1901.

WESTERN AUSTRALIA.

ANNUAL

PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

FOR THE YEAR

1900.

(WITH FOUR PLATES AND ONE FIGURE.)

Presented to both Houses of Parliament by His Excellency's Command.

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Annual Progress Report of the Geological Survey for the Year 1900.

The Honourable the Minister for Mines.

Geological Survey Office, 395 St. George's Terrace,

SIR, Perth, 10th March, 1901.

I have the honour to submit, for your information, the Report of the Geological Survey for the Calendar Year 1900.

The order of arrangement of the different matters dealt with is somewhat similar to that followed in the reports of previous years. A series of maps and sections, in explanation of the work of the Department, is attached.

In a previous report, attention was drawn to the fact that a good deal of the value attaching to reports upon the practical applications of geology is discounted by delay in publication, an inevitable condition of affairs when detailed descriptions are included in the Report presented annually to Parliament. To overcome this difficulty it was suggested that the Report presented to Parliament should take the form of a mere Summary Report, containing only a succinct account of the principal scientific and economic results obtained during the year.

This Report therefore forms, to a certain extent, a summary of the work performed during the year.

THE STAFF.

The work of the Department has been carried out during the year by ten officers. Several changes in the *personnel* of the staff have taken place.

Mr. Torrington Blatchford, the Senior Assistant Geologist, who joined the Department in March, 1897, resigned his position on the Survey on the 31st of May, but owing to the exigencies of the Department it was not possible for his resignation to take effect before the 30th of June. By the severance of his connection with the Department the State has lost the services of an officer whose usefulness was beginning to make itself properly felt, but the increased emolument offered in private professional work weighed heavily with Mr. Blatchford in arriving at this decision.

The vacancy thus caused was filled by the promotion of Mr. W. D. Campbell, and the position of Topographical Surveyor, previously held by him, was abolished. Mr. Campbell's appointment as Assistant Geologist took effect from the 1st of July.

Towards the close of the year it became necessary, in order that the work of the Department might be expeditiously carried out, to fill the appointment of Assistant Geologist, rendered vacant by the promotion of Mr. W. D. Campbell to the post relinquished by Mr. Blatchford. As it was not found possible to secure the services of a trained officer capable of immediately undertaking responsible independent work, it was deemed advisable to appoint an officer possessing the requisite scientific education,

such as is provided by one of the Australian Universities, and to endeavour to train him in the specialised class of work which the duties of the Department demand. To this end Mr. C. G. Gibson, a graduate of the Sydney University, was appointed to the vacant post. This gentleman entered upon his official duties in December, and until the close of the year was engaged in assisting in the Laboratory.

Mr. E. S. Simpson, the Mineralogist and Assayer, was absent on leave from 26th March to 12th May. In small departments, where the duties are of a professional or other exceptional character, it happens that, unless some special arrangements are made, an officer might be practically debarred from obtaining any leave of absence other than recognised public holidays. Under these circumstances it was found necessary for the Department to avail itself of the services of Dr. F. S. Earp, who therefore took charge of the Laboratory during Mr. Simpson's absence.

The appointment of Clerk and Accountant, rendered vacant by the decease of Mr. P. F. Pelly, was filled on the first of January by the transfer of Mr. F. J. Kelly from the Accountant's branch of the Mines Department. During the year this officer has rendered essential service to the Department, attending to the routine work in connection with the accounts, and to the questions raised in the numerous official files, in addition to acting as my amanuensis.

The Laboratory Assistant, Mr. C. C. Williams, was absent on leave from the 10th February to the 9th April.

FIELD WORK.

The field work of the year has been distributed, as in previous years, over various portions of the State.

A considerable portion of my own time during the year was devoted to the work in connection with the geological examination of Kalgoorlie. Visits were also paid to Kanowna, Bulong, and Coolgardie, in connection with proposals to bore for alluvial leads. The first week in September found me at Norseman in connection with the granting of a subsidy in aid of deep sinking to the Norseman Gold Mines, Limited. From the 25th September to the 10th October I was employed in an examination of the Greenbushes Tinfield, while from the 11th to the 14th of October was devoted to the gold finds on the Preston River. The months of November and December found me engaged in an examination of the country between Cue and Carnarvon, in connection with the question of obtaining a supply of artesian water at the latter place.

The Assistant Geologist, Mr. Torrington Blatchford, was absent on leave during the whole of January and up till the 12th February. Thereafter, until the date of his resignation, he was engaged at Donnybrook, the country in the vicinity of Albany (in connection with the possible occurrence of coal), and the Phillips River Goldfield.

The Assistant Geologist, Mr. W. D. Campbell, was engaged during the greater part of the year upon the work in connection with the geological survey of Kalgoorlie, together with periodical inspections, towards the close of the year, of the alluvial boring work at Kanowna and Coolgardie. The work of tracing the underground plans, which had been commenced in the middle of September of the previous year, was not completed, despite Mr. Campbell's most strenuous efforts, until the middle of March. The completion of the topographical information on the map of Kalgoorlie was put in hand immediately the underground plans had been disposed of. The area under examination was about $9\frac{1}{2}$ by $6\frac{1}{2}$ miles, or nearly 62 square miles, of which 33 miles along the most central portion had been previously mapped, leaving about 29 miles to be contoured by Mr. Campbell, in addition to certain corrections which had been found necessary in other portions.

PRINCIPAL RESULTS OF THE YEAR'S FIELD OPERATIONS.

The operations of the Department during the last calendar year have as usual been confined to those which have a direct bearing upon the economic aspects of geology, and it is hoped that in the results therefrom expectations have been fully realised. The following is an account of the year's work:—

KALGOORLIE.—The importance of Kalgoorlie, and the vast interests connected therewith, rendered it imperative that a detailed geological survey should be carried out. The survey was undertaken with the object of furnishing an accurate basis upon which the work of the prospector and the mining engineer might be founded, for universal experience has shown that many mining failures have been due rather to a want of knowledge of structural geology than to a lack of engineering training.

When this work was commenced, it was found that there was no topographical map upon which the areas of the different formations, the geological boundaries, and the underground workings could be laid down, for as a rule any surveys carried out by the different State Departments are designed to meet the immediate demands of the public for land, no attempt, unless under exceptional circumstances, being made to delineate the relief of the ground. As a preliminary step towards remedying this, it was found necessary to prepare a topographical map designed to be issued as a basis for the geological and mining details. This survey was entirely carried out by means of the tacheometer, the efficacy of which for work of this special nature has been amply demonstrated. A great deal of time and labour was involved in this preparatory work, which could have been more profitably expended by the geological staff in other directions. The whole of this work is now virtually complete and ready for publication.

As the examination of all the mines will occupy some considerable time, it is intended to publish in the meantime a first edition of the map of the district giving the topographical details, and subsequently an edition showing the actual or inferred trend of the lodes, together with all the geological information acquired in the course of that examination. When finally complete the work will comprise:—

(*a.*) A two-sheet map, on the scale of 4 chains per inch, of what is known as "The Golden Mile," showing all the underground workings, the trend of the lodes, the area covered by the different geological formations, and other cognate points.

(*b.*) A four-sheet map, on the scale of 10 chains per inch, of the country between Hannan's Lake and a point about a mile North of Kalgoorlie, thus embracing the whole of the productive area of the goldfield.

In addition to these, there will be a sheet of vertical sections, upon a suitable scale, depicting the structural relations of the ore bodies, and the enclosing rock-masses.

The geological map of Kalgoorlie will mark a great advance on any official plan yet issued of the goldfields of the State. In addition to geological and mining information, all the prominent land marks, such as hills, shafts, batteries, etc., are shown, as these are of far greater value for purposes of location than lease pegs, and imaginary boundary lines which can never be regarded as permanent. The map should thus prove of use not only to the mining community, but to the public at large. The carrying out of similar work at other important mining centres, when opportunity offers, is in contemplation. A full report upon the geology of the area embraced by the field work is in course of preparation, but as this involves the completion of many chemical analyses, and much microscopic work which, owing to the increasing demands upon the time of the staff, cannot readily be undertaken during usual official hours, some little time must necessarily elapse before the work is complete, and ready for the

printer. The following is a *résumé* of the salient geological features, so far as they are at present understood.

The geological structure of Kalgoorlie is not, as has been anticipated, of extreme simplicity. The staple formation of the field consists largely of certain schistose rocks, some of which are distinctly of sedimentary origin. The sedimentary rocks are now represented by black and pyritous shales, slates, hæmatite-bearing and jaspery quartzites, greywacke, and sandstone. Associated with these beds are amphibolites, and derivatives therefrom, which in all probability represent igneous rocks; but whether these occur in the form of lava flows or are of intrusive nature has not yet been determined. In addition, certain undoubtedly intrusive igneous rocks of both a basic and acidic type are met with. The structural relations of these different rocks are being exhaustively worked out.

So far as observations have at present been carried, almost all the rocks would appear to have been highly altered both chemically and dynamically, and it is by no means improbable that the mechanical movements to which they have been subjected have been repeated more than once. The alteration produced has not been uniformly distributed, for black pyritous shales with barely any trace of metamorphism occur in intimate association with the more highly altered beds. A pseudo-conglomerate and breccia form a prominent feature underground in a portion of the field. From present observations, it does not appear to be of littoral origin, but rather to be due to the mechanical deformation of the surrounding rocks *in situ*, in reality a crush-conglomerate of breccia. The lodes are for the most part bands of the basic rocks, which are characterised by a strong foliation, the alteration of the amphibole into chlorite and carbonates of iron, lime, manganese, and magnesia, and finally the development of secondary silica, mica, pyrites, gold, tellurides of gold, etc. There are no grounds for believing that the mines of Kalgoorlie have reached the limit of ore deposition, or that the lodes will not prove productive in depth.

Mr. E. S. Simpson is engaged upon a series of quantitative analyses of the rocks of Kalgoorlie, and has submitted to me the following preliminary *résumé* of the results of his researches:—

The chemical examination of the rocks of the Kalgoorlie district has been so far chiefly confined to those from the immediate vicinity of the more important mines of the Boulder belt. The rocks consist of amphibolites and their derivatives, acid eruptive rocks, ultra-basic eruptive rocks, and a series of sedimentary rocks.

Amphibolites and their Derivatives.—The rock mainly developed within this area is a *Greenstone*, or Diabase, the product of chemical alteration of a basic rock, which appears in an undecomposed state on G.M.L. 1219E. On this lease the rock (2117*) is a coarse-grained light green *Amphibolite*, consisting mainly of amphibole, with a little plagioclase and alteration products. It is of too basic a character to be looked upon as a true diorite; its chief constituents being: Silica, 44 per cent.; ferrous oxide, 14 per cent.; alumina, 11 per cent.; lime, 10 per cent.; magnesia, 11 per cent. A massive rock of similar character occurs also close to the junction of the Kanowna and Menzies railway on the North, at Mt. Hunt on the South, and at one or two intermediate points.

Alteration products of this rock compose, however, the greater part of this field. At Mt. Hunt a foliated but otherwise unaltered form (598) appears. Towards the centre of the field chemical changes have been very marked, being first in the direction of the absorption of water with consequent development of chlorite, and in some cases epidote, and also of a little carbonic acid with consequent formation of carbonates of lime and magnesia. The latter are readily removed by underground waters so that we find the greater alteration the rock has undergone the less lime and magnesia does it contain. The average of a number of samples of a Greenstone or Diabase of this nature was: Silica, 45·5 per cent.; carbonic acid, 9·1 per cent.; ferrous oxide, 12·4 per cent.; alumina, 10·8 per cent.; lime, 7·8 per cent.; magnesia, 3·5 per cent. By the further action of carbonated water the whole of the chlorite of this rock is decomposed, and we have as the result a very compact pale grey *Siderite-rock*, in which practically all the iron, manganese, lime, and magnesia are present as carbonates. A rock of this nature (1751) in the Ivanhoe mine, having the outward appearance of a quartz porphyry, was found to contain: Silica, 42 per cent.; alumina, 8 per cent.; ferrous carbonate, 24 per cent.; calcium carbonate, 10 per cent.; magnesium carbonate, 3 per cent.; manganese carbonate, 1 per cent. A second example (1828) from Chaffer's mine was still further altered by the formation of a considerable amount of magnetite, at the expense of the ferrous carbonate. By foliation and the development of a little sericite, this rock passes (in the Golden Horseshoe Mine) into a *Siderite Schist* (1796) containing 22 per cent. of ferrous carbonate.

* The numbers in parentheses are those of the Geological Survey Collection Register.

Returning to the greenstones: by strong foliation these become *Chlorite schists*, varying in colour from dark green to greenish grey. The mean composition of two samples, one (1730) from the Imperial Boulder G.M., the other (1750) from the Oroya G.M. was: Silica, 43·1 per cent.; carbonic acid, 11·5 per cent.; ferrous oxide, 12·8 per cent.; lime, 11·1 per cent.; magnesia, 3·4 per cent.

These chlorite schists being more easily permeated by water than the more massive rocks are still more liable to suffer metasomatic change, and so, especially on the Eastern side of the Boulder belt, there is a large area of schists varying in nature from a dark green highly chloritic rock to a pale grey or pink carbonated rock.

