1917.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 71.

THE GEOLOGY AND MINERAL RESOURCES

OF

THE YILGARN GOLDFIELD.

PART III.

THE GOLD BELT NORTH OF SOUTHERN CROSS INCLUDING WESTONIA,

BY

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ALSO

Notes on the Minerals of Westonia,

BY

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And Petrological Notes by

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ISSUED UNDER THE AUTHORITY OF

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WITH NINETEEN PLATES AND SEVENTY-FIVE FIGURES.

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PREFATORY NOTE.

The present publication forms one of a series of general reports dealing systematically with the geology and mineral resources of the gold and mineral fields of Western Australia. Separate descriptive reports on more or less isolated individual centres have appeared at intervals, and it was realised that the time has arrived when it became possible to undertake the preparation of reports, combining the general results of the departmental work, and presenting a systematic compendious account of the geological features and mineral and allied resources of each of the fields of the State. Reports of this nature will appear from time to time as the requisite investigations are completed, but not necessarily in geographical sequence. The goldfields of the State, as legally defined by the authorities, bear no relation to the geological boundaries, and are not all of the same area, nor do they all contain mining centres of equal importance, so that it will be found that the series of areal reports of necessity differ very materially in size.

In the preparation of such areal reports an attempt has been made to meet the special requirements of the mining community. It has already been pointed out that few mines on any mineral field present data sufficient to enable an accurate mental picture of the real nature of an ore deposit to be obtained, for such can only be arrived at by careful and systematic investigation into the geological structure and stratigraphy of wide stretches of country, where all the mineral deposits are perhaps genetically connected and capable of throwing light one upon another. Work of this special nature comprises, *inter alia,* the accurate mapping of the different geological formations, a correct understanding of the geological structure, the accumulation of information relating to the occurrence of the ore deposits, and their mode of formation. In the search for new deposits, and in defining the limits of those already known, the geologist has, to a large extent, to be guided by an understanding of the methods by which particular ore bodies have been formed, for it is only with this knowledge that the peculiarities of their distribution and the possibility or otherwise of their continuity can be forecasted.

These areal reports, when completed will, it is hoped, give both to the geologist, the mining engineer, the prospector, and others interested in the exploitation of the mineral resources of the State, along legitimate lines a comprehensive view of those salient geological features which have any bearing upon economic questions.

This bulletin marks the third of the series relating to the Yil-

garn Goldfield, and completes the general description of that area. It includes an account of the country to the north of the Eastern Railway and embraces the whole of the northern portion of the Yilgarn Goldfield, as legally defined by the authorities; brief reference is also made to the extension of the Yilgarn gold belt lying to the south of Mount Holland and extending to the Phillips River Goldfield.

The area dealt with in this bulletin comprises about one hundred and sixty miles in length and ninety in width; it includes the principal mining centres of Corinthia, Bullfinch, Golden Valley, Mt. Jackson, Marda, and Westonia, together with the Koolyanobbing and Forrestania centres.

The field work in connection with this portion of the goldfield was carried out, with several unavoidable interruptions, by Messrs. Blatchford and Honman during the years 1914, 1915, and 1916. The area surveyed in such detail as circumstances warranted amounts to about 14,400 square miles. The country embraced by the survey falls within sheets 24 and 35 of the 300-chain series, issued by the Department of Lands and Surveys. The field work having been completed in August, 1916, it follows that mining developments since the officers left the field are not available for description.

The chief interest in the Yilgarn Goldfield centres in the auriferous deposits, which form three belts, trending generally northwest, rather than the more general problems of geology of which it however presents very many calling for much detailed research.

It seemed that legitimate assistance to private enterprise could be rendered in the direction of mapping and otherwise investigating the gold-bearing formations in the hope of furnishing a more or less reliable working guide for the use of the prospector and the mining engineer on the ground. The large scale, 40 chains per inch geological maps, of which there are now seven continuous sheets (viz., Bull. 49, Plate IX.; Bull. 63, Plates II., III., IV.; and Bull. 71, Plates VI., VII., and VIII.) present in the most convenient form the salient geological features adjoining the auriferous ore bodies of the whole of the Yilgarn Gold Belt. From these it will be seen that the Gold Belt is in reality a linear system of interrupted and overlapping veins, arranged more or less *en échelon*.

The Yilgarn field, as one of the important goldfields areas, comprises in its geology and mineral resources much that is typical of the entire Interior Plateau, and exhibits considerable diversity in geological constitution.

The gold-bearing belts may be designated, for convenience of description:—

(a.) The Yilgarn Gold Belt: this, which has a length of over one hundred miles, enters the goldfield on the southern boundary of the field, near Mount Ironcap, and passes through Mount Holland,

Cheriton's, Parker's Range, Marvel Loch, Southern Cross, Corinthian, Bullfinch, Golden Valley, and terminates near Ennuin.

