pebbles and iron pyrites	2	265
Decomposed basalt; gas	18	267
Hard basalt; no water	30	285
Calcite	(?) 2	315
Black mud, apparently bituminous, volcanic matter, and black mud	5	317
Sand, charcoal, and decomposed basalt	9	322
Brown shale, pieces of basalt, iron pyrites, anthracitised matter	9	331
Quartz pebbles	1	340
Pumice, mica, etc.; graphite	8	341
Artesian flow, salt water, sand, scoriæ, ashes, coal particles, graphite	21	349
Apparent cement material of nature of lye, with graphite	(?) 1	370
Dry sand	106	371
Quicksand	25	477
Clay, with sand and shale	10	502
Sand, with garnets and mica (coal particles at 555ft.; slightly saline water at 565ft.)	78	512
Alternating fine and coarse calcareous sandstone, coherent where fine, incoherent where coarse; slight flow fresh artesian water, and fine particles of anthracite below 690ft.	140	590
Calcareous sandstone, fresh artesian water, gas, particles of coal, anthracitised lignite, fireclay, and fossils	(?) 3	730
Fine-grained sandstone, not hard enough to core	27	733
Sand	10	760
Alternating light grey and brown sand	20	770
Sand, with traces of shells, fossils, and anthracitised lignite, at about 820ft.	70	790
Fine-grained calcareous sandstone	40	860
Fine-grained calcareous sandstone, gradually altering in colour from light to dark yellow; coarse grained; not hard enough to core	17	900
Total	917	917

N.B.—The figures are taken from a tracing of the bore section, and as the thickness of the strata are not given in figures in every case on the tracing, they have been scaled off. The tracing appears to be only approximately drawn to scale, hence the figures of the strata given in this table may not be in every case absolutely correct.

A series of samples have been submitted to me from time to time by the Company, and the following is a description thereof:—

Nature of Strata.	Depth.
	feet.
Micaceous shale, with plant remains	Between 195–205
Débris of black sandy shale	322
Sand with fragments of dark shale	Between 492–503
Micaceous and somewhat sandy shale, and portion of a core of grit or quartzite	„ 503–572
Débris of clay shale	505
Coarse angular sand of quartz, felspar, a little mica, pale garnets (?) and fragments of pyritous shale	Between 550–570
Fine angular sand of quartz, felspar, and mica	„ 571–597
Fine angular sand of quartz, felspar, mica, and pale garnets (?)	„ 640–652
Angular sand of quartz, felspar, mica, with a few pale garnets (?)	„ 652–705
Coarse angular sand of clear transparent quartz and white felspar	„ 705–720
Fine angular sand of quartz, felspar, and a little mica	„ 720–722

In addition to the above, there are amongst the material submitted—

(*a.*) Fragments marked "portion of core from lower flow of basalt."

(*b.*) A tin containing fragments of a quartz sand cemented by carbonaceous matter, such as is found in many of the coastal swamps.

These two samples have no distinctive labels; hence it is not quite clear whether they were obtained from No. 3 bore, from which the other specimens have been derived.

Cue.—Having received instructions to visit Cue in connection with an application to carry out some diamond drilling in the district, Mr. Campbell, Assistant Geologist, was employed to collect the necessary geological data bearing on the question. Owing to the nature of the application, it became

necessary to examine a very large extent of country, which embraced an area of about 10 miles in length by about 6 in breadth.

A plan has been made by Mr. Campbell, with the object of throwing light on the proposal for prospecting the reefs at a depth. This plan shows the position and extent of all the reefs of the district, and, wherever possible, the amount and direction of their underlie.

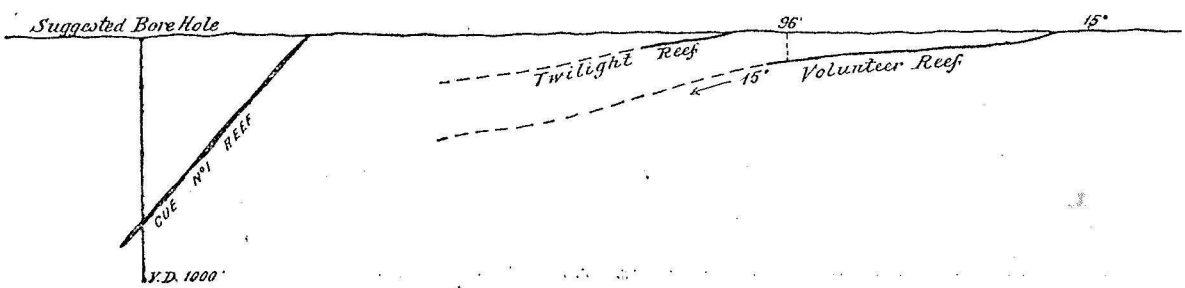
In the year 1897 I visited Cue at a time when enterprise seemed to be on the wane, and the returns showed signs of falling off. It was then pointed out in an official report* that—"The Cue district in its "geological structure is identical with that of the other productive goldfields in Australia and elsewhere, ". . . . . There is no falling off in the supply of ore available for crushing in the district as a whole, "although there are local variations in the dimensions of the reefs in almost every case. . . . . "So far, the reefs have shown themselves to be well defined fissure veins, in some cases, of large size, and, as "such, are likely to be as persistent in depth as anything in the nature of reefs ever can be. Local "fluctuations in the gold yield per ton are, of course, only to be expected in the future, but there are no "scientific grounds for believing that such large and well-defined reefs as those at Cue have, on the whole, "shown themselves to be, will not prove equally productive when followed to greater depths." This condition of affairs still obtains.

The reefs of Cue and Day Dawn are arranged along certain well-defined lines, which have been delineated on the plan, and their assumed continuity indicated.

After giving careful consideration to the whole question, it was recommended that (bearing in mind the general considerations which should determine the granting of State aid in this direction) the best assistance that could be rendered would be by means of a bore put down to the West of the Volunteer leases, just North of the township of Cue, at such a distance as would enable the drill to intersect the reefs at from 800 to 1,000ft.

Over this area there are certain well-defined and persistent parallel reefs which all underlie generally to the Westward. The Volunteer and the Twilight reefs both underlie to the Westward at an angle of 15° from the horizontal. The Cue One reef, which outcrops some distance to the West, underlies in a similar direction at an angle of from 50° to 60°.

A bore put down at a point about five chains East of the North-East corner of G.M.L. 217 would demonstrate the relation which may be called the horizontal reefs bear to the highly inclined. In such a bore the Cue One Reef, its present strike being measured, should be met with at about 800 feet from the surface. The Twilight Reef, if continuous, unless cut off by that last mentioned, should be met with at about 500 or 600 feet, and the Volunteer at about 300 feet lower down.



SECTION SHEWING THE POSITION OF THE VOLUNTEER, TWILIGHT AND CUE No1 REEFS.

In view of the fact that any boring carried out would confer a direct benefit upon the holders of the leased land adjoining, it was further suggested that a contribution on their part, on a basis to be mutually arranged, would not be unreasonable.

The Warden provisionally reserved such an area as would include the ground operated upon.

Lennonville, Boogardie, and Mt. Magnet.—During the year a short visit was paid to Lennonville, with the object of investigating its mineral resources.

It was found that the auriferous deposits were of two distinct types—viz., white quartz reefs and banded quartz or jasper veins (which in some cases proved to be exceptionally ferruginous), approaching very closely the banded hematite-bearing quartzites, which form such a conspicuous feature in some portions of the Murchison. The white quartz reefs present all the characteristics common to deposits of this nature; they are of later formation than the banded quartz veins, for in many cases they intersect the latter. These laminated quartz veins form the principal feature of the district, and, so far as they have at present been worked, have proved to be rich in gold, though it cannot be said that they have had that prospecting which their importance warrants.

The two types of deposits bidding fair to become of economic importance, it seemed that the greatest assistance the Department could render to private enterprise in the district would be in the direction of mapping these formations, in the hope of furnishing a reliable guide for the conduct of the operations of the prospector and the mining engineer.