It would appear that in the extreme stage of alteration of the chlorite schists, a rock is reached in which a considerable amount of the carbonates has been removed in solution with a consequent enrichment in silica up to 62 per cent., and in alumina up to 14 per cent. The study of the gradations between this supposed extreme type and the original chlorite schists is yet to be undertaken.

The surface weathering of the amphibolites and other highly ferruginous rocks results in the formation of cappings of *Laterite* consisting of massive, cellular or nodular ironstone. Remarkably pure iron ores are common in these deposits: one sample (1937) from the Thunderbolt Lease, containing 57·6 metallic iron, only 1·6 per cent. silica, and 8·6 per cent. water. These rocks also require further investigation.

Acid Eruptives.—The only two undoubted acid eruptives recognised within the area under review are *Felspar porphyries*. A foliated white rock (1435) of this nature forms a narrow dyke which has been traced from the South Kalgurli Lease (1208E) to the Eleanor Lease (921E). A dyke of grey felspar porphyry (1743) occurs on the Lake View Consols No. 2 Lease (1064E), which may be only the Southern extension of the first-mentioned dyke.

Ultra-Basic Eruptives.—An outcrop of *Peridotite* occurs on the South shore of a well marked bay* on the Western side of Hannan's Lake, as well as on two adjacent small islands. On the mainland this rock is very much weathered, but in places is found altered into a serpentine (248). On the island near the South headland of the bay the alteration has been into a granular crystalline carbonate rock containing: Silica, 31 per cent.; carbonic acid, 27 per cent.; ferrous oxide, 8 per cent.; lime, 5 per cent.; magnesia, 17 per cent. A less highly altered portion of this peridotite outcrops on a second island 12 chains West-South-West of the first.

A single specimen (274) of a serpentinous nature was collected from the Black Cat lease (3862E), North-East of Kalgoorlie townsite. This may be portion of a second ultra-basic intrusion.

Sedimentary Rocks.—Highly-inclined rocks of undoubted sedimentary origin extend from one end of the field to the other in comparatively narrow bands, bounded on either side by amphibolites or their alteration products. These rocks range in character from a soft grey *Sandstone* (369) to a compact flinty *Quartzite* (2226), or a strongly foliated *Siliceous schist* (1739), in which almost all trace of its original structure has been obliterated; and from soft grey or black *Shale* to a hard grey or graphitic *Slate*, or *Jasperoid claystone* (1475). A *Sericite schist* (597) occurs on the Madge lease (1638E). *Breccias* (159, 1726) composed mostly of fragments of slate are also known.

Only three examples of sedimentary rocks have been analysed, and these do not differ in any marked way from those of other parts of the globe. It is interesting, however, to note that whereas the quartzites of most other districts in central Western Australia are characterised by numerous interbedded bands of hæmatite, those of Kalgoorlie are almost without exception entirely free from them.

More recent *Sands*, *Clays*, and *Gravels* of the usual type cover a large portion of the surface of the field. Between Boulder and Hannan's Lake there is a bed of *Siliceous sinter*.

Auriferous Lodes.—The "lodes" of the Southern portion of the field are for the most part bands of foliated greenstone or of chlorite or carbonate schists derived therefrom, which have been impregnated with gold, gold and silver tellurides, etc., and which pass insensibly on either side into non-auriferous greenstone. They are frequently interlaced in every direction with small veins of quartz. In the Ivanhoe, and some other adjacent mines, some of the ore bodies are composed mainly of quartz, being either quartz reefs or beds of quartzite. A grey sandstone (1732) from the Forrest King Lease (917E) was found to carry 1·688oz. gold per ton, whilst flake gold has been found in slate in the Lake View Consols Mine.

The full details of these investigations will appear in the report on the Kalgoorlie Goldfield, which can only be undertaken on the completion of the field work.

PHILLIPS RIVER GOLDFIELD.—In the early part of the year, an examination of the Phillips River Goldfield was made by Mr. Blatchford, the Assistant Geologist. From this officer's researches it appears that the staple formation consists of crystalline and metamorphic rocks, covered with those nodular ironstone (? laterite) deposits, which form such a striking feature in many parts of the State.

The granitic rocks of the district naturally vary considerably both in composition and form. Both the mica and the felspar occur in places in large masses, in some cases of such a size as to make the exploitation of the former upon a commercial scale possible. In one portion of the field about two miles South of Cocanarup Station, is a

* This is just within the North-West corner of Water Lease 9.

belt of coarse grained tourmaline granite; and about half-a-mile South of Ravensthorpe ("Central Camp") this rock carries very large crystals of Spodumene (silicate of alumina and lithia). The relation of this tourmaline granite to the prevailing granitic rocks of the field is not quite clear as yet. Its occurrence indicates the possibility of tin being found in the vicinity.

The granitic rocks have been intruded by basic dykes, which for the most part are narrow, seldom exceeding a few chains in width. They appear to have a remarkably persistent North-Easterly trend, and can be readily traced across country by the peculiarity of the vegetation. These basic rocks have been the subject of microscopic examination, and have been found to bear a close resemblance to certain of the rocks occurring in the Coolgardie Goldfield, and described in previous reports.* They vary from fine-grained hornblendic rocks, to an almost pure coarse grained amphibolite. The dykes seem to have emanated from a boss of diorite (?), which occurs in the immediate vicinity of the principal mines. This boss attains a width of not less than three miles in places. Mr. Blatchford notes that where the granite has been invaded by these basic dykes, the former has been rendered more or less gneissic, and that it is as a rule impregnated with crystals of garnets of all sizes. These garnetiferous rocks seem to be intimately associated with the occurrence of copper ores. The possibility, however, of the intrusion of these basic rocks in the foliated bands being consequent upon such foliation, rather than the cause thereof, should not be lost sight of.

A fairly large development of banded quartzites forms an important feature in the Ravensthorpe Range. Evidence has been adduced which goes to show that they are of sedimentary origin, and were originally sandstones laid down upon a floor of crystalline rocks, and afterwards subjected to conditions which partly obliterated their clastic character, and also rendered any accurate observations of their dip and strike almost impossible. No evidence has been adduced as to the age of these quartzites. There are, however, good grounds for believing that the quartzites of the Ravensthorpe Range are correlated with those of the Stirling Range, Eyre's Range, and the peaks adjacent thereto.

The ore deposits of the Phillips River district may be divided into two classes, viz., (*a*) siliceous gold ores, and (*b*) ferruginous copper ores. According to Mr. Blatchford's researches, there appear to be two classes of quartz reefs, the larger and more defined class consisting of large bodies of milky white quartz, free from gold; while the others are usually of less size, clearer, and more glassy in appearance, and usually heavily charged with oxides of iron. The latter class contains most of the gold. In most instances the gold in the quartz reefs is not of a coarse nature, very fine gold being most prevalent. There are numerous cases, however, in which the gold is found in "rough" pieces, having a weight of several grains. The gold is well distributed throughout the stone, and in consequence there has been little chance of extracting much of the metal by means of the dolly pot, as was the case on most of the Eastern and Northern fields.

Though copper is a frequent associate of the quartz, it is gratifying to see that, where copper does occur in appreciable quantities, the percentage is great enough to enable the stone to be classed as a copper ore. The ferruginous copper ores appear to be the most important on the field. The lodes attain a considerable size, and seem to present all indications of permanency. Evidence has been collected which tends to indicate that the lodes belong to the true fissure type. The ores consist very largely of malachite, chalcosite, and other rich copper-bearing minerals with little or no gangue

* Torrington Blatchford. The Geology of the Coolgardie Goldfield. Bulletin No. 3, Geological Survey, Perth; By Authority: 1899.
Torrington Blatchford, The Coolgardie Goldfield. Annual Progress Report of the Geological Survey for the Year 1897. Perth; By Authority: 1898; p. 57.

other than oxide of iron. The average composition of this type of copper ore, as determined in the official laboratory proved to be:—

Copper	... ...	31·48 per cent.
Silver	... ...	2·16ozs. per ton.
Gold	... ...	·15ozs. per ton.

Up to the close of 1900 the output of the field, as shown by official data, does not appear to be large, the returns being 39ozs. of gold, together with 34 tons of copper valued at £725.

Gold Finds on the Preston and Ferguson Rivers.—The country drained by the Ferguson River and its tributaries, presents many points of resemblance to that of the adjacent Donnybrook Goldfield. The first sign of mining operations is met with upon Location 639 *, where a shaft has been put down to a vertical depth of 30 feet, on the Eastern slope of a hill which trends North and South. The summit of the hill is covered with a mantle of ferruginous sandstone (? laterite) of no great thickness. The shaft was inaccessible, but enough was visible to show that the sinking had been carried on through a rock—in all probability a porphyry—decomposing in the direction of kaolin, and traversed by a network of quartz veins. The rock itself forms a conspicuous outcrop trending slightly to the West of North, along the summit of the hill. No estimate of the width of the rock can be arrived at owing to the cover of laterite (?), to which allusion has previously been made. Fine gold is reputed to have been obtained from the quartz by those engaged in sinking the shaft. No gold nor any other mineral was visible in any of the stone lying at grass.

Further to the Southward, on Location 48/429 †, a shaft has been carried down to a depth unknown to my informant. The workings were inaccessible. On washing a dish of the material from the dump, a few colours of dendritic gold (so characteristic of certain portions of the Donnybrook goldfield) were obtained by myself.

Location 843 ‡ has also been the scene of prospecting operations, but the shaft was absolutely inaccessible. The material on the dump was identical in its character with the kaolinic matter exposed in the shaft on Location 639, previously mentioned.

The localities previously alluded to are all situated in country drained by the head waters of the Ferguson River. Prospecting operations seem to have entirely ceased in this neighborhood.

A little desultory prospecting has been carried out in the bed of a gully at the head of one of the branches of the Preston River, about five miles from the North-East boundary of the Donnybrook Goldfield, as legally defined by the authorities. Operations have been carried out upon two claims lying about 35 chains South-East of Location 747§. Prospecting, which cannot however be said to have been seriously undertaken, has shown that the alluvium, which is very shallow, and, owing to the physical configuration of the valley, not very wide, contains gold, some of which is extremely coarse.

A trench was put in across an untried part of the valley, under my supervision, and the wash dirt cradled. By this means a fair quantity of gold was obtained from a depth of about eight inches. I was also able to satisfy myself of the auriferous character of other portions of the creek bed in close proximity. The "bottom" was less than two feet in depth, and was formed of those crystalline rocks (traversed by quartz veins) which flank both sides of the valley.

The known occurrence of crystalline rocks indicates the source from which the gold has been derived. Some shafts had been put down on the high ground in the hope of striking a quartz reef; they were, however, not accessible to me, but from the material at grass the impression left on my mind was that they were not very successful. Further prospecting, judiciously carried out, might result in the discovery of the source of the alluvial gold.

* Lands Department. 1-Mile Map, S. 16. † Lands Department. 1-Mile Map, S. 22. ‡ Lands Department. 1-Mile Map, S. 22.
§ Lands Department. 1-Mile Map, S. 22.

On assay, in the official laboratory, a sample of the alluvial gold yielded the following:—

Gold	929
Silver	71
	1,000

The value of the gold therefore being £3 18s. 11d. per ounce.

From all the evidence available, there seems to be good grounds for a little more vigorous and more systematic working of the alluvium in the bed of the gully, than at present obtains. From what can be seen, the lower portion of the valley is just as likely to carry gold as the localities at which it is at present known. No survey having been made of the creek, I am not aware as to where it joins the Preston.

In view of the fact that this district has proved undoubtedly auriferous, and that in the near future prospecting may be extended lower down the creek and its tributaries, it seems that the boundaries of the Donnybrook Goldfield might be reasonably extended so as to include this area. Before, however, the limits of a possible extension can be definitely determined, it seems desirable that a rough traverse of the creek in which the gold discoveries have been made should be carried out. This having been mapped, the Eastern boundary of the extension could more easily be fixed.

The Present Condition and Future Prospects of the Greenbushes Tinfield.—On the occasion of a visit to Greenbushes, in connection with the deep sinking subsidy, I received instructions to examine the district and furnish a report on the present condition and future prospects of the field.

In the report which was made in 1899* a full description was given of such of the workings as were then open to inspection. The progressive development of the field is shown by the quantity of tin raised up to the end of September, 1900, which the latest official data at my command show to be 327·84 tons, valued at £22,637. Owing to the unusually protracted wet season, access was not obtainable to many of the mines on the field, for some had fallen in, whilst in others water was still standing, hence a complete description of the whole of the workings cannot at present be given. What may be called "lode tin" (using the term to mean the ore derived from the parent rock as distinct from the stream tin) has been opened up in several localities since my previous visit was made.

The following notes embrace a description of what could be seen in the few workings open to my inspection:—

Last Chance Lease 172 (149).—This property lies near the Southern boundary of the field, some distance to the South of Hester's Troughs, and considerably beyond the limits of the country prospected at the date of my previous visit to the district. A vertical shaft had been put down to a depth of 38 feet. The sinking showed about eight feet of conglomerate succeeded by a tourmaline-bearing rock, trending N. 20° E., and dipping to the Westward at a high angle. The width of the deposit was about two feet three inches, but at the foot of the shaft it reached as much as four feet six inches. An assay (2519) of what appeared to be a characteristic sample of the concentrates from this rock yielded 52·4 per cent. of metallic tin, whilst a sample (2520) from the dump yielded 43·8 per cent. of tin. The relatively low percentage of the tin in these two samples is chiefly due to the somewhat crude method of washing in the dish. The tin ore seems concentrated round a joint plane, by which the country rock is traversed. In the material in the dump tin ore could be seen embedded in a friable quartzose matrix, which does not, however, seem to be derived from a quartz reef, but is rather a portion of the country rock in the vicinity of a joint plane from which, by the solution of felspar, silica has been set free to produce quartz.