(b.) The Mount Jackson and Bungalbin Belt is the most northerly of the gold-bearing areas, and has a longitudinal extent of a little over thirty miles and a general trend of north-west and south-east; and

(c.) The Westonia Belt, which is an isolated area, lying about 35 miles to the west of the main or Yilgarn Gold Belt. It includes Boodalin, and its length so far as is known does not exceed twenty three miles, whilst its width is about five miles.

The figures giving the mineral production have been compiled from the data furnished by the statistical branch of the Mines Department; these which give the production of the various mining centres included within the confines of the field, show that up to the end of 1916 the Yilgarn Goldfield has returned 756,481.84 fine ozs. of gold obtained from the milling of 1,652,337.97 tons of ore.

Table showing the Total Yield of the various Mining Centres of the Yilgarn Goldfield up to December, 1916.

——	Ore Crushed.	Gold therefrom.	Silver.
	Long Tons.	Fine Ozs.	Fine Ozs.
Blackbourne	1,282·50	341·37	..
Bullfinch	248,781·59	117,768·93	16,442·43
Corinthian	134,581·50	29,167·15	..
Ennuin	235·06	421·92	..
Golden Valley	7,235·06	7,440·14	2·00
Greenmount	109,355·50	27,469·70	944·50
Hope's Hill	131,489·55	35,486·95	1·00
Kennyville	23,445·35	12,636·99	·09
Koolyanobbing	363·00	127·98	..
Marvel Loch	303,469·25	99,115·33	771·03
Mount Jackson	38,181·78	28,334·50	2,305·28
Mount Rankin	666·00	176·55	..
Parker's Range	28,901·75	14,227·89	..
Southern Cross	434,052·30	211,724·08	364·41
Weston's	190,171·50	138,219·07	19·58
Goldfield generally, N.E.I.	126·28	33,823·29	36·54
Total	**1,652,337·97**	**756,481·84**	**20,886·86**

It is probable that these figures do not accurately represent the yield of the Yilgarn field, for in the early days of mining in Western Australia, a great deal of the gold won was probably never officially reported to the Department of Mines, and deemed worthy of no better record than the ephemeral currency of the newspaper. No silver has been mined in the Yilgarn field, its occurrence being incidental to the output of gold. The total amount of silver produced up to the end of 1916 is only 20,886.86 fine ozs.; it occurs,

however, at nearly every mining centre, though in many cases the amount is so small as to be almost negligible.

Full descriptions, illustrated in many cases by plans and sections, are given of the mines in active operation, or otherwise accessible, as occurred in the area embraced by the field work of Messrs. Blatchford and Honman.

The geological plans and sections of the underground workings, which accompany the report, have been based on the plans which the various mine owners lodge with the Department of Mines in compliance with the Mines Regulation Act.

A high grade deposit of iron ore occurs in the Koolyanobbing Range, near Lake Seabrook, associated with the ferruginous quartzites (Jaspilite) which forms the backbone of the range. The ore which consists of a lens of micaceous hematite proves to be some of the purest yet found in the State.

A. Gibb Maitland

GOVERNMENT GEOLOGIST.

Geological Survey Office, Perth,
1st September, 1917.

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GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.

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PART A.

THE GEOLOGY AND MINERAL RESOURCES OF THE YILGARN GOLDFIELD.

By

T. BLATCHFORD, B.A.

THE GOLD BELT NORTH OF SOUTHERN CROSS, INCLUDING WESTONIA.

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I.—INTRODUCTION.

Bulletins Nos. 17, 49, and 63,* already issued, have dealt with the geology of the portion of the Yilgarn Goldfield lying to the south of the Great Eastern Railway and a small area extending from Southern Cross township northwards to Hope's Hill.

The following pages are confined to a description of that portion of the Yilgarn Goldfield extending from the railway line to the northern boundary, with a brief reference to the country extending past the southern boundary into the Phillips River Goldfield, which is really a continuation of the southern portion of the auriferous Yilgarn belt.

Owing to the extensive area to be examined the mapping was divided into two sections with the intention, if possible, of writing the final report conjointly after a general inspection of the whole area under review.

The northern section embracing the country from Trough Well to the northern boundary and including the Koolyanobbing belt was, however, done exclusively by my colleague, C. S. Honman, whose completed and independent report is included in the following pages, for owing to the exigencies of the office work the original idea of a conjoint report had to be abandoned.

The balance of the field work was done exclusively by the present writer.

Camp was first pitched in May, 1914, and the whole of the field work was practically ready for writing up in July, 1915, when orders were received to inspect a reported gold find 100 miles south of Southern Cross. Subsequently, further orders were received to become attached to Mr. McIntyre's prospecting party as consulting geologist.

In May, 1916, owing to the length of time intervening, it was necessary to re-inspect the whole of the mining operations. The field work was eventually completed in August, 1916.

For the mapping of the general geological features a scale of 300 chains to one inch has been used. Along the auriferous belt, however, where more accuracy was warranted, 20 chains to one inch was the scale used, while for underground mining work scales of 30, 40, or 60 feet to one inch were adopted.