From an examination of the Lennonville district, it was found that the ore deposits exhibited a remarkable parallelism, having a general North and South trend. They were found to sweep across country, with scarcely any interruption, for about four miles, and to extend both North and South far beyond the limits of the inspection.

* Cue Water Supply for Crushing Purposes. Perth: By Authority, 1897, p. 6.

A map, embracing an area extending from 11½ miles North, three and a-half miles South, two and a half miles West, and one mile East from the Lennonville Post Office, embodying the results of this work, was issued to the public in the month of September.

It was deemed desirable that the Southern extension of these deposits in the direction of Mount Magnet and Boogardie should be mapped and reported upon; this work was entrusted to Mr. Gibson. The area embraced by his labours extended over about 36 square miles. Upon the map, which is now being prepared for the lithographer, there are shown all shafts, alluvial workings, existing leases, the strike and underlie of all the reef and ore bodies, in addition to the geological boundaries, so far as they can be followed.

The main auriferous series is enclosed in a belt of more or less highly altered greenstones, which extend in a general Northerly direction from West Mount Magnet, through Moyagee, and as far North as Lake Austin and the town of Cue. The belt attains a maximum width of about 15 miles. This belt is composed of rocks, for which the term Greenstone has been provisionally adopted, and includes diorite, pyroxenite, together with hornblendic and chloritic schists, which may merely represent the crushed or plated out variety of the former, induced by shearing. Owing to the paucity of natural sections, it has been found impossible to distinguish on the map, or even trace out the field, the relative area occupied by each, and further, mining operations have not been carried sufficiently far to afford much assistance in this direction. The Greenstones are intersected by numerous faults, and are also traversed by belts of laminated quartzites (cherts?), often highly ferruginous, which rise up from the surrounding country in the form of low ridges.

The Greenstones are bounded on either side by belts of Granite, from which small tongues of aplite emanate. In many portions of the district there are dykes of granite intersecting the greenstone. The foliation of the greenstone seems to have taken place prior to the intrusion by the granite.

The laminated quartzites (cherts?), which are exclusively confined to the greenstones, are of two distinct varieties, viz., the hematite-bearing, the purely silicious type; the former predominates in the neighbourhood of Boogardie, whilst the silicious type is more prominent at Lennonville. The deposits of the Lennonville type are practically vertical, and forms belts varying from two to four chains in width. They invariably carry gold, but not always in payable quantities; they are, however, traversed by numerous rich chutes, which are being worked with satisfactory results.

The deposits of the Boogardie type differ somewhat from those of Lennonville in that, at any depth yet attained, they prove to be more compact, and are in some places exceptionally magnetic, rendering work with a compass well nigh impossible. They are traversed by numerous faults, the mapping of which is of considerable importance from a mining point of view, in that it is along these lines that the rich chutes of gold for which the district is noted occur. The bulk of the gold has been found to occur in rich chutes where the faults intersect the quartzites. Wherever seen, these faults cross the strike of the quartzite at right angles, and as the latter are generally only about from 30 to 60 feet in width, it necessarily follows that the width of the chutes is small; they are never found to continue into the country rock in either wall. The fault fissures are invariably filled with brecciated quartzite, recemented with chalcedone quartz, and traversed by small angular quartz veins. The fissures vary from three to six feet in width.

The quartzites (cherts?) appear to have been old fault lines, or shear zones, along which thermal solutions carrying iron, silica, etc., have found their way to the surface.

The quartz reefs occur plentifully in both the granite and the Greenstone, though, as a rule, it is only those close to the Greenstone which have proved to be auriferous to any extent. The chutes in these reefs are short, but frequently rich. It is interesting to note that these quartz reefs often form the continuation of the faults by which the laminated quartzites (cherts?) are intersected.

So far as observations have at present been carried, these auriferous deposits of Boogardie bear a remarkable resemblance to those of Peak Hill and the Horseshoe. It is highly desirable, in the interests of the State, in view of the light conferred by the recent work in the Mount Magnet District, that when opportunity offers the Northern extension of this belt should be geologically examined with the view of showing its relation to the deposits of Nannine, Meekathara, and other districts in the North Murchison District.

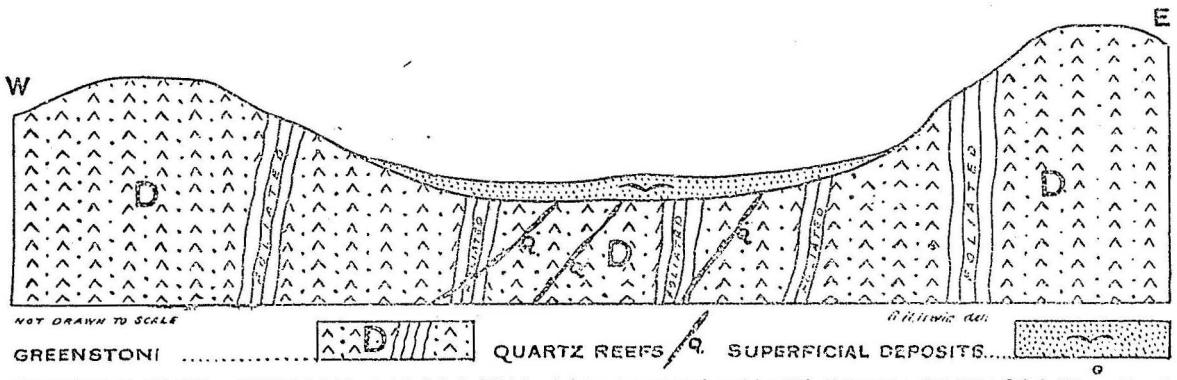
The map and report on the Boogardie District will be shortly available to the public.

Yalgoo.—In accordance with instructions, I visited Yalgoo on my return from the Murchison, for the purpose of reporting upon the alluvial deposits in the more immediate vicinity of the Township.

The Township of Yalgoo lies in a broad valley, flanked on either side by low ranges composed of amphibolite rock, which seems to be the staple formation of the district. It is in this valley that deep alluvial ground has been held to exist. The valley is drained by a small watercourse, which carries all the water Southwards. The broad expanse of the valley is covered with a variable thickness of superficial deposits, some of which are partially cemented into solid rock. The dam at the Railway Reserve shows the nature of the "cement."

The Public Battery water shaft is reported to have met with "alluvial wash" in a drive which had been put in from the bottom, but no gold was apparently obtained. I visited the site of the shaft, which is at present inaccessible. From what can be seen at the present time, it would seem that the sinking was through (below a few feet of superficial deposits) decomposed amphibolite of the type prevailing in the district. There is no evidence as to the existence of "deep alluvial" in the shaft. I incline to the belief that the "wash" encountered in the drive is nothing more than a belt of decomposed fault rock containing rounded and sub-angular fragments of the surrounding rocks. In many places along the flat in the valley the country rock is exposed at the surface. This, coupled with the evidence

derived from such of the sections as are open to inspection, would make it appear that no deep alluvial deposits exist in the Carlaminda Valley. The generalised section herewith shows the structure of the Carlaminda Valley :—



GENERALISED SECTION ACROSS THE CARLAMINDA VALLEY NORTH OF YALGOO TOWNSHIP

While in Yalgoo the opportunity was taken to examine the various workings on the Emerald Reef, which yielded such sensational returns in the early days of the field. About 4,000ozs. of gold were obtained from a flat or boat-shaped reef, about 100 feet in length, and 10 feet in width and depth. Since the flat reef has been worked out a good deal of prospecting work has been done in the hope of finding the continuation thereof, but so far without any success. A fairly well-defined fissure has been proved to extend along what may be called the outcrop of the reef, which has a trend of North-East and South-West. The Emerald Reef is hemmed in, as it were, between two comparatively barren belts of foliated greenstone, separated by either a line of fault or joint, which is fairly persistent to the North-East and South-West. The deposit seems to be neither more nor less than a network of irregular veins, embraced within certain well defined limits, parallel to the general strike of the reef. The known phenomenal richness of the surface would seem to me to encourage the prosecution of more judicious prospecting than has been up to the present carried out. No attempt would seem to me so far to have been made to seriously test the possible continuity of the reef at a depth.

