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1921.

WESTERN AUSTRALIA.

ANNUAL PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

FOR THE

YEAR 1920,

WITH

A MAP OF WESTERN AUSTRALIA SHOWING THE FOUR MILES TO THE INCH SERIES OF GEOLOGICAL SKETCH MAPS AND OTHER GEOLOGICAL MAPS ISSUED SINCE 1896.

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

1921.

041/21.

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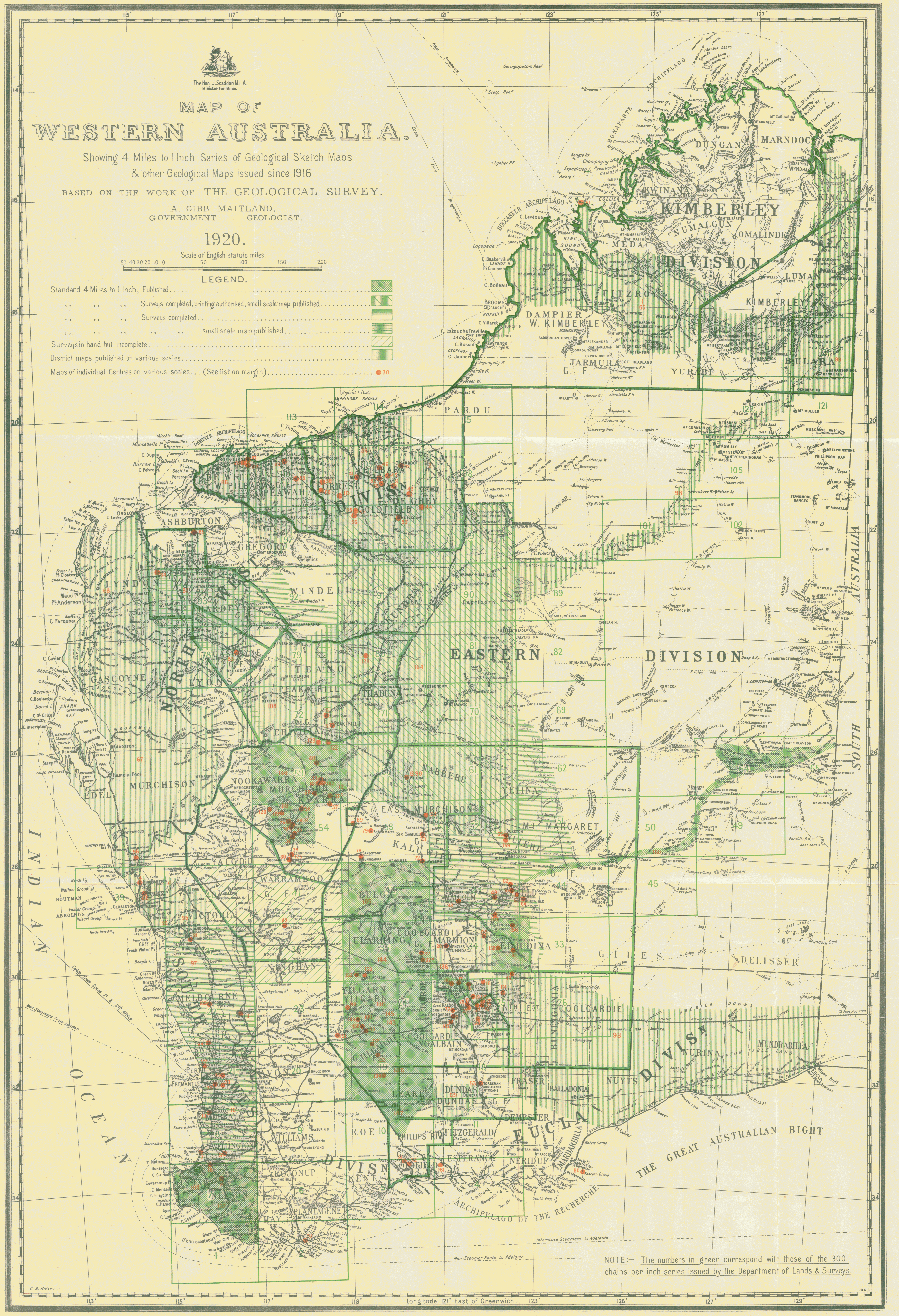

Geological Maps of Individual Centres.

Map.	Annual Report. Year.	Annual Report. Plate.	Annual Report. Scale.	Bulletin. No.	Bulletin. Plate.	Bulletin. Scale.
3. Coolgardie	1897	VII.	20 chains per inch	3	II.	40 chains per inch
4. Northampton	,,	I.	40 ,, ,,	9	....	40 ,, ,,
5. Peak Hill	,,	II.	4 ,, ,,			
6. Horseshoe	,,	III.	10 ,, ,,			
7. Bunbury	,,	IV.	8 ,, ,,			
8. Kanowna	,,	VI.	20 ,, ,,			
9. Collie Coal Field	1898	I.	80 ,, ,,	64	I.	95 ,, ,,
11. Wongan Hills	,,	IV.	10 ,, ,,			
13. Lake Way (Wiluna)	,,	VI.	20 ,, ,,			
14. Greenbushes	1899	I.	43 ,, ,,	32	....	20 ,, ,,
15. Mulgarrie	,,	II.	25 ,, ,,			
16. Lindsay's and Hayes' New Find	,,	III.	25 ,, ,,			
17. Bardoc	,,	IV.	37 ,, ,,			
18. Donnybrook Goldfield	,,	V.	37 ,, ,,			
19. Kanowna	,,	VI.	6 ,, ,,			
20. Menzies	,,	VII.	37 ,, ,,	21	III.	40 ,, ,,
21. Arrino (2 sheets)	1903	....	40 ,, ,,			
22. Wanneroo	,,	....	1½ miles per inch			
23. Canning River Valley	,,	....	20 chains per inch			
24. Helena River Valley	,,	....	20 ,, ,,			
26. Kalgoorlie (separately) (6 sheets)	,,	....	10 ,, ,,			
Do.	1910	I.	30 ,, ,,	42	II.	30 ,, ,,
Do.	....	....	....	42	I.	26·6 ,, ,,
Do. (North-End), (Sheets 1, 2, 5, 6, 7, 10–11)	....	....	....	51	XII.	2 ,, ,,
Do. ,,	....	....	....	69	XII.	10 ,, ,,
Do. ,, (Sheets 10–21)	....	....	....	69	XIV.	2 ,, ,,
27. Boulder Belt (2 sheets)	....	....	4 chains per inch			
28. Auriferous Reefs, Cue and Day Dawn	....	....	....	7	I.	20 ,, ,,
29. Lennonville	....	....	....	8	....	15 ,, ,,
30. Boogardie and Mt. Magnet	....	....	....	8	....	15 ,, ,,
31. Edjudina and Yarri	....	....	....	11	I.	40 ,, ,,
32. Mulline	....	....	....	12 64	I. XVI.	40 ,, ,, 40 ,, ,,
32A. Mulwarrie and Davyhurst	....	....	....	12	II.	40 ,, ,,
33. Leonora	....	....	....	13	....	30 ,, ,,
34. The Island, Lake Austin	....	....	....	14	II.	20 ,, ,,
35. The Mainland, Lake Austin	....	....	....	14	III.	20 ,, ,,
36. Tuckanara	....	....	....	14	IV.	20 ,, ,,
37. Quinns	....	....	....	14	V.	20 ,, ,,
37A. Gabanintha	....	....	....	14	VI.	20 ,, ,,
38. Nannine	....	....	....	14	VII.	20 ,, ,,
39. Meekatharra	....	....	....	14	VIII.	20 ,, ,,
Do. (Sheets A and B)	....	....	....	68	IV.	40 ,, ,,
Do. (Sheets 1–9)	....	....	....	68 68	XIII. XXI.	132 feet per inch 80 chains per inch
40. Abbotts	....	....	....	14	XI.	21 ,, ,,
41. Lalla Rookh	....	....	....	15 40	.... II.	20 ,, ,, 20 ,, ,,
42. Bamboo	....	....	....	15 40	.... IV.	40 ,, ,, 40 ,, ,,
43. Yandicoogina	....	....	....	15 40	.... V.	40 ,, ,, 40 ,, ,,
44. Mosquito Creek	....	....	....	15 40	.... VI.	40 ,, ,, 40 ,, ,,
45. Moolyella Tinfield	....	....	....	15 40	.... VII.	20 ,, ,, 20 ,, ,,
46. Auriferous Reefs, Talga Talga	....	....	....	15 40	.... III.	40 ,, ,, 40 ,, ,,
47. Southern Cross	....	....	....	17 32 48 49	.... I. IX	20 ,, ,, 20 ,, ,, 47 ,, ,, 40 ,, ,,
48. Mt. Morgans	....	....	....	18	....	20 ,, ,,
49. Mulgabbie	....	....	....	18	....	20 ,, ,,
50. Nullagine	....	....	....	20 40	I. VIII.	20 ,, ,, 20 ,, ,,
51. Warrawoona	....	....	....	20 40	III. X.	20 ,, ,, 20 ,, ,,
52. Marble Bar	....	....	....	20 40	VII. XIV.	20 ,, ,, 20 ,, ,,
53. Norseman (2 sheets)	....	....	....	21	....	20 ,, ,,
55. Tambourah	....	....	....	23 40	I. XV.	10 ,, ,, 10 ,, ,,
56. Western Shaw	....	....	....	23 40	II. XVI.	10 ,, ,, 10 ,, ,,
57. Tambourah and Western Shaw	....	....	....	23 40	III. XVII.	80 ,, ,, 80 ,, ,,
58. Just in Time	....	....	....	23 40	IV. XVIII.	5 ,, ,, 5 ,, ,,
59. Wodgina Tinfield	....	....	....	23 40	V. XIX.	10 ,, ,, 10 ,, ,,
60. Stannum	....	....	....	23 40	VI. XX.	10 ,, ,, 10 ,, ,,
61. Laverton	....	....	....	24	I.	20 ,, ,,
62. Lancefield	....	....	....	24	II.	20 ,, ,,
63. Heaphy's Find (Ida H)	....	....	....	24	III.	20 ,, ,,
64. Burtville	....	....	....	24	IV.	20 ,, ,,
65. Auriferous Reefs, Duketon	....	....	....	24	V.	40 ,, ,,
69. Dandaraga	....	....	....	26	III.	1 mile per inch
70. Princess Royal Harbour	....	....	....	26	IV.	1 ,, ,,
72. Lawlers	....	....	....	28	....	20 chains per inch
73. Sir Samuel	....	....	....	28	....	20 ,, ,,
74. Cue	....	....	....	29	....	20 ,, ,,
75. Cuddingwarra	....	....	....	29	....	20 ,, ,,
76. Day Dawn	....	....	....	29	....	20 ,, ,,
77. Bonnievale	....	....	....	31	....	20 ,, ,,
78. Sandstone and Nungarra	....	....	....	31 62	.... V.	30 ,, ,, 40 ,, ,,
79. Birrigrin	....	....	....	31	....	20 ,, ,,
80. Christmas Island	1908	....	9⅓ chains per inch			
81. Koolan Island, Yampi Sound	1908	....	67 ,, ,,			
83. Bangemall	....	....	....	33	II.	10 ,, ,,
84. Uaroo	....	....	....	33	III.	10 ,, ,,
85. Red Hill	....	....	....	33	IX.	5 ,, ,,
87. Roebourne	....	....	....	33	XI.	2 miles per inch
88. Station Peak	....	....	....	33	XII.	10 chains per inch
89. Barrambie	....	....	....	34	....	20 ,, ,,
90. Auriferous Reefs, Wiluna	....	....	....	34	....	20 ,, ,,
91. Ravensthorpe	....	....	....	35	....	20 ,, ,,
92. Desmond and Kundip	....	....	....	35	....	20 ,, ,,
94. Gingin	....	....	....	36 55 72	....	1 mile per inch 1 ,, ,, 1 ,, ,,
96. Geraldine	....	....	....	38	II.	108 chains per inch
101. Whim Creek	....	....	....	41	I.	10 ,, ,,
102. Glenroebourne	....	....	....	41	IV.	20 ,, ,,
103. Weerianna	....	....	....	41	V.	20 ,, ,,
107. Kanowna	....	....	....	47	I.	20 ,, ,,
109. Moora	....	....	....	48	III.	300 ,, ,,
110. Kelmscott Clay Deposit	....	....	....	48 48	IV. V.	8 ,, ,, 80 ,, ,,
111. Pinjarra Limestone Deposit	....	....	....	48	VI.	300 feet per inch
112. Payne's Find	....	....	....	48	VII.	40 chains per inch
113. Soanesville Asbestos Deposit	....	....	....	52	IV.	10 ,, ,,
115. Tindall's and Londonderry	....	....	....	53	II.	40 ,, ,,
116. Ora Banda	....	....	....	54	I.	15 ,, ,,
119. Coodardy	....	....	....	57	III.	20 ,, ,,
120. Poona	....	....	....	57	V.	20 ,, ,,
121. Kurnalpi	....	....	....	59	II.	40 ,, ,,
122. Ruby Well	....	....	....	59	IV.	20 ,, ,,
123. Mikhaburra (Holden's Find)	....	....	....	59	VII.	10 ,, ,,
124. Mt. Keith	....	....	....	59	VIII.	20 ,, ,,
125. Lennonville, Mt. Magnet, and Boogardie	....	....	....	59	IX.	60 ,, ,,
126. Woodline Rush	....	....	....	59	XIII.	6 ,, ,,
127. Golden Ridge	....	....	....	59 66	XV. III.	10 ,, ,, 10 ,, ,,
128. Illgarere	....	....	....	59	XVIII.	6 ,, ,,
130. Narra Tarra	....	....	....	59	XXIII.	10 ,, ,,
132. Marvel Loch	....	....	....	63	II.	40 ,, ,,
133. Great Victoria and Parker's Range	....	....	....	63	III.	40 ,, ,,
134. Olga, Dulcie, and Cheriton's	....	....	....	63	IV.	40 ,, ,,
135. Yerilla	....	....	....	64 64	III. V.	20 ,, ,, 40 ,, ,,
139. Speakmans	....	....	....	66	IX.	10 ,, ,,
141. Yaloginda (Sheets 1–4)	....	....	....	68	XXII.	132 feet per inch
142. Karangahaki (Sheets 1–3)	....	....	....	68	XXIV.	132 ,, ,,
148. Eenuin	....	....	....	71	VI.	40 chains per inch
149. Bullfinch	....	....	....	71	VII.	40 ,, ,,
150. Corinthian	....	....	....	71	VIII.	40 ,, ,,
151. Westonia	....	....	....	71	IX.	20 ,, ,,
152. Jackson	....	....	....	71	XVII.	40 ,, ,,
153. Marda	....	....	....	71	XVIII.	40 ,, ,,
156. Linden	....	....	....	73	II.	40 ,, ,,
157. Yundamindera, Pennyweight Point, Pike's Hollow, and Eucalyptus	....	....	....	73	III.	40 ,, ,,
158. Yilgangi	....	....	....	73	VII.	30 ,, ,,
159. Field's Find (Duketon)	....	....	....	74	III.	10 ,, ,,
161. Munglinup	....	....	....	76	I.	2 ,, ,,
162. Bulong and Lake Yindarlgooda, the Country between	....	....	....	82	I.	30 ,, ,,
163. Bulong Magnesite Area	....	....	....	82	II.	15 ,, ,,

DISTRICT GEOLOGICAL MAPS.

Map.	Annual Report. Year.	Annual Report. Plate.	Annual Report. Scale.	Bulletin. No.	Bulletin. Plate.	Bulletin. Scale.
1. Kimberley District	....	....	....	2	IV.	80 miles per inch
2. Pilbara Goldfield (Part of)	....	....	....	2	V.	20 ,, ,,
10. South-Western Districts	1898	III.	20 miles per inch			
12. Murchison and Sandford Rivers	,,	V.	10 ,, ,,			
13. Irwin River Coalfield	1903	....	20 ,, ,,			
34. Pilbara Goldfield	....	....	....	23 40 15 33 40	[illegible]	10 ,, ,, 10 ,, ,, [illegible] [illegible] [illegible]
66. Kimberley District	....	....	....	25	....	40 ,, ,,
67. Artesian Area North of Northampton	....	....	....	26	I.	[illegible]
68. Artesian Area between the Minilya and Ashburton Rivers	....	....	....	26	II.	25 ,, ,,
71. Greenough River District	....	....	....	26	V.	1 ,, ,,
72. Ashburton and Gascoyne Goldfields	....	....	....	30	I.	10 ,, ,,
76. West Pilbara Goldfield	....	....	....	41	I.	[illegible]
93. Country along Transcontinental Railway	....	....	....	41	X.	[illegible]
95. Country between Arrino and Northampton (2 sheets)	....	....	....	30	....	20 ,, ,,
97. Country between Carnarvon and Moora to the Coast	....	....	....	36	I.	240 chains per inch
98. Wiluna to Hall's Creek (2 sheets)	....	....	....	38	III.	240 ,, ,,
99. Hall's Creek to Tanami	....	....	....	39	I.	15 miles per inch
100. Country North of Southern Cross	1910	II.	10 miles per inch	39	II.	10 ,, ,,
104. South-West Division (Portion of)	....	....	....	[illegible]	[illegible]	[illegible]
105. Lake Darlot, Country in the neighbourhood of	....	....	....	44 45	I.	100 chains per inch 4 miles per inch
107. Yilgarn Goldfield (Part of)	....	....	....	[illegible]	[illegible]	[illegible]
108. Peak Hill Goldfield and Parts of Ashburton and Gascoyne Goldfields	....	....	....	46 48	I. II.	[illegible] 15 ,, ,,
114. Coolgardie and Londonderry, the Country between	....	....	....	53	I.	80 chains per inch
117. Coolgardie and Boulder, the Country between	....	....	....	56	I.	80 ,, ,,
118. Murchison Goldfield (Part of)	....	....	....	57	I.	4 miles per inch
129. Bremer Range	....	....	....	59	XIX.	4 ,, ,,
131. Yilgarn Goldfield (South Part)	....	....	....	62	I.	4 ,, ,,
136. Kalgoorlie and Mulline, the Country between	....	....	....	64	XV.	4 ,, ,,
137. Extreme South-Western Portion of Western Australia	....	....	....	65	I.–II.	4 ,, ,,
138. Coolgardie and East Coolgardie Goldfields, Part of	....	....	....	66	I.	120 chains per inch
140. Meekatharra District	....	....	....	68	II.	4 miles per inch
143. Yilgarn Goldfield	....	....	....	71	[illegible]	[illegible]
144. Lake Barlee and Jackson, the Country between	....	....	....	71	I.	4 ,, ,,
145. Lake Carnegie and Southern Cross, the Country between	....	....	....	71	III.	4 ,, ,,
146. Marvel Loch and North Iron Cap, the Country between	....	....	....	71	IV.	4 ,, ,,
147. Middle Mt. Ironcap and Ravensthorpe Range, the Country between	....	....	....	71	V.	4 ,, ,,
150. North Coolgardie Goldfield (Part of)	....	....	....	73	[illegible]	[illegible]
153. Yerilla District	....	....	....	73	[illegible]	[illegible]
160. Laverton through Warburton range to South Australian Border	....	....	....	78	II. and III.	[illegible]
164. North West, Central, and Eastern Divisions between Long. 119° and 122° 45' E. and Lat. 21° 30' and 27° S.	....	....	....	83	....	[illegible]

By Authority: Fred. Wm. Simpson, Government Printer, Perth.