The present Bulletin completes the survey of the Yilgarn Goldfield, and should be read in conjunction with Bulletins 17, 49, and 63, which are detailed descriptions of the southern areas.

* Bulletin No. 17, by C. C. Gibson. Perth: By Authority, 1904. Bulletin No. 49, by E. C. Saint-Smith and R. A. Farquharson. Perth: By Authority, 1913. Bulletin No. 63, by T. Blatchford. Perth: By Authority, 1915.

II.—PREVIOUS GEOLOGICAL INVESTIGATIONS.

The following is a list of departmental reports on the whole or portions of the Yilgarn Goldfield:—

(a) Annual Report of the Government Geologist, 1888-1889.

(b) Annual Report of the Government Geologist, 1890.

(c) Report of the Government Geologist, 1892. Parliamentary Papers No. 12 of 1893.

(d) Report on Central Goldfields. Appendix, Parliamentary Papers No. 8, 1894.

(e) Report on the Yilgarn Goldfield. Parliamentary Papers No. A4 of 1891. By H. P. Woodward, Government Geologist.

(f) Report on the Interior Gold Region of Western Australia. By S. Göczel. Perth: By Authority, 1894.

(g) Mining Handbook to the Colony of Western Australia. By H. P. Woodward, Government Geologist. Perth: By Authority. 1st Edition, 1894; 2nd Edition, 1895.

(h) Report on the Mines of the Yilgarn Goldfield. By A. Montgomery, M.A., F.G.S., State Mining Engineer. Perth: By Authority, 1908.

(i) Geology and Auriferous Deposits of Southern Cross, Yilgarn Goldfield. By Chas. G. Gibson, B.E. Perth: By Authority, 1904.

(j) A general description of the Northern portion of the Yilgarn Goldfield and the Southern portion of the North Coolgardie Goldfield. By H. P. Woodward. Perth: By Authority, 1912.

(k) Geology and Mineral Resources of the Yilgarn Goldfield, Part I.—Southern Cross. By E. C. Saint Smith, A.S.T.C., and R. A. Farquharson, M.A. (Oxon.), M.Sc., F.G.S., with Chemical Notes by E. S. Simpson, B.E., B.Sc., F.C.S. Perth: By Authority, 1913.

(l) The Geology and Mineral Resources of the Yilgarn Goldfield. Part II.—The Gold belt south of Southern Cross. By T. Blatchford, B.A., with Petrological Notes by R. A. Farquharson, M.A. (Oxon.), M.Sc., F.G.S., and Mineralogical Contributions by E. S. Simpson, B.E., B.Sc., F.C.S., and A. J. Robertson, M.Sc. Perth: By Authority, 1915.

Of the foregoing, Woodward is the only writer who has touched on the general geology of the portion of the field under review, the other reports deal with the southern or Southern Cross areas only, or are descriptions of individual mines.

III.—HISTORICAL.

Records show that the portion of Western Australia now known as the Yilgarn* Goldfield was traversed as early as the year 1846, when A. E. and R. T. Gregory passed through Mount Jackson on their journey to Menzies.

Two years after this, in September, 1848, Roe reached the Bremer Range immediately to the south of the Southern boundary of the goldfield.

B. D. Clarkson, C.E., A. Dempster, and C. Harper traversed the Yilgarn Hills in the year 1861.

In 1864 Hunt passed over portion of the same country on his way to Coolgardie.

The primary object of these exploring parties was not so much the search for minerals as for pastoral areas and, hence, we do not read of their finding any gold or of their making any systematic search for the same.

The Government, in 1862, to stimulate a searching for gold and base metals, offered a reward of £5,000 for the discovery of a payable goldfield within a radius of 50 miles from Perth. In 1869 the distance was extended to one of 300 miles.

The first real impulse to prospect for gold east of Perth was given by the discovery of a small speck of gold found in 1887 by a Mr. Glass, at Mowjakine, whilst excavating a tank near his homestead.

This discovery, though insignificant in itself, led to the forming of a gold prospecting party under the leadership of one Bernard Colreavy.

Colreavy's first expedition met with little success. The country he traversed was between Newcastle and the Wongan Hills.

However, on his second trip he set out towards the Yilgarn Hills.

Whilst he was in the field on this second trip another party, under the leadership of Anstey, returned with some rich specimens of gold in quartz found at Eenuin. Shortly afterwards Colreavy returned with specimens of gold-bearing quartz from Golden Valley.

These discoveries caused a rush of prospectors, and one party, known as the Phoenix,† whilst travelling south from Golden Valley, found the permanent reefs at Southern Cross, afterwards known as Fraser's Gold Mines.

Discoveries soon spread north and south of Southern Cross, in fact, Southern Cross became a busy centre from which pros-

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* *Yilgarn*—aborigine for *quartz*.