In addition to this, Carlaminda was visited, but as most of the properties had long been abandoned, or otherwise inaccessible, description thereof is impossible. So far as could be seen the reefs were remarkably persistent in their strike, and all had a steep underlie to the West. The quartz, judging by that lying on the various dumps, was of an exceptionally glassy nature, and, in places, contained small though appreciable quantities of the green and blue carbonates of copper, together with a little limonite.

A visit was also paid to the almost deserted township of Melville, where similar conditions prevailed.

To the South of the old Gold Mining Lease 94 three men were engaged in dryblowing, but with what success I was unable to learn. In the vicinity of this locality were several quartz and jasper veins, identical in character with those occurring at the Horseshoe, Peak Hill, the Weld Ranges, Lennonville, and elsewhere on the Murchison. The judicious prospecting of these should lead to the discovery of rich ore chutes here as elsewhere.

I was guided by Mr. Howie, of Yalgoo, to the gullies west of Melville, which appeared to have been extensively worked in the early days for alluvial deposits. These deposits, however, did not attain any thickness. The occurrence of deep leads anywhere in these gullies is not to be expected.

Paddington and Broad Arrow.—The residents of Paddington and Broad Arrow, through the medium of the Town Clerk of the two Municipalities, approached the Government for assistance in boring for either lodes or alluvial deposits, at the same time agreeing to pay one-half of the expense. In accordance with an official request the local authorities delineated upon a plan those places which, in their eyes, seemed to merit especial attention, and for which aid was required, it being held that the discovery of fresh deposits would tend to establish confidence in the future of the district, and encourage the systematic exploration of the deeper ground.

Having received instructions to visit Paddington and Broad Arrow in connection with the application, the Assistant Geologist, Mr. Gibson, was employed to collect the necessary geological data bearing on the question.

The mining centres of Broad Arrow and Paddington are, in their geological features, identical with those of Bardoc, with which the various formations are coterminous. The gold produced from Broad Arrow and Paddington has been derived from two distinct sources, viz., the superficial deposits and the lode formations or quartz reefs: these having yielded, up to the end of 1901, 57,199·13ozs. of gold by the crushing of 68,815·13 tons of ore, being at the rate of ·83ozs. per ton. At the time the district was visited very little mining was going on, and most of the properties were abandoned, or otherwise inaccessible. Abandonment of a mining district, however, does not necessarily mean that the locality is worked out; and, further, strangulation of lodes or reefs is not a proof of limited extent in depth, but a necessary consequence of their mode of origin. The auriferous belt of Paddington and Broad Arrow is confined to a comparatively narrow strip of country a little over a mile in width, and is practically coincident with the area over which the country rock has suffered the greatest amount of movement. The reefs and formations are all practically parallel, and trend generally North-West and South-East. These, as far as can be seen on the surface, have a considerable longitudinal extent, being, however, cleavage veins they are liable to pinch out at any time, but will make again. Most of the numerous workings being

inaccessible, I was unable, by ocular demonstration, to form any idea as to their behaviour or nature underground. The element of chance in the discovery of reefs is unusually prominent in such capricious deposits as those along cleavage or shear planes.

The superficial deposits of Broad Arrow and Paddington cover a great extent of ground, and consist for the most part of the rocks decomposed *in situ*.

The proposal made to the government by the Municipalities embraced four areas in which it was held that alluvial deposits were likely to occur, and which should be prospected, and two which would seem to afford the best chances of success in respect to boring for reefs.

The Northernmost of the alluvial areas lay in a broad valley, flanked on either side by low hills of amphibolite, and was covered with a small thickness of superficial deposits. Several shafts have been put down on the flanks of the valley and expose nothing but amphibolite; one or two shafts have been sunk in the depression of the valley, and expose little else than rock decomposed *in situ*, overlaid by a foot or two of loam. From all the evidence available it does not appear at all likely that the cover can be more than 20 or 30 feet thick.

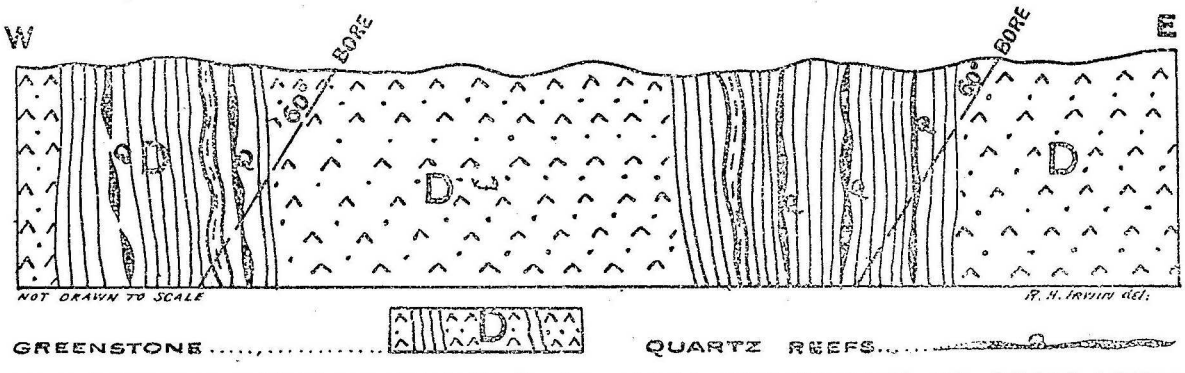
The next area lay in a low broad valley between the Explosives Reserve (4101) and the Railway Line; this had been exhaustively tested by several shafts, which were abandoned and inaccessible. From what could e seen in the dumps the sinking had been through the ubiquitous superficial deposits and the decomposed slaty rocks which, in many cases, weather in the direction of kaolin. In the dumps of one or two shafts were large boulders of a quartzose cement, so characteristic of certain of the claims near the head of the North Lead, Kanowna.

A little further to the Westward of this area is the head of the wide valley embracing the third tract of country pointed out by the Municipalities. This valley trends Southwards, and from its physical conformation would seem hardly likely to contain any material thickness of alluvium. The floor of the valley is underlaid by amphibolite and its decomposition products. Several shafts have been sunk, and they show that the bed of the valley is concealed by merely a foot or two of superficial deposits. There would seem to be little probability of any deep alluvial ground being found to the north of the Cemetery.

Another suggested possible alluvial area lay to the West of Paddington; the surface of the ground is covered with a thin mantle of superficial deposits. Near the northern end of the area one or two shafts of shallow depth show that the cover nowhere exceeds a few feet. It would, therefore, be hardly probable to expect any development of deep alluvial ground in this area.

A considerable portion of what may be called the Smithfield Area has been dryblown, but with what result there appears to be no record. The slaty country rock (and its decomposition products) rises practically to the surface, and is concealed by a few inches only of superficial *débris*. Several shafts have been sunken in the area, but they all bore signs of having been for a long time abandoned. Judging by the material lying in the various dumps, it would seem that only small quartz leaders had been worked. The prospect of any deep alluvial ground over this area is remote.

The most northerly area selected by the Municipalities lies between the township of Windanya and Paddington, and is about two miles long and half a mile broad. The ground is traversed, however, by several persistent lines of reef, all of which are roughly parallel to one another. The mode of occurrence of these deposits is shown in the following generalised section:—



GENERALISED SECTION SHEWING THE SUGGESTED BORE SITES Nr BROAD ARROW

From a careful inspection of the district, and such evidence as was available, it appeared that (*a.*) the chances of discovering payable deep alluvial deposits are remote, and the search for such would be in the nature of "blind stabbing"; (*b.*) the greatest service which could be rendered to the district would be in the direction of testing the nature, character, and continuity of the lodes at a depth. It was suggested that the ground shown in the section above be tested by two bore holes located in such a position as would intersect the deposits at such a depth as would be attained in 500 feet of boring in each hole. To intersect any of the deposits in the required depth of boring, the hole would have to be inclined at an angle of about 60° from the horizontal.