ANNUAL PROGRESS REPORT OF THE GEOLOGICAL SURVEY FOR THE YEAR 1920.

DESPITE the fact that during the year 1920 the personnel of the field staff of the geological survey suffered such further reductions as to practically bring it to vanishing point, a good record of work, not as the result of a change of policy but rather as an adaptation to circumstances, has been shown. If, however, governmental efforts tending towards the industrial development of the State's mineral and allied resources are to be carried out upon scientific lines, which alone will prove ultimately effective, it is absolutely imperative that immediate steps be taken to bring the field staff up to its normal strength by the appointment of adequately trained and experienced geologists.

THE STAFF.

There were 13 classified officers engaged upon the work of the geological survey during the year 1920. There have again been some reductions in the field staff, the department losing the services of Messrs. Talbot and Clarke.

Mr. Talbot, who originally joined the Survey in the year 1902, found himself, owing to a self sacrificing devotion to duty, no longer able to carry out the arduous field work upon which he had been engaged during his term of service, and was in consequence retired under Section 56 of the Public Service Act, such retirement dating from the end of December. Few men have contributed more to our knowledge of the inaccessible and arid regions of the State; the value of Mr. Talbot's personal contributions to our knowledge of the topography and structural geology of large tracts of country is shown by the records of his published work, and forms the foundation upon which future investigations must be based. As the result of Mr. Talbot's retirement, the Geological Survey loses the services of an officer possessing an accumulation of specialised local knowledge, whom it will be difficult to replace.

Mr. E. de C. Clarke, who was selected from a large number of candidates for the position of field geologist, joined the staff in 1913, a position which he resigned to accept the more lucrative appointment of Lecturer in Geology at the University of Western Australia. During his term of service Mr. Clarke has carried out a good deal of that multifarious work called for in a Government department, viz., reconnaissance geological surveys, detailed work in mining fields in active operation, investigations into the geological aspects involved in dealing with applications for State aid, and towards the development of mining, etc.

Mr. Clarke's work on the mining field at Meekatharra represents a type of the most detailed work carried out by the Survey, whilst that on the Warburton Range country, near the South Australian frontier, carried out in conjunction with his colleague, Mr. Talbot, is typical of that important class of exploration work covering in a general way large tracts of country.

The retirement of the two previously mentioned field geologists has brought about a condition of affairs which, in the public interest, demands serious and immediate attention. It is to be hoped that when the positions are filled better financial inducements will be offered than has been the case in the past, so as to enable the services of experienced officers capable of undertaking more or less independent work to be secured and retained.

FIELD WORK.

The table hereunder shows the distribution of the field work, and gives the names of the officers engaged in the different portions of the State during the calendar year 1920.

Table showing the Distribution of Field Work for the Year 1920.

Goldfield or Land Division.	H. W. B. TALBOT.		E. DE C. CLARKE.		F. R. FELDTMANN.	
	No. of days in the field.	Percentage of working days.	No. of days in the field.	Percentage of working days.	No. of days in the field.	Percentage of working days.
Coolgardie Goldfield	...	...	93	25·47	...	...
North-East Coolgardie Goldfield ...	...	...	87	23·83	...	...
Mt. Margaret Goldfield	77	21·09	...	...	...	...
South-West Division	2	54	...	...	47	12·87
Total	79	21·63	180	49·30	47	12·87

The areas of those portions of Western Australia covered by geological maps on the different scales published by the Geological Survey are shown on the plan by which this report is accompanied.

H. W. B. Talbot, Field Geologist.

Mr. Talbot, after returning from his annual leave, was actively engaged at headquarters until the middle of April, with the exception of a brief visit to Collie, preparing the plans and reports in connection with the work of the previous field season. This officer left Perth on the 13th April for Laverton, and the period between that date and the 30th June was devoted to extending the geological reconnaissance survey northward from the point at which the work ceased during the previous year to the south-eastern portion of the area, which has been fully described in Bulletin 83, *i.e.*, northward from the latitude of Duketon to the Lee Steere Range. The remainder of the year was spent at headquarters in the preparation of plans, the writing of reports, the revision of Bulletin 83, and other work necessitated by Mr. Talbot's retirement at the end of the year. The total number of days spent in the field by Mr. Talbot amounted to 79.

E. de Courcey Clarke, Field Geologist.

Mr. Clarke, after returning from annual leave in the middle of January, was at headquarters until the end of May, engaged in writing up the results of the previous season's field work on the Yalgoo Goldfield and in collecting data for the survey of the mining centres of Mt. Monger and St. Ives. The officer was engaged at the Mt. Monger centre, from the beginning of June (with the exception of 10 days' sick leave) until the 6th of August, in making a geological survey of that centre on a scale of five chains per inch, and of about 150 square miles of the surrounding country on the scale of 80 chains to the inch. St. Ives was reached on August the 10th, from which date until the 23rd of November (except for 17 days occupied by a visit to Perth to deal with the question of boring for coal in the south branch of the Irwin River) Mr. Clarke was engaged in mapping the St. Ives, Love's Find, and Paris centres on a scale of 10 chains to the inch, and about 200 square miles of surrounding country on the scale of 80 chains per inch. The last week in November was spent in examining developments which had taken place at Mt. Monger since August. On December the 2nd Mr. Clarke, having been appointed to the position of Lecturer in Geology at the Western Australian University, left Monger for Perth in order to complete the necessary office work, relinquishing his position in the Survey. Six interim reports on the geological features of the new finds were written in the field, and at least four of them were published more or less *verbatim* in the Goldfields press.

An informal lecture on the geology of St. Ives and neighbourhood was delivered at the conclusion of Mr. Clarke's field work; it was contemplated delivering a similar address when revisiting Mt. Monger, but the decrease in population at that centre, the expenditure of time required to prepare the suitable maps, etc., seemed unwarranted, and the project was abandoned.

Mr. Clarke spent 180 days in the field, which were distributed throughout the fields enumerated in the table.

F. R. Feldtmann, Field Geologist.

Owing to the exigencies of the department, it was found impossible for Mr. Feldtmann to spend but a very short time in the field. The period between the 7th and 15th of July was spent in examining the barytes deposit at Cranbrook; that between 30th of August and the 2nd of September was devoted to an examination of the reported gold find at Bila, near Brunswick, and from the 21st of October to the 25th of November Mr. Feldtmann spent in more or less detailed examination of the lodes of that district, including the Surprise lode at Galena. The total number of days spent by Mr. Feldtmann in the field amounted in all to 47.

PRINCIPAL RESULTS OF THE YEAR'S FIELD OPERATIONS.

1.—DEVELOPMENT OF WATER POWER FOR THE GENERATION OF ELECTRICITY, KIMBERLEY DIVISION.

(A. Gibb Maitland).

The Kimberley or Northern Division forms part of what may be conveniently described as the Great Plateau of Western Australia. The portion of the plateau lying within the Kimberley Division consists of an elevated tableland, the King Leopold Plateau, the highest point of which is believed to be about 2,800 feet above sea level.

This dissected plateau is built up of horizontal or gently inclined strata, and in general possesses all the scenic features of such formations, viz., flat-topped hills with more or less precipitous sides.

This plateau, which lies within the 30 to 40 inches rainfall belt, is drained by the principal rivers, viz., The Prince Regent, Roe, Lawley, King Edward, Drysdale, Chamberlain, Hann, Isdell and Charnley. These rivers, all of which extend for considerable distances inland, flow seaward through gorges (cañons), sometimes of great extent and of exceptional beauty, without the water being of any special service to the country.

Such waters, if properly controlled, have some potential value as a possible source of power. The advantages to the State from the development of water power, if such is found to be feasible, are, as can be readily understood, almost beyond measure.

The distance, however, to which power from such sources can be economically transmitted is naturally limited.

The possibility of utilising the energy of the waters of the Glenelg, Isdell, and Charnley Rivers for the generation of power for a hydro-electrical installation required in connection with the development of the iron deposits of Yampi Sound, has led to applications for water rights by private persons.

During the course of an exploration carried out in the King Leopold Plateau in the year 1901 I travelled down the valley of the Isdell River, and on July 8th saw several of the rapids and gorges.

The most important of these ("Deep Gorge" of the map xix./800) is that which lies immediately above one of the water rights applied for. The waters of the Isdell enter the gorge below our camp,

C. 4. The gorge at this point forms a narrow, picturesque cañon, cut out of gently inclined beds of quartzite, seamed with thin veins of quartz. After flowing some miles down this cañon the Isdell River enters the open tidal water, Walcott Inlet, through a narrow gorge. As I saw it on the 11th of July, 1901, the mouth of the Isdell River was about 150 yards wide, with steep, muddy banks, and a sandy bar across it; so far as could be judged, the rise and fall of the tide at this spot appeared to be about 20 feet.

The Charnley River, the subject of another application, enters the head of Walcott Inlet, and at some distance above its mouth flows through a steep-sided cañon excavated out of quartz of the type prevailing on the plateau. This cañon I found to be about 150 yards wide, with walls of from 200 to 300 feet in height.

The Calder River, which also flows into Walcott Inlet, likewise traverses some cañons on the way to the sea.

Of the portion of the Glenelg River which forms the subject of another application, I have no personal knowledge; its position, however, as shown by reference to the plan, indicates that it is a tidal arm of the sea, into which the waters of the river flow after falling about 1,150 feet from its source in the Elizabeth-Catherine Range.

As pointed out previously such waters as have been referred to possess a certain potential value, and the question for investigation is how this potential wealth can be turned into actual wealth.

The somewhat abnormal high rise and fall of the tide has led to expectations in regard to the utilisation of this source of power, which, theoretically, is great; while this is undoubtedly the case, experience elsewhere has shown that the difficulties in making use of a tidal flow, though not insuperable, are great, whilst the power produced is expensive in proportion to the energy furnished.

Experience has shown that satisfactory and effective water power requires the maintenance of a uniform flow in the rivers developed, and, in order to increase the dependable flow, it is necessary to impound a sufficient quantity of water above the power station; this would involve the erection of a storage dam or dams of sufficient capacity for the purpose.

Whether or not it is possible to utilise the waters of the Isdell, Charnley, Calder, Sale and Glenelg Rivers as a source of power, can, of course, only be satisfactorily ascertained after careful surveys have been made by hydraulic engineers—work which, of necessity, would take some considerable time to carry out.

It seems that, at the present stage, the most important aspect arising out of the applications for water rights is for the Government to consider as to whether—

(a) water powers—whatever may be their ultimate value—which are the property of the people as a whole, should be controlled by the State, or whether

(b) they should be leased to others for development on a scale sufficient to adequately meet public requirements, in such a way that the community may reap the fullest advantage from one of the Nation's resources.

2.—ARTESIAN WATER, GERALDTON.

(A. Gibb Maitland.)

The matter of obtaining water from artesian sources, suitable for domestic or most industrial purposes to meet the requirements of Geraldton, has been dealt with by this Department at different times since the year 1897, as may be seen by reference to the reports which have already been supplied, viz.:—

(a) One by the Government Geologist dated the 5th of March, 1897.

(b) One by the Acting Government Geologist dated the 3rd of December, 1908.

(c) Report upon the Prospects of obtaining a Water Supply for Geraldton, either Artesian, Sub-Artesian or Catchment Areas, by the Assistant Government Geologist, dated the 16th of February, 1910, and communicated to the Public Works Department on the 10th of March, 1910, and

(d) A memo to the Chief Engineer for Water Supply dated the 11th of June, 1920.

The results of such boring operations as have been carried out demonstrated that an artesian water basin exists in the vicinity of Geraldton—the term "artesian" being defined in this connection as waters under a natural pressure which rise above the level at which they are encountered, though not necessarily reaching to or flowing over the surface of the ground.

The geological features of the Coastal Plain in the vicinity of Geraldton have already been dealt with in previous reports and hardly need much further elaboration.

The salient features which have a bearing upon the probability of striking fresh water in the vicinity of the Geraldton Racecourse are briefly recapitulated in the following paragraphs.

The rocks which make up the Coastal Plain in the vicinity of Champion Bay are sands, sandstones, clays and, subordinately, limestones, which have been comparatively little altered from their original condition and are mainly of marine origin.

The land area of the Coastal Plain stretches from Dongara to the mouth of the Murchison River, whilst the underwater extension reaches to the 100 fathom line, about 70 or 80 miles to the west of Geraldton.

The strata, so far as is ascertainable in the vicinity of Champion Bay, have a gentle dip to the east, the inclination being measurable in feet per mile rather than in degrees.

The lower members of the strata underlying the Coastal Plain in the vicinity of Champion Bay do not outcrop but merely abut against the older crystalline rocks ("bedrock"), a stratigraphical arrangement which is of high importance in its bearing on the question of the possibility of the occurrence of potable artesian water.

Many of the sandy beds of the Coastal Plain are of such a lithological character as conduce to the absorption and transmission of water.

The geological conditions are suitable for the storage of considerable quantities of deep-seated water, provided the strata are disposed in such a way as to admit of the absorption of the rainfall, which is the source of the artesian water in this portion of Western Australia.

The strata lie on an uneven surface, which may have been modified by faulting. Only one borehole has unequivocally reached the floor of ancient crystalline rocks, viz., that at the Railway Yard at Geraldton, which is reported to have struck granite at a depth of 420 feet, without a supply of water having been obtained.

The Geraldton Race-course bore was carried down to a depth of 1,531 feet, and is stated to have yielded a supply of salt water which rose to a height of 45 feet from the surface. The water on analysis was found to contain a quantity of salt, about equal to that in sea water.

From such evidence as is available it is not by any means quite clear as to whether the salt water reported came from the upper levels or not. A manuscript geological map in the Geological Survey Office contains the following note relating to the Geraldton Race-course bore: "Fresh flow 11,688 gallons at 73 feet." The original source from which this information was derived is unknown, though it is contained on a geological map used by the late Mr. H. P. Woodward in the field investigations carried out by him in the neighbourhood of Geraldton.

It has been demonstrated by boring operations at Dongara and the Geraldton Race-course, in the Champion Bay neighbourhood, that the salt-water areas are relatively near the sea, and in fairly low-lying land near the coast. The water drawn from the Yardarino bore, 9 miles from the coast and 130 feet above sea-level, proved to be much more potable, containing 67.76 grains per gallon of sodium chloride as against 1,154.86 and 907.20 in the Dongara and Geraldton Race-course bores respectively.

Shallow saline waters which may owe their origin to the direct entrance of sea water to the strata have no necessary relation to any deeper waters which may be present in the rock series.

Some, at any rate, of the saline waters occur in beds of marine origin, in which the imprisoned sea water has never been completely replaced by fresh water, owing to the structural arrangement of the strata preventing the escape of the contained water.

Salt water is not peculiar to any one particular horizon and does not bear any necessary relation to the geological age of the deposits.

The presence of salt water may be due either to the leaching of marine deposits, the penetration of sea water, or a leaching of the marine beds into underlying deposits.

The occurrence, however, of artesian water in the vicinity of Geraldton is now no longer a matter of theory, as has already been demonstrated by boring operations carried out; the main point for consideration now being whether by boring in the vicinity of the Racecourse (it being considered impracticable to deepen the existing borehole) a supply of potable water can be reasonably anticipated from the strata lying at a deeper level than that already encountered at a depth of 1,531 feet.

Salt water beds tend to freshen as circulation down the dip is established. It may be that the high salinity of the water at Dongara and the Geraldton Race-course results in a large measure from an effective penetration of sea water through the superficial beds overlying the deeper sediments. The actual measure of freshening from a salt water area in a series of beds has already been determined in the case of the Dongara and Yardarino bores, where a very notable variation in salinity within a few miles has been observed.

Whether the water obtained from relatively deep-seated sources is likely to be chemically purer than that drawn from the two bores in question is one of those questions to which a definite answer can hardly be given.

The feasibility, therefore, of obtaining water suitable for domestic or industrial purposes from the deep-seated sediments in the vicinity of the Geraldton Race-course is doubtful until established by actual boring operations, which have been, as pointed out in my report of the 5th of March, 1897, carried down through the whole thickness of beds, and operations only cease when the floor of the old crystalline rocks has been reached.

In considering the advisability of continuing operations down to bedrock, it ought not to be lost sight of that water which percolates beneath the surface dissolves the soluble constituents of the strata to an extent which appears to be in some measure dependent on the composition of the rock it traverses, the depth and the time it remains confined.

As a rule it has been found that artesian waters are less chemically pure than surface waters, for the reason that, the farther they penetrate, the longer they remain embedded in the strata, the greater are the opportunities for solution. Where water is absorbed by quartzose sandstones and allied rocks of the nature met within the bore at the Geraldton Racecourse, without coming in contact with calcareous beds, such would naturally be expected to be relatively free from mineral impurities.

Geological conditions are suitable for the storage of artesian water in the sedimentary rocks of the Coastal Plain of the Champion Bay neighbourhood, and it is very much to be regretted that nearly all the bores put down by the State in the area of the Coastal Plain have not been carried down deep enough to reach bedrock.

In the case of the Geraldton water supply, had this been done as recommended in 1897, the problem as to whether the town could depend upon artesian water for its use would have been settled for all time. Should operations be decided upon, over 1,500 feet of needless boring will probably have to be undertaken, as in all probability it may be found impracticable to either ream out or deepen the Racecourse bore hole.

The relative merits of artesian sources as against surface catchments for town supplies are, of course, a matter outside the province of a geologist, though it may be pointed out that in the Coastal Plain of the eastern portion of the United States of America, where the geological conditions have proved to be favourable, hundreds of artesian wells constitute the chief public water supplies in many town and cities, and are also numerous in villages and rural districts.

3.—PETROLEUM PROSPECTS OF THE BUSSELTON NEIGHBOURHOOD, SOUTH-WEST DIVISION.

(A. Gibb Maitland).

The work of the Geological Survey is, as is well known, carried out for what it is worth, and when properly interpreted serves a variety of purposes, not the least important of which is the aid it supplies in dealing with questions relating to the possibilities of the occurrence of petroleum-bearing rocks, etc.

It has already been pointed out in previous reports dealing with the subject of the occurrence of oil in different portions of Western Australia, how it is generally recognised that the foundation of successful petroleum enterprise must be laid by the geologist rather than by the engineer. Hence the necessity for careful and detailed geological surveys forms an essential preliminary to (a) the search for areas of suitable petroleum-bearing rocks, and (b) any intelligent scheme of boring operations designed to locate favourable geological structures and the occurrence of oil pools.

In this connection, attention may be drawn to the debate in Parliament on the subject of prospecting for petroleum, as reported in *Hansard* No. 15, Session 1919, p. 1326:

> . . . . prospecting for oil is not merely a matter of putting down a bore. We have to do the preliminary prospecting first in order to decide which is the most likely site to start operations upon. I am not satisfied that geologists are the best judges. I shall, however, have to depend upon the advice that is given by our geologists. We may be doing something in the direction of finding oil, but others who have different grounds to work upon may find a likely spot more speedily than geologists would do.