† The Phœnix party comprised Messrs. T. Risley, Michael Toomey, and Charles Crossland. The date of their original discovery was January 21st or 22nd, 1888.

pectors went farther afield to meet with the successes they deserved in opening out the still richer fields to the east. The rapidity of these discoveries is evidenced by the dates of opening of railways: Southern Cross, 1st July, 1894; Kalgoorlie, January, 1897.

Unfortunately, there are no reliable records of the amounts of gold won in individual years prior to 1897.

The total amount recorded from the Yilgarn Goldfield to 31st December, 1896, is 174,325 tons for 93,456 ounces. With the exception of 29,000 tons from Hope's Hill gold mine, 1,500 tons from Mount Jackson, and 166 tons from other sources, the whole of this ore came from Fraser's reefs at Southern Cross.

The following table shows the progression and retrogression of the yearly outputs from the year 1897 to 1915:—

Output of Gold for the Yilgarn Goldfield from the year 1897 *to the year* 1916 *(inclusive).*

Year.	Ore treated in long tons.	Gold therefrom in ozs.	Remarks.
			Value per oz.
Prior to—			£ s. d.
1897	174,925	93,456	..
1897	35,988	17,072	..
1898	27,807	11,769	..
1899	33,403	16,371	..
1900	54,403	29,155	..
1901	25,529	26,564	3 10 0¾
1902	41,218	23,115	3 13 3
1903	50,623	23,403	3 8 10½
1904	66,051	25,461	Fine gold.
1905	47,965	19,284	,, ,,
1906	64,763	23,464	,, ,,
1907	50,833	19,263	,, ,,
1908	54,047	22,149	,, ,,
1909	44,337	20,879	,, ,,
1910	34,114	27,785	,, ,,
1911	18,897	18,678	,, ,,
1912	73,199	30,633	,, ,,
1913	154,495	82,226	,, ,,
1914	211,453	88,714	,, ,,
1915	205,331	91,092	,, ,,
1916	181,949	87,930	..
Total, to end of 1916 ..	**1,652,340**	**756,481***	..

From the foregoing figures it is obvious that there was a gradual falling away of the gold production up to the year 1912,

* Total return in fine ounces excluding alluvial 89·88ozs., and 1,394·70 ounces dollied.

when, after that year, there was a very pronounced increase. This increase was, undoubtedly, due to a phenomenal revival of mining during the years 1910 and 1911.

In the latter part of 1909 a discovery of gold was made at a spot now known as Bullfinch, which became one of the most noted in the history of mining in Western Australia. The name of the discoverer was Charles Jones, the representative of a prospecting syndicate formed by Messrs. D. L. Doolette and party. Jones' original application for leases was made on the 29th of December, 1909. The leases were situated about 22 miles north-west of Southern Cross, and are now known as the Bullfinch Proprietary group. The sequel to the first rich crushings from these leases was the applying for old and neglected mines and the prospecting for new mines throughout the whole field. Hence such mines as the Mountain Queen and Corinthian North were capitalised and turned into regular gold producers. The Mount Jackson and Marda centres were also revived.

In addition, an impetus was given to prospect farther afield. Thus we find applications for Weston's Reward on 12th December, 1910; the Recovery, 29th December of the same year; the Myrtle Central (now Edna May Central) early in the following year, and many others too numerous to name. This portion of the field's history is very significant and demonstrates clearly how a mining centre can almost pass into oblivion and be suddenly resurrected by one sensational discovery.

Suffice it to say that of the total production for the year 1914, the output from five mines only, which undoubtedly owed their development to the Bullfinch discovery, was 180,836 tons, yielding 71,874 ozs. fine gold.*

EXTENT AND BOUNDARIES OF THE YILGARN GOLDFIELD.

In the *Government Gazette* publish on 28th January, 1916, the following boundaries were fixed for the Yilgarn Goldfield:—

Bounded by lines starting from a point north of Cairn H26 on Koorarawalyee rock and west of Cairn NB1 at Wangine Soak, and extending south along the west boundary of the Coolgardie and Dundas Goldfields, and passing through Cairn H26 at Koorarawalyee rock to a point east of the summit of Mount South Ironcap; thence west, passing through the summit of Mount South Ironcap to a point on the southern section of the No. 1 Rabbit-proof Fence near the 113-mile post; thence north-westerly and northerly along the fence to the 14-mile post on the northern section of the fence; thence east 20,833 links, north 24,000 links, and west 20,833 links to the 17-mile post on the fence; thence northerly along the fence to the 158-mile post; thence

* During the years 1912 and 1913 these mines were busy erecting plants and developing ore.

easterly about 75 miles to a Cairn marked AN11 on an island at the eastern end of Lake Barlee; thence southerly about 11 miles to a Cairn marked GDR40 on Mount Elvire; thence south-south-easterly about 41 miles to Johnston's rocks; thence south-easterly about 26 miles to starting point.

IV.—PHYSICAL FEATURES.

The physiographical features of the northern portion of the field have already been described in detail by my colleague in his report on the Mount Jackson District.

In the south-western section of the area under review there is little relief in the surface features.