* A. Gibb Maitland. The Greenbushes Tinfield. Annual Progress Report of the Geological Survey for 1899. Perth: By Authority, 1900. Page 15.

Messrs. Offer and Gilbert's Ground.—This property lies a little distance North of the "Last Chance." A shaft has been sunk to a depth of about 40 feet vertically below the surface. The shaft itself is not straight, but has been sunk partly vertically and partly inclined, its course having been determined by that of the ore-body. The shaft which has not yet been sunk far enough to reach sound rock, follows down a rock decomposing in the direction of kaolin, and carrying very coarse tin and tourmaline. The ore deposit is merely an impregnation along a line of weakness, either a joint plane or a fracture. So far as work has at present been carried, it seems that this impregnation has extended across a width of about two feet six inches to three feet. A characteristic sample of my own selection from the foot of the workings was carefully washed for the purpose of concentrating the tinstone, which was found to assay (2514) 63·4 per cent. of metallic tin. This percentage, of course, gives no indication of the quantity of tinstone in the matrix. The cassiterite itself was very brittle, owing to its being traversed by strings of decomposing country rock.

Messrs. Neville and Party's "Haphazard" (M.L. 147).—Two shafts connected by a crosscut at 50 feet from the surface have been put down upon what has been regarded as "lode matter." Shaft No. 2, having been timbered to within a short distance of the bottom, prevents the section of rock pierced being examined. The foot of the shafts shows a decomposing tourmaline bearing gneiss, dipping West, and trending N. 30° E. The tourmaline is often of large size, and some very highly ferruginous ore is associated with it. From the foot of No. 2 shaft a crosscut 50 feet in length connects with No. 1 shaft. The first 30 feet of the crosscut from No. 2 shaft has been carried through a decomposing granite rock, succeeded by about 20 feet of tourmaline gneiss dipping to the West. No "lode" has yet been discovered in the workings. In other portions of the property the residuary sands and gravels have been worked with fair results. Some of the material assaying (in the official laboratory) low in tin, viz., 11 per cent., was found to be associated with quartz, garnets, limonite, magnetite, tantalite, zircon, and ilmenite.

N. B. Salmon (Claim 617).—This claim is situated on Bunbury Gully, to the Eastward of the Yarana Lease. Two shafts have been put down to reputed depths of 15 and 27 feet respectively. Being full of water both were inaccessible to me. The owner, Mr. Salmon, informed me—and I have no reason for doubting the authenticity of his information—that in the deeper shaft the "wash" (residuary gravels, etc.) extends down to about 16 feet from the surface, and that the rest of the sinking had been through a decomposing granite. I satisfied myself from sampling the dump that the material was stanniferous, and that the tinstone was coarse and angular, and could not have travelled very far from its parent source.

Queen of Greenbushes (M.L. 80).—Three vertical shafts have been put down in close proximity to each other upon the property. The most Northerly, No. 2 shaft, had been carried down to a vertical depth of 60 feet, through a white granitic rock, carrying small quantities of tourmaline. From the foot of the shaft a drive had been put in to the North for a distance of 15 feet through a whitish granitic rock identical in character with that passed through in the shaft. At nine feet from the face the granite gives place to a clay, which may represent the decomposition product of a porphyry. The junction between the two deposits dips to the South at an angle of from 40 to 50 degrees. This drive has been continued Southwards from the shaft, through a similar granitic rock, for some distance until it intersects another drive trending East and West, connecting with No. 1 shaft. Where the two drives intersect, a winze has been sunk for a vertical distance of 18 feet to what is known as the 80-feet level. A few feet below the floor of the level in the winze a fairly large quartzose portion of the granite which carries tourmaline is said to have yielded fair prospects of tin. None,

however, was visible to me. No. 1 shaft, 60 feet in depth, has been sunk through a rock carrying a little mica and decomposing in the direction of kaolin, in all probability a granite of the type prevailing on the field. A drive has been put in a few feet South from the shaft through clayey country, intersected by a quartz leader. No. 3, or the Main Shaft, (five feet by three feet) has been carried down to a depth of 100 feet, through a decomposing granitic rock. From the bottom of the shaft a drive has been put in to the Westward for a distance of 20 feet. The face of the drive exposes a hard foliated quartzose granitic rock with tourmaline, inclined at a steep angle to the Westward, and trending approximately North and South. What may be called the hanging wall of the foliated granite is a highly micaceous schist which has been penetrated a few inches. The thickness of the foliated granite—the so called lode—is about 10 feet. A carefully selected sample of the "lode" yielded, on assay in the official laboratory, an appreciable quantity of tin, viz., ·09 per cent. On the arrival of my specimens in Perth, it was found that certain fragments of metallic tin—not obtained from the "lode"—were included in the sample. These were, of course, extracted before assaying. A small sample of the dressed ore from the property yielded on assay 47·6 per cent. of metallic tin. A great deal of genuine labour has been done upon the property, which the owners inform me represents about £600 in cash. There is no true fissure lode opened up anywhere in the mine, the appearance of a hanging and foot wall being due to the jointing of the country rock, and a deceptive indication from a miner's point of view.

Greenbushes Tin Development Company (Cornwall M.L. 40).—This property lies near the centre of the tinfield, and not far from its highest point. A three-chambered shaft has been sunk to a depth of about 120 feet, and is closely timbered throughout, thus preventing a section of the rock passed through being examined. The present holders of the property did not sink the shaft to 100 feet, this depth having been attained by previous owners. The last 20 feet of the shaft put down by the present holders being full of water, was not open to inspection. At 100 feet a crosscut has been put in due East about 49 feet, connecting with the workings in an old shaft adjoining. The rock exposed in the crosscut is a dark highly micaceous schist, dipping at a high angle to the West. The workings in the old shaft show that the place of the mica schist has been taken by a granitic rock, the "lode" (greisen) consisting essentially of quartz, a greenish mica, and a little felspar. The rock itself is tin-bearing. In 1899, on visiting this mine which had been abandoned, and was consequently inaccessible, I carefully sampled the material lying on the dump, which, on assay in the official laboratory, yielded tin to the extent of 1·79 per cent. About $2\frac{1}{4}$ cwt. of the greisen from the property was recently bagged and forwarded to the Mines Department, and subsequently carefully assayed. The ore was contained in three bags, the first sample (2493), weighing about 1cwt., yielded 0·55 per cent. of tin; the second (2494), weighing about 1cwt., returned 3·46 per cent. of tin; whilst the third (2495), which weighed about $0\frac{1}{4}$cwt., yielded tin to the extent of 1·09 per cent. The old workings in the crosscut show that the tin-bearing greisen, which is not of any great width, has been subjected to dislocation, as shown by the slickensided faces. This faulting introduces certain elements of uncertainty as to the unbroken continuity of the ore body in the mine in depth, though not as to the permanency of the tin ore, which, finding its origin below the limits of practical mining, is likely to persist to great depths. Whether the ore will prove sufficiently concentrated to be payable can be best determined practically.

The Ruby Tin Mining Company (M.L. 158).—Two shafts have been sunk upon the lease to a vertical depth of 80 feet each. The main shaft was inaccessible to me, but the material at grass showed the sinking to have been through ferruginous mica schist. The present working shaft has been carried down through decomposed micaceous schist, traversed by a few quartz leaders, the whole formation underlying to

the West. From the foot of the shaft a crosscut 37 feet in length has been put in to the Westward with the object of connecting with the main shaft. The crosscut exposes nothing but fine grained micaceous schist, traversed by quartz veins. Near the face of the drive two barren-looking quartz reefs of about 12 inches in thickness dip at a fairly high angle to the West. A crosscut, 20 feet in length, has been put in to the Westward from the 50-feet level. It exposes nothing but ferruginous mica schist, with gneissic bands. Twenty feet higher up the shaft, a drive has been put in to the South-West, for a distance of 14 feet it laid bare nothing but schist with tourmaline. No semblance of a lode has been opened up anywhere in that portion of the workings accessible to me.

Jas. Eadie and Party (*M.L. 166*).—Two shafts 48 feet apart have been put down to a vertical depth of 60 feet, and connected by a crosscut at the bottom. At the foot of the new, or working shaft, a crosscut has been put in to the West for a few feet, and exposes a micaceous granitic rock carrying varying proportions of tourmaline. Near the main shaft a band of foliated country rock ("lode"), about 15 feet in width, underlies at a moderate angle to the South-East. A fair quantity of angular tin can be obtained from the surface of the ground. An assay in the official laboratory of some of the dressed tin ore from the property yielded 66·3 per cent. of metallic tin. No true lode has been discovered on the property. In addition to these deposits the superficial accumulations have been extensively worked; these, however, have been fully described in my previous report.*

On what is known as McNess's Claim, near the head of Bunbury Gully, a shaft has been put down to a depth of 28 feet, and work has been carried out upon the residuary gravels, of apparently somewhat low grade. A sample of the dressed ore (2508) presented to me by the owners, assayed 53·6 per cent. of metallic tin. A sample of the dressed ore from the adjoining claim, held by Messrs. Smith and Jones, yielded a very low return of metallic tin, viz., 41·7 per cent. (2513). No observations have yet been made as to the cause of this low assay value. It is, however, worthy of note that the ground in the immediate vicinity of the above mentioned properties has yielded relatively large quantities of the mineral tantalite, a niobate and tantalate of iron and maganese. It may therefore be to the presence of this mineral that the low assay value of the ore on the claims above mentioned is due. Lower down in Elliot's Gully, on the ground held by Messrs. Brayney and Brennan, the tin ore was found to be associated with tantalite, stibiotantalite, ilmenite, garnets, and zircons.

In my previous report* it was pointed out that the ore deposits of the field fell naturally into two distinct categories, viz., superficial deposits, and deposits in country rock. With reference to the latter it was pointed out that the deposits in country rock were not lodes within the strict meaning of the term, but were merely a network of irregular tin-bearing veins distributed over a fairly well defined area, which, owing to their deep-seated origin, were likely to be as permanent as anything in the nature of such ever could be. Special attention was also devoted to the mineralogical characteristics of the tin ore with the view of investigating the reason of the low assay value of some consignments of what appeared to be practically clean tin ore. These investigations confirm those made by the Government Analyst of South Australia, in 1893, who noted the occurrence of a tantalo-niobate of antimony, which has a deleterious effect upon any of the dressed ores with which it may be associated.

From the above descriptions it will be seen that (*a*) the superficial deposits have been extensively worked and continue to yield quantities of tin; (*b*) the deposits in country rock have also been opened up, though save in one or two localities they do not appear to be very rich in tin. Whether these latter deposits can be made to pay can only be determined practically. Owing to the absence of suitable mechanical appliances

* *Loc. Cit.*

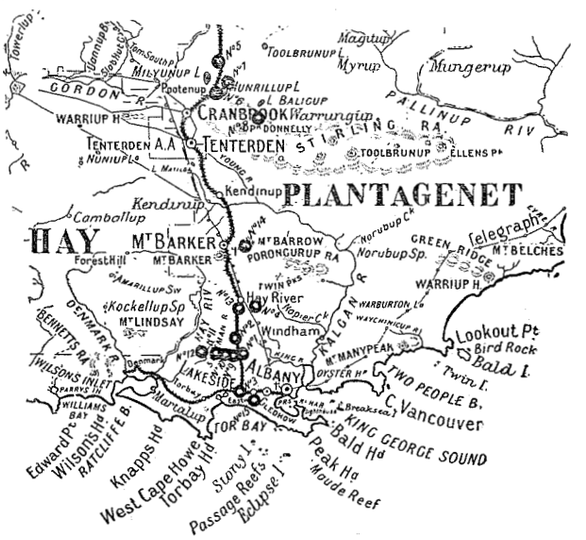
for dealing with the ore, once it is raised, no mining for "lode tin" can be carried out under present conditions at greater depths than the zone of decomposition.

The occurrence of stibiotantalite, as well as the mineral tantalite, has been recognised in various localities, viz., Spring Gully, Floyd's Gully, Bunbury Gully, and Elliot's Gully. The presence of the former mineral having such a deleterious effect upon any of the dressed ore with which it may be associated, it seems desirable that steps might be taken to ascertain the localities where this occurs in the greatest quantities. A method which naturally suggests itself is, in the event of a State dressing plant being erected, to have assays made of each parcel of dressed ore treated at the works, and any parcels in which the mineral occurs could very well be smelted separately, and so avoid contaminating the whole of the tin from the field.

As stated in the previous report, the future of the field, after the exhaustion of the superficial deposits, will depend upon the economical working of the ore deposits occurring in the country rock, and that can only be carried out by the admission of capital upon advantageous terms, so as to admit of a proper system of scientific mining being inaugurated.