Queen Margaret Gold Mining Co., Ltd., Bulong.—The Queen Margaret Gold Mining Company of Bulong has made application to the Government for assistance towards prospecting the as yet untested ground to the East of the present workings, at a depth of 600 feet from the surface.

It was proposed to do this by penetrating the country from the face of the eastern crosscut for a distance of 1,000 feet, in the hope that other lodes parallel to those already worked on the property of the Company may be found.

In accordance with instructions, a personal inspection of the property of the Queen Margaret Company was made. Owing to the nature of the application it was found unnecessary to devote much time to a detailed examination of the existing workings, attention being principally directed to that portion of the country which would be explored by the present operations, with the view of ascertaining whether there were any reasonable geological grounds for believing that the ground might be likely to develop further reefs.

The geological constitution of the neighbourhood consists of graphitic and talcose schists, breccias and quartzites, associated with igneous rocks of somewhat obscure origin (diabase?). That a considerable amount of *bonâ fide* work has been done upon the Company's property may be seen by an inspection of the mine plans.

There are two distinct lodes—the Queen Margaret and the Eastern Lode—upon the property, both of which have been worked. These have been opened up by means of two shafts for a length along the strike of about 1,400 feet as shown by the plan. The deepest workings have been carried down to a vertical depth of about 700 feet from the surface. From the 600 feet level a crosscut has been driven to the East for a distance of 1,320 feet from the shaft. The crosscut has been carried through a considerable thickness of graphitic and talcose slates and schists, dipping at an angle of 50° to the West, intersected by diabase and certain other igneous rocks of doubtful origin. These rocks are traversed by certain parallel fissures, two of which have proved to be ore channels containing gold in such quantities as to render them worth working.

Some considerable distance to the East of the Queen Margaret, a parallel lode—the Great Oversight—has been worked along its outcrop, and has proved to be extremely rich in places. In its mode of occurrence the ore deposit of the Great Oversight is practically identical with that of the Queen Margaret.

The mode of formation of fractures which prove to be ore channels is such as to produce more or less parallel fissures of variable extent, and that such a condition obtains in the ground under consideration is evidenced by the section exposed in the crosscut and the workings to the East.

The surface of the ground between the two lodes, the Queen Margaret and the Great Oversight, contains quantities of quartz fragments of such a nature as indicate that they have resulted from the disintegration of rock *in situ*, in which case it would not be at all unreasonable to expect that the strata beneath would be traversed by similar quartz veins, some of which might possibly be of workable dimensions.

In view of all the evidence available, there are no grounds for believing that the unexplored country between the face of the Eastern crosscut and the Great Oversight cannot be traversed by further ore channels parallel to those already opened up, but whether any such would prove to be payable could only be determined by practical work.

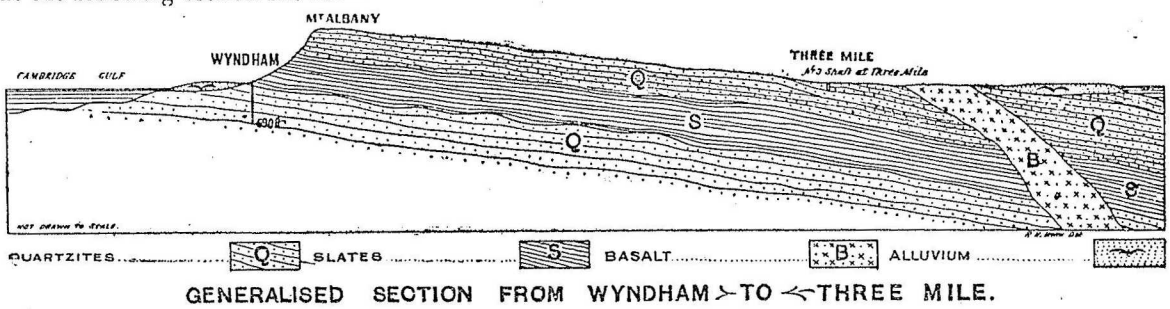
On the grounds that the discovery of lodes in the country to the East of the face of the long crosscut would tend to encourage prospecting at greater depths than those at present obtaining in the more immediate vicinity, I am of opinion that the request of the Queen Margaret Gold Mining Company for a subsidy might very reasonably be granted. Such subsidy should be given on the basis of pound for pound, but contingent upon satisfactory answers being given to queries put to the local Inspector of Mines as to the method in which the mine has hitherto been worked. The Government would be involved in a liability of about £500 to enable the amount of boring, viz., 1,000 feet, to be carried out. In order to enable the greatest amount of virgin ground to be tested in the 1,000 feet of boring, it will be necessary to incline the hole at an angle of from 20° to 30° from the horizon.

To minimise the possibility of undue advantage being conferred upon the lessees at the expense of the general public, I am of opinion that a reserve of some extent should be created to cover the site of the bore.

Water Supply.

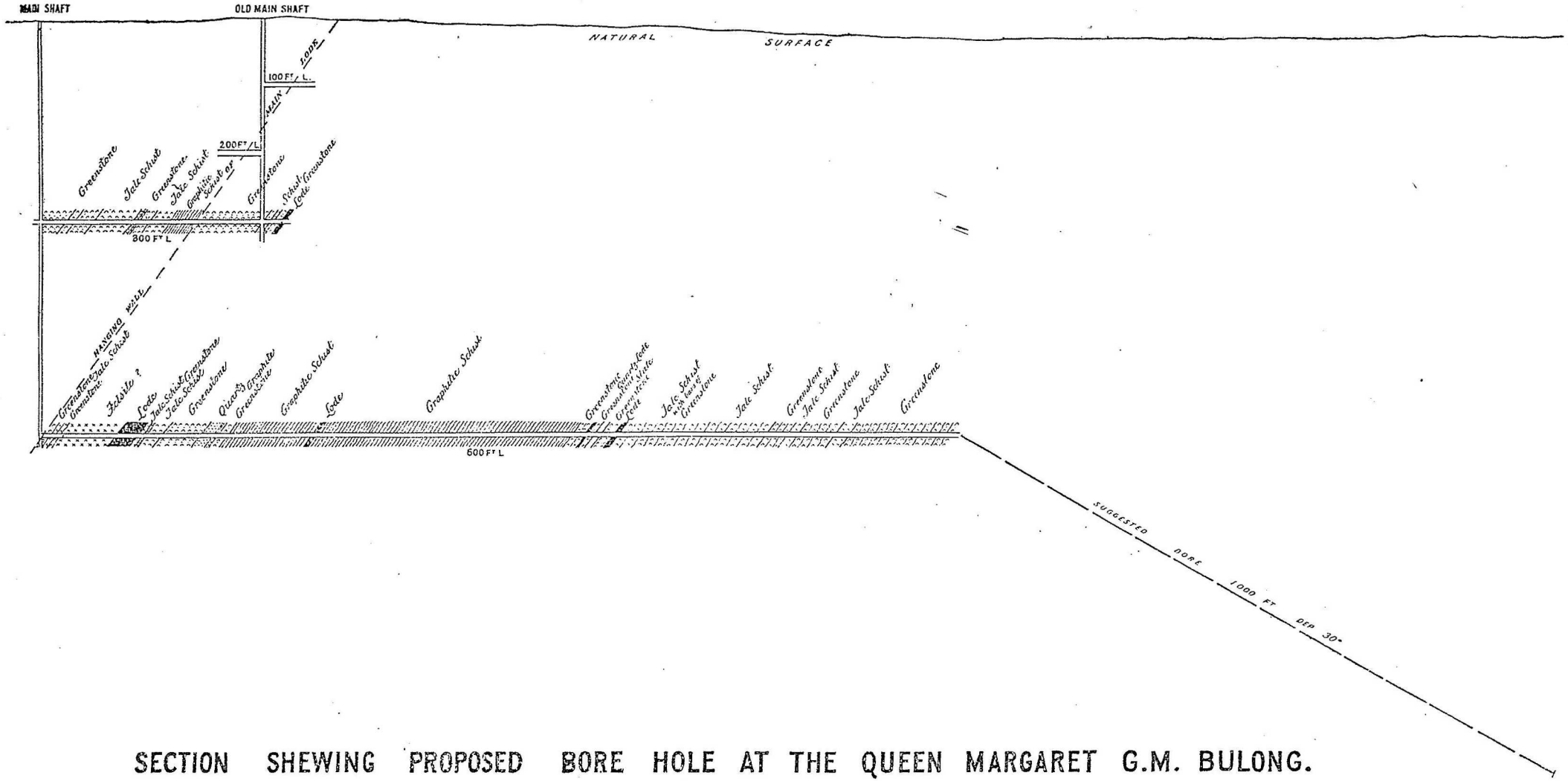
During the year the advice of the Department was sought in the matter of the geological conditions affecting the water supply of different portions of the State.