Viewed from any of the higher points, the general aspect is one of a vast undulating plain from which rise comparatively insignificant ridges, the highest points of which, such as Koolyanobbing and Bundalbin, stand out in bold contrast. Occasional isolated granite knobs, like Yorkrakine and Baladjie, also form good landmarks.

The dry lakes are usually found following round these ridges and higher points.* Jutson has included this area in his central or salt lake division,† and described it as an elevated plateau of arid erosion, the present surface being mainly the planed surface of the old plateau.

Taking the railway levels as indicative of the average height above sea level on an east to west section, we find the minimum height above sea level is 1,060 feet, with a maximum of 1,343 feet, a difference in elevation only of 283 feet in a distance of 81 miles.

The highest portions in this section are due to ridges running in a general north-north-west-south-south-east direction.

Of these, the first crosses the railway at Noongar and extends north-westward past Warrachoppin, on to the Rabbit-proof Fence.

The other passes through Southern Cross, Bullfinch, on to Ennuin.

From Karalee eastwards there is a general and decided increase in elevation of from 100 to 200 feet, the maximum being reached at Koorarawalyee, 1,522 feet.

The "old plateau" is not extensively represented, and most of the remnants of the older land surface are to be found in the middle western area. Middle Double Gunyan is one of the best examples. There we find a flat-topped ridge, with the characteristic "breakaway" weathering well represented.

The isolated granite knobs, Yorkrakine, Baladjie, and Karolin rocks, may also be considered as further remnants.

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* *Vide* Plates I., II., and III.

† Bulletin 61,—Physiographical geology of Western Australia. Perth: By Authority 1914.

Of the greenstone areas, the Yilgarn Hills, apparently, though they do rise from areas of depression, may still be regarded as portions of the old plateau. There is little doubt that they owe their presence to their greater weather-resisting properties, due to their composition, and particularly to the prevailing quartz haematite core which is a typical feature.

In the Golden Valley area isolated hills of quartz conglomerates have also defied denuding agencies and, in consequence, remain as fairly conspicuous monadnocks.

RIVERS.

Rivers are absolutely non-existent, and except, perhaps, immediately after the heaviest rainfalls, there is practically no flow of water at the surface.

Surrounding the lakes minor watercourses have been cut by storm water falling on the bare hills, but such are too insignificant to deserve further notice. Under normal conditions there is no flowing water at the surface.

LAKES.

A very extensive "dry" lake system occurs in the centre of the northern Yilgarn field, extending from Southern Cross northwards to Mount Jackson, the extent of which is clearly shown on Plate 1.

As their name would imply, the lakes in this system are usually dry, and even with their maximum quantity of water seldom attain a depth of more than a few inches, and that only after heavy rainfalls.

With regard to the deposits in these lake beds the information is, unfortunately, most meagre. Some of the lakes have undoubted rock floors, which are bare of deposits. Examples of this may be found in Lake Seabrook where crossed by the greenstone at Koolyanobbing,* and a portion of Lake Deborah, near Marie's Find.†

In both the foregoing instances greenstone forms the floor of the lake, which may account for the absence of any deposits, for where the basins are resting on granite the conditions are different, the floors being soft and boggy.

Probably this is due to the granite being more easily weathered rather than to the accumulation of detritus carried from a distance, a point which is still obscure owing to the fact that the lake floors have never been pierced by bores or shafts. That the denuded surface of the floors is robbed of its detritus by wind action is evident, for round the lake edges are usually to be found large deposits of

* Plate XVIII. † Plate VII.

sand in the form of sand dunes, and in several instances even extensive deposits of seed gypsum. The seed gypsum is without doubt derived from the breaking up of the crystals by wind, the crystals, in the first place, being deposited on the lake floors from the water concentrated by evaporation. At the present day it is not at all uncommon to find gypsum crystals in the mud of the lake floors and, at times, scattered over the dried surface.

Furthermore, it is interesting to note the directions from which the prevailing winds blow by studying the sides of the lakes on which these sand and gypsum deposits occur.

As a general rule, with, of course, minor exceptions, it will be found that the deposits occur on the southern or south-eastern edges of the lakes, the western and northern shores being usually bare rock floors, or covered with very thin deposits. In consequence, the northern and western shores are usually more or less precipitous, more particularly so when they abut on the greenstones.

From the foregoing, the natural deduction is that the lakes are migrating westward.*

One of the best examples of the foregoing lake characteristics is to be seen at Marie's Find. Marie's Find is on a peninsula jutting out north-eastwards into Lake Deborah. The northern side of the peninsula is a succession of sand dunes, whilst the southern side is precipitous, bordering a rock floor bare of sand. Numerous islands rise up from the basin far out in the lake, illustrating the migration, whilst the southern shore of Lake Deborah forms another instance of the sand dune formation.

V.—CLIMATE.

The climate is intensely hot and dry in the summer months, with usually cold, bleak, but bracing weather in the winter.