Boring for Coal near Albany.—It having been held by the residents of Albany that coal might possibly be discovered in the neighbourhood, the Government was approached with the view of obtaining advice from the Department as to the most likely spots upon which to conduct boring operations. To this end the then Assistant Geologist, Mr. Blatchford, was instructed to proceed to the district to locate at least two likely areas in which to bore for coal. An examination having previously been made of the country to the Eastward of Albany as far as Cape Riche,* with the object of reporting upon the possibilities of the occurrence of coal deposits, Mr. Blatchford's operations were of necessity somewhat circumscribed.

A careful examination of the central and Southern portions of the country between the Stirling Range and the Pallinup River was made. Two well-defined depressions, separated by a granite ridge, trending approximately East and West, were known to occur within the area under examination. The more Southerly of these lies to the North of the Stirling Range (Fig. 1), and embraces a series of lakes. The other



SKETCH MAP SHEWING
THE APPROXIMATE POSITIONS
OF
THE COAL BORES
NEAR ALBANY.

FIG. 1.

* The country between Cape Riche and Albany. A. Gibb Maitland. Annual Progress Report of the Geological Survey for the Year 1898. Perth: By Authority, 1899. P. 29.

depression extends from Lake Toolbrunup to the Westward, and crosses the railway line at a distance of about 84 miles from Albany. A minor depression is traversed by the railway at the 79-mile post. A bore previously put down in this depression showed that the valley was filled with beds of clay, sand, and mud, 76 feet in thickness, and that the deposits rested upon a surface of decomposed granite, which latter was penetrated for 35 feet.

The contour of the country examined by Mr. Blatchford showed that the most likely spots, near Pootenup, in which sedimentary rocks—possibly associated with coal seams—might have accumulated, were the two main depressions to which allusion has previously been made.

Having this in view, the Assistant Geologist selected three sites for experimental boring, viz., (*a*) A spot one mile to the East of Lake Munrilup; (*b*) a locality three miles to the South-East of Lake Munrilup, in the vicinity of the Salt Lakes; and (*c*) a spot in the vicinity of the 84-mile post, on the Great Southern Railway line.

The following are the particulars of the strata pierced in two of these bores:—

(*a.*) One Mile East of Lake Munrilup.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Sandy clay	16	0	0	0
Light blue clay (very tough)	49	0	16	0
Dark mud, impregnated with decomposed vegetable matter	45	0	65	0
Decomposed granite	10	0	110	0
Total	120	0	120	0

(*b.*) Three and a half Miles South-East of Lake Munrilup.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Blue and white clay, with coarse grit	39	0	0	0
Yellow clay with bands of lime deposit	23	0	39	0
Coarse sandstone	3	0	62	0
Decomposed Granite	6	2	65	0
Total	71	2	71	2

In all, 16 bores appear to have been put down in the vicinity of Albany in search of coal. For convenience of comparison the particulars furnished by the Department of Public Works in connection with this question are attached. The approximate location of these bores is shown in Fig. 1. The deepest bore was carried down to a depth of 234 feet, and in all cases the floor of older crystalline rocks upon which the beds were laid down was unequivocally reached.

No. 1 Bore, 15½ Miles from Albany.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Sand and Mud	38	0	0	0
Light Brown Shale	59	0	38	0
White Pipe-clay	16	0	97	0
Quartz	0	3	113	0
Decomposed Diorite (?)	37	9	113	3
Total	151	0	151	0

No. 2 Bore, 17¾ Miles from Albany.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Soil	1	0	0	0
Soft White Sand	42	0	1	0
Brown Shale	11	0	43	0
Compressed Sand	13	0	54	0
Decomposed Diorite (?)	13	0	67	0
Total	80	0	80	0

No. 3 Bore, Torbay Junction.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Drift Sand	92	0	0	0
Hard Blue Clay	4	0	92	0
Drift Sand	38	0	96	0
Decomposed Diorite (?)	17	0	134	0
Total	151	0	151	0

No. 4 Bore, Chorkerup.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Soil and sand	3	0	0	0
Green sandy clay	60	0	3	0
White sand	51	0	63	0
Decomposed diorite (soft)	25	0	114	0
Total	139	0	139	0

No. 5 Bore, 79-Mile Peg from Albany.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface clay	10	0	0	0
Sandy clay	38	0	10	0
Black mud	15	0	48	0
Coarse drift sand	13	0	63	0
Coarse sand with clay bands	59	0	76	0
Decomposed granite	60	0	135	0
Very hard granite...	1	0	195	0
Total	196	0	196	0

No. 6 Bore, *vide (a)* above.
No. 7 Bore, *vide (b)* above.

No. 8 Bore, 9 Miles East-South-East of Pootenup.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Yellow clay	14	0	0	0
White sand	6	0	14	0
Pink clay with grit	4	0	20	0
Blue and yellow clay	16	0	24	0
Decomposed granite	8	0	40	0
Total	48	0	48	0

No. 9 Bore, 1 Mile West of 15½-Mile Railway Peg from Albany.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Ironstone conglomerate	2	0	0	0
Clay	20	0	2	0
Red sand	21	0	22	0
Red and white sand	94	0	43	0
Soft black mud	7	0	137	0
Hard brown shale	81	0	144	0
Coarse black sand	7	0	225	0
Decomposed granite	2	0	232	0
Total	234	0	234	0

No. 10 Bore, 2 Miles West of 15½-Mile Railway Peg from Albany.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Ironstone conglomerate	2	0	0	0
Clay	12	0	2	0
Red sand	6	0	14	0
Red and white sand	92	0	20	0
Soft grey sand	12	0	112	0
Brown shale with hard bands	77	0	124	0
Decomposed granite	14	0	201	0
Total	215	0	215	0

No. 11 Bore, 3½ Miles West of 15½-Mile Railway Peg from Albany.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Ironstone conglomerate	3	0	0	0
White sandy clay	25	0	3	0
Fine red and white sand	45	0	28	0
Brown shale	77	0	73	0
Decomposed granite	12	0	150	0
Total	162	0	162	0

No. 12 Bore, 6 Miles West of 15½-Mile Railway Peg from Albany.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Yellow Sand	55	0	0	0
Ferruginous Sandstone	0	6	55	0
Yellow Sand	12	6	55	6
Brown Shale	14	0	68	0
Coarse Dark Sand	12	0	82	0
Brown Shale	19	0	94	0
Coarse Dark Sand	3	0	113	0
Decomposed Granite	5	0	116	0
Total	121	0	121	0

No. 13 Bore, 24-Mile Railway Peg from Albany.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface Sand	2	0	0	0
Ironstone Conglomerate	4	0	2	0
Sandstone	47	0	6	0
Fine Sand (? Incoherent Sandstone)	61	0	53	0
Decomposed Granite	26	0	114	0
Total	140	0	140	0

No. 14 Bore, 4 Miles East of Mount Barker.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Soil and Gravel	2	0	0	0
Soft Sandstone	3	0	2	0
Decomposed Granite	35	0	5	0
Total	40	0	40	0

No. 15 Bore, One Mile South of Eastwood.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Dark Sand	61	0	0	0
Dark Sandy Mud	48	0	61	0
Decomposed Granite	21	0	109	0
Total	130	0	130	0

North Lead, Kanowna.—In the Annual Report for 1899 a full description was given of the North Lead, Kanowna, and its tributaries the Fitzroy, Cemetery, Wilson's Gully, and Q.E.D. Leads. The probability of other similar leads existing in the district was also pointed out. It was mentioned, however, that owing to the completeness with which the old land surface has been buried beneath more recent accumulations, any other leads could only be tapped by a judicious system of boring, though they were hardly likely even then to be discovered without many failures.

Application was made to the Government by the local residents, through the Municipal Council of Kanowna, for a bore to be put down "with the view of ascertaining what mineral indications are obtainable." A site was selected by the local authorities upon which to bore, but after a personal inspection of it, I reported that the chances of the discovery of payable lodes in the locality were hardly sufficiently strong to warrant the expenditure of public money in searching for them. After a careful consideration of the whole question of giving effect to the request of the municipality, it seemed that the greatest benefit the Department could render to private enterprise in the district would be to endeavour to locate by means of a series of bores the continuation of the North or other leads, for so long as these old water courses are continuous there is always a chance of payable deposits occurring in them.

To this end a series of bores was put down at stated intervals along the lines shown in the plan attached (Plate I). A section has been prepared, and appears on the same plate, showing the information derived from the work already accomplished. The bores at present in progress, in the diagonal series, indicate that deeper ground is being rapidly approached from which it is evident that the old drainage channel lies in close

proximity. Whether the channel will prove well defined, or be merely a lake-like expansion thereof, can only be determined as the work proceeds. A little gold has been discovered in the detritus passed through in several of the bores, but in no case in such quantities as would warrant the sinking of expensive shafts.

The exact location of the channel being of such importance to the community, it is proposed to continue boring operations until the whole series is complete.

Bulong Deep Leads.—Application having been made by the residents of Bulong for assistance in the direction of boring for alluvial leads, the following report was prepared and submitted:—

In the year 1898, auriferous alluvial deposits were met with at a depth of a little over 100 feet below the surface. Since that date the deposits would seem to have been worked more or less vigorously. According to official figures the deposits have yielded 17,476ozs. of gold up to the end of June, 1900; there are, however, good grounds for believing that these returns are somewhat less than the actual output. At the present time practically no alluvial mining other than dryblowing is carried on. A considerable sum of money (as evidenced by the number of abandoned shafts) having been expended in work to the South-West of the township of Bulong, with very good results, the local residents seem reluctant to abandon the search for further deposits, and have made application to the Government, through the Municipal Council, asking, if it be possible, to have the leads in the district tested by boring.

I visited Bulong and carefully examined the neighbourhood, with the view of ascertaining whether there were any geological grounds for believing that the district might be likely to develop any extensive deposits of deep alluvial ground. The country is undulating, and traversed by rather insignificant watercourses, which eventually find an outlet into the claypan known as Lake Yindarlgooda. There is not much diversity in the geological formations in the vicinity of Bulong. Schists, breccias, quarzites, and black slates, associated with igneous rocks of obscure origin, form the ground work of the district generally. Three leads have been worked in the neighbourhood; the attached sketch map* gives a rude idea of the connection and relation of the three old watercourses, but as these have never been geologically mapped, and the workings are now inaccessible, precise details are not obtainable.

In 1898 I saw a complete section of the alluvial deposits in the Queen Margaret South Extended Lease, as depicted in the section attached.* There was a fairly well-marked gutter trending approximately Southwards. The drift rested upon a bottom of schistose rocks, decomposing in the direction of kaolin, at a depth of a little over 100 feet. On the Royal Margaret Lease to the North, the bottom rose to about 40 feet from the surface. A shaft has been carried down in the Queen Margaret Consols No. 1 to a depth of 140 feet, and an auriferous drift of 18 inches in thickness was met with at a depth of 110 feet. The gutter is said to have attained a width of 300 feet. Forty tons of the wash dirt treated yielded gold at the rate of 7dwts. per ton. It will thus be seen that the lead commenced to the North with shallow sinking, and deepened to about 110 feet in the shaft on G.M.L. 638y.

A tributary lead, the Oversight, rising a little to the West of the town, and trending gradually Southwards, appears to have been successfully worked. In 1898 the only shaft on this lead was open to my inspection. The shaft was situated somewhere in the locality of what is known as G.M.L. 643y. The section in the shaft, which was 90 feet in depth, showed a quartzose gravel, resting directly upon a "bottom" of practically vertical silky schists, which readily decompose into clay. The workings on the Southward extension of the Oversight Lead are inaccessible at the present time, but

* Not reproduced.

from the information gathered on the spot there is distinct evidence of a gradual dip of the bottom to the Southward.

Everything points to the fact that the three leads may be expected to junction on the extensive flat to the South.

The flat traversed by these leads falls gradually to the lake (?), along the shores of which the bedrock rises to the surface, showing that the old water channels (the continuation of which may have been destroyed by denudation) are not continuous for the whole distance, although the area between the most Southerly of the workings and the edge of the lake is somewhat extensive, thereby holding out possibilities of the lead being located between the two places. The old gutter would appear to be nothing more or less than a very much attenuated trough, of which the full extent has not yet been determined. This can only be expeditiously and cheaply carried out by a series of comparatively shallow bores put down at frequent intervals along a line across the flat, approximately at right angles to its course.

It is very doubtful, however, if any very extensive area of deep alluvial ground exists in the neighbourhood of Bulong, but in view of the returns which have been obtained from the deposits already worked, the flat lying to the Southward of the Royal Margaret seems worthy of further trial. I cannot, however, with any confidence recommend very much expenditure being incurred in the direction asked for. In view of all the circumstances, I am of opinion that if the townspeople are prepared to raise a little capital to carry out the work, a claim on their part for assistance from the public purse should be favourably considered. Such assistance might take the form of the loan of a boring plant, together with a contribution of say one pound for every pound raised locally, or, in other words, half of the cost of the labour, etc., might be contributed by the townspeople and the other half by the Government, who also would provide the necessary boring plant free of cost.