Wyndham.—In considering the question of the water supply of Wyndham, from the geological standpoint, it is merely necessary to ascertain whether the structure of the country renders it probable that an abundant supply of potable water will be found. The geology of the Wyndham district is simple, as the following section shows:—



GENERALISED SECTION FROM WYNDHAM TO THREE MILE.

A very large portion of the district consists of a plain of a considerable extent covered with deposits of estuarine origin. The staple formation, however, is made up of a great series of quartzites, sandstones, fine conglomerates, shales, and igneous rocks; these sedimentary beds are disposed in a series of broad anticlinal folds.



SECTION SHEWING PROPOSED BORE HOLE AT THE QUEEN MARGARET G.M. BULONG.

60 0 60 120 180 240 300

Scale of Feet

R.H. Irwin del.

The superficial deposits, owing to their mode of origin, contain more or less salt; hence there is no reasonable prospect of any fresh water being obtained by wells deriving their supply from them.

The quartzites and associated rocks, being practically incapable of absorbing and transmitting water through their component granules, hold out no chance of obtaining an artesian supply.

The Northern face of the Bastion Range, at the foot of which the town of Wyndham lies, exposes a section of the sedimentary beds, in which several wells have been sunk, the most important well being that at the Gaol, which attained a depth of 96 feet. From the bottom of the well, boring carried it down to a depth of 690 feet below the surface. After passing through 156 feet of clay shales (and their decomposition products) the drill entered a series of quartzites with thin shaley bands, which continue without interruption to the depth at which operations ceased. This well is reported to yield 1,600 gallons of water per diem in a dry season. There appears, however, to be no information available as to the depth from which this supply is drawn. The clay shales exposed in this well form the base of those outcropping in the Cattle Road in the Range. About 50 or 60 feet above this well another has been put down, and by means of above a fair supply of good water was obtained from a depth of about 40 feet below the surface. The water rose and remained stationary at 15 feet in the bore. This water evidently finds its origin in one of those numerous fissures by which the strata are traversed.

The prevailing dips of the strata being (as may be seen by the Geological Section) towards the South-East, the mass of the water absorbed would be conveyed in that direction towards the Three-Mile and the Southern face of the Bastion Range.

There is a mass of basalt penetrating the rocks of the Bastion Range, which extends without interruption from the Three-Mile as far as the Twenty-Mile; the result of this intrusion being that any water received on the Northern face of the Range, and percolating down the dips, would be checked by this wall of impervious rock, behind which it would tend to accumulate until the water is thrown out by springs.

The well at the Three-Mile is being carried down through the quartzites exposed in the escapement of the Bastion Range, and, if carried deep enough, should penetrate the underlying shales which are seen to be outcropping in the Cattle Road from the wharf of the Three Mile.

The shales are essentially non-water bearing, and any water which they are capable of absorbing and transmitting is that which percolates along the bedding planes, joints, etc. Such being the prevailing geological conditions the Three-Mile Well can hardly be expected to supply more than a limited quantity of water, and it is very doubtful whether such a supply would be independent of the seasons.

None of the wells of the Wyndham district, with one exception, supply really good water, nor is there sufficient prospect of making any material improvement in either quantity or quality to justify any heavy expenditure or sinking deep wells.

Under the circumstances Wyndham will have to depend (failing the success of the Three-Mile Well and that on the face of the range) upon surface conservation.

Owing to the jointed nature of the rocks of the neighbourhood, efficient steps will have to be taken to prevent the possibility of serious leakage from any reservoir or dam. The exact nature of these precautions is a matter for an engineer rather than a geologist.

Metropolitan and Suburban Water Supply.—In the month of September the Royal Commission on the Metropolitan and Suburban Water Supply and Sewerage approached the Department with the object of obtaining a geological report on the probability of obtaining a continuous supply of water from artesian sources within the Metropolitan Area. From the information supplied by the Chairman it appeared that the quantity of water desired to be provided for was five million gallons per diem, and information was especially desired as to whether the supply could be augmented by going deeper than the sources supplied by the bores now existing within the Metropolitan Area, and also as to whether water to be obtained from such greater depths would be likely to be chemically purer or not than that drawn from the present bores.

Geological Conditions.—The consideration of the probability or otherwise of obtaining a continuous supply of water from artesian sources within the Metropolitan Area is pretty much a matter of geological investigation and mapping. Something has been done in this direction, and though the work has been carried out in a restricted way over a comparatively small area, yet sufficient has been accomplished to determine the question at issue.

The map* herewith shows the broader geological features of the neighbourhood, in so far as they have any bearing on the question. The area defined on the attached map by a bold red line marks the boundary of the crystalline rocks and the strata of the Coastal Plain.

It is from the strata of the Coastal Plain that the supply of artesian water has been obtained.

The strata of the Coastal Plain consist for the most part of shallow water deposits, very little consolidated, which were deposited during the various periods of elevation and depression to which this plain was subjected. These strata consist of sandstones, conglomerates and thin shales, with occasional incoherent sands and clays (? marls). These beds are overlain by æolian drifts, partially consolidated by the action of rainwater.

As will be seen by the transverse and longitudinal sections * (upon which have been plotted the geological data obtained from the records of the bores put down during the last few years) the

* It has not been deemed necessary to reproduce this map and sections.

structure of the Coastal Plain differs in some respects from the typical areas in which artesian water has been obtained in the Eastern portion of Australia. The strata of the Coastal Plain are horizontal or nearly so; being at the most inclined at a very slight angle seaward, which is, however, a little greater than the surface gradient. The effect of this disposition of the strata is shown by the fact that the water-carrying beds do not outcrop on the surface at the foot of the Darling Range, but impinge directly against that portion which is at present concealed from view. These layers, clays (? marls), sandstones with occasional limestones, do not maintain a uniform thickness throughout, but are disposed in the form of lenticular beds, some of which have a sponge-like capacity for absorbing water.

Rainfall.—The average rainfall of the Coastal Plain in the vicinity of the Swan and the Canning is over 30 inches per annum, a precipitation which is fairly considerable. The rainfall is disposed in three ways:—

(*a.*) Evaporation.
(*b.*) Surface "run off."
(*c.*) Percolation.