As may be seen from the accompanying meteorological tables the highest shade temperature recorded was in January, 1910, when the thermometer rose to 115°, whilst the lowest record was 25°, the latter registration occurring in August, 1900, June, 1908, and July, 1902, 1906, and 1914. The average rainfall, taken for a period extending over 26 years, is 994 points (100 points representing one inch), the maximum for one year being 1,957 points in 1915, and the minimum 512 in 1894. The three wettest months are June, July, and August.

* *Vide* Plate VI.

Shade Temperature for Southern Cross.

(Means for 18 years.)

——	Mean Max.	Mean Min.	Mean.	Highest Max.	Date.	Lowest Min.	Date.
January	95·1	62·3	78·7	115·0	1910	44·0	1899
February	92·8	62·1	77·4	112·0	1900	46·0	1905
March	87·4	57·2	72·3	107·9	1906	38·2	1910
April	79·2	51·1	65·4	101·1	1906	30·0	1914
May	69·2	44·9	57·0	92·0	1914	26·0	1914
June	62·8	41·2	52·0	79·0	1912	25·0	1908
July	61·8	39·0	50·4	75·3	1906	25·0	1902 1906 1914
August	65·3	40·9	53·1	95·9	1907	25·0	1900
September ..	71·9	43·4	57·6	92·3	1914	26·0	1908
October	78·1	48·4	63·2	102·0	1914	33·0	1909
November.. ..	87·0	54·9	71·0	110·2	1913	35·6	1907
December ..	93·1	60·3	76·7	114·6	1908	41·0	1913
Year	78·6	50·5	64·6	115·0	Jan. 1910	25·0	August 1900 July, 1902 July, 1906 June, 1908 July, 1914

Rainfall for Southern Cross, W.A.

Year.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1889	59	4	*Nil*	46	224	227	170	88	101	59	39	*Nil*	1,017
1890	..	..	..	..	..	35	121	73	88	92	53	25	..
1891	*Nil*	*Nil*	21	3	145	135	100	22	50	24	*Nil*	23	523
1892	62	4	417	86	266	41	252	179	79	119	25	40	1,510
1893	71	19	128	142	347	144	159	83	70	16	48	177	1,404
1894	63	18	108	4	37	46	80	69	42	5	19	21	512
1895	4	10	2	17	81	168	61	155	42	2	*Nil*	*Nil*	542
1896	73	19	316	*Nil*	28	66	225	55	14	15	89	178	1,078
1897	11	69	59	4	29	233	68	114	34	6	1	107	735
1898	1	145	*Nil*	3	75	251	65	193	14	93	23	*Nil*	863
1899	4	12	*Nil*	4	12	158	142	55	89	55	226	*Nil*	757
1900	55	12	25	260	224	129	54	73	59	171	40	27	1,129
1901	*Nil*	39	45	10	133	143	108	189	49	7	12	3	738
1902	105	254	33	*Nil*	94	128	115	83	93	54	45	17	1,021
1903	*Nil*	70	*Nil*	113	96	126	116	75	112	81	53	60	902
1904	14	*Nil*	165	2	229	262	262	59	418	187	59	88	1,745
1905	43	54	*Nil*	27	185	30	97	45	85	54	8	105	733
1906	3	98	*Nil*	5	225	99	193	199	28	7	55	50	962
1907	35	12	199	16	62	86	339	79	84	3	12	17	944
1908	*Nil*	25	35	212	176	107	110	59	32	28	88	11	883
1909	78	53	4	254	79	266	56	346	22	47	20	*Nil*	1,225
1910	22	119	3	2	219	232	258	92	63	120	31	*Nil*	1,161
1911	70	40	20	25	147	38	135	49	28	28	*Nil*	10	554
1912	97	41	50	127	266	24	239	21	74	42	60	143	1,184
1913	7	*Nil*	83	87	40	107	107	220	181	87	22	137	1,078
1914	38	7	*Nil*	28	*Nil*	54	85	83	*Nil*	226	134	32	687
1915	389	306	58	123	350	174	246	162	77	30	*Nil*	42	1,957
Average for 26 years ..	**50**	**54**	**68**	**61**	**143**	**134**	**148**	**109**	**75**	**60**	**43**	**49**	**994**

VI.—DESCRIPTIVE AND ECONOMIC GEOLOGY.

The geological features of the northern section of the Yilgarn Goldfield readily lend themselves to a general classification into four main parallel belts of greenstones and their associated rock formations, surrounded by a vast area of massive granite. Taken consecutively from north to south, these are referred to for descriptive purposes, in the following pages, as the Mount Jackson, Marda, Koolyanobbing, Southern Cross, Bullfinch, and Westonia belts. My colleague has written a full report on the Mount Jackson, Marda, and Koolyanobbing areas, and such will be found included in the present Bulletin.

The following observations will be confined to the Bullfinch and Westonia areas.

VII.—PREVIOUS GEOLOGICAL OBSERVATIONS.