Coolgardie Deep Leads.—The search for deep leads has been carried out in different parts of the Coolgardie district, but without very much success. With the single exception of that extensive flat near Colreavy's Tank, the alluvial deposits do not attain any great thickness. In this locality several bores and shafts have been put down and have proved the existence of a comparatively deep gorge. In two instances only has the bottom been unequivocally reached, viz., in Rollos' Bore, when diorite (?) was met with at 400 feet, and in Bore No. 1, some little distance to the South-West, where the deposits were found resting upon schists. The superficial extent of the flat, together with its unknown depth, except on the North side, seemed to encourage further efforts to accurately define the depression. To this end a series of bores has been put down across the width of the flat, near Colreavy's Tank (Reserve 3142); such a series would be expected to accurately define the contour of the depression, and demonstrate the nature and thickness of the deposits by which it is filled; at the same time everything points to the fact that no extensive area of deep alluvial ground can possibly exist.

A plan of the bore sites, and sections showing the information at present obtained, has been prepared and is attached (Plate II.) from which it will be seen that the object of the boring has practically been attained.

Alluvial Deposits, Donnybrook Goldfield.—In the early part of the year a request was received from the residents of the district for assistance to prospect for alluvial deposits, the occurrence of conglomerates, interstratified with sandstones and shales carrying a little gold, having suggested the possibility of deep alluvial leads being discovered.

The presence of gold in the sandstones which form the Western portion of Donnybrook, is an interesting occurrence. So far, however, it does not appear that the

gold is detrital. It is confined to certain ore bodies which traverse the sedimentary rocks, and present characteristics which point to a secondary origin. The ultimate derivation of the gold is to be found in the quartz reefs, etc., which traverse the metamorphic rocks on the Eastern side of the creek, and which appear to have been successfully mined. It is, however, not beyond possibility that rich leads may occur among the sedimentary beds, but there is nothing in the evidence adduced by a scientific inspection of the district to justify the hope that any such will be found associated with the Donnybrook sandstones. On these grounds the Government was not advised to incur any expenditure in searching for leads in such localities.

It appears, however, that, owing to the difficulties consequent upon the influx of water, the alluvial deposits of the creek separating the metamorphic from the sedimentary rocks* had not been properly tested; hence it seemed that a series of bores would be of some practical value in demonstrating the actual thickness of the deposits. Should any auriferous wash be discovered, shafts could readily be sunk to determine its commercial value. To this end the Government were advised to put down a series of experimental bores along an East and West line, just above the junction of the two creeks traversing Location 671. Consequent, however, upon difficulties with the owner of the property, the project for boring in that locality had to be abandoned.

The only available site for conducting operations was on Location 598† further up the creek, and having regard to the change of locality, it was not anticipated (as actual results have demonstrated) that any greater depth than 100 feet would have to be penetrated. Seven bores have been put down at intervals of two chains, in a direct line across the alluvial flat, whilst an eighth was put down three chains West of the seventh. The deepest bore was 50 feet; and in four of them detrital gold was obtained in the wash. A small shaft was put down between bores 6 and 7, and a little driving on the "bottom" carried out. Samples from the bottom showed a little gold.

The following are the particulars in connection with the bores based on data furnished by the Works Department, under the direction of which operations have been carried out:—

No. 1 Bore.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface Soil	1	0	0	0
Ironstone	1	0	1	0
Clay	5	0	2	0
Sandstone	10	6	7	0
Clay and Sandstone Boulders	1	6	17	6
Sandstone, Ironstone, and Quartz	7	9	19	0
Hard Sandstone and Quartz	13	9	26	9
Total	40	6	40	6

No. 2 Bore.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface Soil	2	6	0	0
Clay	10	0	2	6
Sandstone	2	6	12	6
Red Pug	0	9	15	0
Hard Sandstone with Ironstone Bands	11	3	15	9
Hard Sandstone and Quartz	8	0	27	0
Total	35	0	35	0

Vide Geological Sketch Map of part of the Donnybrook Goldfield: by T. Blatchford. Plate V. Annual Progress Report of the Geological Survey for the year 1899. Perth: By Authority, 1900.

† *Loc. Cit.*

No. 3 Bore.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface Soil	2	6	0	0
Black Sand	1	0	2	6
Yellow Sand	2	6	3	6
Sand and Gravel	1	6	6	0
Clay	4	6	7	6
Clay and Ironstone	1	0	12	0
Clay	7	6	13	0
Sandstone and Quartz	1	6	20	6
Crystalline Rocks (?)	2	6	22	0
Total	24	6	24	6

No. 4 Bore.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface Soil	1	0	0	0
Yellow Sandy Clay	3	6	1	0
Yellow and Blue Clay	16	0	4	6
Clay Wash	5	6	20	6
Clay and Decomposed Quartz	2	0	26	0
Hard Quartz	3	6	28	0
Decomposed Quartz and Clay	1	7	31	6
Quartz and Clay	1	5	33	1
Crystalline Rocks (?)	1	6	34	6
Total	36	0	36	0

Note.—Fine gold met with between 20ft. 6in. and 26ft.

No. 5 Bore.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface Soil	1	0	0	0
Clay	34	0	1	0
Blue Clay and Sand	4	0	35	0
Wash	5	6	39	0
Blue Clay	2	0	44	6
Sandstone and Clay	1	6	46	6
Crystalline Rocks (?)	2	6	48	0
Total	50	6	50	6

Note.—Good prospects of gold met with between 39ft. and 44ft. 6in.

No. 6 Bore.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface Soil	2	0	0	0
Clay	4	6	2	0
Yellow Sand and Clay	3	0	6	6
Clay	29	0	9	6
Clay Wash	8	0	38	6
Crystalline Rocks (?)	0	6	46	6
Total	47	0	47	0

Note.—Fine gold met with between 38ft 6in. and 46ft.

No. 7 Bore.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Surface Soil	2	0	0	0
Clay	19	0	2	0
Sand and Clay	8	0	21	0
Blue Clay	2	0	29	0
Clay Wash	4	0	31	0
Blue and Yellow Clay with Quartz	9	0	35	0
Sandstone and Quartz	2	0	44	0
Granite	1	0	46	0
Total	47	0	47	0

Note.—Fine gold met with between 31ft. and 35ft.; also between 35ft. and 40ft.

No. 8 Bore.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Sandy Loam	4	6	0	0
Sand	7	0	4	6
Sand and Clay	3	6	11	6
Ironstone	0	6	15	0
Sandy Clay	5	0	15	6
Ironstone	1	6	20	6
Yellow Sand and Clay	5	0	22	0
Blue Clay	6	0	27	0
Blue Clay and Decomposed Quartz	2	6	33	0
Yellow and Blue Clay	1	6	35	6
Crystalline Rocks (?)	3	0	37	0
Total	40	0	40	0

Samples sent to the Department of the wash from the shaft put down between bores 6 and 7 yielded a trace only of gold.

Subsidy to the Norseman Gold Mines, Ltd.—In the month of August I visited Norseman for the purpose of inquiring into the question of granting a subsidy to the Norseman Gold Mines, Ltd. On my return to Perth the following report was prepared and submitted:—

In accordance with your instructions, I have carefully inspected the property of the Norseman Gold Mines, Limited, which has made application for a subsidy to carry on deep sinking.

It having been already decided to subsidise the company in the direction of assisting in the sinking of one of the shafts, it only became necessary for me to inquire into which portion of the property seemed best suited to carry out the experimental operations, and to what depth these might reasonably be extended with Government assistance.

It is always a difficult matter to arrive at the value of mines, except in those cases where crushings have been recorded. The method of carefully sampling the property (a method which cannot be regarded as always satisfactory) was open to me; but for obvious reasons I did not adopt it, preferring to carefully examine the reef, with the object of ascertaining its size and nature and how far its geological characteristics were likely to affect its continuity in depth. This information, in conjunction with the results of crushings recorded in accordance with the law, being, for the special purpose, far more reliable than the results of sampling could ever be, no matter how carefully conducted.

In its geological structure the country is identical with that of other mining fields of the Colony. The reef (quartz) has been opened out upon the property by means of several shafts—the Viking, the Mildura, the Hardy, the Cachuca, and the Sydney—for a length along its outcrop of about 3,600 feet, as shown by the working plans. The deepest workings have proved the value of the reef down to no greater depth than 500 feet vertically. From a careful examination of the workings, it is evident that the reef is a true fissure reef, attaining in some places a very large size. There are portions of the property in which the quartz has pinched out; this, however, is not a proof of limited extent in depth, but merely a consequence of the nature of the fissure. There is every indication of the permanence of the reef in depth.

The reef crops out along the face of the Norseman Hill in a North and South direction. Owing to the contour of the ground, the outcrop of the reef gradually falls to the Southwards, there being a

difference of nearly 100 feet in level between the North and South ends of the outcrop. The underlay of the reef is to the West. The present depth of the Viking shaft—the most Southerly—is about 400 feet below the mouth. It is unnecessary to describe the various workings in detail for they are delineated upon the mine plans now filed in this office.

Application has been made for a subsidy to enable the sinking of either the Mildura or the Viking shafts to be proceeded with.

I inspected the upper levels of the Mildura, but owing to the shaft being full of water the lowest portions of the mine were not accessible to me. On this ground alone I am unable to recommend that any assistance be granted towards continuing this shaft.

A careful inspection of the Viking workings was made and especial attention paid to the reef in its lower levels. At 440 feet the reef consisted of about 3 feet of quartz, carrying a small quantity of pyrites and galena. During my visit the shaft was deepened about 4 or 5 feet to enable me to see the character of the reef. The face showed about 3 feet of quartz, carrying sulphides of iron, zinc, and lead. An unsophisticated sample of the whole face, collected under my own supervision, yielded in the mine laboratory a free milling value of about 12dwts. of gold to the ton. A fire assay of the more highly mineralised portions of the same stone yielded, in the official laboratory in Perth,—

Gold ... ... 1oz. 0dwts. 9grs. per ton.
Silver ... ... 1oz. 2dwts. 0grs. per ton.

The relatively large proportion of galena in the sample may be held accountable for the high silver contents. Free gold shows in some of the stone from the face, and specimens are now in the possession of the Department.

The following table shows the yield of the Viking workings, as culled from the records at the mine. These no doubt can be verified by the data in the archives of the Mines Department:—

Year.	Tons Crushed.	Yield of Gold therefrom.			Rate per Ton.		
		ozs.	dwts.	grs.	ozs.	dwts.	grs.
1898	849	1,078	0	0	1	5	9
1899	1,459	941	4	3	0	12	21
1900 *	3,205	1,381	6	0	0	8	14
Total	5,513	3,400	10	3	0	12	8

* Up to and including August.

From these figures it will be seen that the reef is of low grade. There must always be local variations in the contents of reefs and lodes, but there are no scientific grounds for believing that the reef has reached the limits of ore deposition, or that it will not prove equally productive when followed to greater depths.

In view of the above facts, I am of opinion that the Viking shaft might reasonably be subsidised to an extent that would enable it to be carried down to a depth of 700 feet. At this depth it should be proved whether such a low grade reef—which has apparently been made to pay expenses—can be worked at a profit. According to the books at the mine, the cost up to date of sinking the Viking shaft has been about £10 per foot. On the basis of pound (£) for pound (£), to carry the shaft from 450 to 700 feet, would involve the Government in a liability of about £1,200, unless of course the management is able to reduce the costs. So far as I am in a position to judge, the machinery, working plant, and other appliances are properly adapted to carry out the operations suggested.

I append a plan and section of the Viking workings, that portion of the shaft coloured green shows the present depth, whilst the additions in red indicate the proposed extension.†

Gascoyne District.—All utilitarian applications of geology must, of course, be based upon a thoroughly systematic examination of geological structure, so that towards the close of the year I was engaged investigating the geological structure of the country between Cue and Carnarvon, with a view to determining the possibility of the occurrence of artesian water in the vicinity of the township of Carnarvon and elsewhere.

I started from Cue, and travelled across the head of the Murchison as far as Dairee Creek. By so doing it was reasonably hoped to examine the intervening country in some detail, and to elucidate as much as possible of its structure as would throw light upon the continuation of the metalliferous country examined and reported upon by myself when travelling between Northampton and Peak Hill in the year 1897. In that report attention was drawn to the occurrence of some exceedingly valuable iron ores in a range of hills comprising Mounts Taylor, Hale, Matthew, Yarrameedie, and

† It has not been deemed necessary to reproduce this.

Erawondoo. It is worthy of remark that iron ores are distributed over a very large area of the country at the head of the Murchison, and, although at present practically neglected, they are destined in the future to form one of the most important assets that the State possesses. Opportunity was taken in this connection to examine more especially the iron ores of the Weld Range. These deposits form the Southern continuation of those described in 1897, and are in every respect identical, and perhaps, if anything, occur in larger quantities. Two analyses have been made by Mr. Simpson, with the following results:—

G.S.M. 2277, *Hæmatite.*

Iron (metallic)	61·91 per cent.
Silica	1·13 „
Hygroscopic Water	·13 „
Combined Water	3·97 „

G.S.M. 2278, *Red Wilgi.*

Iron (metallic)	34·17 per cent.
Silica	21·93 „
Hygroscopic Water	1·11 „
Combined Water	11·51 „

A large number of specimens have been obtained with a view to having a chemical analysis made as to their suitability for the purpose of producing iron therefrom. All these iron ores, if located elsewhere, would probably make the fortunes of those securing the privilege of exploiting them, but at present, owing to their geographical position, they are practically valueless. Increased means of communication, and the discovery of a valuable coalfield, would materially change the condition of affairs.