The general geology of the Busselton neighbourhood, using the latter term in its widest sense, has been fully set out in Bulletin 44—A Geological Reconnaissance of a Portion of the South-West Division of Western Australia. The results of this survey, which are graphically summed up in the geological sketch maps and the sheet of sections which have been appended to the report, are of high importance in their bearing upon the possibility of the occurrence of crude petroleum in the area which it covers. A good deal of boring has been carried out in the Busselton district, particulars regarding which are given in Bulletin 44, pages 29-34, and the records show that the Government Bore (No. 5), at the Vasse River, struck bedrock (gneiss and granite) at 655 feet 6 inches below the surface, and that at Newtown (No. 6) reached the floor of ancient crystalline rocks (gneiss), at 330 feet. Neither of these bores gave any indication leading to the belief that the occurrence of petroleum was likely. Official reports (Bulletin 74, Report 66) have also been made on the area in the vicinity of Block 687, about 6 miles from Busselton, on the Abba River, which discharges into the Vasse Estuary. This area is underlaid by sands, clays, and gravel, estimated to be about from one to two hundred feet thick, beneath which lie the beds of the Donnybrook Series, the thickness of which is unknown; though from such evidence as is available, it does not appear at all likely that the floor of ancient crystalline rocks upon which the beds rest is more than (even if as much as) 200 feet below the coal-bearing horizons, as shown in the bores at Newtown and Busselton. No undoubted indications of the occurrence of petroleum or rock oil have been found in the neighbourhood.

The possible existence of a commercial petroleum field is, as well known, dependent upon three essential factors resulting from the conditions of deposition, viz., (a) the original oil-forming material, (b) a porous reservoir rock, and (c) an impervious rock cover. As has been pointed out in previous reports, the most important evidence in regard to the petroleum carrying character of formations consists of traces of residues of oil, viz., such as (a) a seepage of petroleum, or (b) exudations of asphaltum, *i.e.*, black veinlets of solid hydro-carbons at points on the surface. Petroleum seepages stain the rocks for some distance around them, and are accompanied by a characteristic odour. It was the occurrence of seepages which ultimately led to the development of pretty nearly all the leading oil fields of the world. Oil seepages, while of the utmost importance as "indicators," are, of course, not the only thing required, for the structural features of the strata must be of such a nature as to favour the accumulation of petroleum in commercial quantities. Geological research has definitely established the intimate connection which exists between pools of rock oil and foldings in the earth's crust, and in this way the foundations have been laid of intelligent and successful modern boring operations.

It is known that if petroleum occurs distributed in a porous and more or less horizontal stratum, such as underlies the Coastal Plain, in the vicinity of the Vasse, it cannot accumulate in sufficient quantity to make its exploitation a remunerative commercial undertaking.

One of the many wide-spread popular fallacies relating to the occurrence of petroleum is that such can be obtained by boring in unsuitable rocks if you only go deep enough.
Such a view is, apparently, not without its adherents in Western Australia, in so far as may be inferred from the following statement appearing in *Hansard* No. 15, Session 1919, p. 1326:

> Lord Fisher declares that although he is not a geologist, there is no part of the world where oil cannot be found if boring is conducted deeply enough. Others who are not geologists have declared that Lord Fisher is a lunatic . . . . I hope he will prove to be a lunatic in regard to oil discoveries in Western Australia, and that by following his advice we shall find that much needed commodity in this State.

In this connection it is only necessary to direct attention to the following statement of one of the world's leading authorities on petroleum geology:

> *Drill Deep.*—Very frequently the statement is made that all that is necessary to secure oil is to drill deep enough, and the failure to obtain oil in a well is explained as lack of depth. This is possibly true in the case of an individual well correctly located on a structure, but as generally applied the statement is fallacious. To drill without the knowledge that the well is actually on a favourable structure and that in depth we may hope to strike a favourable reservoir is a waste of money and time. Whenever this argument is presented it is well to call to mind the fact that if depth were the only requisite to a producing well, the investor would probably prefer to sink wells in his own back yard where markets and transportation facilities are at hand.

In regard to the matter of boring for rock oil in the neighbourhood of Busselton, such would be absolutely unwarranted until some definite "indications" of petroleum have been discovered in localities which are, from the point of view of geological structure, suitable. To initiate any scheme of boring operations until some such indications of the occurrence of rock oil have been met with savours of putting the cart before the horse.

To sum up the available evidence relating to the possibility of the occurrence of oil in the vicinity of Busselton, it appears that (a) there is a fairly large area of strata of sedimentary origin which contain amongst their members rocks of varying degrees of porosity, and some coal seams; (b) the beds have not been proved to be very thick nor in any way thrown into folds; (c) no oil seepages or other exudations of petroleum residuals have been noticed anywhere in the vicinity; (d) granite and allied crystalline rocks have been met with at relatively shallow depths in two of the bore holes, the positions of which are shown in the plan attached to Bulletin 44.

The Hon. the Premier, in reply to the deputation which waited upon him on the 6th of March at Busselton regarding boring for petroleum, intimated that:

> The public must carry out their own boring operations, and that when there was a reasonable chance of success, the Government would assist.

This being the declared policy of the Government, State aid should only be granted in those cases where undoubted indications of oil exist, and the bore sites selected in accordance with the information afforded by a study of the structural geology of the area. Anything short of this would tend to leave the public interest in jeopardy, in as much as without it the Government might be placed in that undesirable position of enabling company promoters, *et hoc genus omne,* to utilise the fact of the State's contributing towards the cost of boring operations as a means of deluding the public into the belief that its official scientific advisers are of the opinion that there might be more in the venture than "very considerable gambling chances."

4. NOTE ON A SPECIMEN OF SUPPOSED BITUMEN FROM TURKEY CREEK—KIMBERLEY DIVISION.

(A. Gibb Maitland.)

A sample of supposed bitumen was received at the Geological Survey Office on the 30th of June through the Hon. the Colonial Secretary, to whom it had been handed by Mr. Walter Okes of Ningbing Station, near Wyndham, with the statement that he believed it to be "oil shale or coal."

An identical sample was received on the same date from Mr. Hobler, the engineer for Commonwealth Railways, who stated that it had been handed to him while accompanying the Ministerial party in Kimberley.

Mr. Okes, it appears, had been prospecting for coal in the Kimberley Division prior to serving in the war, and has now apparently resumed his operations about 50 miles from Turkey Creek. He informed the Minister that he was confident a valuable oil deposit had been discovered.

The sample received from Mr. Hobler, which is in every respect identical with that submitted by the Hon. H. P. Colebatch, has been examined in the Geological Survey Laboratory and reported on by Dr. Simpson (G.S.L. 6104E) as follows:—

> The sample consisting of a brilliant black organic substance associated with rock fragments, chiefly limestone, claystone, and cherty rock. The black substance is firmly adherent to some of the rock and penetrates deeply into it along fissures and other cavities, but does not impregnate it. It is brittle, not sticky, is slightly heavier than water, has no perceptible odour, and does not melt at temperatures up to a red heat.
>
> By washing, some of the black material was obtained as free as possible from the associated rock. This had the following composition:—

Moisture	0.84	per cent.
Volatile matter	38.20	"
Fixed carbon	41.00	"
Ash	19.96	"
	100.00	

> A distillation experiment showed the volatile matter to consist of:—

Water	1.9	per cent.
Oil	16.0	"
Gas	20.3	"
	38.2	

> The gas burnt freely with a slightly luminous flame. The oil was dark brown in colour, translucent, fluorescent, and of small viscosity.
>
> Treatment of the black substance with carbon bisulphide extracted 10.3 per cent. of a brilliant black bitumen.
>
> Though different in some respects from any asphalt with which I am acquainted, I am inclined to consider this black material to be a true asphalt akin to glance pitch, and therefore a surface indication of petroleum.

So far there is no definite information as to the precise whereabouts of the locality from which Mr. Okes obtained the sample handed to the Hon. the Colonial Secretary, and to Mr. Hobler. An inspection of the geological map of Kimberley indicates that Turkey Creek is made up of metamorphic rocks such as slates, schists, gneisses, etc., which are certainly not coal-bearing.

On the other hand, there are large areas of limestone to the south of Turkey Creek, on the outcrops of which there might be bituminous exudations.

Bituminous limestones are not uncommon in many geological formations in different parts of the world, though not always in such quantities as to render distillation of the oil commercially practicable. In some cases, however, it has been found possible to utilise bituminous limestones, sandstones, etc., for paving and allied purposes.

Glance pitch, to which the samples submitted bear some resemblance, is not uncommon in Egypt, East Syria, and the Dead Sea region, none of which, however, are productive oil-fields, though crude petroleum has been found locally.

Mr. Okes, it appears, has applied for a prospecting area (P.A.) for oil, the position of which does not appear to have been fixed by survey, but it is stated to be about 10 miles from the junction of the Ord and the Negri Rivers. Its assumed position lies just to the south of Mount Close, on the extensive basaltic plateau which covers such a large area of country in this portion of Western Australia.

It is necessary to have some definite and authentic data as to the precise locality, mode of occurrence, etc., relating to the specimens submitted by Mr. Okes. At present, for reasons which are self evident, it is advisable to withhold judgment and to act with caution.

5.—GLAUCONITIC SANDSTONE IN ROBERTS STREET BORE, METROPOLITAN AREA.

(A. Gibb Maitland.)

A bore in search of artesian water was put down to a depth of 665 feet at Roberts Street, Osborne

Park, towards the latter end of 1920, the section as supplied by the Engineer for Metropolitan Water Supply being as follows:—

Strata.	Depth.		Thickness.	
	ft.	in.	ft.	in.
Fine white sand	0	0	31	0
Yellow sand	31	0	58	0
Brown conglomerate and sandstone	89	0	0	6
Coarse sand	89	6	7	6
Clay	97	0	4	0
Clay and Gravel	101	0	7	0
Dark shales and sandy shales ...	108	0	92	0
Dark shales	200	0	90	0
Dark sandy shales	290	0	70	0
Soft sandstone (*water bearing*) ...	360	0	15	0
Sandy shale (*with increase of water*)	375	0	75	0
Green sandstone (GLAUCONITIC)	450	0	20	0
Dark puggy shales with pyrites	470	0	20	0
Grey sandstone (*with increase of water*)	490	0	48	0
Dark grey shale	538	0	12	0
Sandstone (*containing water*) ...	550	0	50	0
Dark grey shale	600	0	25	0
Sandstone (*containing more water*)	625	0	20	0
Dark shales and pyrites ...	645	0	7	0
Black micaceous sandy shale ...	652	0	13	0

At a depth of 370 feet the yield from the bore was 12,000 gallons of water per day; at 538 feet it was 50,000 gallons; from between 652 and 676 feet the yield of overflowing water was 1,200,000 gallons of good cool potable water.

A band of glauconitic sandstone 20 feet in thickness was encountered at a depth of 450 feet.

A complete analysis of it was made in the Geological Survey Laboratory, and its composition shown to be as follows:—

Complete Analysis of a Greensand (G.S.L. 6658E) from 450ft. to 470ft. Roberts Street Bore, Osborne Park.

	Per cent.
SiO_2	86·82
Al_2O_3	3·63
Fe_2O_3	2·98
FeO	·78
MnO	Trace
MgO	·54
CaO	Trace
Na_2O	·45
K_2O	2·54
H_2O-	·70
H_2O+	1·21
TiO_2	·27
ZrO_2	Trace
CO_2	·05
P_2O_5	Trace
B_2O_3	Trace
FeS_2	·20
Cl	Trace
	100·17
Acid Soluble Na_2O	·12
" " K_2O	1·04

Analyst—D. G. Murray.

The approximate mineral composition is—

Quartz	71
Glauconite	16
Felspar and Mica	12
Pyrite, Rutile, Dolomite, Zircon, Tourmaline, Kyanite, Epidote, and Staurolite	1
	100

The greensand forms part of that series which outcrops in the neighbourhood of Gingin and which is of Cretaceous Age. The Gingin greensand is over 30 feet in thickness.

6.—BORING AT COLLIE.

(A. GIBB MAITLAND.)

During the year a deep bore was put down in the Municipal Water Reserve 4919 in the township of Collie. The operations were carried out by a Calyx plant and the total depth attained was 1,135 feet 10 inches, most of which was represented by cores, type samples of which have been preserved [1/2800] in the Geological Survey Office.

The boring presents two features of particular interest: (1) it is one of the deepest yet made on the Collie field, and (2) it met with two bands of sandy limestone at depths of 1,083 and 1,133 feet 6 inches respectively, indicating a change from fresh water or estuarine to marine conditions.

The bore, which was primarily sunk for the purpose of finding water, passed through several seams of coal at depths set out in the log as supplied by the driller.

No. 1 BORE TRENCH WELL, COLLIE.

Strata.	Depth.		Thickness.	
	ft.	in.	ft.	in.
Sandy clay	0	0	20	0
Ironstone conglomerate ...	20	0	1	0
Coarse sand with clay seams ...	21	0	17	0
Sandy clay	38	0	10	0
Fine sand	48	0	8	0
Yellow clay	56	0	3	0
Coarse sand	59	0	11	0
Sandy clay	70	0	13	0
Coarse sandstone conglomerate	83	0	5	0
Coarse sand	88	0	14	0
Sandstone conglomerate ...	102	0	1	0
Fine sandy clay	103	0	3	0
Coarse sandstone "Soft" ...	106	0	16	0
Fine sandstone	122	0	14	0
Hard puggy clay	136	0	3	0
Hard sandstone	139	0	9	0
Pipe clay	148	0	1	0
Hard sandstone with clay bands	149	0	11	0
Coarse sandstone	160	0	6	0
Fine sandstone with clay bands	166	0	7	0
Coarse sandstone	173	0	17	0
Sandstone with clay bands ...	190	0	2	0
Coarse sandstone	192	0	48	0
Grey shale	240	0	2	0
Coarse sandstone	242	0	17	0
Fine sandstone	259	0	8	0
Coarse sandstone	267	0	6	5
Coal	273	5	0	3
Coarse sandstone	273	8	7	4
Black shale with carbonaceous bands	281	0	7	0
Sandy shale	288	0	5	0
Coarse sandstone	293	0	11	0
Black shale	304	0	0	3
Fine sandstone with shale bands	304	3	14	3
Coal	318	6	1	0
Carbonaceous shale	319	6	1	0
Hard fine sandstone with shale bands	320	6	5	0
Carbonaceous shale	325	6	3	6
Coal	329	0	3	0
Hard fine sandstone with shale bands	332	0	6	0
Coarse sandstone	338	0	8	0
Coal	346	0	0	3
Black shale	346	3	2	9
Carbonaceous shale	349	0	1	0
Hard fine sandstone with shale bands	350	0	10	0
Carbonaceous shale	360	0	0	6
Coal	360	6	0	6
Carbonaceous shale	361	0	0	6
Coarse sandstone	361	6	19	6

No. 1 BORE, TRENCH WELL, COLLIE—*continued.*

Strata.	Depth.		Thickness.	
	ft.	in.	ft.	in.
Coal	381	0	0	6
Sandy shale	381	6	2	6
Coarse sandstone	384	0	43	0
Coal	427	0	4	0
Hard fine sandstone with shale bands	431	0	7	6
Sandstone	438	6	4	6
Coal	443	0	0	6
Hard fine sandstone with shale bands	443	6	9	6
Coarse sandstone	453	0	52	0
Coal	505	0	3	0
Hard fine sandstone with shale bands	508	0	5	0
Carbonaceous shale	513	0	1	0
Coarse sandstone with pyrites boulders	514	0	15	0
Carbonaceous shale	529	0	1	0
Coal	530	0	2	0
Hard fine sandstone with shale bands	532	0	2	0
Coarse sandstone with pyrites boulders	534	0	14	0
Coal	548	0	9	6
Shale	557	6	4	6
Coarse sandstone with quartz and pyrites boulders	562	0	25	0
Carbonaceous shale	587	0	1	0
Coal	588	0	1	0
Hard fine sandstone with shale bands	589	0	4	3
Carbonaceous shale with *coal* bands	593	3	11	3
Sandy shale	604	6	3	6
Fine sandstone	608	0	9	0
Coarse sandstone	617	0	25	2
Coal	642	2	0	3
Fine sandstone with shale bands	642	5	0	7
Coal	643	0	16	6
Hard sandstone with shale bands	659	6	2	6
Coal	662	0	4	0
Hard fine sandstone with shale bands	666	0	15	6
Coarse sandstone	681	6	17	6
Coarse sandstone cemented with clay	699	0	19	0
Carbonaceous shale	718	0	8	0
Coarse sandstone	726	0	4	0
Carbonaceous shale with *coal* bands	730	0	2	6
Coal	732	6	2	0
Carbonaceous shale with *coal* bands	734	6	2	6
Coarse sandstone	737	0	9	0
Coal	746	0	4	0
Fine sandstone with shale bands	750	0	3	0
Coarse sandstone	753	0	14	0
Shale	767	0	1	0
Coal	768	0	3	0
Fine sandstone with shale bands	771	0	20	0
Coarse sandstone	791	0	4	0
Fine sandstone with shale bands	795	0	4	6
Pyrites boulder	799	6	0	6
Coarse sandstone with pyrites boulders	800	0	8	0
Coal	808	0	0	6
Sandy shale	808	6	1	0
Coarse sandstone with pyrites and quartz boulders making a little water	809	6	75	6
Sandstone with shale bands ...	885	0	2	0
Coarse sandstone with pyrites boulders	887	0	13	0
Fine sandstone with shale bands	900	0	3	0
Coarse sandstone	903	0	16	0
Fine sandstone with shale bands	919	0	10	0
Fine sandstone, hard	929	0	45	0
Black puggy shale	974	0	7	0
Hard mudstone band	981	0	2	0
Black puggy shale	983	0	12	0
Fine sandstone	995	0	5	0
Black shale	1,000	0	2	0
Hard fine sandstone	1,002	0	5	0
Sandy limestone at	1,083	0	0	9
Do.	1,133	6	Bored into for 2 feet 4 inches.	

The bore yields 45,000 gallons of water per day.

The following proximate analyses of certain of the coals have been made in the Geological Survey Laboratory:—

A.

No. 1 Bore, Trench Well, Municipal Water Reserve Pumping Station, Collie. 9ft. 6in. seam at 548ft.

G.S.L. No.	6387E	6388E
Mark.	No. 1. Top half.	No. 2. Bottom half.
Analysis :	per cent.	per cent.
Moisture	11·04	11·65
Volatile Hydrocarbons	27·69	28·41
Fixed Carbon ...	49·25	52·71
Ash	12·02	7·23
	100·00	100·00
Calorific value, B.T.U. ...	9,870	10,455

Two small (2in.) shale bands rejected from upper half. All this seam is dull black, rather tender, with well defined bedding and joint planes. The coal core had been exposed to the air for some weeks before it was analysed.

B.

No. 1 Bore, Trench Well, Municipal Water Reserve Pumping Station, Collie. Three sections of 16 feet 6 inches seam at 643 feet.

G. S. L. No.	6504E. Top 5ft. 6in.	6505E Middle 5ft. 6in.	6506E Bottom 5ft. 6in.
Moisture	10·26	11·85	11·37
Volatile	20·12	26·37	31·28
Fixed Carbon	46·66	52·24	48·86
Ash	16·96	9·54	8·49
	100·00	100·00	100·00
Calorific value B.T.U	9,058	10,000	10,041

This is a strong, rather dull, coal of the Proprietary type. It does not form a coherent coke. The coal had been air-dried for several weeks before it was analysed.