Despite the fact that gold was first found on the Eastern Goldfield in the Bullfinch belt, the discovery was soon eclipsed by more important and richer finds further afield. Hence the Yilgarn field was for a considerable time neglected by the mining world.

However, when the Bullfinch mine was opened up and mining in the district revived, fresh interest was taken in the field. Up to this time the only departmental officer to report on the mining of the Bullfinch belt was H. P. Woodward*, who visited Golden Valley shortly after the first discovery on 22nd January, 1888.

In the year 1912 Woodward made a reconnaissance survey of the Bullfinch belt and the country lying to the north, with the object of ascertaining the extent of the Bullfinch belt and the possibility of locating others of a similar nature.†

It should be noted that prior to this survey others had been made of the southern portions of the Yilgarn Goldfield. Thus we have a report by Gibson on Southern Cross,‡ one by Saint Smith and Farquharson§ on the same area, but in greater detail, and a subsequent one by Blatchford and Saint Smith¶ on the southern extremity of the belt extending from Southern Cross to Cheriton's. These should be read in conjunction with the present report, for though references will be made to these reports in the following pages, there is such a similarity in the geology that the full text should be perused. Of the Westonia belt, which is a comparatively new field, there is no available literature except an interim report by Blatchford, published in the year 1914.‖

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* Annual Reports by Government Geologist, 1888–1889, 1890.
† Bulletin 46.—A general description of the northern portion Yilgarn Goldfield, by H. P. Woodward. Perth: by Authority, 1912.
‡ Bulletin 17, by C. G. Gibson. Perth: By Authority, 1904.
§ Bulletin 49, by E. C. Saint Smith and R. A. Farquharson. Perth: By Authority, 1913.
¶ Bulletin 63, by T. Blatchford and E. C. Saint Smith. Perth: by Authority, 1915.
‖ Annual Report, Geological Survey, W.A., 1914.

VIII.—GEOLOGY OF THE BULLFINCH BELT.

On the frontispiece, and more particularly on Plates VI. and VII., the extent of the Bullfinch belt can be seen like a narrow "island" in a "sea" of granite.

In detail, the rocks of the belt are found to be essentially of basic igneous character in which occur remnants of a highly altered sedimentary series. Through the greenstones are found numerous acid or granitic dykes the apophyses of the surrounding granite. These are of a later age than the main basic rocks. At a very much later time basic intrusives burst through the granites and greenstones and such are now found as fresh narrow dykes (dolerites). Exclusively in the greenstones, and usually following the granite-greenstone boundary, are long lenses of quartz-haematite schists. It will be pointed out later on that these probably owe their origin to the greenstones being crushed by the action of the intruding granite (probably due to heating and contraction on cooling), and to the after alteration along these fissures by circulating underground solutions. Thus the crushed material has been replaced by silica and iron contained in the underground circulating waters.

Quartz reefs are found both in the greenstones and granite areas, being, in the latter case as a general rule, non-auriferous.

The geological age of the rock types is not known, except relatively to one another. The only rocks which could throw any definite light on this point are the sediments. Unfortunately, these have so far been proved to be unfossiliferous.

However, there is evidence to indicate that the metamorphic sediments are probably the oldest rocks of the field, and their lithological characteristics are such as to suggest an age far back in geological time. Placed in relative chronological order, the following rock species are represented. The order is placed starting with the oldest rocks first:—

1. Sedimentary (metamorphic) (non-auriferous).
2. Greenstones (massive igneous) (auriferous).
3. Granites, massive igneous (non-auriferous).
4. Quartz haematite schists and lodes (auriferous).
5. Quartz reefs (auriferous).
6. Acid or granitic dykes (seldom auriferous).
7. Quartz reefs (auriferous).
8. Greenstones (intrusive), dolerites (non-auriferous).
9. Laterites and superficial deposits (non-auriferous).

SEDIMENTARY ROCKS.

There are two well-defined developments of sedimentary strata in the Bullfinch belt. Of these the first is found striking north-west through the townsite of Bullfinch,* and from here it extends

* *Vide* Plate VII.

south to the 18-mile post on the Bullfinch-Southern Cross road. The total length is a little more than four miles with a maximum width of about 25 chains.

The second belt starts on the southern end at the 28-mile post and runs approximately parallel with the Jackson road, as far north as the 41-mile post, thus forming a belt of some 13 miles in length. The greatest width of the belt is found near Golden Valley where it measures on the surface about 60 chains.

A smaller belt lying to the east of the 42-mile post is probably a continuation of the second belt. The width of this third series is about 20 chains in the centre with a total length of 1¾ miles.

All three sedimentary beds are represented by fine-grained bands of phyllites (originally shales) and dark graphitic stained quartzites, whilst crushed quartz conglomerates are of frequent occurrence.

Fig. 1.

Photo: R. H. Irwin. **Crushed quartz conglomerate.** Neg. 1342.

Unfortunately, sections are rare, in fact good sections do not occur.