It is the balance that is left after evaporation and "run off" which is available for absorption by the strata upon which the water falls, and is capable of being reached by wells. The data collected and tabulated by the Public Works Department with reference to the actual discharge of the Helena River shows that a good deal of water must disappear underground. These observations, made at two stations, one near Midland Junction and the other near Greenmount, and extend over the years 1899-1901. The westernmost locality is situated on the outcrop of the permeable strata of the Coastal Plain, and the other on the crystalline (or impermeable) rocks. The following table shows the rainfall and discharge at two stations on the Helena River:—

	Station near Midland Junction (A).			Station near Greenmount (B).		
Year.	Mean rainfall.	Discharge of Helena River from catchment 10 sq. m.	Percentage of rainfall on catchment.	Mean rainfall.	Discharge of Helena River from catchment 40 sq. m.	Percentage of rainfall on catchment.
	inches.	gallons.	inches.	inches.	gallons.	inches.
1899 ...	29·49	338,933,885	7·915	33·50	1,653,501,850	8·498
1900 ...	36·99	1,210,242,300	22·533	41·29	5,408,127,410	22·552
1901 ...	31·37	596,500,000	13·096	33·57	2,615,000,000	13·412

From the figures recorded it can be shown that on the average about twenty-two thousand million gallons annually falling on the catchments of the two stations, does not reach these gauging weirs; in other words, allowing nothing for evaporation, there is a total possible absorption of a little over twenty-two thousand million gallons of water per annum.

The conditions which prevail over large areas of the Coastal Plain, as shown by the Geological Sketch Map of the Southern and Western Districts,* demonstrate that rivers of a much larger catchment discharge their drainage into the Plain. It is therefore only reasonable to assume that a large portion of the water from their catchments disappears beneath the surface and helps to feed the artesian reservoir below.

Extent of boring operations.—So far as the latest official statistics with reference to the extent of boring operations available show there are 19 artesian wells in the Metropolitan Area reaching an aggregate depth of 17,738 feet, yielding a total flow of 5,669,504 gallons per diem, which is equivalent to 2,069,368,960 gallons per annum. In addition to these there are three sub-artesian wells of an aggregate depth of 2,654 feet, from which 2,345,000 gallons of water can be pumped daily, or 855,925,000 gallons per annum. Two are in progress, viz., one at Garden Hill, Guildford, and the other at Claremont. The deepest well is at the Zoological Gardens, South Perth, which has attained a depth of 1,856 feet, and yields a daily flow of 372,384 gallons. The largest flow is that of the Guildford Municipal Bore, which is estimated at 1,120,000 gallons per day. Few observations seem to have been made as to the temperature of the water issuing from the bore holes, but up to the present the warmest is that of the Melville Park Estate, on the Canning, where the water issues with a temperature of 91° Fahrenheit.

Variation in pressure and extent of supply.—There does not appear to have been, as yet, any noticeable diminution in the supply of water from the bores in the Metropolitan Area. A lessening or even the cessation of flow would not of necessity indicate permanent exhaustion, for there is always a come-and-go, as it were, in the level of underground water. A diminished flow due to either: (*a*) lateral leakage, through superincumbent porous beds; or (*b*) the choking of the bore, due to "creep," which may affect such soft and plastic rocks as clays and clay shales, or such loose rocks as sand and half coherent sandstone; (*c*) the accumulation of sand and fine mud, or some mineral product; and (*d*) the wearing out of or defects in the piping, can be remedied by methods known to engineers. In the event of any constant draft upon the underground supply having any serious effect, there should be a distinct and marked diminution of the pressure, which constant observation alone could detect. So far as any of the official observations have at present been carried, it does not appear that any considerable diminution in static head has resulted. Obviously if the annual draft exceeds that which the water-bearing beds can absorb and transmit (for a good deal depends upon the rate at which the water can reach the well) a time will come when, after the water accumulated during long periods has been excessively drawn upon, the flow of water over the surface will diminish or possibly cease altogether. A

* Annual Progress Report of the Geological Survey for the year 1898. Plate III. Perth: By Authority, 1899.

decrease in the flow, due to the exhaustion of the head by a constant daily draft is irremediable; the possibility of such can be minimised by shutting off the water at such time as the supply is not required.

Increasing the Supply.—It is desired to provide a continuous daily supply of 5,000,000 gallons, to meet the public requirements. The present daily supply is 8,014,504 gallons drawn from 22 wells within the Metropolitan Area. To bring about an increase in the supply of water, it might be possible to enlarge the existing bores by reaming out to a larger diameter.

The records * of the bores at present put down demonstrate that, with the possible exception of that at the Melville Park Estate, none have been carried deep enough to reach the crystalline rocks forming the floor upon which the strata of the Coastal Plain rest.

From all the available evidence it seems highly probable that other water-bearing horizons (perhaps of greater water-carrying capacity) than those at present known, exist beneath the Metropolitan Area; whether the water obtained from such deeper sources would be likely to be chemically purer than that drawn from the present bores is one of those questions to which a definite answer can hardly be given. The water which percolates beneath the surface dissolves the soluble constituents of the strata to an extent which appears to be in some measure dependent on the composition of the rock it traverses, the depth and the time it remains confined. As a rule artesian waters seem to be less chemically pure than surface waters, for the reason that the further they penetrate and the longer they remain embedded in the strata, the greater are the opportunities for solution. The first water that is drawn from an artesian well is naturally that which has been for a long time without any other means of escape, except the slow method of flow through the stratum in which it is confined. After the first draft upon the accumulated supply the amount which can be taken afterwards is governed by the rate at which the water can travel to the well from ever widening limits, and as such presumably would travel less slowly through the rock, it would be less likely to be so highly impregnated with impurities. Such conditions prevailing it would *primâ facie* appear that with a constant draft on the supply there would be a tendency to less mineralisation. Whether this possible reduction is of practical consequence is a matter of chemical investigation. Where water falls on and is absorbed by quartzose sandstone and allied rocks, and again reaches the surface without coming in contact with calcareous rocks, such would naturally be expected to be relatively free from mineral impurities.

In order to test the artesian possibility of the deeper ground, it would seem on purely geological grounds advisable to put down wells at relatively wide distances apart in order that a much larger area of water-bearing strata would be drawn upon. The distribution of the wells is a matter of considerable consequence, as the evidence adduced by the two bores at Hampton road, Fremantle, testifies. They were put down 142 feet apart.

In the event of experimental boring being undertaken, it would seem desirable to carry out the operations, subject to local modifications, along a line at right angles to the direction of the flow of underground water, or, in other words, parallel to the intake area, *i.e.*, the boundary between the strata of the Coastal Plain and the crystalline rocks.

Winning Pool, Gascoyne River.—The consideration of the question as to whether the rich pastoral lands lying between the Gascoyne and the Ashburton Rivers are capable of yielding artesian water is very much a matter of geological mapping. According to the information extant, it appears that the Lyndon River (on a branch of which Winning Pool is situated) practically drains the carboniferous mesozoic, and tertiary formations. These formations contain beds of such a nature as to readily absorb a large portion of the water which falls upon them, and the various members are so disposed that the lowest of the series crops out in the higher ground which forms the water-shed of the Minilya, the Lyndon, and the Henry Rivers. Owing, however, to the absence of more geological mapping than has at present been carried out to the north of the Lyons, it is impossible to pronounce any very definite opinion on the question of the possibility of the occurrence of artesian water at Winning Pool, beyond that it is within an area a portion of which may be considered favourable in so far as the possibility of the absorption of large quantities of water is considered. During my visit to the Gascoyne no opportunity of carrying my observations so far North presented itself, but from a knowledge of the structural relations of the various geological formations in the Valley of the Gascoyne, the Minilya, and the Lyndon, the impression left on my mind is that the position of Winning Pool is too near what may be called the catchment area to lead one to hope for any overflowing water.

The bore which is now being put down at Carnarvon, will, however, throw a flood of light upon the possibility of artesian water in the pastoral lands of the North-West, but until that is completed I am not of opinion that it would be wise at this stage to carry out any experimental boring so far North as Winning.

Boring.

The following details in connection with the various boring operations in the State were acquired during the year covered by this report.

Carnarvon.—In 1900 † reference was made to boring in the carboniferous rocks of the Gascoyne, with the object of definitely setting at rest the question of the occurrence of coal seams in the formation, as well as artesian water.