The sandy limestone, the first encountered in the Collie Basin, met with at a depth of 1,133 feet 6 inches, on being analysed in the Geological Survey Laboratory, showed its composition to be in parts per hundred:—

Limestone [1/2800], *No. 1 (Municipal) Trench Bore Well, Collie, Depth* 1,133 *feet* 6 *inches.*

	per cent.
SiO_2	45·43
Al_2O_3	8·19
Fe_2O_3	·69*
FeO	1·48
MnO	·93
MgO	1·07
CaO	20·18
Na_2O	1·22
K_2O	2·51
$H_2O—$	1·22
H_2O+	1·10
TiO_2	·33
CO_2	15·83
P_2O_5	·17
SO_3	·20
Organic	·33†
Cl	·01
	100·89

G. 2·615

* Approximate owing to the presence of organic matter.
† Contains ·18 per cent. carbon.

Minerals recognised: Calcite, Quartz, Felspar, Kaolin, Ilmenite, Rutile and Organic Matter.

Analyst—J. N. A. Grace.

7.—BORING FOR COAL AT WILGA.

(A. Gibb Maitland.)

In the Annual Progress Report of the Geological Survey for the year 1918, reference was made to what appears to be an extension of the Collie Coalfield situated on the upper reaches of the Collie River about five and a-half miles to the northeast of Wilga Siding in the Donnybrook-Preston Valley Railway.

From such little evidence as is available it does not appear that the extent of the coal measures in the vicinity of Wilga is very great, and the area is, in consequence, somewhat circumscribed.

It was decided during the year 1919 to carry out some boring operations on the field at the State expense, with the view of, if possible, penetrating the whole thickness of the coal measures and thus ascertaining something of the sequence of the strata and their capabilities as a coal-bearing series.

A detailed geological survey of the area is an essential condition precedent to undertaking boring operations designed to systematically test the field. This, however, being at the time impossible, a site for an experimental bore was selected to the east of the western boundary of Location 2009/93, and boring carried out to a depth of 598 feet, when it appeared that bed-rock was unequivocally reached.

The following is a record of the strata pierced in the bore hole:—

RECORD OF STRATA IN No. 1 BORE AT WILGA.

Strata.	Depth.		Thickness.	
	ft.	in.	ft.	in.
Ironstone gravel	...		7	0
Ironstone conglomerate ...	7	0	13	0
Grey clay	20	0	7	0
Ironstone conglomerate ...	27	0	2	0
Grey clay	29	0	5	0
Coarse sand	34	0	5	0
Shale	39	0	3	0
Sandy shale	42	0	5	0
Coal	47	0	1	6
Sandy shale with quartz boulders	48	6	11	6
Greasy shale	60	0	6	0
Coal with carbonaceous shale bands	66	0	3	0
Hard sandy shale	69	0	4	0
Coarse sandstone	73	0	6	0
Sandstone	79	0	8	0
Coal	87	0	5	0
Carbonaceous shale	92	0	1	0
Sandy shale	93	0	6	0
Sandstone	99	0	10	0
Carbonaceous shale	109	0	1	0
Puggy shale	110	0	2	0
Sandstone	112	0	7	6
Carbonaceous shale with *coal* bands	119	6	7	6
Sandy shale	127	0	3	0
Sandstone	130	0	3	6
Coal with stone band in middle	133	6	2	6
Sandy shale	136	0	2	0
Sandstone	138	0	11	0
Coal	149	0	1	0
Sandy shale	150	0	2	0
Sandstone	152	0	29	0
Carbonaceous shale with *coal* seams	181	0	4	0
Sandy shale	185	0	1	0
Coal	186	0	1	0
Black shale	187	0	4	0
Sandstone	191	0	85	0
Sandy shale	276	0	3	0
Sandstone	279	0	39	6
Shale	318	6	1	6
Carbonaceous shale	320	0	0	6
Shale	320	6	2	6
Sandstone	323	0	39	6
Greasy shale	362	6	16	9
Hard band, mudstone and sandstone conglomerate	379	3	0	9
Hard dark sandstone	380	0	1	6
Granite boulder	381	6	0	6

RECORD OF STRATA IN No. 1 BORE AT WILGA—*continued.*

Strata.	Depth.		Thickness.	
	ft.	in.	ft.	in.
Hard dark sandstone	382	0	8	0
Hard grey shale with fine sandstone seams	390	0	15	0
Grey shale	405	0	1	0
Hard mudstone band	406	0	0	6
Dark shale	406	6	2	0
Hard mudstone band	408	6	0	6
Dark shale	409	0	4	0
Brown shale with hard seams ...	413	0	56	8
Lime and mudstone band ...	469	8	0	7
Brown shale	470	3	9	3
Lime and mudstone band ...	479	6	0	6
Brown shale	480	0	4	8
Lime and mudstone band ...	484	8	0	7
Brown shale	485	3	13	6
Lime and mudstone band ...	498	9	0	9
Hard grey shale	499	6	5	0
Lime and mudstone band ...	504	6	0	3
Hard grey shale	504	9	10	3
Lime and mudstone band ...	515	0	1	0
Hard grey shale	516	0	3	9
Lime and mudstone band ...	519	9	1	0
Hard grey shale	520	9	8	6
Lime and mudstone band ...	529	3	0	9
Hard grey shale	530	0	10	0
Granite boulder	540	0	0	6
Hard grey shale	540	6	4	6
Hard grey shale with granite boulders	545	0	3	6
Conglomerate, sandstone, and granite boulders	548	6	7	0
Fine sandstone	555	6	6	0
Conglomerate, sandstone, and granite boulders	561	6	2	0
? Amphibolite	598	0	...	

8.—IRWIN RIVER COALFIELD, SOUTH-WEST DIVISION—BORING OPERATIONS.

(E. de C. CLARKE.)

In October, 1920, boring to a depth of 700 feet at bore-site No. 1, selected by me last year (Annual Report, 1919), being nearly completed, I was required to report on the advisability of further boring on the Upper Irwin River. On plotting the data obtained from this bore (which will be named P.W.D. bore No. 1) on to a section showing also the information obtained from previous shallower bores, it is apparent that between 400 and 700 feet P.W.D. bore No. 1 is at the horizon of the coal-bearing beds cut in the old bores. The results obtained show that it is improbable that payable coal seams will be found near the new bore.

As, however, it might be deemed more economical to test the Upper Irwin for coal in a conclusive manner, additional bore-sites have now been selected. Of these bores P.W.D. No. 2 would determine whether or not the coal seams thicken southwards along the general strike of the Permo-Carboniferous beds; P.W.D. No. 3 would determine whether there is a payable development of coal in the country between the north and south branches of the Upper Irwin; P.W.D. No. 4 would explore beds lying below the horizon of the known coal-bearing beds; P.W.D. No. 5 would ascertain whether there is any northward extension of the seams exposed in the north branch of the Irwin River. These bores are numbered in the order in which it is advisable they be undertaken. In my opinion, if P.W.D. bore No. 1 is a failure the chances of a coalfield in the Upper

Irwin are so small that a private company could not be advised to spend more money there; but it is another question whether, having regard for the great benefits that would accrue to the whole community by the opening up of such an important industry in this part of the country, the State would not be justified in spending money on a rather forlorn hope.

In my first report (Annual Report, 1918) on the Irwin River I recommend that "boring should not . . . be undertaken until the country has been carefully mapped in considerable detail." However, boring was undertaken without any such preliminary work, and I understand that Prof. Woolnough, who has since spent some months in the district, is of opinion, as a result of his work, that the best locality for boring would have been some miles farther south.

[Note by A. Gibb Maitland.—In a paper on The Sequence, Glaciation and Correlation of the Carboniferous Rocks of the Hunter River District, New South Wales, by Messrs. Sussmilch, David and Walkom, published by the Royal Society of New South Wales, Vol. LIII., 1919, pp. 305-321, there appears an account (Section 5, the Irwin River and Gascoyne River Areas, Western Australia) of a section near Nangetty Station, to which the following footnote is appended:—

Dr. W. G. Woolnough informs me that a coal seam eight feet thick has just been discovered there.

Prof. Woolnough in a letter to myself dated the 25th of January, 1921, advises that the statement of the thickness of the coal seam as mentioned is certainly a mistake, and that so far as he could judge from the meagre evidence available it is between five and six feet.

The boring which has been carried out on the south branch of the Irwin River by the Department of Works has proved the existence of six thin seams of coal at the following depths:—

Depth from Surface. feet.	Thickness. ft.	in.
342	1	0
354	1	0
357	1	6
410	1	0
457	1	0
460	1	0

None of the seams are of workable thickness, and therefore of no value whatever.

The geological structure and constitution of the Irwin River Valley are of such a nature that the boring already carried out determines for all time the question of the likelihood of the occurrence of coal seams of commercial value in the vicinity.

The failure of the Government bore to prove the seam referred to by Prof. Woolnough clearly indicates the patchy nature of the seams and confirms the results obtained by the previous borings, which were designed to test the capabilities and extent of the Irwin River field.]

9.—THE GEOLOGY OF MT. BURGES AND NEIGHBOURHOOD, COOLGARDIE GOLDFIELD.

(E. de C. Clarke.)

A day was spent in examining Mt. Burges and the country along the old "90 mile road" between Mt. Burges and Coolgardie, in order to obtain information for the last edition of the State Geological Map. It was found that the chief constituent of Mt. Burges is serpentine similar in character to the ultra-basic rocks of the Monger Serpentine belt, which are briefly described in another part of this report.

10.—GENERAL GEOLOGY OF THE MONGER-ST. IVES DISTRICT, COOLGARDIE AND NORTH-EAST COOLGARDIE GOLDFIELDS.

(E. de C. Clarke.)

My field work in 1920 was distributed over an area of about 800 square miles, between the latitude of Wombola (the old Mt. Monger centre) in the north, and that of the north shore of Lake Cowan, near the Paris group in the south; and between the longitude of Binyarinyinna on the east and that of Love's Find on the west. This area will be called the Monger-St. Ives District. Of this district it has been possible to map little more than 400 square miles with any approach to certainty, the geology of the balance being completely obscured by superficial deposits or by salt "lakes."

About three-quarters of the season's field work was spent in examining the new finds at Monger, St. Ives, the Paris, and Love's Find in as much detail as was warranted by their undeveloped condition.

The following general account of the geology of the whole district and of the various mining centres may require revision when microscopic examination of rock-specimens has been completed. Moreover, about two more months of broad field-work are necessary to link up the various belts of rock in this area with those shown by Feldtmann at Bulong to the north (Bull. 82, Pl. II) and by Honman to the north and west (Bull. 66, Pl. II).

The chief places of interest in the district are the new mining centres of Monger and St. Ives. The Monger workings are nearly 40 miles S.E. of Kalgoorlie by the track through Boorara and Golden Ridge. St. Ives is nearly 50 miles in a straight line SSE. of Kalgoorlie. The nearest railway station (Widgiemooltha, on the Coolgardie-Norseman Railway) is 25 miles from St. Ives by track.

The whole region is one of very low relief, none of the most prominent hills—Carnilya, Mt. Monger, Parker Hill and Yalca—rising much more than 300 feet above the surrounding plain-or lake-country. In the northern (Monger) portion of the district, the higher country consists not of defined lines of hills but of groups of irregularly arranged knolls. In the southern (St. Ives) section two or three fairly marked lines of hilly ground occur, the most prominent being that which extends from Parker Hill southwards nearly to the Paris—a distance of about 25 miles. However, in the southernmost part of the district—on the north shore of Lake Cowan—is a jumble of low hills. These differences of topography are due to structural differences which need not be detailed here.

The most striking topographic features of the Monger-St. Ives district are the three large salt "lakes": at the south end Cowan, with longer axis running about NE.; on the west side Lefroy, with greatest extension north and south; on the east side Randall's, extending mainly eastwards. The mutual relations of these three lakes are puzzling: thus, was

Randalls originally connected with Lefroy, or are the two lakes now approaching union, and, if so, which is the more active in the move; does Lefroy connect with Cowan, and what is the relation between Lakes Cowan and Randalls?

However, a question of a more practical nature has also to be answered with regard to these and others of the Western Australian "lakes," namely, whether or not they contain deposits of alluvial gold which would pay for recovery by dredging or some other means. This question is discussed a little more fully in my unpublished report on the Leonora-Duketon district, and the arguments there advanced for the testing of Lake Carey apply equally to the lakes of the Monger-St. Ives district.

During the latter part of this year boring for deep alluvial has been begun about two miles S.W. of Mt. Monger Trig. on the shore of an arm of Randalls Lake, and has proved the existence of about 50 feet of "wash" half a mile from the lake. Without extraordinarily good luck no actual discovery of gold-bearing wash can be expected until a considerable amount of further boring on some carefully thought-out method has been done.

The chief difficulty in unravelling the geological structure of the Monger-St. Ives district lies in the masking of the fundamental geology over so large a proportion of the area by superficial deposits of sand, loam, etc.: a second obstacle is the difficulty of obtaining specimens not hopelessly obscured by weathering: a third is the intermediate character of many of the rocks: thus, at St. Ives a suite of specimens collected only a few feet apart shows gradation from quartz-porphyry or porphyrite to greenstone, no boundary between the two types being definable.

Broadly, the district consists of a central belt of greenstones—in part sheared, in part massive—with a general N.W. trend. Several intrusive bodies of acid rock occur in this greenstone area, the two largest—disposed with their main axes generally parallel to the shear-planes of the greenstones—being in the southern part of the district.

The greenstone is bounded on the west side by a belt of porphyrite breccias and flows. Another similar belt occurs in the N.E. corner of the district, and a third, possibly the tail-end of a belt of sediments mapped by Honman just east of Kalgoorlie, occurs in the N.W. corner, forming the prominent Carnilya Hill. Later dykes and intrusive masses of basaltic and gabbroid rocks are found at Monger, at St. Ives, and, particularly, along the north shore of Lake Cowan south of the Paris group. Certain light friable rocks collected from the shore of Lake Cowan are possibly representatives of the tertiary or post-tertiary sponge-spicule beds of Norseman.

At present the microscopic data available are not sufficient to attempt more than a generalised account of the character of and the relation between the various rock types included in the above groups.

The greenstones are probably divisible into three main groups: fine-grained, slaty rocks; coarser more massive epidiorites; and serpentines. Possibly the fine-grained greenstones and the porphyrite-breccia series mentioned above are contemporaneous and are older than the coarser epidiorites; also, the balance of the evidence as to the relation between the epidiorites and the serpentines appears to favour the view that these two groups are contemporaneous, being differentiations from the same magna, and that the serpentines are not, except in a very restricted sense, intrusive into the epidiorites.

The acid intrusives appear to be mainly biotite-microcline granites and quartz-porphyries, but many varieties of porphyry and porphyrite could probably be distinguished, particularly at St. Ives, where, as already mentioned, some remarkable gradations from porphyry to greenstone (probably a result of digestion of the greenstone by the porphyry) have been noted. Moreover, care has to be exercised in the field if one is to discriminate between country composed of decomposed intrusive acid rocks and that formed from the weathered products of the older porphyrite breccia flow series.

The later basaltic and gabbroid intrusions probably belong to the same period of igneous activity as the norites and similar rocks that occur near Norseman and in many other parts of the State. They are probably the youngest of the deep-seated rocks in the district, being subsequent to the period of gold injection, and therefore have no effect on ore-bodies beyond cutting through and interrupting them.

A short generalised account of the geology of the whole district, and of the mining centres which have lately been attracting some attention, is all that can be usefully added to the foregoing description in a report unaccompanied by maps, etc.

Monger.—The lately discovered "lode formations" are on a line of low hills which extends for about four miles in an E.S.E. direction from near Creedon's homestead towards the Mt. Monger Trig. station. These hills are composed of ultra-basic rocks forming an apparently unbroken belt, which averages about a quarter of a mile in width. As usual in ultra-basic areas, the rock alters very much in appearance from place to place. This variableness increases the difficulty of those prospecting such a belt for the first time and accustomed to the uniform character of lodes in the doleritic greenstones which in most parts of this State are the gold-bearing rocks. The tendency is, naturally, to pay too much attention to fancied resemblances and differences between the various ultra-basic types and, on the strength of these, to plan ambitious and futile schemes of development.

Flanking the ultra-basic belt in most places, and probably in close genetic relationship with it, are rather coarse-grained epidiorites similar to the "Warden's House" type of Kalgoorlie. Farther out from the ultra-basics, both to the east and to the west, are sheared porphyries, porphyrites, sediments, and fine-grained rather slaty greenstones, in which occur rich leaders at "Creedon's Welcome" and adjoining leases on the west side, and again at the "Daisy" and other leases on the east.

Later dykes of porphyry and porphyrite occur in a few places, intruding all the rocks described above, and a (probably still later) dyke of gabbro, with an east and west strike, has been noted at the north end.

A few particulars regarding the Lass o' Gowrie-Monger Proprietary line of gold occurrences in the ultra-basic (serpentine) belt may be of interest:

Much disappointment has been felt in various quarters owing to the allegedly erratic behaviour of gold-bearing "lodes" in the Monger serpentine belt. A well known case is that of the Lass o' Gowrie lease, where the first discovery was in chlorite rock showing gold freely. Other occurrences of similar rock, said to yield fair prospects, were found on the property, and it was thought by many that three large ore-bodies could be traced on the "Lass o' Gowrie." A rather ambitious policy of sinking and driving was adopted, but very contradictory results were obtained by the various parties who sampled the various workings. It is not proposed to discuss these results here, but certainly no large body of stone yielding results comparable to those of the original discovery has been found.

On the other hand, farther north, on the "Monger Proprietary" and adjoining "McCahon's Great Hope," a shoot at least 150 feet long has been opened up, and from this shoot the "Monger Proprietary" had by November, 1920, crushed 71 tons of picked ore for a yield of about 1,030 ozs. of gold.

The discovery and development of this shoot were mainly due to the policy of "sticking to the gold" instead of "standing off, sinking to 50 feet (or 100 feet) and cross-cutting" to get a lode of new type of which such all-important features as direction of strike and dip, amount of dip, and direction of pitch of shoots were quite unknown.

Judging from what has been disclosed in those workings where makes of ore have actually been followed as, particularly, on the Monger Proprietary and McCahon's Great Hope, it appears that gold is found in the Monger ultra-basic belt mainly in a black or dark-green talc-chlorite rock, which occurs in fairly narrow seams along planes of strong shearing. These shear planes strike more or less parallel to the main axis of the ultra-basic belt, *i.e.*, W.N.W., and dip in some places N.N.E., in others S.S.W. The bulk of the evidence indicates that the gold is localised into south-pitching shoots.

It appears probable that the seams of black massive rock are small ultra-basic intrusions slightly later than the main ultra-basic belt, and were responsible for the introduction of the gold. In some places it is true the highest values are found in strongly sheared talc-chlorite-magnetite rock bordering on the black, massive, supposedly later rock, but such an occurrence is probably due to the gold having left the later intrusions in solution and having been precipitated in the schist. If this view of the origin of the gold in the serpentine belt at Monger be correct, then values should "live down."

In the country near Monger there are four main directions of strike: W.N.W. for the fine-grained slaty greenstones and belts of serpentine and coarser epidiorite between Mt. Monger Trig. and Wombola: E.N.E. for the quartz veins and slaty rocks of Wombola; N.N.W. for the "Sudden Jerk" country; N.N.E. for the country towards Randalls. Of particular interest is the strike of the Wombola country, which is practically at right angles to the general trend of the Monger belt. Probably it is this feature to which MacLaren refers as the "Monger Thrust Plane." If, when the geological survey of the district has been completed, further detail regarding these different trend-lines is obtained, it should throw light on the nature and origin of the various ore deposits.

St. Ives.—At the St. Ives centre there are 214 newly surveyed leases, which may be divided into two groups: the main St. Ives group and the smaller Victory group, lying north of the main group and separated from it by a gap of about three-quarters of a mile.