Having completed the examination of the country in the vicinity of the Weld Range, the investigation of the carboniferous rocks at the head of Dairee Creek, Dalgety Creek, and the Wyndham, Arthur, Lyons, and Minilya Rivers was undertaken, for the purpose of ascertaining the occurrence or otherwise of artesian water. It was also recognised that among rocks of this age commercial coal might possibly occur. Special attention was naturally paid to this, in view of its utility in connection with the exploitation of the iron ores mentioned before. An almost complete section of these sedimentary rocks has now been obtained by a careful examination of all the sections exposed to view in the various creeks and on the faces of the ranges. Owing to its comparatively open character, the district affords exceptional opportunities to grasp the geological structure with a minimum amount of travel and physical exertion. Unfortunately, the upper portion of the carboniferous rocks was concealed by a covering, more or less thick, of much more recent deposits. Hence it cannot be definitely affirmed, with what knowledge we at present have, that these bodies do not contain coal, in their upper portions at any rate. It is contemplated putting down a bore in the vicinity of Carnarvon to a considerable depth. This bore will be an important one, in that it will demonstrate (1) whether or not that portion of the carboniferous rocks which we cannot see, owing to the causes above mentioned, contains associated with them any coal seams; and (2) whether or not any water-bearing horizon occurs at a considerable depth. There does not seem to be any reasonable doubt but that the bore will be successful in its main object, namely, searching for artesian water.

The season being exceptionally good, although it was somewhat late in the year, almost all the salient features were examined. I was forcibly impressed with one point, viz., that there was a large area of pastoral country, of which better use could be made were an adequate water supply available. No attempt seemed to have been made by those engaged in pastoral pursuits to undertake anything beyond what might be called the sinking or boring of shallow wells under 250 feet in depth. Even if, in certain

portions of these good pastoral areas, a supply of overflowing water could not be discovered, there are no scientific grounds whatever for believing that a supply which could be readily reached by means of a pump would not be obtained.

During the trip, of course, the combined scientific and practical objects of the Department have been steadily kept in view. So closely are pure science and industrial progress associated that at any moment what might be supposed to be a matter of purely theoretical importance might be discovered to be of highly practical significance and value. During the course of the examination of the country between the heads of the Wooramel and the Minilya Rivers one of the most important contributions of this State to pure science was obtained. There has been discovered, associated with the carboniferous rocks, an extensive deposit of glacial origin. This deposit has already been proved to exist for a distance considerably over sixty miles. Although this may seem to be one of those things which interest the scientist only, it affords, from a practical point of view, a most important stratigraphical horizon which can be readily recognised and traced across country for a considerable distance, and which will prove of material assistance in any boring which may be undertaken in the future. With this deposit, the character of which is shown in Plate III. are ice-scratched boulders, photographs of which are attached, Plate IV.

A detailed report, accompanied by maps, sections, and photographs, illustrating the structure of the districts examined and the practical application of the facts acquired, is in course of preparation and will be duly submitted.

EXTENSION OF ARTESIAN WATER-CARRYING STRATA FROM SOUTH AUSTRALIA.

In 1897* attention was directed to the probable occurrence of an artesian water area on the South coast of the State, extending from Eucla to Israelite Bay. The question has been revived in connection with the Transcontinental Railway Line; the necessity for the selection of a well-watered route being of prime importance.

In the month of February a communication was submitted to the Right Hon. the Colonial Treasurer by Mr. Panton, Police Magistrate in Melbourne, on the subject of "the indications which point to an artesian water-bed extending from your colony into South Australia."

In this communication the following passages occur:—

> You will there† observe that from Lake Eyre basin, which is studded with mound springs (natural artesian water escapes) the cretaceous rocks extend due Westward into your colony, bounded on the North by granite and slate (silurian) outcrops, which favoured exploration along their course. Between Mount Squires and Victoria Spring, at about latitude 28° 20′, Lindsay found an extinct mound spring near to his Limejuice Camp, which is clear evidence that the artesian water-bed exists at that spot. Between that and Victoria Spring a belt of silurian crops up, but probably does not extend far to the South-East, and South of this there is another bay of the cretaceous rocks extending to the South of Victoria Spring, where another belt of silurian runs in. Probably from longitude 125°, the cretaceous rocks extend along the 29° latitude to the granites North of the Bight. Should you desire to open up a watered route right up to the South Australian railway, it ought to follow latitude 28° 30′. Mound springs have been found along this route from the point already indicated through Limejuice Camp right up to the line.
>
> If you determine on running your railway near to the coast, say about latitude 31°, you will get water probably from longitude 124° up to about 80 miles East of Eucla, and from that to Port Augusta the country is devoid of water anywhere, surface or artesian. Small cups or mounds containing fresh water are found in the bed of Lake Gardiner, which may indicate the existence of the cretaceous rocks under the limestone there, but the granite is dangerously near on the West of that Lake. . . . How far the cretaceous rocks run into Western Australia I have already demonstrated in a paper on "Australia Deserta" in the transactions of our ‡ Geographical Society which was sent to you. . . . I would suggest that you try your first bore North-East from Victoria Spring, about Lindsay's 57 Camp or back from Eucla, but do not look for water there under 3,000 feet. . . . The water at Eyre's Sand Patch

* A. Gibb Maitland, Artesian Water. Annual Progress Report. Geological Survey, 1897. Perth: By Authority, 1898, p. 29.
† The Geological Map of the Lindsay expedition from the South Australian Railway Line to Victoria Spring. ‡ Victoria.

near Eucla is from under the limestone, and has nothing to do with the artesian basin. In South Australia the pressure is so great that the springs gush out at the junction of the Silurian rocks with the cretaceous.

The following report was prepared and submitted at the request of the Right Hon. the Colonial Treasurer:—

A knowledge of the geology of the country at the head of the Great Australian Bight has demonstrated the existence of an enormous expanse of recent and Tertiary strata, entering Western Australia on its Eastern border, in the Nullabor Plains, and extending without any interruption as far as Israelite Bay.

The strata consist of porous limestones, associated with beds into which the rainfall is rapidly absorbed and discharged seawards in the form of freshwater springs, rendering the occurrence of underground water more than probable. These beds have been pierced by means of five bores on the South Australian side of the border. The section in these bores invariably shows a thickness of sandy water-bearing beds covered by limestone from 300 to 500 feet thick. The beds have a prevailing dip towards the Great Australian Bight, and the water (sub-artesian) rises in the bore holes to a height equal to that of the sea level. So far, however, the water obtained has proved to be either salt or brackish, but still suitable for stock purposes. The quantity of water obtained, so far as the official information at my command shows, is ample for the purpose to which it is put, viz., watering stock. The bore nearest to the Western Australian frontier is at Albalakaroo, on or near the telegraph line, at about 45 miles east of Eucla. The bore attained a total depth of 1,084 feet, and bottomed on granite at 1,073 feet, after passing through (in descending order) 565 feet of limestone, 428 feet of clay, and 82 feet of "a hard rock," which those in charge of the operations could not determine. At the base of the limestone a sub-artesian supply of stock water was obtained which rose to 490 feet below the surface. Salt water, however, was encountered at the top of the granite which rendered the bore valueless.

The next bore further to the East (the Guinewarra bore) about 65 miles from Eucla, also bottomed on granite at 1,253 feet from the surface, after passing through a somewhat similar succession of strata. Salt water was obtained from depths of 975 and 1,004 feet respectively, and rose to 205 feet below the surface.

None of the other three bores further East exceeded 850 feet in depth, nor were they carried down sufficiently far to reach the floor of impermeable rocks upon which the sedimentary beds were laid down. They all succeeded in obtaining a copious supply of excellent stock water. The information in connection with these bores has been thrown into a tabular form for convenience of reference, and their positions shown on the map of Australia* appended. The following are the particulars in connection with the South Australian bores:—

ALBALAKAROO BORE, 45 MILES EAST OF EUCLA.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Limestone	565 0	...	At 565ft. a subterranean supply
Clay (? Shale)...	426 0	565 0	of stock water rose to 490ft.
Hard Rock (undetermined)	82 0	991 0	below the surface.
Granite	11 0	1,073 0	Salt water at the bottom.
Total	1,084 0	1,084 0	

*Not reproduced.

GUINEWARRA BORE.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Limestone	570 0	0 0	Salt water obtained at 975 and 1,004 feet, which rose to 205 feet below the surface.
Sand and limestone	29 0	570 0	
Clay (? Shale)	509 0	599 0	
Conglomerate	12 0	1,108 0	
Hard blue and red rock	133 0	1,120 0	
Granite	24 0	1,253 0	
Total	1,277 0	1,277 0	

NULLABOR PLAINS, No. 2 BORE.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Red loam and travertine	5 3	0 0	Very brackish water rising to 183 feet below the surface.
Limestone	466 0	5 3	
Clay (? Shale)	266 0	471 3	
Sand and gravel with clay bands	81 2	737 3	
Total	818 5	818 5	

NULLABOR PLAINS, No. 5 BORE.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Limestone	330 0	0 0	Good stock water rising to 207 feet below the surface.
Clay (? Shale)	262 6	330 0	
Sand and gravels with thin clay beds ...	77 0	592 6	
Total	669 6	669 6	

ROBERTS' BORE.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Soil	1 6	0 0	Good supply of excellent stock water rising to 135 feet below the surface.
Limestone	412 6	1 6	
Clay (? Shale)	334 6	414 0	
Sand and gravels, with clay beds	28 0	748 6	
Total	776 6	776 6	

The attached map* shows what may be called the Artesian Water areas formed by the Cretaceous and Tertiary strata in Australia.

The Cretaceous Area occupies a portion of South Australia and New South Wales, but attains its greatest development in Queensland. This Cretaceous basin does not appear to extend into Western Australia unless it be represented—as is by no means improbable—by certain of the table-topped hills noticed in the course of the Elder Exploration Expedition in 1893.

The Tertiary Area attains its largest development in this Colony, and is coloured yellow and brown upon the map; the former colour representing what may be called the Eucla Limestone, and the latter the underlying sandy beds. The average altitude attained by the outer margin of the Tertiary basin is about 1,000ft. above sea level on the North, but it gradually falls to the sea level both on the Eastern and Western margins along the shores of the Bight.

Observations have shown that the Cretaceous and Tertiary basins are separated by a belt of granite and metamorphic or other equally impermeable rocks, and have no connection with each other: hence both are distinct areas.

* Not reproduced.

No boring has been carried out in the Western Australian extension of the Tertiary basin. There may be, and undoubtedly are, local variations in the thickness, the relative porosity of the beds and the unevenness of the floor upon which these strata were laid down. With the somewhat meagre knowledge at present available, it is almost impossible to forecast with even any approach to approximation whether the beds attain a thickness of 3,000ft., as would be inferred from Mr. Panton's letter. From all the evidence before me I incline to the belief that this estimate is excessive, and that the water-carrying beds beneath the Eucla limestone will be met with at considerably shallower depths than that indicated.

Should it be contemplated putting down a series of experimental bores in this area, it would seem advisable to do so along a line due North and South from the head of the Bight starting from any locality which might, on engineering grounds, be deemed most expedient. It would not be possible to convey a Calyx plant into the interior unless water could be obtained, so as to secure the retreat of the boring party should the exigencies of the situation demand it. A hand-boring plant capable of penetrating about 100 or 200 feet would be essential to secure water for use in connection with the Calyx plant, unless any could be obtained on the surface, which, from all accounts, seems a remote possibility.

I am, however, not very sanguine of success in obtaining anything but a sub-artesian supply of water anywhere towards the Northern edge of the Tertiary basin. Any such supply would be expected to be at least brackish, though, no doubt, suitable for stock. Should the supply be copious there should be no difficulty in condensing it.

LABORATORY WORK.

Much of the work of the laboratory staff has been of necessity, as in previous years, of a routine character, owing to the large number of analyses and assays required by the different Government Departments and the general public. Some of the other results obtained during the past year have been embodied in the previous pages dealing with the field operations, hence no further reference thereto is necessary.

The Mineralogist and Assayer, Mr. E. S. Simpson, reports to me that the total number of assays made in the Survey Laboratory has been 1,236, as against 1,153 for 1899, and 848 for 1898. The following table shows a detailed statement of the work carried out under Mr. Simpson's more immediate supervision:—

Table showing the Details of Assays, etc., made in the Departmental Laboratory during 1900.

Classification.	Public.		Official.		Totals.
	Pay.	Free.	Geological Survey.	Other Departments.	
Total samples dealt with	139	224	220	259	832
Determinations	3	34	17	67	121
Assays for Gold	111	168	38	194	511
Do. Silver	24	130	27	57	238
Do. Copper	6	23	25	3	57
Do. Lead	1	9	1	1	12
Do. Tin	5	19	21	5	50
Do. Iron	...	4	4	...	8
Do. Antimony	2	2	...	...	4
Do. Nickel and Cobalt ...	1	1	...	...	2
Coal—Proximate analyses... ...	...	6	...	...	6
Chemical analyses, Partial ...	13	3	36	3	55
Do. Complete ...	8	1	21	1	31
Microscope sections cut	...	...	97	...	97
Specimens valuated...	...	1	...	30	31
Miscellaneous	4	1	5	3	13
Totals of Assays, etc.	178	402	292	364	1,236

The principal feature in the operations of the laboratory is the large decrease in the work performed for the general public, a condition of affairs in all probability due to the more general employment of assayers on the firmly established mines. There is also a marked increase in the work done for other Government Departments, chiefly in connection with the public batteries.