Boring operations were eventually started at Pelican Hill, near the coast, and work is at present in progress.

* The Mineral Wealth of Western Australia, by A. Gibb Maitland. Geol. Surv. Bulletin No. 4, Chap. xi., pp. 129-143. Perth: By Authority, 1900.

† Annual Progress Report of the Geological Survey for the year 1900. Perth: By Authority, 1901, p. 27.

The following is a section of the strata pierced :—

Formation.	Nature of Strata.	Thickness. ft.	Thickness. in.	Depth. ft.	Depth. in.
Recent	Superficial deposits	38	0	0	0
	Soft limestone	2	0	38	0
	Soft ferruginous sandstone	29	0	40	0
	No record	7	0	69	0
	Compact limestone	49	0	76	0
	White clay	21	0	125	0
	Fossiliferous limestone	4	0	146	0
	No record	22	0	150	0
	Soft calcareous clay	28	0	172	0
Tertiary ?	Soft calcareous sandstone	50	0	200	0
Mesozoic ?	Soft calcareous clay	100	0	250	0
	Light blue calcareous clay	50	0	350	0
	Blue calcareous clay	150	0	400	0
	Light calcareous clay...	50	0	550	0
	Blue calcareous clay	50	0	600	0
	White calcareous clay	50	0	650	0
	Soft calcareous clay	340	0	700	0
	Tough calcareous clay	10	0	1,040	0
	Soft grey clacareous clay	55	0	1,050	0
	Black pyritous shale	45	0	1,105	0
	Black shale	50	0	1,150	0
	Dark calcareous shale	38	0	1,200	0
	Hard calcareous clay	10	0	1,238	0
	Soft calcareous clay with veins of calcite	8	0	1,248	0
	No record	12	0	1,256	0
	Hard clay shale with small veins of calcite	2	0	1,268	0
	Hard clay shale	16	0	1,270	0
	Hard black shale	14	0	1,286	0
Carboniferous	Hard black shale and small nodules of calcite	30	0	1,300	0
	Hard black shale	27	0	1,330	0
	Green sandstone	4	0	1,357	0
	Sand	45	0	1,361	0
	Shell limestone	32	0	1,406	0
	Dark clay shale	8	0	1,438	0
	Limestone and shell beds	50	0	1,446	0
	Black fossiliferous shale	50	0	1,496	0
	Dark calcareous shale with bands of hard limestone ...	100	0	1,546	0
	Shell beds	50	0	1,646	0
	Dark clay shales	50	0	1,696	0
	(Bore in progress.)				

The bore yielded an overflowing supply of water at the rate of 20,000 gallons per diem.

It is proposed to continue the bore until the base of the Carboniferous Formation has been reached if the tools employed will permit.*

Fremantle Hampton Road Bore.—During 1902 the cores obtained from the Hampton Road No. 2 bore were submitted to me for report. The following is a section of the strata pierced :—

Nature of Strata.	Thickness. ft.	Thickness. in.	Depth. ft.	Depth. in.
Limestone	160	0	0	0
Hard sand (no sample)	1	0	160	0
Mudstone	196	0	161	0
Grey sand and gravel	41	0	357	0
Mudstone	32	0	398	0
Quartz gravel and sand (calcareous)	25	0	430	0
Very soft calcareous sandstone	38	0	455	0
Quartz gravel and boulders	55	0	493	0
Sandy mudstone	141	0	548	0
Hard calcareous grit	1	0	689	0
Sandy and calcareous mudstone	116	3	690	0
Hard grey limestone	0	9	806	3
Soft sandy mudstone	50	0	807	0
Hard mudstone and shell fragments	2	0	857	0
Soft sandy mudstone	20	0	959	0
Shaley mudstone	39	10	879	0
Hard mudstone cemented with carbonate of lime	1	8	918	10
Mudstone with shell fragments	50	11	920	6
Hard mudstone cemented with carbonate of lime	0	4	971	5
Mudstone with shell fragments	17	3	971	9
Granite boulder	0	3	989	0
Mudstone with shell fragments	77	9	989	3
Very hard fine-grained mudstone	1	0	1,067	0
Mudstone with shell fragments, also pyrites nodules, and boulders of granite and diorite	28	0	1,068	0
Coarse sand and mud (? soft sandy mudstone)	57	0	1,096	0
Quartz gravel and grey sand	12	0	1,155	0
Grey clay	7	0	1,165	0
Grey sandy clay	24	0	1,172	0
Grey clay shale	11	0	1,196	0
Yellow sand	115	0	1,207	0
Total	1,322	0	1,322	0

* On the 8th of June, 1903, the depth reached was 2,611 feet, and the water yielded about 300,000 gallons per diem.

The mouth of this bore is 68 feet above sea level; the principal water-bearing horizons are at 490 and 1,246 feet respectively. The static head of the water from the first horizon is 24·5 feet above sea level, and the second 110 feet. The supply of artesian water from 1,246 feet when allowed to flow uncontrolled is 120,000 gallons per day. A sub-artesian supply of 1,227,000 gallons per diem can be pumped from the 490 feet level.

Northampton.—In the year 1901 Messrs. Woodward and Lightly were commissioned to visit the Murchison district in connection with a proposal to erect State Smelting Works at Geraldton. As a result of their investigations it was recommended, *inter alia*, that a diamond drill be sent up to the district with a view of testing some of the lodes at a depth. Instructions were ultimately issued for the selection of sites for experimental boring to be continued on Crown Lands. A site was eventually selected at the Wheal Margaret Copper Mine. The lode is embraced within the limits of a number of abandoned leases, lying about one mile to the East of Northampton. The "Wheal Margaret" lode is said to have varied from seven inches to two feet in width of pretty rich ore. The lode was originally worked by five shafts, which were put down in close proximity in the central lease to a depth of 180ft. in the underlay, and the chute stoped out for a length of 200ft.

Boring operations commenced on the 12th of July, and were suspended on the 8th of October, after the drill had penetrated to a depth of 651ft. Operations commenced at a point about 257ft. from the outcrop, and boring was carried out at an inclination of about 59 degrees from the horizontal.

The bore proved unsuccessful; full details of the strata pierced are found in Pl. I. herewith. It is conceivable that what is shown in the bore record as fault rock (lode stuff?) occurring between 387 and 408 feet, may represent the Wheal Margaret lode, occurring along a line of fault; if so the drill pierced the deposit at a point where it happened to be poor. The total cost of the bore, including incidentals, etc., amounted to £807 16s. 5d.

The second bore was put down at the Old Cow Rock, at Narra Tarra, at an angle of 45 degrees. Operations were commenced on the 1st of November, 1902, and ceased on the 3rd February, 1903, having penetrated to a depth of 600ft. The drill passed through more or less decomposed granite. At 83 and 90 feet, bands of decomposed rock, with a little copper sulphide, were passed through, and at 239ft. a small quartz leader, carrying a little galena and zinc blende, was met with. The bore-hole intersected no lode of any importance. Particulars of the strata pierced will be found on the plan attached, Pl. I. The total cost of this hole amounted to £635 18s. 11d.

GENERAL.

The various members of the staff have, without exception, continued to discharge their respective duties with assiduity.