The majority of the leases are on a belt of gently rising ground between Lake Lefroy and Parker Hill. On this rising country a line of small hills begins near the Reward lease and trends northward for about a mile. Another inconspicuous line begins at the "Mentone" and thence runs N.W. for more than a mile. A slightly higher and rougher size-system runs N.W. from the "Jubilation" for about a mile.

The country occupied by the St. Ives leases is mainly greenstone in contact, along its eastern side, with a belt of acid rock (porphyry grading into granite) which separates it from the more or less parallel greenstone belt of Parker Hill. The belt of granitic rock swings westward at the Victory end, and there, caught up in it, are small patches of greenstone. Farther south a few porphyry dykes, right in the heart of the greenstones, are probably off-shoots from the main belt of granite.

The St. Ives greenstone belt contains the usual varieties of greenstone—grading from coarse massive to fine-grained slaty. It also has a considerable development of ultra-basic rock (serpentine) and also many jasper bars, the trend of which last features may be roughly summarised by stating that along the eastern and central parts of the belt the bars strike consistently a little west of north, while on the western side they swing westward, so that their course becomes northwest in the neighbourhood of the "Cooee" lease. In the "Cooee" part of the field the makes of ore appear to be associated with the jasper bars, being probably deposited along faults in them. Again, on the "Clifton" lease, south of "Ives Reward," the jasper bars and accompanying porphyry have an almost east and west trend, although on the next lease to the north their strike is almost due north. Apparently a line running northwest from the "Clifton" separates country with a predominantly northerly strike from country in which the strike varies but is mostly northwest.

Two irregularly-shaped areas of serpentinous rock closely associated with doleritic greenstones occur at St. Ives, but up to the present little if any gold has been discovered in them.

At the Victory end the boundary between acid rocks (porphyry and granite) and greenstones is very intricate. Gold occurs along, or very close to, the contact between the two classes of rock.

The original, and apparently the most important finds at St. Ives, lie on the "Ives Reward" and "Lake View Reward East" leases, through which run two parallel porphyry dykes, about 10 chains apart, striking a little west of north. The eastern one is associated with a jasper bar and forms the Ives Reward East Lode. On, or close to, the western dyke (on "Ives Reward" lease) a make of sulphide ore in sheared basic greenstone is now being explored by sinking and cross-cutting in Shafts Nos. 3 and 4. Farther south gold is being obtained in this dyke itself, probably in the majority of cases in minute quartz leaders.

Love's Find.—Eight leases have been surveyed at this centre, which is about 10 miles S.S.W. of St. Ives, and lies in the western belt of porphyrite breccias, etc., mentioned in the introductory part of this report. The original find was made in a porphyry dyke with many quartz stringers carrying large patches of pyrite. With one exception, however, the other leases seem to be in porphyrite country and to be working either cross-leaders, which are probably off-shoots fom porphyry dykes, or else so-called lodes in the porphyrite. So little work has been done at this centre that no opinion regarding its future is justified.

PARIS GROUP.—This group of 34 leases is about 17 miles S.S.E. of St. Ives, near the western edge of the main greenstone belt. The predominant country is a coarse epidiorite which is cut by a large porphyry dyke. Gold-bearing quartz veins with a W.N.W. trend have been located on the "Observation," "H. H. H.," and "Saltbush" ("Paris") leases. The "H. H. H." workings could not be examined. On the "Observation," which is now abandoned, the ore-body does not appear to live below the zone of weathering. The ore-body on the "Saltbush" is now being prospected and appears to have the same general characteristics as the "Observation" body, but to differ in being closer to this porphyry dyke and in having a north-and-south striking formation which might, so far as development work had disclosed by the end of November, 1920, be either a distinct ore-body crossing the W.N.W. body, or merely a locally disturbed portion of it.

11.—PRELIMINARY REPORT ON THE LEAD LODES OF THE NORTHAMPTON MINING DISTRICT, SOUTH-WEST DIVISION.

(F. R. FELDTMANN.)

INTRODUCTION.

The present investigation of the Northampton lead lodes arose from a request by the manager of the Fremantle Trading Co., Ltd., the owners of the Baddera Lead Mine, for an examination of that mine, owing to the ore being nearly exhausted. None of the mines of this district being accessible during previous examinations and surveys by officers of the Geological Survey Department, it was considered advisable to take the opportunity to obtain such information as was possible as to the structure and composition of the ore-bodies, and their relationship to the rocks of the district.

Location.—Northampton township, the centre of the mining district, is situated 27 miles north of Geralton (34 miles by rail). The new township of Galena is situated immediately south of Murchison River, about 31 miles (45 miles by road) north of Northampton and about 8½ miles (12 miles by road) N.N.E. of Ajana, the terminus of the railway from Geraldton.

GEOLOGY OF THE DISTRICT.

General statement.—The metalliferous district consists of an elevated tract of country, the present surface of which is strongly undulating, where the removal of the overlying Jurassic strata has exposed the crystalline rocks. The southern portion of this area of crystalline rocks, which consist largely of garnetiferous gneiss or gneissic granite, has been surveyed by Mr. W. D. Campbell, whose map * shows the southern end of the main belt to be about seven miles due east of Geraldton. The northern extension of this belt has not yet been determined, and in view of the economic importance of these rocks a broad survey of this portion of the gneissic belt is highly desirable. From hasty observations made on the road from Northampton to Galena, it appears probable that the gneissic rocks extend without a break to and beyond the Murchison River, with the possible exception of the high Binnu Sand Plain. How far they extend eastward along Murchison River has not been determined, but I was informed that they occur at the 10 Mile Pool.

The length of the metalliferous belt, if continuous, is therefore at least 70 miles, the maximum width being probably about 15 miles. The belt, however, is very irregular and the average width is probably considerably less.

The gneiss is cut by a number of basic (greenstone) dykes, striking nearly northnortheast, and by a greater number of pegmatite dykes or veins, with, so far as could be determined, similar strike, as have also the lodes. The lodes are closely associated with these dykes, but their relationship to the basic dykes is purely structural, the lines of fracture along many of which these dykes made their way forming lines of weakness during subsequent periods of shearing. On the other hand, the formation of the ore-bodies appears to be closely connected with the introduction of the pegmatites, which probably extended over a considerable period, the earlier stages of which were marked by high temperatures—as shown by the wide development of garnet in the gneiss and also, though but sparsely, in some of the pegmatites and the formation of tourmaline in a few of the pegmatites and their ultra-acid varieties, such as certain of the quartz reefs. The formation of the ore-bodies took place during the final stages of igneous activity, under lower temperature conditions. The occurrence of lead, zinc, and copper deposits as the final products of granitic magmas is by no means uncommon in other countries. In Australia the Broken Hill deposits form a notable example, being genetically connected with a series of pegmatite dykes,† which from Mawson's ‡ description closely resemble those of the Northampton district.

In prospecting for new lodes it is advisable to examine closely the immediate neighbourhood of the greenstone and pegmatite dykes.

The gneissic rocks.—These are pale to fairly dark greyish rocks, usually fine in grain, which proved to be garnetiferous wherever examined. The ferromagnesian appears to be chiefly biotite, possibly chloritised in places. Pegmatitic facies of these rocks, with large felspars and garnets, occur. In some places the gneissic structure of the rocks is well marked, in others the rocks are compact and massive, the only traces of a gneissic structure being a slight parallelism of the composing minerals. Occasional zones of sheeted or laminated rock occur in the gneiss, marking lines of intense shearing and probably corresponding to the laminated jaspers so commonly associated with the goldfields greenstones and, in places, with the Pre-Cambrian sediments. The general strike of these sheeted zones is nearly northwest; they were apparently formed prior to the introduction of the basic dykes and the pegmatites.

The basic dykes.—These rocks are for the most part coarse to fine-grained massive epidiorites, from dolerites, but they probably range from intermediate-basic to ultra-basic in composition. Their most remarkable feature is the general uniformity of their strike, which round Northampton averages about N. 32° E.; they appear to be nearly vertical. They are of great length, and, on the average, of considerable width, several of those examined being 60 or

* W.A. Geol. Survey Bull. 38, Pl. I., 1910.

† *Vide* Mawson, Douglas, Geological investigations in the Broken Hill area: Roy. Soc. S. Aus. Mem., Vol. II., pt. 4., pp. 236, 286 *et seq.*

‡ *Op. cit.* pp. 292–295.

70 feet wide in places, and Gregory mentions some as attaining a width of 180 feet. Being harder than the surrounding gneiss they usually form prominent outcrops, a rounded outline being characteristic of the weathered outcrops and boulders.

The structural relationship of these rocks to many of the lodes has been noticed by previous writers, and specimens showing fragments of one of these dykes in the lode breccia were obtained by me from a dump on the Wheal Ellen North M.L. 143.

Among those lodes which for a part of their length at least occur along the margins of basic dykes are the Wheal Ellen, Gwalla (south lode), Unaring, Derby Syndicate (Loc. 325), Wheal Beta, and Yandanooka at Northampton, and the Surprise at Galena.

The pegmatites.—These are of great variety. The occurrence of pegmatitic veins apparently as a facies of the gneissic rocks has already been mentioned, but most of the pegmatites undoubtedly belong to the stages of igneous activity immediately preceding ore deposition, and are intrusive into the gneiss. No direct evidence was obtained as to the relative age of these rocks and the basic dykes, but from their composition and close relationship to the lodes they appear to be younger than the basic rocks. The pegmatite dykes are much more numerous and much smaller, as a rule, than the epidiorites, their width usually ranging from a few inches to a few feet, but it is probable that much larger dykes, particularly of the more acid varieties, occur. Their dip appears to be very similar to that of the lodes.

One of the commonest types of pegmatite is a coarse-grained rock, consisting chiefly of felspar and quartz, mainly in graphic intergrowths, with some large and small flakes of a silvery greenish-grey mineral, probably vermiculite; flakes of graphite are common in some specimens and are probably contemporaneous with the other minerals composing the rock. In some localities the felspars are white, in others, such as the Baddera and Victoria mines, they are of a dark red colour. Aplitic facies of these rocks are common. Specimens of pegmatite of this type, from the Wheal Alpha Mine, contain malachite and azurite, deposited in thin films throughout the rock as well as, in one specimen, in a vughy veinlet, probably on the wall of the dyke. A variety from an outcrop on the Gwalia Mine (Loc. 315) contains large felspar crystals in a ground-mass consisting largely of a graphic intergrowth of tourmaline and quartz.

A different and much more acid aplitic type of pegmatite occurs in the Baddera and Wheal May mines. It is composed of greyish glassy quartz, containing numerous small pale salmon-pink felspars. Another highly acid type from the Baddera is a rock composed of glassy quartz with fairly numerous small garnets; a few minute specks of mica are also present.

Extreme ultra-acid types are represented by some large quartz reefs, carrying very sparsely distributed groups of large tourmaline crystals.

THE LODES.

General features.—The lodes occupy zones of intense shearing and brecciation in the gneissic granite. Where a shear zone is along the margin of a greenstone or pegmatite dyke, these rocks may also be sheared and brecciated.

The strike of the lodes is roughly parallel to that of the greenstone dykes, but is, however, less regular. A few of the lodes, including the Uga, the Baddera branch lode, and parts of the Chiverton, Nooka, and Wheal Alpha lodes strike approximately north. The Surprise lode, at Galena, strikes nearly northnorthwest.

The dip is usually northwest, at a steep angle, but in places the lodes are vertical, or even have a slight southeasterly dip. The Surprise lode dips westsouthwest.

In length the lodes range from about three chains (Derby Syndicate lode) to about one mile (Waneranooka lode), averaging, perhaps, between 30 and 40 chains.

The width is very variable, and a distinction must be drawn between the width of the "lode" channel, or zone of shearing and brecciation, and that of the ore veins or shoots. The "lode" may contain no ore, even where the shear zone is of moderate width, and shearing and brecciation are fairly well marked, or payable ore may occupy the full width of the channel. The ore-bodies may range in width from a fraction of an inch to 30 feet, or even more. In the Surprise mine sheared rock, carrying veins of galena, occupies a width of more than 100 feet at the 110 feet level.

In most of the lode channels the shearing stresses have found relief along one or more planes in a main zone of intense shearing, with the formation of a narrow band of crush clay (flucan) along the planes; the remainder of the rock in the main zone being brecciated. Shear planes, roughly parallel to the main planes, as well as irregular joint planes, were also formed in the rock for some distance outside the main shear zone.

That the ore-bearing solutions were introduced during a period of relief from pressure is indicated by the numerous vughs, the sugary, or crystalline and glassy character of the quartz, and the coarsely crystalline structure of the galena in the larger veins. In the main body of the lodes, where most affected by the ore-bearing solutions, the rock breccia has been recemented by silica, the cement now consisting of very finely crystalline quartz, coloured greyish by inclusions of partly digested rock, and in places containing minute specks of pyrite. As is usual in lode formations the boundaries of the ore-bodies are ill-defined, and the ore is not necessarily confined to the rock enclosed between two particular planes or "walls"; a shear plane, which forms a convenient hanging-wall at one point in a mine, may be used as a footwall at another point.

It is probable that shearing also took place along the lode channels subsequently to ore-deposition. In addition to the varied directions of the striæ on the shear planes, which in the Wheal Ellen mine are in places vertical, in places horizontal, thus suggesting local movement, the main shear planes are in many places marked by a few inches of crush clay, and by a band of crushed rock and clayey material, which carry no ore even where the lode is rich; moreover, bands of barren schist and occasional joint or shear planes occur in the body of the lode. It is difficult to explain why these should contain no ore, except on the assumption that they are subsequent to ore deposition.

Classification.—So far as could be judged all the lodes of this district are similar in structure and, with the exception of the Surprise lode, where barite veins are a conspicuous feature in the ore-shoot, in their gangue, though differing in their degree of silicification. Any classification is therefore necessarily arbitrary. It is, however, convenient to group them according to the proportions of economic minerals present into:—

(a) Galena lodes carrying only negligible quantities of sphalerite (zinc blende or black jack), copper ores and pyrites—the Baddera, Surprise, and Wheal May lodes being of this type.

(b) Galena-sphalerite lodes, carrying galena and blende in nearly equal proportions with minor quantities of copper ores (chiefly chalcopyrite), pyrite, and marcasite—the Wheal Ellen belonging to this group.

(c) Copper lodes, in which galena and blende, if present, occur only in small quantities; in this group, however, pyrite and marcasite are probably present in fair quantities; the Wheal Margaret and Victoria may be taken as representative of this group.

As stated, this classification is purely arbitrary, the three groups grading into each other through intermediate types.

Detailed observations had, unfortunately, to be confined to lodes of the first two groups, as none of the workings on the Northampton copper lodes were accessible and practically all the ore had been removed from the dumps.

In the lodes of the first group the galena occurs usually as veins of coarsely crystalline material along the main shear planes; as coarse octahedral or cubo-octahedral crystals lining vughs and in places associated with glassy or sugary quartz; as veinlets of more finely crystalline material in the body of the lode; or, more rarely, in a fine-grained massive, in places schistose, form, probably a replacement of the rock along narrow zones of intense shearing. In the rich shoot in the Surprise mine groups of coarse galena crystals separated by tiny irregular veinlets of quartz occur over a width of 20 feet in places. The blende and pyrite usually occur as narrow veins or veinlets filling shear or joint planes outside the main body or in the poorer portions of the lode.

In those of the second group the galena occurs as before but blende is also found in fairly large masses in the body of the lode as well as occurring as in the first group. Pyrite occurs as in the first group, but marcasite is, in places, associated with galena in the body of the lode. In addition, finely disseminated chalcopyrite (altering to malachite in the oxidised zone) is fairly common in the more quartzose portions of the lode.

Secondary enrichment.—The secondary deposition of galena or blende on a large scale appears to be very doubtful, no deposits definitely formed in this way being known. As is suggested by their mode of occurrence, rich shoots such as those of the Surprise, Geraldine, and Baddera mines are most likely due to the primary deposition of galena from ascending solutions under favourable conditions.

On the other hand, the secondary deposition of copper sulphides on a large scale near water-level is of common occurrence. Whether this has taken place to any great extent in the Northampton lodes, it is, in the absence of accessible workings, impossible to say. That a certain amount of secondary deposition has taken place is, however, suggested by the presence of such minerals as covellite and chalcocite, though even these may be of primary origin.

Other Minerals of Economic Value.

Graphite.—Graphite is found as sparsely distributed small flakes or groups of flakes in many of the pegmatites, also in a more concentrated form in a few lodes. A small graphite lode occurs on the Wheal May mine, two or three chains east of the southern end of the lead lode. In the deposits so far discovered the graphite has proved to be either too sparsely distributed or too intimately mixed with iron ore to be payable.

Jarosite and alunite.—These potash-bearing minerals have been found near Wibi Well on Udandarra Creek, on Lot 12. A shaft has been sunk to a depth of about 30 feet on the deposit at a point about 15 chains SW. of the well. The rock near the shaft is largely obscured, and the shaft was inaccessible, so that little information could be obtained as to the mode of occurrence of the minerals. Judging by the material on the dump, they are, however, associated with graphite and decomposed pegmatite; fragments of greenish-grey and light-brown opal were also found on the dump. The formation of the potash-bearing minerals is probably due to the action of sulphuric acid, from decomposing pyrite, on potash-bearing felspars of the granitic rocks.

Mica.—Muscovite flakes of moderate size occur in a few of the pegmatites, but no dykes carrying mica in sufficient quantity or sufficiently large to warrant working were seen.

Tin and Wolfram.—The occurrence of wolfram in the gneissic area near Galena has been reported, but whether in any quantity is not known. Wolfram is commonly associated with cassiterite in pegmatite veins and its occurrence, if of any extent, indicates the possible occurrence of tin-bearing veins, although these are usually associated with soda-bearing pegmatites rather than with potash-bearing types such as those of this district.

Summary and Conclusions.

The metalliferous area consists of a belt of garnetiferous gneiss and gneissic granite, exposed by the denudation of the Jurassic rocks.

This belt has a probable length of at least 70 miles and a maximum width of about 15 miles.

The gneiss is intersected by a series of basic dykes with an average strike of about N. 32°E., and also by a series of pegmatite dykes of varied composition.

The lodes are genetically connected with the pegmatites and were formed during a period of relief from pressure under conditions of falling temperature. They represent the final stages of the period of igneous activity, of which the garnetisation of the older granitic rocks and the introduction of the pegmatites marked the earlier stages.

Many of the lodes occur at the junctions of basic and pegmatite dykes and the gneiss. Such junctions should therefore be carefully examined in the search for new lodes.

The rich shoots of galena are probably wholly or almost wholly of primary origin, but some secondary deposition of sulphides may have taken place in the copper lodes.

There is every probability of the lodes extending to very considerable depths below the limits of the present workings, and there is no evidence to show that rich shoots may not occur below those hitherto discovered.

At greater depths, however, the lead ore may change in character, becoming more compact and finer-grained and containing larger proportions of pyrite and chalcopyrite, and probably, also, of blende in lodes like the Surprise and Baddera.

In spite of the number of years since mining first started, the district has not been thoroughly prospected, and the recent discovery of the Surprise lode shows that by careful prospecting other rich lodes may yet be found.

12.—THE BARITE VEINS OF CRANBROOK, SOUTH-WEST DIVISION.

(F. R. Feldtmann.)

Introduction.