It has been found impossible to include in the table all the numerous determinations and partial analyses of minerals, etc., required by the Department itself. The figures under these heads fall, therefore, considerably short of the actual number.

During the year, at my request, Mr. Simpson commenced the preparation of a pamphlet designed to include the result of the chemical and mineralogical researches carried out in the Survey Laboratory since its inception. Owing, however, to the limited time available for this, and the amount of analytical work necessary to elucidate certain investigations, some little time must elapse before the manuscript will be ready for the Press. It is hoped that this work will be the forerunner of a much larger one dealing systematically with the distribution, mode of occurrence, and composition of the minerals of the State, material for which is being slowly but steadily accumulated.

Thin sections of specimens of rocks, chiefly from the Kalgoorlie District, to the number of 97, have been prepared in the laboratory during the year, and added to the collections. The total number of slices now in the possession of the Department is 244. Of these 15 are from the East Murchison Goldfield, 12 from the Murchison, 12 from Northampton, seven from North Coolgardie, 11 from North-East Coolgardie, 10 from Broad Arrow, 114 from East Coolgardie, 27 from Coolgardie, eight from Dundas, eight from the South Coast, three from the South-West, 12 from the Darling Ranges, and five from the Eastern Agricultural District. Owing to the constant demands upon the time of the Geologists for work in the field, upon which they can always be most profitably employed, it has not been found possible to study the microscopic structure of the rocks which have been acquired. It is hoped that some steps will be taken towards providing an extra trained assistant to whom this very necessary work can be entrusted.

Amongst the mass of material examined by the Department during the year, Mr. Simpson notes the following minerals new to Western Australia:—

Gadolinite (silicate of beryllium, iron and the yttrium metals), in granite, at Coglegong Creek, Pilbarra Tinfields.

Tantalite (tantalate of iron and manganese), in tin wash, at Greenbushes.

Spodumene (silicate of lithium and aluminium), in granite, at Ravensthorpe, Phillips River Goldfields.

Fuchsite (chrome mica; silicate of potassium, aluminium, and chromium), in diabase schists, at Kalgoorlie.

These are supplementary to those enumerated in the Census of Minerals of Western Australia previously prepared by Mr. Simpson.*

Applications having been made to the Department at the request of the patentees for an investigation to be carried out in the official laboratory in connection with the Dillworth-Honeus process for the treatment of refractory ores, the Mineralogist and Assayer was instructed to carry out the experiment.

Mr. Simpson reports to me that:—

This process is protected by two patents, Nos. 3141 and 3168, in the specifications of which it is stated that the process is chiefly intended to be used in the extraction of gold from its ores. It is also said to be applicable to silver ores and those containing both silver and gold, more especially those usually known as refractory or incapable of treatment by the battery alone.

As described in patent No. 3141, the process has for its object the complete oxidation of the ore by roasting with "carbon (or) sulphur and a potassium of sodium compound . . . having an oxidising action." According to patent No. 3168, the roasting is done with "sulphur, with or without the addition

* E. S. Simpson, Census of Minerals of Western Australia. Chap. XII. Bull. 4. The Mineral Wealth of Western Australia. Perth: By Authority, 1900.

of a potassium or sodium compound . . . having an oxidising action." This complete roasting is expected to render the ore amenable to treatment by any of the ordinary processes for gold or silver extraction.

A somewhat exhaustive experiment with this process was made in the laboratory on a sample of Kalgoorlie ore upon lines in part suggested by the patentees themselves. The ore was a foliated diabase rock, of the usual Kalgoorlie type, in which the gold existed mainly in the form of tellurides. It assayed 109·850ozs. of gold per ton, and 14·700 ozs. of silver per ton.

The main outlines of experiments were as follow:—

The ore was treated by (*a*) Direct amalgamation, (*b*) Direct cyanidation, (*c*) Direct amalgamation followed by cyanidation, and the percentage of gold and silver extracted by each method was calculated. These three treatments were applied to (1) the raw ore; (2) the ore after roasting in the usual way; (3) the ore after roasting with sulphur as described in patent No. 3168; (4) the ore after roasting with sulphur and nitre as described in Patent No. 3141. At the patentees' own suggestion the ore in experiment (3) was crushed fine, as also in (2); in experiment (4) it was crushed comparatively coarse. The actual size of the particles of ore used in the experiment was as follows:—

				(1), (2) and (3).		(4).
Passed	5 mesh.	Refused	10 mesh	*nil*	...	14 per cent.
„	10 „	„	20 „	*nil*	...	38 per cent.
„	20 „	„	30 „	*nil*	...	13 per cent.
„	30 „	„	60 „	21 per cent.	...	13 per cent.
„	60 „	„	90 „	21 per cent.	...	6 per cent.
„	90 „	—	— —	58 per cent.	...	16 per cent.

The amalgamation was effected by grinding the ore in contact with mercury for 15 minutes, and with sodium amalgam and mercury for a further 15 minutes.

The cyanidation was effected by leaching the crushed ore with a 0·1 per cent. solution of the purest potassium cyanide for 24 hours, the solution being changed altogether five times during that period.

The roasting was effected in a muffle furnace at such a rate that two hours were required to complete it. In series (3) the sulphur at the rate of 10lbs. per ton of ore was stirred into the ore before roasting. In series (4) the sulphur was added as in (3), and, 15 minutes before the completion of the roast, nitre at the rate of 4lbs. per ton of ore was stirred into it.

The following were the extractions obtained. They are expressed in percentages of the total gold and silver in the untreated ore:—

	(1) Raw ore.	(2) Ore roasted in usual way.	(3) Ore roasted with sulphur.	(4) Ore roasted with sulphur and nitre.
GOLD.				
A. Direct amalgamation	26 per cent.	53 per cent.	49 per cent.	50 per cent.
B. Direct cyanidation	Trace	33 „	25 „	5 „
C. Direct amalgamation followed by cyanidation ...	26 per cent.	66 „	59 „	57 „
SILVER.				
A. Direct amalgamation	21 per cent.	32 per cent.	17 per cent.	2 per cent.
B. Direct cyanidation	Trace	22 „	11 „	7 „
C. Direct amalgamation followed by cyanidation ...	21 per cent.	34 „	31 „	9 „

It is very evident from these tables that far from exerting a beneficial effect upon the extraction, the treatment of the ore by either of these patent processes causes a marked reduction in the extraction in the case of this Kalgoorlie ore. Ore of this nature is, doubtless, of exceptional occurrence in Australia; but theoretical reasons would tend to make one very sceptical as to the processes proving of any value in rendering refractory ores more amenable to ordinary methods of extraction.

OFFICE ACCOMMODATION.

The time is rapidly approaching when proper accommodation will have to be provided for the Geological Survey. The necessity for this provision is one to which attention has been drawn in the Annual Reports for a number of years past, and is one which, in the interests of the State, should not be lost sight of.

The offices of the Department naturally become the centre of reference for authentic information in regard to what may be called the practical side of geology, so that the material acquired by the staff in the ordinary course of their duties should be made available for constant and ready reference by the staff and the public. The advantages to the State of having an adequate display of its mineral wealth, which is

so intimately associated with the daily life of the community, are too obvious to require much comment. It is impossible in the present cramped quarters to do justice to the resources of the State in this direction, although even in its present state the Museum attached to the Department affords an instructive object lesson, and its value is fully appreciated. Not only is the space available for displaying the mineral resources of the State (as represented by geological and mining maps, photographs, and minerals and rocks collected by the officers of the Department in illustration of their reports) too restricted, but the space at our disposal for the preservation of specimens and for work rooms for material undergoing examination is inadequate, whilst certain additions to the Laboratory must be made if the efficiency of the Department is to be maintained.

The urgent desire of the Education Department to secure the premises occupied by the Geological Staff for the purposes of Technical Instruction is one which, in the interests of the State, cannot be much longer ignored. It has been suggested that accommodation for the Geological Department be provided in one or other of the Government buildings. To this, however, there are grave objections. In the first place, the presence of chemical and assay laboratories would seriously interfere with the transaction of the routine work of clerical departments; whilst the establishment of a Museum in the same building would be impossible, as any such place must be capable of expansion, a condition of affairs unattainable in a clerical office, but rather the reverse. It is desirable, in the public interest, that the whole of the scientific collections of the State, as well as the staffs, should be under one roof. Economy in administration and convenience to the general public would be secured by such an arrangement. It has been found expedient to have the offices of the Geological Survey in the National Museum in Canada, South Africa, the United States, and elsewhere.

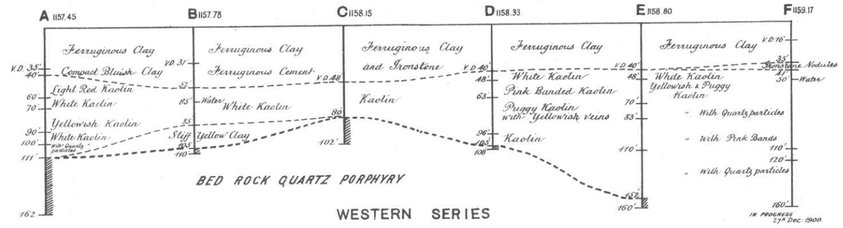
I beg leave to suggest, for the serious consideration of the Government, the advisability of arrangements being made with the Trustees by which accommodation can be provided for the offices and collections of the Department in the State Museum. By a modification of the plans for the contemplated additions to that building, adequate accommodation could very readily be secured.

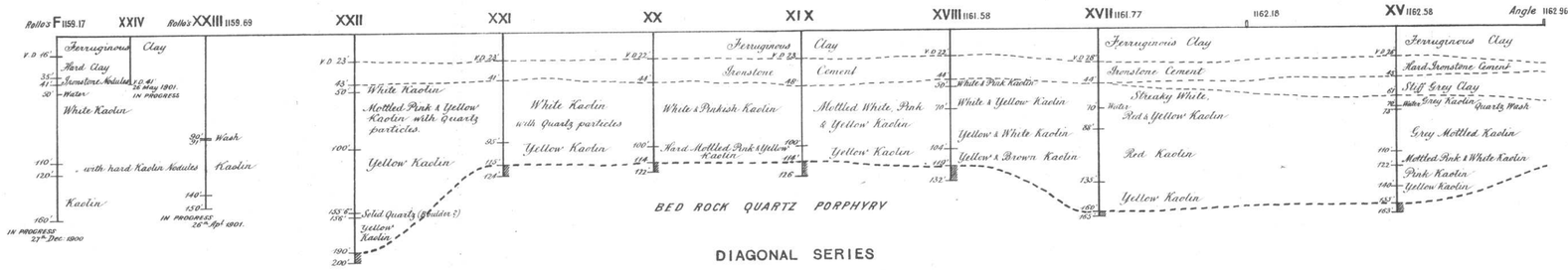
It is entirely beyond my province to enter into the question of ways and means, but I may be permitted to point out that the expenditure necessary to place the present offices in such a condition as to meet the requirements of the day would probably be found to go a long way towards providing the interest upon the amount required to adapt a portion of the new wing of the State Museum to the purposes of the Geological Survey.

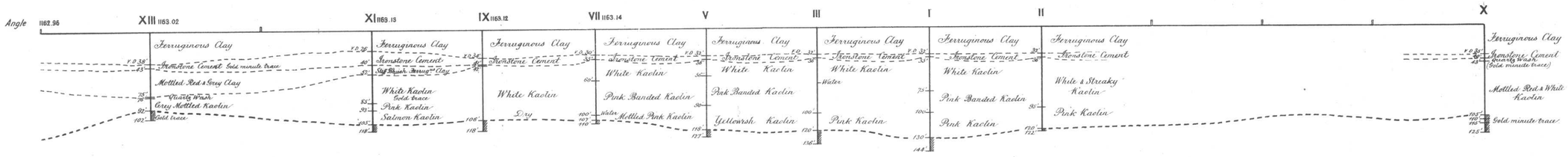
I have the honour to be,
Sir,
Your obedient servant,
A GIBB MAITLAND,
Government Geologist.

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

Sections of Bores







0 50' 100' 200'

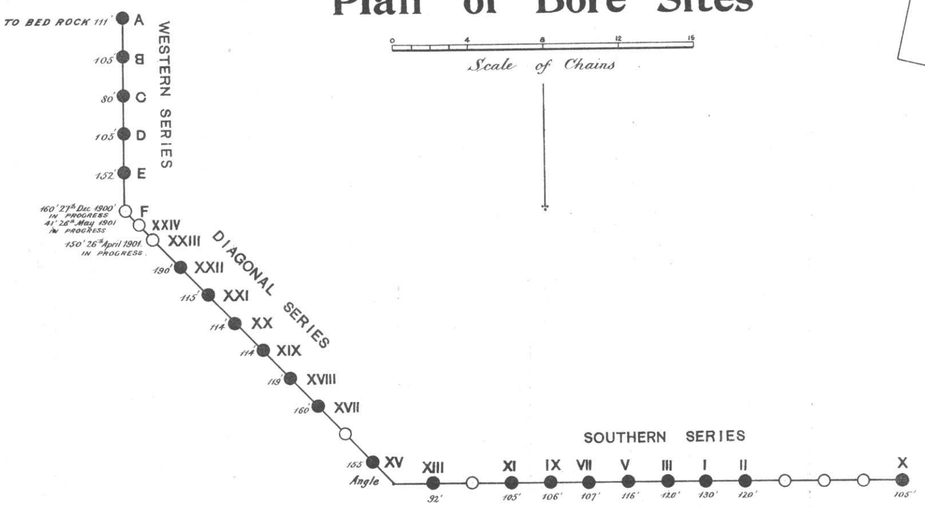
Vertical and Horizontal Scale.