I have, etc.,

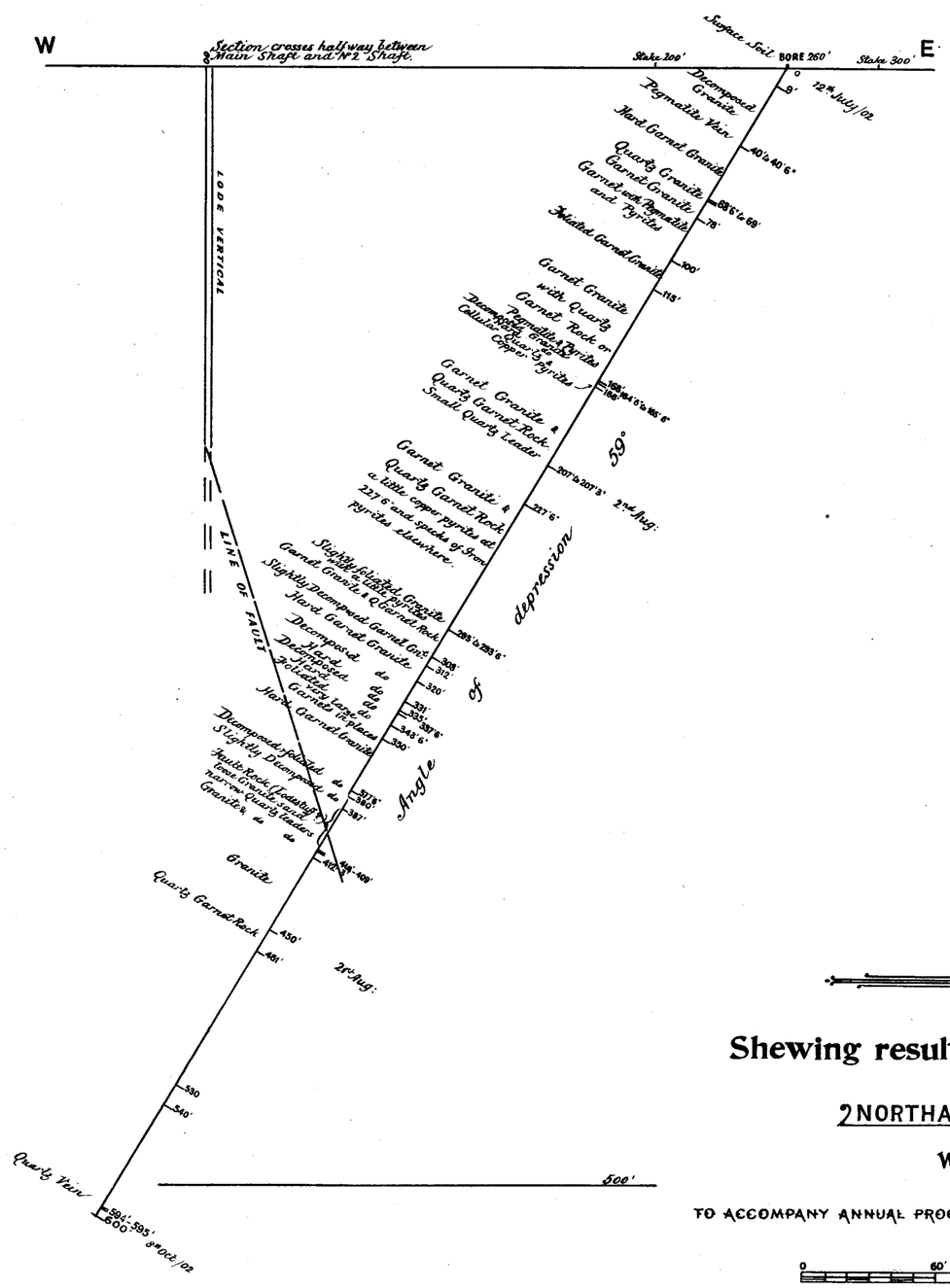
A. GIBB MAITLAND,

Government Geologist.

By Authority: Wm. Alfred Watson Government Printer, Perth.

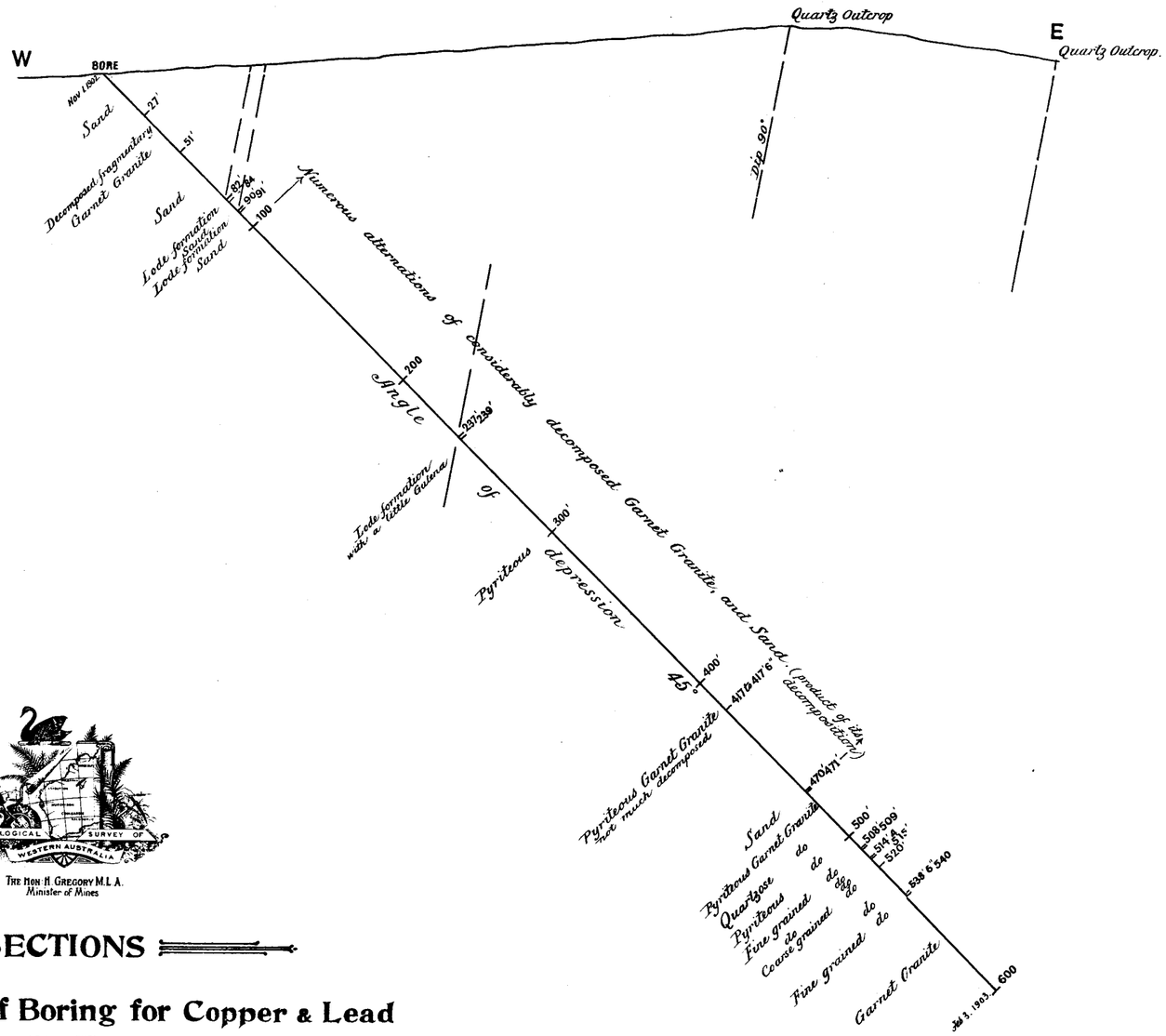
CROSS SECTION
OF THE
WHEAL MARGARET COPPER MINE

MAGNETIC BEARING 142°



CROSS SECTION
AT
BORE SITE NEAR OLD COW ROCK NARRA TARRA.

MAGNETIC BEARING 284°



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

SECTIONS

Shewing results of Boring for Copper & Lead

IN THE

NORTHAMPTON MINING DISTRICT

BY

W.D. Campbell A.M.I.C.E., F.G.S.,
ASSISTANT GEOLOGIST

TO ACCOMPANY ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY FOR 1902

0 60' 120' 180' 240'

Scale of feet.

Alfred Maitland
Government Geologist

R. H. Irwin del. 11/3/03.

H. J. Pecher, Government Photolithographer, Perth, W.A.