Barite is the natural sulphate of barium, with the composition $BaSO_4$, and containing 65.7 per cent of barium oxide. It is usually white, creamy, or pale-grey in colour, and is distinguishable from other non-metallic minerals by its weight—its specific gravity ranging from 4·3 to 4·6.

Barite has been found at several localities in this State, notably at Breen's Camp* in the Pilbara Goldfield. Barite veins of fair size also occur in the Surprise lead mine at Galena, on the Murchison River.

The Cranbrook barite deposits were discovered about 1897 by J. H. Cox, a farmer in the district, whose attention was drawn by the weight of fragments of the mineral. Cox had a specimen of the mineral determined, but being informed that there was, at that time, little market for the mineral, made no attempt to work the deposits. In 1912 a specimen of the Cranbrook barite was sent to the Departmental Laboratory by C. J. R. LeMesurier. Analysis showed the specimen to consist of good commercial barite, but to contain sufficient iron oxide to give a creamy colour to the powdered mineral.

On May 10, 1920, a mineral lease (277^H) of 48 acres was pegged out by J. H. Cox, and on the 22nd of the same month a prospecting area (341^H) of 12 acres was pegged out by J. H. Cox, F. Leslie, and Maurice Brown as agents for L. M. Healy. A mineral claim (9^H) of 240 acres was pegged out on June 15, round the area previously taken up, by W. E. O'Neill, as agent for C. G. Stevenson and W. E. O'Neill; I was informed that earlier on the same day the ground covered by P.A. 341^H and an area to the east was repegged by F. Leslie, as agent for L. M. Healy, as a lease of 48 acres. Instructions to examine the deposits were received on June 23, the examination being carried out between the 8th and 14th of July.

Geography.

Cranbrook is situated on the Great Southern Railway, 274 miles from Perth. The barite deposits are from 3½ to 3¾ miles E. of the railway station and from 1¼ to nearly 1¾ miles ENE. of Sukey Hill—the westernmost extension of the hilly area of the Stirling Range.

The country round the town and for a considerable distance to the north and northeast is flat and swampy, and round Pootenup, seven miles NE. of Cranbrook, there is an extensive area of salt-lake country. The hilly area gradually widens as it extends eastward from Sukey Hill. In the immediate vicinity of the barite deposits, the country is undulating.

The timber is chiefly white gum and yate.

* Blatchford, Torrington, Mineral Resources of the North-West Division: W.A. Geol. Survey Bull. 52, pp. 28-29, 1913.

Geology.

The country rock of the higher ground is a fine-grained pale-reddish or cream-coloured quartzite—presumably of the Stirling Range Series. On the tops of some of the hills, the rock resembles a dark-reddish sandstone with threadlike veinlets of quartz. This alteration is probably due to lateritic action. Owing to the quantity of debris covering the surface and the fact that the outcrops are seldom more than a few inches above the general surface of the ground, the strike and dip of the quartzites are difficult to determine. At a point about six chains E. of the north-east corner of M^l C^m 9^H, the strike appeared to be about N. 39° W. and the dip nearly vertical, but probably slightly to the east.

The flats are covered by superficial deposits which completely obscure the underlying rock in the area examined. It is possible, however, that they are in part underlain by an extension of the Miocene beds which outcrop about four miles E. of Kendinup and about 16 miles SE. of Cranbrook.

Other than those of the quartzites, the only rock outcrops seen were those of what are either two aplite dykes, or aplitic marginal portions of a granite mass, about 30 chains WNW. and 50 chains NNW., respectively, of Sukey Hill, their strike being approximately ENE.; and a small outcrop of epidiorite, probably a dyke of the Darling Range Series, on the track from the townsite to the surveyed pipe-track north of Location 1529.

The Barite Veins.

Occurrence.—Up to the present, three barite veins have been found, two being in M.L. 277^H and one—the smallest—in P.A. 341^H. None have so far been discovered in M^l C^m 9^H. The enclosing rock is quartzite, here stained slightly reddish by iron oxide, but on one wall of the small vein in P.A. 341^H there is an irregular band of white material of clayey appearance, but probably consisting largely of minute quartz grains.

The largest vein is from about 1 to 4 chains NW. of the southwesterly portion of the southeast boundary of M.L. 277^H, and has been traced for a distance of about 380 feet. It strikes N. 83° E. and is practically vertical so far as exposed. The vein has been worked in a shaft about 10 feet deep, about 10 chains N.E. of the south corner of the lease; here it is approximately 4 feet wide near the surface but narrows slightly going down. The vein consists for the most part of finely-crystalline opaque white barite with irregular lenses of more coarsely crystalline translucent (occasionally transparent) barite consisting of more or less divergent groups of crystals ("crested barite"), and occasional irregular or broadly lenticular areas of the more coarsely crystalline mineral stained reddish by iron oxide; no other impurities were visible in the specimens examined. The vein has been cut in three costeans west, and two east, of the shaft. In one costean, about 150 feet west of the shaft, the vein is only a foot wide; it has been traced for about 155 feet further west. It also narrows east of the shaft. The vein appears to fork near the easternmost costean, the branch vein running a few feet south of the shaft.

The second vein has been traced from a point about 410 feet E. of the west corner of the lease to a point about 175 feet further E. It strikes about N. 85° E., and appears to be vertical. It has been worked in a shaft or pot-hole about 4½ feet deep, about 560 feet east of the west corner of the lease. Here the vein is about 4 feet wide and consists of material closely resembling that of the first vein, but with, perhaps, a larger proportion of the more coarsely crystalline translucent barite; there appeared, also, to be less iron present. There are three costeans west, and one east, of the shaft; that immediately west of the shaft failed to cut the vein, which appears to bend northwards at this point.

The small vein in P.A. 341H has been worked in a shaft about 40 feet deep near the centre of the P.A. This vein has only been traced about 50 feet E. of the shaft. It strikes approximately N. 70° W. and dips about 80° N. It was about 18 inches wide in the shaft at the surface but gradually narrowed and apparently pinched at the bottom. This vein differs from the others in that it consists practically entirely of dense fine-grained barite, either very slightly translucent and of a creamy colour, or opaque and white, the opaque white mineral occurring on the walls or along cracks in the vein. Analysis of the opaque white material might show it to be of a different composition to the rest of the vein, but the vein appears on the whole to consist of purer material than the others.

Origin.—As to the origin of the veins, the evidence is very slight. Of the various theories which have been put forward as to the origin of different barite deposits, three are considered here, namely:—(1) Deposition on the sea-bottom of barite from organic remains, with later concentration in fissures by percolating solutions; (2) the action of oxidising pyrites on barium-bearing felspars or micas; (3) deposition from solutions of deep-seated origin.

(1) Samoilov*, after a careful examination of the barite deposits of northeast European Russia, which are associated with clay beds of Upper Jurassic age, came to the conclusion that the barite, which occurs as nodules in certain horizons, owed its origin to the accumulation on the sea-bottom of the remains of a group of Rhizopods—the Xenophyophora—the bodies of which contain small granules of barium sulphate. The occurrence of barite as a cement in sandstones has also been described by various writers.

No analysis has yet been made of the Cranbrook quartzite to prove the presence or absence of barite therein, but in any case it appears too compact and fine-grained to permit of the free circulation of ground-water through the body of the rock, as would be required to allow the concentration of sufficient barite to form veins of any size, even assuming that the compact nature of the rock near the surface is in part due to laterisation. Moreover, barium sulphate is highly insoluble. The formation of these veins through the concentration and deposition of barite derived from the surrounding quartzite is therefore unlikely.

(2) Barium sulphate is said to be formed when barium bicarbonate solution, formed by weathering processes from barium-containing felspars (two barium felspars, celsian and hyalophane, are known) and micas in crystalline rocks, comes into contact with oxidising pyrites.

Against the application of this theory to the Cranbrook veins are the facts that no igneous rocks occur near the deposits, nor was pyrites found anywhere in the vicinity.

(3) That barium may be derived from deep-seated magmas is shown by its occurrence in certain felspars and micas; averages of a number of analyses of igneous rocks show that, as a whole, they contain about twice as much barium as sedimentary rocks. Barite is also known to occur as a hot-spring deposit. In view, therefore, of the mode of occurrence of the Cranbrook barite, of the fact that overlying rocks may be affected by solutions from an igneous magma even when that magma is not otherwise manifested at the surface, and of the evidence against the first two theories it seems most reasonable to regard the barite as derived from a deep-seated magma. After a careful investigation, Tarr* concluded that the Missouri barite deposits, many of which occur as veins in dolomitic limestone, were deposited from solutions of deep-seated origin, and a similar origin has been assigned to the English barite veins.

Uses of Barite.

Barite, after cleaning and grinding to a fine white powder, is used in the manufacture of white lead and zinc white, and as a base in other pigments—for paints of fine quality particularly fine-grinding is said to be essential. The mineral is also used for weighting wall-papers, linoleum, rubber goods, and fertilisers; for bleaching shoddy cloth; in the preparation of artificial ivory and in the manufacture of pottery and porcelain.

Barium hydrate is used in the refining of sugar, beet sugar in particular, and the carbonate, nitrate, or sulphate in the manufacture of certain glasses.

Summary and Conclusions.

The Cranbrook barite occurs as veins in quartzite of the Stirling Range Series.

Three veins have so far been found, of which the largest has been traced for a distance of about 380 feet, its greatest width being about 4 feet.

Careful prospecting may reveal the presence of other veins of the mineral.

The barite is of good quality, but is, in places, discoloured by iron oxide; hand-picking would therefore be necessary.

The veins appear to be of deep-seated origin.

Regarding the depth to which the deposits may extend, the deposition of barite, notwithstanding the fact that it may be of deep-seated origin, is said by authorities to be confined to comparatively shallow depths. Some of the English veins, however, have been followed to a depth of 400 feet or even more. The only local evidence on this question is the pinching of the small vein in P.A. 341H at a depth of about 40 feet. It is, however, reasonable to expect that the larger veins extend to a considerably greater depth.

Analyses of Cranbrook Barite:—

		A. Per cent.	B. Per cent.
Barium Sulphate ($BaSO_4$)	...	96·38	98·69
Calcium Sulphate ($CaSO_4$)	...	0·34	*Nil*
Iron Oxide (Fe_2O_3)	... ...	0·39	·02
Silica (SiO_2), etc.	... ...	2·89	1·55
		100·00	100·26

*Samoilov, J. V., Palæophysiology: the organic origin of some minerals occurring in sedimentary rocks. Min. Mag. Vol. XVIII., No. 84, pp. 87-98, 1917.

*Tarr, W. A., The Barite Deposits of Missouri: University of Missouri Studies, Vol. III., No. 1, pp. 99-100, 1918.

13.—REPORTED GOLD FIND NEAR BILA, SOUTH-WEST DIVISION.

(F. R. Feldtmann).

Location.—The spot shown me as the site of this find is in Lot 11 of Mr. W. J. George's Maroondah Downs Estate—forming part of Location 1—at a point, roughly, 2¼ miles SE. of Bila Siding*, on the Brunswick-Collie Railway, and approximately 15 chains S. of peg No. L73 on the Lunenburgh Road and 18 chains W. of the west boundary of Location 51. It is near the foot of the northern slope of a small, steep hill; a small watercourse runs in a northeasterly direction a few chains north of the alleged site.

The district is exceedingly hilly, the hills and ridges, which are well timbered with jarrah and, in places, red gum, being scored by a number of small creeks and watercourses, which run into Brunswick and Lunenburgh Rivers.

History.—A specimen of pyritous quartz, about 8lbs. in weight was, it was stated, picked up prior to the war by G. R. Smith, of Clifton Area, Brunswick, when kangaroo-hunting, in company with Herbert Piggott, of the same locality. On his return from the war, Smith, I was informed, gave portions of the stone to J. Ewing, Esq., M.L.C., who had two assays made, one giving an average of 1oz. 2dwts., the other of 10dwts. of gold to the ton. A Prospecting Area of six acres was pegged out under Mr. Ewing's direction. A small specimen, said to resemble the first, was, it was stated, picked up about 20 feet east of the first find by Mr. Cammilleri, of Busselton, and I was informed that two small pieces were picked up by two of Smith's brothers, in Mr. Ewing's presence, on the slope of the hill, about a chain south of the supposed site of the first find. When the news of the find leaked out, a small rush set in, and several areas were pegged round Smith's P.A., but it is said that those men who had had previous experience in prospecting or gold-mining returned without pegging out any ground.

Geology.—The country rock of this locality is a coarse-grained biotite granite, containing large porphyritic felspar crystals. The granite has been intensely sheared in places. A few small masses of basic rock, apparently epidiorite, some of which have also been sheared, occur in the granite; the boundaries of those seen were obscured, rendering it difficult to determine whether they were dykes or basic segregations in the granite. Some pegmatite veins, striking about eastnortheast, also occur; most of these consist almost entirely of granular glassy quartz with a few small crystals of felspar and occasional flakes of dark-greenish biotite; small flakes of pale yellowish-brown mica are also present in some of the veins.

Examination of the site.—I visited the site on August 30 in company with Mr. Frank George. No work was then being carried on. A small pothole, about four feet deep, had been put down on a small pegmatite vein, a few feet from where the first and also Mr. Cammilleri's specimens were said to have been found. The ground where the other two small specimens were picked up had also been examined, and a pegmatite vein, about a foot to 18 inches wide, near the top of the hill, had been knapped in places. Examination of the ground failed to reveal any vein or fragments of pyritous quartz.

The ground was revisited the following day in company with Mr. F. George and Mr. G. R. Smith. Mr. Smith showed me what he had left of the first specimen. This consisted of two small fragments of greyish quartz, one of which contained a large proportion of fine pyrites; a small quantity of pyrites was also present in the second piece. The ground was again examined, but without success, the only veins seen being the previously-mentioned pegmatites and another some distance to the southeast, and a little east of the west boundary of Loc. 51. Specimens of this vein and of that near the top of the first hill were dollied and panned off, but no trace of gold was seen in either.

The ground covered by the Prospecting Area, and the small watercourse to the north, were again unsuccessfully examined on September 1.

Conclusions.—The evidence as to the exact locality of the original find is somewhat unsatisfactory. As stated, no specimens in any way resembling that first picked up were found by me, and were it not for the fact that those picked up in Mr. Ewing's presence resemble the small fragments seen of the first, considerable doubt would exist as to whether that was actually found at the spot indicated by Reuben Smith, especially as I was informed that Mr. Piggott was of the opinion that the scene of the discovery was on or near Lot 1, near Bila Siding and some two miles northwest of the spot indicated by Smith. Moreover, the granite in the immediate vicinity of the site on Lot 11 shows comparatively little sign of shearing and vein-alteration. In view, however, of the other specimens picked up, it is probable that a systematic search on the north slope of the hill, above where the last specimens were found, would locate the vein from which they were derived, but from the small number of fragments found, the erratic distribution of the pyrites therein, and the fact that previous search has been without result, I am of the opinion that it would prove too small, and its gold content too erratic, to work profitably, especially as, owing to the difficulty of thoroughly prospecting the ground, some time might elapse before the vein was located.

That this district is auriferous has already been shown by the discovery, in 1898, of sheared pyritous quartz rock, containing traces of gold, on Rural Lot 45 of the Ditchingham Estate,* north of Olive Hill Siding, also by the discovery, about 1900, of gold near the head waters of Ferguson River, and of alluvial gold in the bed of a branch of Preston River.† None of these finds, however, proved payable, and there does not appear to be much hope of the occurrence of payable deposits in the district.

CHEMICAL AND MINERALOGICAL WORK.

(E. S. Simpson).

During the year 1920, the work of the laboratory has continued upon the lines followed during recent years, viz., in assisting by chemical and physical investigations as well as by experimental manufacture, in the development of the State's mineral resources and in the establishment of industries likely to use local raw materials. The large amount of data regarding the latter, which is now preserved in the laboratory is each year proving of greater value to established and prospective manufacturers.

* *Vide* Lands Department Map $\frac{411A}{40}$

*Maitland, A. Gibb, W. A. Geol. Survey, Ann. Rept. for 1898, p. 12, 1899.

† Maitland, A. Gibb, W. A. Geol. Survey, Ann. Rept. for 1900, p. 11, 1901.

With additional temporary professional assistance during part of the year, the staff was just sufficient to keep the routine work up to date and to devote a small amount of time to additional research regarding some unutilised minerals. Much more could have been done, were suitable accommodation and apparatus available, the present accommodation having long outgrown its utility and being a severe tax upon the health of the staff during the summer months, when the temperature in the coolest part of the building is frequently over 95°, and for several days in each year is over 100°. This state of affairs has been referred to on previous occasions and calls for immediate rectification by the housing of the staff in a brick or stone laboratory of modern design, with separate rooms for different investigations and abundant head room and ventilation.

The accompanying table gives an indication of the routine work carried out during the year. It shows a slight increase over that for the previous year.

TABLE SHOWING THE ROUTINE WORK CARRIED OUT BY THE GEOLOGICAL SURVEY LABORATORY DURING 1920.

——	Public Pay.	Public Free.	Geological Survey.	Other Departments.	Total.
Samples	58	482	81	985	1,606
Analysis—					
Complete	2	7	21	9	39
Mechanical	...	2	...	...	2
Partial	3	11	1	14	29
Proximate	4	8	6	9	27
Qualitative	...	...	...	2	2
Assays for—					
Antimony	...	...	...	1	1
Arsenic	...	...	...	1	1
Barium	...	1	...	...	1
Cerium	...	1	...	...	1
Chromium	1	1	1	...	3
Copper	12	66	3	18	99
Gold	30	198	14	809	1,051
Iron	...	12	2	31	45
Lead	4	22	...	4	30
Lime	1	8	...	2	11
Manganese	...	...	...	56	56
Mercury	...	4	...	1	5
Molybdenum	...	1	...	...	1
Nickel	...	...	...	1	1
Nitrogen	...	5	...	...	5
Petroleum	...	4	...	7	11
Phosphorus	...	14	2	4	20
Platinum	...	4	...	...	4
Potash	1	4	1	95	101
Silica	...	9	3	27	39
Silver	20	85	12	23	140
Soda	...	1	...	94	95
Sodium Chloride ...	...	1	...	...	1
Sulphur	...	3	...	14	17
Tellurium	...	...	...	1	1
Tin	1	11	...	4	16
Titanium	...	4	1	...	5
Tungsten	...	6	...	...	6
Yttrium	...	1	...	...	1
Zinc	...	2	...	...	2
Mineral Determinations ...	3	243	35	34	315
Miscellaneous— Tests for:					
Burning	3	1	...	...	4
Calorific value ...	7	1	6	5	19
Clay	...	6	...	3	9
Concentration ...	...	2	...	...	2
Grading	...	1	...	2	3
Graphite extraction ...	...	9	...	1	10
Metallurgical	...	2	...	2	4
Pigment	1	32	...	2	35
Plaster	1	8	...	9	18
Miscellaneous ...	...	2	1	12	15
Total	94	803	109	1,297	2,303

Clays.—An extensive research into the clays of extra-tropical Western Australia has been carried on for several years past, with the added help of a small subsidy from the Federal Government. The first stages of this were completed during the year and a start made to prepare a Bulletin which will give, in a convenient form for reference, the many valuable results obtained. Meanwhile, a short report upon each individual clay received has been issued to the person submitting it, and the general results of the research, as well as all the test pieces, are available to manufacturers on application. It was found possible during the investigation to give much help in the establishment of the roofing tile industry, in improving the locally made refractories and sanitary ware, and in laying the foundations of a white-ware industry.