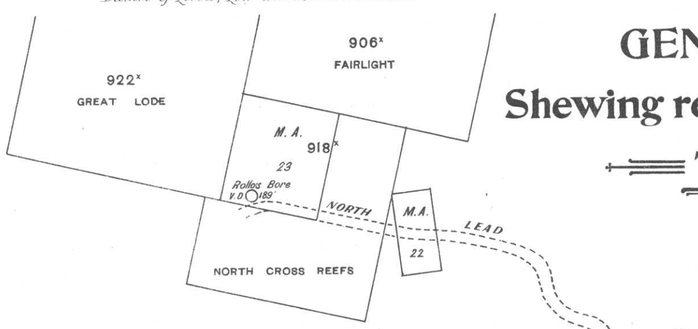
Datum of Levels, Low Water Mark Fremantle.

Plan of Bore Sites

0 4 8 12 16

Scale of Chains





Hon: H.B. Lefroy M.L.A.
Minister of Mines.

GENERAL PLAN And SECTIONS

Shewing results of Boring for the continuation of

THE NORTH LEAD

KANOWNA

BY

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

TO ACCOMPANY ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY FOR
1900

Alfred Gibb Maitland
Government Geologist

Photo-lithoed at the Govt Photo Lithographic Department, Perth, W.A.

Hon: H. B. Lefroy M. L. A.
Minister of Mines.

GENERAL PLAN And SECTIONS
Shewing results of Boring for Alluvial Deposits at
COOLGARDIE

BY

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

TO ACCOMPANY ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY FOR 1900

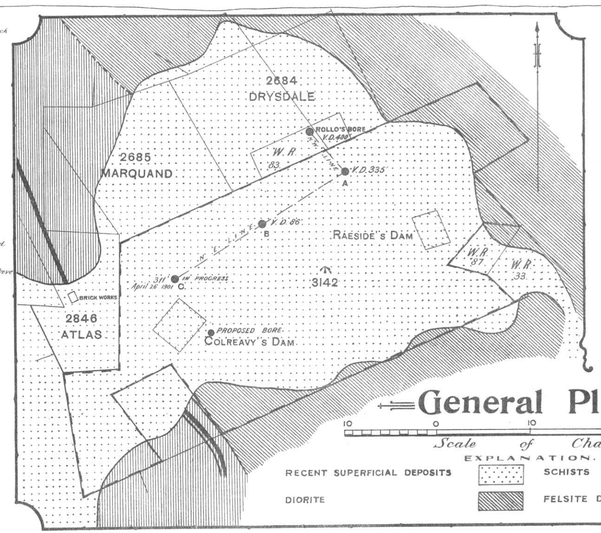
Horizontal and Verfical Scale

100' 80' 0' 100' 200' 300' 400' 500'

DATUM OF LEVELS LOW WATER MARK FREMANTLE

C. BORE. 1335.86

- 7'6" Ferruginous Clay & with Sandstone pebbles
- 10' Compact Yellowish Clay with fragments of rock
- 32' Mottled Red & Blue Clay
- 50' Compact Blue Clay with Pyrites
- 66' Light Blue Clay
- 67'6" Grey Clay mixed with carbonaceous matter
- Soft carbonaceous material with Pyrites. Compact in parts
- Has an odour of Kerosene when fresh
- 231'6" 238' Compact Light Blue Clay with Black sand
- Soft Carbonaceous material similar to above
- 331'6" 334' BED ROCK



General Plan

10 0 10 20 30

Scale of Chains

EXPLANATION.

RECENT SUPERFICIAL DEPOSITS — SCHISTS

DIORITE — FELSITE DYKES

B. BORE. 1327.24 — N. E. LINE

- 8'7" Ferruginous Clay
- Compact Brown Clay
- 19'4" Mottled Brown & Red Clay
- 25' Red Clay
- 51' Brown Clay with fragments of Diorite & Sandstone
- Ferruginous Clay & fragments of Rock with decomposed fragments of Rock & Crystals of Selenite
- 61' Mixed Clay
- Yellow
- 71'6" Dark blue Clay Red Clay
- 78'6" Dark Clay Clay with carbonaceous matter
- 80'6" Brown Clay with decomposed fragments of Diorite
- 82'6" Brown Clay and Gravels decomposed fragments of Rock
- 83'6" Compact Brown Clay
- BED ROCK DIORITE

A. BORE. ANGLE 1324.16 — N. W. LINE

- 5' Surface Gravel
- Red & Blue Clay
- 28' 40'5" Blue Clay
- Dark Clay with Carbonaceous matter and Pyrites
- 121'6" 128'6" Blue Clay & Quartz particles
- 132'6" 145' Quartz & Lignite & Pyrites
- Blue
- Dark Blue Clay with Lignite
- 165'6"
- Blue Clay
- 312'
- Blue Clay with rounded and angular fragments of Diorite and Quartz
- 335' BED ROCK
- APPARENTLY DIORITE

ROLLO'S BORE. & SHAFT (Previously made) 1326.27

- 6' Red Alluvium
- Blue Clay
- 36'
- Yellow Clay
- 85' 87' Heavy Sand School Headers &c
- Blue Clay
- 118'
- Blue Clay containing bands of Lignite and Sheets of Pyrites
- 200'
- Yellow Clay
- 235'
- 270' Coarse Diorite Boulders
- Mixed Schist & Diorite Boulders
- 310'
- Dark Wash
- 358'
- Blue Clay & Diorite Boulders
- 380'
- 388' Carbonaceous Shale
- 438' Diorite & Quartz Wash
- 500' BED ROCK
- PROBABLY DIORITE

A. Gibb Maitland
Government Geologist

Photo Litho'd at the Govt Photo Lithographic Department, Perth, W.A.

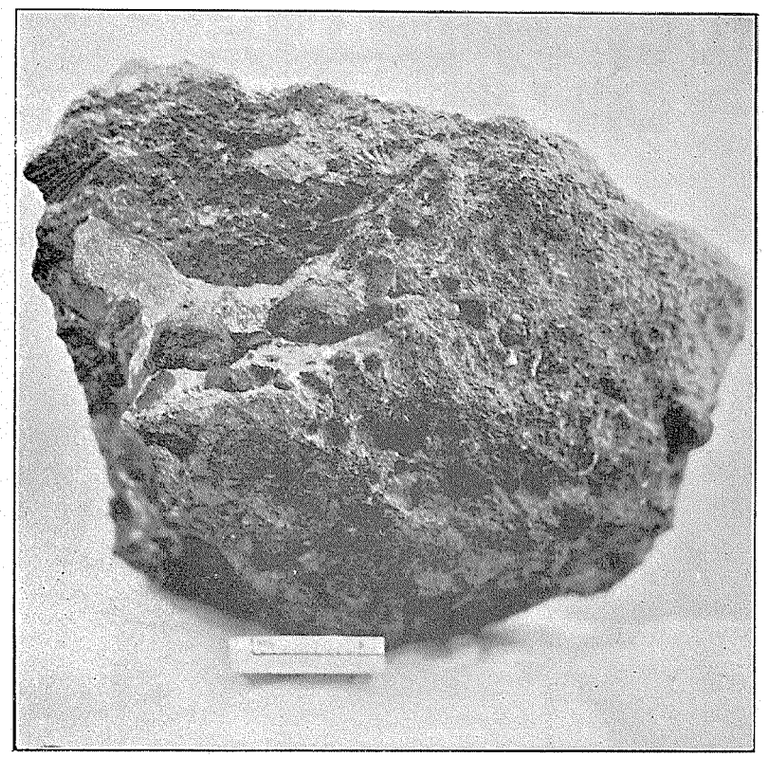


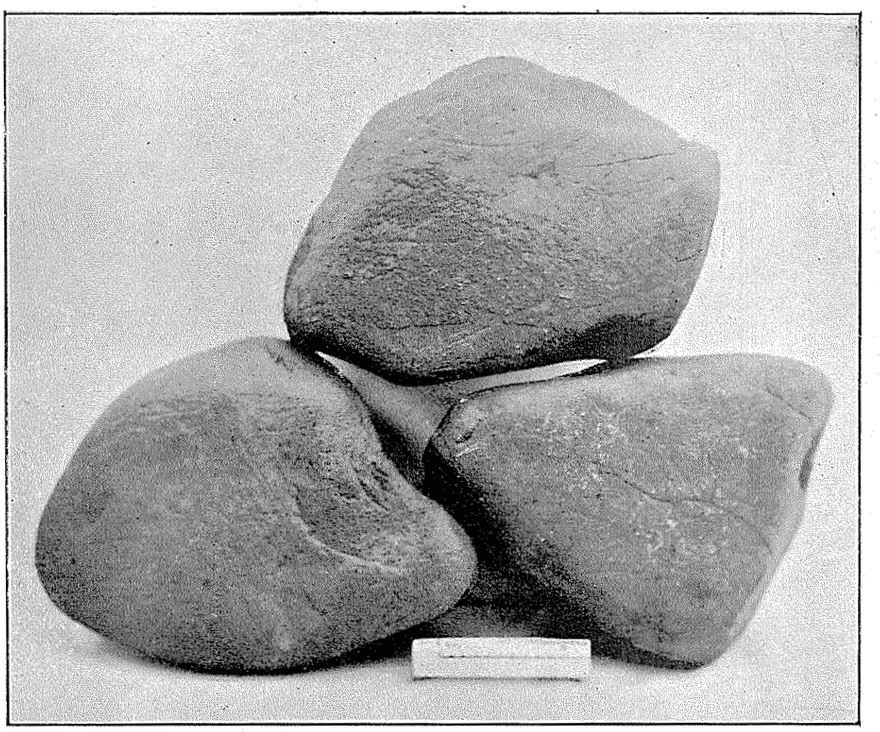
PHOTO. A. PURDIE. WEST AUSTRALIAN NEWSPAPER CO., LTD.

PLATE III.

FOSSILIFEROUS GLACIAL CONGLOMERATE,

CARBONIFEROUS AGE,

GASCOYNE RIVER, WESTERN DIVISION, WESTERN AUSTRALIA.



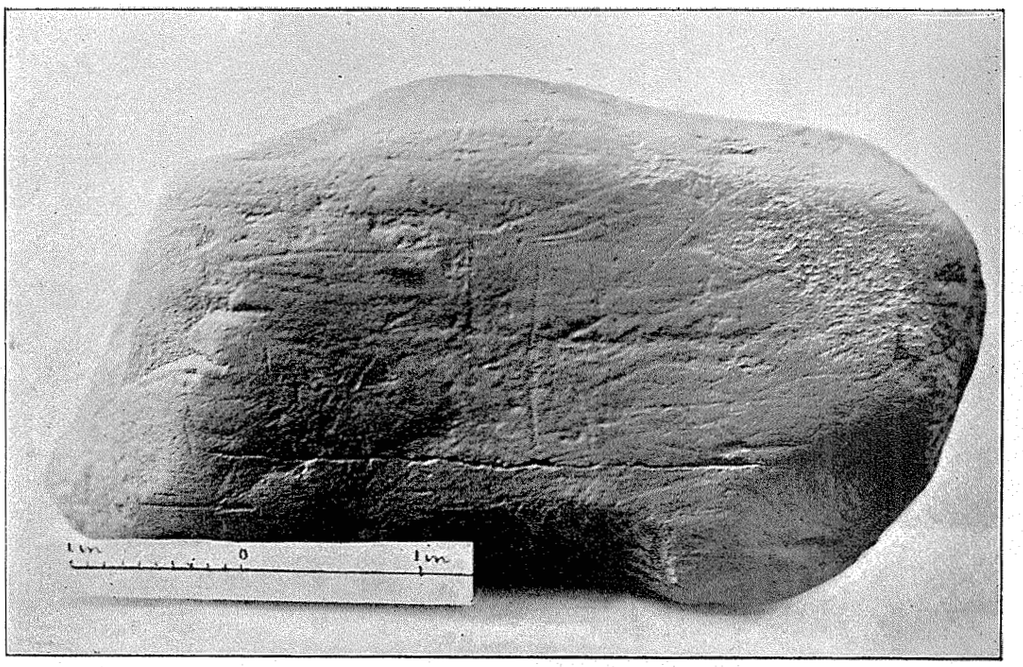


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PLATE IV.

GLACIATED BOULDERS FROM CARBONIFEROUS FORMATION,

MINILYA RIVER, WESTERN DIVISION, WESTERN AUSTRALIA.