Gypsum.—The search still continues for a high grade gypsum which will yield a pure white plaster. This matter was dealt with in my last report, when it was pointed out that our visible supplies of gypsum consisted chiefly of:—

(1.) Wind blown dunes of kopi (flour gypsum) always strongly tinted with organic matter and yielding a cream coloured to ash grey plaster;

(2.) Surface deposits of "seed gypsum," usually less strongly coloured than the kopi;

(3.) Subsurface layers of gypsum crystals embedded in the muddy beds of dry lakes. These usually give a good plaster when washed free from mud, a process which is simplified by the slow solution and coagulating effect of the gypsum itself.

The most promising deposit disclosed during the year was that of seed gypsum on the south shore of Lake Seabrook, an average sample of which had the following composition:

	A.	B.	
Gypsum, $CaSO_4 \cdot 2H_2O$ ...	96·31 ...	95·29	per cent.
Calcite, $CaCO_3$	1·50 ...	4·44	„
Insoluble in Acids ...	1·88 ...	·44	„

This yields a pure white plaster which sets quickly to a strong body, and is therefore suitable for all building and modelling purposes. A large tonnage is said to be available, but the deposit is very inconveniently situated, being 26 miles by road from Southern Cross, which is 237 miles by rail from Perth.

Ochres.—The establishment of a paint and distemper factory in Perth and the continued demand for ochres by Eastern States manufacturers have maintained the interest in the search for suitable earths and soft rocks for the production of red and yellow pigments. Thirty-five samples of such material have been dealt with. The wide discrepancy between the prices offered to producers for the crude rock and those charged the public for the same material ground into pigment has adversely affected the prospects of opening up local deposits on an extensive scale. Further difficulty is caused by the fact that no scientific colour standard has ever been adopted in the local trade, each maker and merchant being a law unto himself in the matter of colour nomenclature.

An exhibit of paints prepared in the Laboratory from local ochres was shown at the Royal Society's Conversazione in June, and again, with some additions, at the Western Australian Chemical Society's Conversazione in October. In both cases the exhibit attracted a large amount of attention.

Asbestos.—Excellent chrysotile asbestos has been known at Soanesville in the Pilbara Goldfield for many years and small quantities were mined at one time, but the expense of getting it to market from such an adversely situated deposit caused the locality to be abandoned. During recent years almost equally good chrysotile has been found in a more convenient locality at Hale's Well on the same field, and already a small tonnage has been placed on the market with excellent results. During the present year a third find of the same mineral was found in this district at Eginba, and small quantities of short fibre (three-eighths to one-half inch) at Murrin on the Mt. Margaret Goldfield. F. R. Feldtmann has also detected minute veinlets of chrysotile in association with the actinolite asbestos at Bulong.

The only asbestos deposits now being worked are those of chrysotile at Hale's Well and anthophyllite at Walebing, east of Moora. It is to be noted that a recent price list received from America showed that from £500 to £600 per ton was being quoted for the highest quality chrysotile. Such a price is altogether exceptional and must not be expected to prevail for long.

Potash Supplies.—Further investigations have been made into the possibility of obtaining sources of agricultural and industrial potash within the State. The three most promising sources hitherto disclosed are:—

(1) Alunite, a basic sulphate of aluminium, potassium and sodium.
(2) Jarosite, a basic sulphate of iron, potassium and sodium.
(3) Glauconite, a hydrous silicate of iron and potassium.

The utilisation of alunite has been dealt with at some length in Bulletin 77, "Sources of Industrial Potash," and in my Annual Reports for 1918 and 1919. The chemistry of this mineral has not previously been worked out in detail, though it must necessarily form the basis of all its industrial applications. For this reason great interest attaches to the paper entitled "Contribution to the Chemistry of Alunite" read by Mr. H. Bowley, Assistant Government Mineralogist and Chemist, to the Royal Society during this year, and shortly to be published in their Journal. The use of this mineral in conjunction with lime for agricultural purposes is sufficiently encouraging for the Government to have authorised an extensive series of plot experiments with potatoes, which are now in progress. Later it is hoped to make further experiment with grapes, sugar beets, and other leading crops requiring much potash.

A very big deposit of jarosite having been discovered at Ravensthorpe (S.W. Division), a large number of analyses were made of the mineral and a series of experiments upon the utilisation of the contained potash.

This deposit is genetically related to the large pyrites vein which traverses the Ravensthorpe Range, the weathering of the vein giving rise to large quantities of ferrous sulphate and sulphuric acid, the latter attacking adjacent micas and felspars, and the combined iron alkali sulphate solution precipitating jarosite on reaching the surface of the ground on the slopes of Cordingup Gully.

Jarosite and natrojarosite are completely isomorphous, and the mineral in the deposit varies from a high grade jarosite to a fairly high grade natrojarosite, the former with 5.42 per cent. of acid soluble potash and 0.89 per cent. soda, the latter with 1.57 potash and 3.47 per cent. soda. The average of thirteen samples was: acid soluble potash 3.54 per cent. A complete analysis of a sample approaching this average gave:—

Jarosite, Ravensthorpe.

	per cent.
K_2O	3·70
Na_2O	1·97
NaCl	·44
Fe_2O_3	38·83
FeO	2·25
SO_3, H_2O sol. 2·50 ... ... } ,, Acid sol. 24·04 ... ... }	26·54
H_2O+	8·79
H_2O-	·20
Insoluble	17·40
	100·12

An approximate mineral composition deduced from these figures is:—

	per cent.
Jarosite	70·2
Melanterite	5·3
Basic ferric sulphate	4·1
Limonite	2·5
Insoluble	17·4
Salt	·4
Moisture	·2
	100·1

After calcining at a temperature of about 900° C. practically the whole of the potash present can be leached out as sulphate, leaving a rich red residue which forms an excellent pigment.

It has been proved that jarosite and natrojarosite are completely broken up by warm weak solutions (1.3N) of caustic soda or potash, the whole of the alkali going into solution. Very weak solutions (0.03N) of caustic lime also attack these minerals, the alkalis and sulphate radicle going into solution. It is hoped shortly to publish in another place the results of all the experiments made on this and other specimens of jarosite. The mineral looks quite promising as a source of industrial potash, as it is much less rare than was hitherto supposed.

Mineral Notes.

Mendozite (hydrated sulphate of aluminium and sodium), Denmark and Bremer Bay.—This natural soda alum, not previously recognised in Australia,* has been found to constitute a large proportion of certain yellowish efflorescences occurring along the south coast on the outcrops of carbonaceous shales, possibly of Miocene Age, which include many nodules of marcasite. Specimens from these two localities contained approximately:—

	Denmark. per cent.	Bremer Bay. per cent.
Mendozite	74·3	26.7
Natroalunite	6·9	Trace ?
Natrojarosite	Trace ?	20·1
Quartz and Silicates ...	9·0	27·5

Corundum (oxide of aluminium), Southern Cross. —The discovery of corundum is not only of interest because it can be made into a useful abrasive, but also because the rare gem forms, sapphire and ruby, may be found with common corundum. Grey opaque corundum with occasional small specimens of rich blue corundum, not sufficiently translucent to constitute a gem, was found some years ago in sedi-

*A soda-potash alum has been described from Mt. Flinders, near Ipswich, Queensland.

mentary material at Jacob's Well, S.E. of York. This year a specimen was received consisting of grey corundum with a thick crust of semi-translucent rich blue material, sufficiently promising to warrant a search being made for gem sapphire. This specimen was said to have been obtained a little south of Southern Cross. As it was intergrown with coarsely crystallised mica it was evidently derived from a pegmatite. A corundum-bearing pegmatite was previously known at Ubini, between Southern Cross and Coolgardie.

Halloysite (hydrous silicate of aluminium), Dundas.—Halloysite is a mineral which is wax-like when dry, but like soft tallow when wet. It is an important constituent of ball clays and Fuller's earths, and occurs in small quantities in all clays, though seldom found in pure masses. In Fuller's earth it is the active cleansing constituent. Recently it has been strongly recommended as an ingredient of soaps, whose detergent properties and capacity for lathering are said thereby to be improved. A good sample of unusually pure halloysite suitable for this purpose has been received from the Dundas district.

Manganese Ore, Horseshoe.—The existence of commercially important quantities of psilomelane at Horseshoe has been known for some years, and in my annual report for 1919 an analysis of a picked specimen was given. During this year the two adjacent deposits were examined and sampled by the State Mining Engineer, and the samples were analysed in the Laboratory. They consist of intimate mixtures in variable proportions of psilomelane (hydrated manganite of potassium and manganese) and limonite (hydrated oxide of iron), forming a "saddle" across the Horseshoe Range. Individual samples from the main (southern) ore body varied from

	Mn 24·16%	Fe 34·49%	SiO_2	0·63%
to	Mn 50·81	Fe 7·61	SiO_2	0·36

The average compositions of eleven of the better samples from the southern deposit and of all four samples taken from the much smaller northern deposit were:—

Manganese Ore, Horseshoe.

	Southern deposit. per cent.	Northern deposit. per cent.
MnO_2	66·32	75·78
MnO	6·04	3·51
Fe_2O_3	14·59	8·05
SiO_2	·90	·68
CoO	·23	·24
NiO	*Nil*	trace
BaO	·62	·43
K_2O	1·97	2·54
Na_2O	·30	·30
CaO	*Nil*	*Nil*
MgO	·25	·10
Al_2O_3	2·43	2·84
TiO_2	·12	·07
CO_2	*Nil*	*Nil*
P_2O_5	·17	·11
SO_3	·25	·10
H_2O + 100°	5·76	4·55
H_2O − 100°	·67	·69
	100·62	99·99
On dry Ore:		
Total Mn	46·90	50·63
Fe	10·28	5·68
P	·074	·048
... ...	·101	·040

No gold or silver could be detected in either deposit. They have been very fully described by Mr. A. Montgomery in a pamphlet issued by the Government Printer in 1920. He estimates that over a million tons of marketable ore are in sight within 12 feet of the surface.

Bitumen, Texas Station, Kimberley Division.—Some notable specimens were received from the bed of the Negri River at this locality consisting of limestone and calcareous claystone with ramifying veins of a bright black bitumen, resembling glance pitch. The veins range from about one inch in width down to the thickness of a sheet of paper. Some of the carefully selected black mineral was found to be brittle, not sticky; it ignited and burnt freely, and did not melt at temperatures up to 300° C. Analyses showed:—

	per cent.
Moisture	0·37
Volatile matter	41·54
Fixed carbon	56·27
Ash	1·82
	100·00

A low temperature distillation test showed that the volatile matter was made up of:—

	per cent.
Water	1·74
Oil	19·89
Gas	19·91
	41·54

The gas burnt freely with a slightly luminous flame. The oil had a density of 0.758 at 25° C., and a low viscosity. It was dark brown in colour, translucent and fluorescent.

The calorific value of the mineral was 16,570 B.T.U. Treatment with carbon bisulphide in the cold extracted 15.38 per cent. of a bright black bitumen.

Publications.—During the year the sixth of a series of monographs on regional mineralogy was written. This deals with the minerals of the Kimberley Division. The other papers of the series are:—

1. Kalgoorlie-Boulder ... Published 1912, Bulletin 42
2. Meekatharra ... ... Published 1916, Bulletin 68
3. Westonia ... ... Published 1917, Bulletin 71
4. Comet Vale and Goongarrie ... ... Written 1918: Not yet printed
5. Ashburton and Gascoyne Valleys ... Written 1919: Not yet printed.

As time affords, papers are submitted to scientific societies giving results of importance which emerge during the course of the work of the laboratory but which are not suited for inclusion in Departmental Bulletins. During 1920 a paper entitled "A graphic method for the comparison of minerals with four variable components forming two isomorphous pairs" was submitted to the Mineralogical Society (London) and has since been printed in the Mineralogical Magazine. Papers entitled "Cobaltiferous Epsomite at Parkerville," and "Notes on Staurolite from the Mogumber District" were read before the Royal Society of Western Australia, as also was a paper "Contributions to the chemistry of Alunite," by Mr. H. Bowley. These will shortly appear in print in the Journal of the Society.

PETROLOGICAL WORK, 1920.

(R. A. Farquharson.)

The work for the past year, which has been both large in amount and varied in character, may be conveniently summarised, as usual, under the following heads:—

I. Determinations and Reports for the Geological Survey Staff.
II. Determinations and Reports for Mine Managers, for other Departments, for Prospectors, and the public generally.
III. Miscellaneous.

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

As in previous years, a considerable part of the work has been the determination, description and correlation of rocks collected by the officers in the field, discussions with the officers concerned of the geological problems of each district, and, after careful consideration of these problems in the light of the field occurrence of the rocks and the ascertained microscopic characters, an interpretation of all the facts disclosed. The results of this work are that, so far as field data and specimens can be obtained, the general and mining geology of the various districts and the mapping, which should be, and is, of the utmost importance to prospectors and in live mining fields to mine managers, is as accurate as possible.

Owing, however, to the revival in mining during the year, due to the discoveries at Hampton Plains, Mount Monger, etc., a larger part than usual of the work has been investigations for mine managers of problems arising in the course of their work, upon the solution of which the future development of their mines, to a large extent, depends, and investigations for prospectors anxious to know what class of country they are in and what is its geological relation to already proved areas in its vicinity.

The total number of sections cut and registered during the year was 314, but in addition to these, I have myself cut 294, or over 100 more than in any previous year; a number due to the large increase in the work for individual mines and prospecting shows.

The suites of rocks examined include those from—

1. Noongall (Melville), Yalgoo Goldfield:—

These rocks are chiefly greenstones, acid rocks, and gabbroid rocks.

The greenstones comprise—

(a) Fine and medium-grained metamorphosed dolerites, some of which are quartzose, and some of which are both granulated and foliated.

(b) Coarse-grained rocks that are probably metamorphosed gabbros.

(c) More basic varieties, of which some were almost certainly ultra-basic and are now tremolite-chlorite rocks and hornblendites.

The greenstones vary greatly in the amount of shearing visible to the naked eye, some being extremely foliated and others almost massive. A few exceptional facies occur which may be due in part to silicification, in part to assimilation of incorporated greenstone fragments by granite.

The acid rocks comprise quartz porphyries, granite porphyries, biotite microcline granite and pegmatite dykes. It is in the pegmatites, or rather in the quartz genetically connected with them, that the bismuth ores of Melville are found.

The gabbroid rocks are probably related to the later basaltic dolerites of other centres. Some are decomposed with amphibolised augite, and others are micro-pegmatitic quartz epidiorites with relics of original augite.

2. Rothesay:—

The country at Rothesay consists of a mass of basic and ultra-basic igneous rocks (greenstones) which have been more or less sheared, a few pegmatite dykes and a few basaltic dolerite dykes. The greenstones include epidiorites and hornblende schists, hornblendites, tremolite rocks and serpentines. The serpentines contain tremolite probably derived from olivine. From the field occurrence of the rocks, from their mineral composition and structure, it would appear that all varieties are but differentiations from one magma.

The basaltic dolerite dykes intrude the zoisitic epidiorites and all cut through a quartz vein on the British Queen Lease.

3. Payne's Find (Goodingnow):—

The rocks occurring in this locality are:

(a) Greenstones: epidiorite, hornblende schist, serpentine.
(b) Hornblende-biotite gneiss.
(c) Foliated quartz porphyry.
(d) Granite, porphyry, aplite and pegmatite dykes.

The greenstones and serpentines are perhaps contemporaneous, but their relation to the gneiss is unknown. Some of the acid dykes intrude the greenstones and are hence younger than the latter, and as some of them also cut through the quartz veins, they are of later age than these.

The epidiorites and hornblende schists are all dark-green in colour, fine in texture, and distinctly sheared, and a few contain large phenocrystal plates of felspar broken down by dynamic agency. The serpentines are bluish-green in colour, soft and mostly massive, with an appearance on decomposition suggestive of fragmental structure. Both epidiorites and serpentines have been dynamically metamorphosed, both rocks are cut by acid dykes, and the serpentines are probably basic segregations or differentiates from the magma that gave rise to the greenstones.

The hornblende-biotite-gneisses are the most interesting rocks at Payne's Find, both economically and geologically. In general appearance they are all foliated, dark-grey in colour, and composed of strings of biotite or of hornblende or of both minerals, separated by lighter-coloured strings of felspar and quartz or of felspar alone.

Two varieties are recognised, a foliated, granulated hornblende gneiss with a little biotite and a few grains of quartz (in addition to felspar elongated parallel to the foliation) and a similar rock in which biotite is the chief constituent and hornblende much less common, and in which quartz is very common in grains and elongated rectangular plates. The quartz veinlets in the Payne's Find gneiss are very suggestive of a *lit par lit* injection of quartz into a finely foliated gneiss, and, as dynamic metamorphism combined with quartz injection acting on the hornblende gneiss would produce finer foliation and lenticles of quartz, and would convert the hornblende (and chlorite) to biotite, it is most probable that the two varieties of gneiss are genetically the same. The recognition of a foliated granodiorite differing but slightly from many specimens of the hornblende-biotite-quartz gneiss suggests that the original rock of the gneiss was granodioritic.

The important feature of these gneissic rocks is their very strong resemblance to those at Westonia which are associated with high gold values, and the very marked differences between them and any of the gold-bearing rocks from the Eastern Goldfields. It would appear that the Payne's Find and Westonia gneiss belong to a totally different rock suite from the rocks of Kalgoorlie, Southern Cross, etc., that they are genetically related, and that, in consequence, the country west and north-west of Westonia and between the latter and Payne's Find is well worth prospecting.

The foliated quartz-porphyry is a light-yellow, highly sheared and weathered rock of somewhat doubtful character. It is older than any of the acid rocks noted below and recalls the gold-bearing porphyries of Leonora District.

4. Neighbourhood of Mt. Burges:—

These specimens were collected by Mr. Clarke, partly to elucidate his own work and partly to enable blanks in the general geological map of Western Australia to be filled in.

The rocks comprise—

- Actinolitic chloritic amphibolites and hornblendites,
- Schistose or foliated epidiorites,
- Chlorite rock,
- Hornblendic porphyrite,
- Serpentines (some chloritic),
- Finely fibrous fine-grained amphibolite derived from a basaltic dolerite.

5. Payne's Find, Kurrawang Woodline:—

These rocks were collected by Mr. Talbot to enable an investigation to be made into the origin of the jaspers. Evidence was obtained proving that a gradual passage can be traced from a fine-grained amphibolite or epidiorite, through a severely sheared facies of this rock, to a facies still severely sheared but in which the green colour is replaced by brown, and thence to a foliated highly ferruginous jasper. There can be no doubt from the evidence afforded by this suite that some at least of the jaspers are but highly sheared and metamorphosed zones in the epidiorites. It is intended shortly to publish a paper embodying the facts accumulated to date in regard to these rocks.

6. Boogardie:—

An examination was made for Mr. Feldtmann of quartz collected by him from the Mount Zion mine and of specimens obtained from the same mine by Mr. Jutson, with the object of throwing light on the origin of the quartz and of the gold. The results have been embodied in the report by Mr. Feldtmann on the Mt. Zion mine.

7. Mount Monger and St. Ives:—

From time to time small suites of rocks were sent down by Mr. Clarke for determination and correlation to enable light to be thrown on the mining operations in these two localities, and to enable short interim reports to be written by Mr. Clarke for the benefit of prospectors and small leaseholders. The results of examinations of these rocks have all been embodied in Mr. Clarke's reports, pending the publication of the general geological report on the Mt. Monger and St. Ives field.

The rocks from Mt. Monger and St. Ives obtained by Mr. Clarke include: quartz porphyries, sheared micacised quartz porphyries, sheared micacised quartz porphyrites and chloritised porphyrites, coarse and fine serpentines, fresh olivine serpentines, talc rock and talc schist, deep green chlorite rock, zoisitised quartz epidiorite, black quartz porphyrite, fresh ophitic dolerite, olivine basaltic dolerite or porphyritic olivine picrite, coarse fibrous epidiorite, talc serpentine and talc-chlorite schist, graphitised phyllitic slates, sheared porphyritic fragmental rocks, etc.

Details of the occurrence of the rocks, descriptions and correlations of them, will be found in Mr. Clarke's reports and in the general report on the whole field now in course of preparation.

8. Paris Mine:—

In this mine it was found that the nature and relations of the rocks would throw much light on its mining geology. Specimens were therefore examined for Mr. Clarke to determine these, and it was found that all the rocks were facies of the same mass and were but varieties of epidiorite.

9. Country between Long. 122° 30′ and 123° 30′ E., and between Lat. 25° 30′ and 28° 15′ S., in the Central and Eastern Divisions:—

The rocks from this district were collected by Mr. Talbot and comprise:—

- Boulder clay and grey granite and gneiss boulders.
- Limestones.
- Conglomerates, grits, sandstones, quartzites and shales.
- Granites (pink and grey microcline).
- Epidiorites (some epidotised, some foliated).
- Hornblendites and hornblende schists.
- Quartz-porphyries and pegmatites.
- Hæmatite-quartz schists.
- Felspathic and chloritic gabbro.
- Dolerites (as dykes).

The details of the rocks have all been embodied in Mr. Talbot's report.

10. Northampton Lead Mines, Jarosite Deposit at Kalgan River, etc.:—

Short investigations for officers of the Staff have been made from these and other localities, and the results appear in their reports.

11. Sectioning the general collection of rocks from the Mines, the Prospecting Shows, and the Country of Mount Monger and St. Ives:—

These rocks have been collected by Mr. Clarke in addition to those of the small suites sent down from time to time during the course of his work for the clearing up of problems of immediate interest to those engaged in mining and prospecting on the field. Fully 130 sections have had to be prepared, and the majority of these were ready by the end of the year. The results of investigation of these form part of the work of 1921 and will be embodied in the Bulletin on Mount Monger and St. Ives.

II.—Determinations and Reports for Mine Managers, for other Departments, for Prospectors, and for the Public generally:—

A. For Mine Managers, for other Departments, and for Prospectors.

Owing to the new discoveries at Hampton Plains and Mount Monger and the consequent renewed interest in prospecting and mining in other parts of the State, the number and variety of requests for petrological information from mine managers and others engaged in mining and prospecting shows a distinct increase on the figures for 1919, and again bears witness to the importance of the results of microscopical research in the investigation of the problems arising in actual mining operations and in operations other than mining which may give rise to discoveries of great value to the State.

The work carried out under this head includes:—

1. Examination of Bore Cores from the Edna May Consolidated Mine for Mr. Stokes, and correlation of these with the rocks of the Edna May Lens.

2. Determination of and notes on rocks from the Golden Hope, and Agnes May mines, and from St. Ives and the Rothesay mine for Mr. C. M. Harris.

3. Determination and notes on rocks from Block 45, Hampton Plains. These were sent in by a syndicate of Returned Soldiers with a request for all information that could be given concerning both the rocks and the contained minerals.

4. Determination of and notes on rocks from the Edna May Golden Point Lease at Hampton Plains and from the Golden Hope Mine for Mr. H. G. Stokes.

5. Determinations of and notes on rocks from the Hampton Celebration Mine for Mr. Hawkins. After inquiry as to whether the work could be done, the manager of the Celebration forwarded fourteen rock specimens for determination and correlation and any other information that could be given to assist him in interpreting the mining geology of the mine.

Of the fourteen rocks all except one were more or less altered and decomposed. In fact, so decomposed were they that by ordinary methods only four of them admitted of being sectioned, and, had it not been for the employment of a process of mine for the treatment of decomposed rocks, only these four could have been determined with any degree of accuracy. By the use, however, of special methods all were sectioned and 36 sections were examined. As pointed out in the report, the determination of very decomposed rock depends entirely on whether the decomposition is so far advanced that all relics of original structure and composition have been obliterated. If any relict structures remain, the rock can be determined with a greater or less degree of accuracy according to the definiteness of these structures. If no relict structures are recognisable, then nothing of any practical value can be said about the rock, for though the present composition of the specimen may be made out, as a product of alteration it may have been formed from any one of several different types. Of the fourteen samples, ten were definitely determined, but the other four were of doubtful character.

The rocks comprised:—

(a) Very fine-grained quartz-porphyry.
(b) Felsitic quartz-porphyry.
(c) Sheared or schistose decomposed quartz-porphyry.
(d) Decomposed forms of a serpentine with veinlets of chloropal.
(e) Sheared coarse-grained epidiorite, very similar to that forming the country rock of the White Hope Mine.
(f) Very decomposed epidiorite.
(g) Several somewhat doubtful clayey rocks.

All information possible was given Mr. Hawkins, and the results were discussed with him in the light of his knowledge of the peculiarities of the mine.

6. Sectioning and determination of rocks from Mount Monger for State Mining Engineer. These included the well-known "chlorite rock," fresh olivine serpentines, and talc schists and talc chlorite schists.

7. Determination of rocks for Mr. Blatchford from Ives' Find, Mount Monger, and Mount Goddard.

These comprised—

Fine-grained serpentines.
Talc-chlorite rocks.
Carbonate-chlorite-quartz rocks probably derived from epidiorites.
Chloritised and sheared quartz-dolerite greenstone.
Quartz porphyries.
Porphyritic olivine picrite (or fine-grained basaltic olivine dolerite).
Black albitic porphyrite.
Sheared green porphyrite.

The relations of the rocks were fully discussed with Mr. Blatchford previous to the writing of his preliminary report, and appear in his report and on his maps.

8. Determination of rocks from four miles north of the Celebration Mine for Inspector Gourley. These were prospectors' samples about which information was desired in regard to their relationships to the rocks of proved auriferous areas in the neighbourhood. They comprised chloritised carbonated quartz-epidiorites, fibrous tourmaline, quartz with tourmaline.

9. Report on samples of ferruginous clayey greenstones as a source of pigments and iron ore for the State Mining Engineer. These specimens were all merely very much weathered somewhat schistose greenstones, which by oxidation have had the ferromagnesian decomposed with the production of brown iron ore. They were too hard and gritty for pigments and too poor in iron to be of any value as an iron ore.

10. Determination of and notes on rocks from Whim Well and Mons Cupri for Mr. Blatchford. This work was undertaken in connection with the report by Mr. Blatchford on the ore resources and the mining geology of these mines, and necessitated the overhaul of specimens formerly collected from the same localities. The rocks included chloritic sheared slates, acid porphyry, granodiorite, a fine-grained volcanic agglomerate or tuff, black chloritic slates, etc. The results were discussed with Mr. Blatchford in the light of the occurrence of the specimens and of the ore.

11. Determination of rocks from the Wilga Coal Bore for the State Mining Engineer, as to the probable occurrence of further seams, the proximity of the bed rock, and the character of the limestone band.

12. Determination of and report on samples from the Robert Street Water Bore, Osborne Park. The samples so far examined are as follow:—

0ft.-31ft.:—

A white quartz sand, fine granular and somewhat similar to the Lake Gnangara sand.

31ft.-39ft.:—

A brown quartz sand of medium to fine grain.

39ft.-89ft. 6in.:—

Brown ferruginous sand, largely consolidated into friable sandstone by brown oxide of iron.

89ft. 6in.-97ft.:—

A brown quartz sand with coarse and fine grains.

97ft.-101:—

A small amount of round and sub-angular brownish quartz grains forming a sand; pieces of dirty-brown clay in part gritty; pieces of black carbonaceous gritty clay or silt; pieces of sandy clay or silt.

101ft.-105ft.:—

Greenish-brown limey clay (marl) with grains of quartz and fragments of felspar, and with fragments of small shells. The greenish hue is probably due to glauconite.

105ft.-200ft.:—

A black very sandy carbonaceous clay or silt.

360ft.-375ft.:—

Fine greenish-white glauconitic sand.

375ft.-450ft.:—

Black carbonaceous grit.

450ft.-470ft.:—

Typical fine-grained greensand.

470ft.-490ft.:—

Black gritty carbonaceous clay, possibly in places glauconitic, with pyritic nodules.

490ft.-538ft.:—

Medium-fine quartz sand.

538ft.-550ft.:—

Black carbonaceous shaly mudstone.

550ft.-600ft.:—

Coarse quartz sand, in part compacted.

600ft.-625ft.:—

Same as at 538ft.-550ft.; black carbonaceous mudstone.

625ft.-645ft.:—

Medium coarse to fine-grained sand with microcline felspar grains.

645ft.-652ft.:—

Coarse gritty carbonaceous mudstone.

652ft.-676ft.:—

Medium coarse sand.

676ft.-681ft.:—

Carbonaceous shaly mudstone with pyritic nodules.

13. Examination, determination, and registration of the core from a bore put down at Collie by the Public Works Department.

B. For the public generally:—

1. Determination of rock in a water bore from Karonie in connection with the prospects of obtaining a water supply. The rock, though resembling a black shale, proved to be a decomposed dolerite.

2. Determination of and report on samples of opal, with hints on the occurrence of precious opal. It was pointed out that precious opal may always be looked for in deposits of common opal.

3. Determination of rocks from the Mica Find near Mount Morrison for Mr. Underwood, and discussion with him on the characters, occurrence, and origin of the mineral.

4. Determination of and notes on additional rocks from the Kimberley Division. These were old specimens sent in for the collection from time to time by prospectors and travellers and a few specimens collected by E. T. Hardman traced to some drawers in the Museum. The rocks include: Fresh ophitic dolerites, epidiorites, basaltic dolerites (some vesicular), quartzites of several varieties, diorites and quartz-epidiorites.

5. Determination of and report on supposed oil stones from near Kelmscott, and on a rock as a source of pigment.

6. Determination of rocks in connection with the occurrence of glance pitch, sent in by Mr. Durack. This occurrence is of some importance in that a certain amount of petroleum has been distilled from the pitch, and hence the associations of the mineral are specially worthy of note. The rocks proved to be very decomposed basaltic dolerite in places more or less carbonated.

7. Investigation of the probable place of origin of a rock for the Wallman Pistol Company. In a consignment of pistols from Spain, some rock had been placed as a make weight in the place of pistols, and the company were desirous of discovering whether the rock had probably been inserted in Spain or elsewhere. The rock was an organic limestone (foraminiferal), and by reference to the geological map and accounts of the geology of Spain it was possible to show that, as the actual rock found in the consignment occurred in great extent in the vicinity of the town in which the pistols were manufactured, and is rather uncommon, and does not occur in Western Australia, it was most probably inserted in that town.

8. Determination of rocks from Broome. These comprised basic slag, decomposed epidotised basaltic dolerite, epidotised vesicular dolerite, epidote and chalcedonic quartz, etc.

III.—*Miscellaneous.*

While the above is an outline of a large part of the work which occupied my attention during the year, it by no means represents the whole of it. In addition to investigating problems in general and mining geology from the standpoint of the rocks, I have been called on to devote quite a considerable amount of time to the following:—

1. Determining specimens of rocks and minerals for prospectors, the Mines Department, and the general public, and giving information both orally and in notes on the values of ores and their mode of occurrence and associations. Fully 190 determinations of this nature were made during 1920, and in quite a number of instances short reports on the minerals were written for prospectors.

2. Writing the Annual Report for 1919.

3. Correcting proofs of reports and bulletins, both in typescript and in printed form, and editing Bulletin 83.

4. Registering rocks and minerals, record work and sectioning rocks.—This work devolved on me during Mr. Welsh's absence on long service leave.

5. Cutting sections of minerals and rocks. During 1920 I have myself cut 294 sections for microscopical examination from mine managers, prospectors, and the public, and these are exclusive of those cut and registered for the collections.

6. Repairing the grinding machine.—The old belting, which latterly had certainly not given satisfaction, having worn out, I had it replaced by horizontal shafting, flat pulleys, a starting switch, and a new frame, and the machine is now much more efficient than it ever has been.

7. Arranging the rock and mineral collections of the Survey.—As opportunity could be made, the whole of the rocks and minerals belonging to the Survey have been arranged in consecutive numbers and a plan has been drawn up showing the exact drawer any particular registered specimen may be found in. This was a work of some magnitude, for approximately 17,000 specimens had to be handled, but the time expended on it is more than compensated for by the celerity with which any specimen can now be obtained.

8. Preparing collections of rocks and minerals of the State for prospectors, the general public, etc. During the year no fewer than eight collections have been made up and despatched, this number including, amongst others:

(1) A collection of Western Australian rocks for use in teaching agriculture at the Narrogin State Farm.

(2) Collections of the ores of base metals and rocks for soldier prospectors.

(3) A collection of economic minerals of the State for Sheffield University.

GEOLOGICAL SURVEY MUSEUM AND COLLECTIONS.

The Geological Survey collections, for the reasons which have been fully set out in previous Annual Reports, remain precisely in the same unsatisfactory condition as heretofore.

The accessions during the year 1920, which included rocks, minerals, fossils and suites of bore cores, amounted to 379, bringing the total number of specimens registered up to 17,009, most of which are in duplicate.

The number of micro-sections cut and registered during the period under review was 314, which brings the total number of micro-slides up to 4,542, for the storing of which a new cabinet is essential.

Special acknowledgment must be made of the donation to the Geological Survey collections of the following:—

Registered No.	Donor.	Mineral.	Locality.
$\frac{1}{2920}$	D. Lambie ...	Marble, Garnets	Ashburton River, N'th-West Division
$\frac{1}{2926}$	A. Stephens ...	Gypsum	Stuart Range, 148 miles North of Tarcoola, South Australia
$\frac{1}{2929}$	C. F. Vickery	Muscovite Mica	Prothero Lead Mine, *via* Geraldton
$\frac{1}{2934}$	C. J. LeMesurier	Barytes	Four miles west of Cranbrook
$\frac{1}{2935}$	Do. ...	Calcite	Near Cave House, Yallingup
$\frac{1}{2763}$	A. Ballantine...	Gypsum Crystal	Salt Lake, west of Wongan Hills
$\frac{1}{2771}$	— Rae... ...	Rutile Needles on Chlorite Rock	Mt. Monger
$\frac{1}{2802}$	F. Piesse ...	Tinstone with Tourmaline	Near Boyanup, South-West Division
$\frac{1}{2850}$	E. S. Simpson	Brown Iron Ore...	Main Quarry, loc. 17564, Clackline
$\frac{1}{2862}$	F. Ward ...	Epidote Crystals with Quartz Crystals	Ashburton River, N'th-West Division
$\frac{1}{2864}$	A. Montgomery	Stalactitic psilomelane and Limonite	Main Manganese Deposit, Horseshoe.
$\frac{1}{2907}$	Inspector Gourley	High grade Alunite	Ende and Currans claim, Breakaways, Kanowna.
$\frac{1}{2848}$	C. M. Harris	Sulphide ore ...	70ft. level, Golden Hope, G.M., near Mt. Goddard.

Eight mineral collections, comprising not less than 20 specimens each, were made up and distributed.

Owing to the extent to which the reserve of duplicates have been drawn upon, there is very little now left available for such purposes.

Library.

The Geological Survey Library was enriched during 1920 by direct gifts from cognate institutions throughout the world of 838 publications, in addition to which 159 volumes were added by purchase and one volume bound. The full titles are recorded in the official catalogue.

The distribution of the official publications of the Geological Survey during 1920 amounted to 6,867.

PUBLICATIONS.

The publications for the year 1920 have been as follow:—

Annual Progress Report for the year 1919.

There are, in addition, the following in the hands of the Government Printer:—

Memoir No. 1.—The Mining Handbook of Western Australia, of which the following Chapters and Sections have been issued:—

Chapter I.—A Summary of the Geology of Western Australia.

Chapter II.—

Sections—Antimony.
Artesian Water.
Bauxite.
Coal.
Copper.
Iron.
Lead.
Magnesite.
Manganese.
Mica.
Molybdenite.
Rare Metals.
Rutile.
Tin.
Tungsten.

Chapter III.—The Physiography of Western Australia in its Relation of Prospecting and Mining.

Chapter IV.—Minerals of Economic Value.

Chapter V.—Petrology.

Chapter VI.—Relation of the Law to Prospecting and Mining in Western Australia.

Chapter VII.—Assistance to Prospecting and Mining.

Chapter VIII.—Glossary of Some Terms used in Mining, Field, and Physiographical Geology.

The publication of the following Bulletins has been authorised, and these are being proceeded with as rapidly as exigencies will at present permit:—

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

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

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

LXXXI.—The Geology and Mineral Resources of the Yalgoo Goldfield, Part I. The Warriedar Goldmining Centre: by F. R. Feldtmann, Field Geologist.

The following have been completed:—

LXXXIV.—The Field Geology and Broader Mining Features of the Leonora-Duketon District, including Parts of the North Coolgardie, Mount Margaret, and East Murchison Goldfields; and a Report on the Anaconda Copper Mine and Neighbourhood, Mount Margaret Goldfield: by E. de C. Clarke, Field Geologist.

LXXXV.—A Geological Reconnaissance of Part of the Ashburton Drainage Basin, with Notes on the Country Southwards to Meekatharra: by H. W. B. Talbot, Field Geologist.

LXXXVI.—The Geology and Mineral Resources of the Yalgoo Goldfield, Part II., the Geology of

Goodingow (Payne's Find), Rothesay, and of Noongal (Melville): by E. de C. Clarke, Field Geologist.

LXXXVII.—A Geological Reconnaissance in the Country between Longitude 122° 30′ and 123° 30′ East, and between Latitude 25° 30′ and 28° 15′, in the Central and Eastern Divisions: by H. W. B. Talbot, Field Geologist.

There are in active preparation or contemplated:—

The Present Condition of our Knowledge of the Geology and Mineral Resources of the Kimberley Division: A. Gibb Maitland.

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

The Clay Deposits of Western Australia: E. S. Simpson, and others.

General Geology and Mineral Resources of the Monger-St. Ives District-Coolgardie and East Coolgarie Goldfields: E. de C. Clarke.

Geological Sketch Map of Western Australia, Four Sheets, Scale 25 miles per inch, Natural Scale 1 : 1,584,000.

It is very much to be regretted that in the public interest arrangements cannot be made to have the whole of the outstanding bulletins of the Geological Survey issued by extra-official printers and thus ensure more prompt publication than is otherwise possible, until all the present arrears have been wiped out.

A very large part of the usefulness of the Geological Survey depends almost entirely upon the promptitude with which the final results of its work are made available to the public. Whilst this is the case, it ought not to be forgotten that reports which are expected to have scientific and official accuracy take time to prepare—which only those who are called upon to do it adequately realise—and that for those who have to accept the responsibility in connection therewith it is, *inter alia*, essential that the necessary facts should be definitely ascertained, and their accuracy assured, rather than that demands for hastily written and badly digested reports, not based on accurate survey, which tend to defeat their own ends, should be acceded to.

A. Gibb Maitland

Government Geologist.

Geological Survey Office,
Perth, 10th March, 1921.

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