The absence of sections is, no doubt, due to the easy weathering of the soft shales and also to their being the prevailing type in the series. Furthermore, they are less resistant than the greenstones, and hence are usually found on the lower-lying ground, and covered over partially or completely by the detritus washed down from the greenstone hills. The portions composed of conglomerates, however, are sometimes seen forming detached hills (monadnocks).

This is more particularly the case about a mile north of Golden Valley. Here some of these crushed beds can be observed, and the characters studied without difficulty.

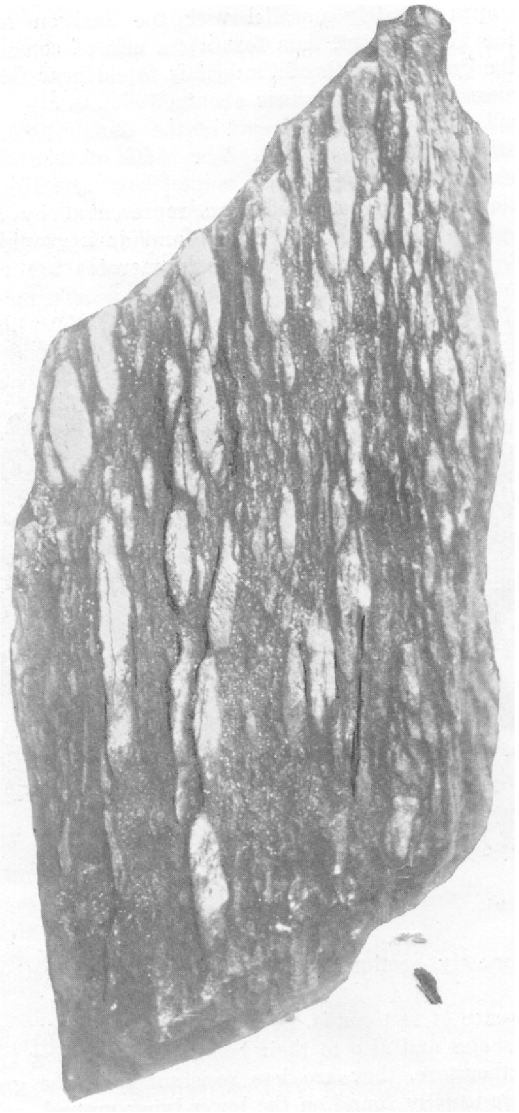

Fig. 21. **Crushed quartz conglomerate.** Neg. 1343.

Photo: T. Blatchford.

These beds consist essentially of quartz pebbles varying in size from four or five inches in length to the size of a pea. In almost

every instance the pebbles have been elongated or drawn out by intense pressure.

A characteristic diagonal cracking is also very common. Both the cracks and elongation are well illustrated in Figures 1, 2, 3, and 4. The pebbles are held together by a siliceous cement, thus forming a hard, brittle rock, which would have resisted weathering much more than it has were it not for the extensive cracking of the pebbles, and also the fissuring of the rock *en masse*.

Fig. 3.

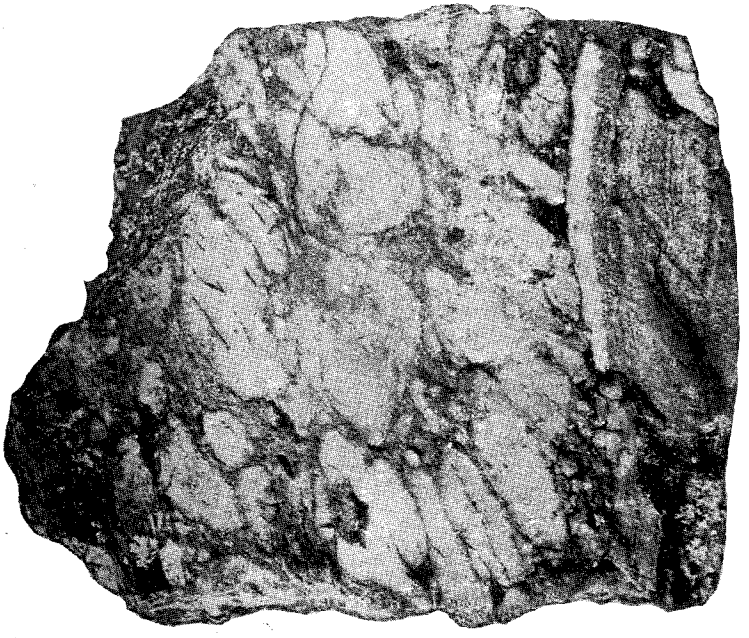

Photo: T. Blatchford. Neg. 1340.

Crushed quartz conglomerate.

Sections in some costeans at Bullfinch expose a dark, gritty rock, at times almost black in colour, but usually a very dark grey. Sections of this rock correspond almost entirely with those obtained from the Westonia sediments. The rock consists of an aggregate of quartz grains, the colouring being due to the presence of fine graphitic dust. This rock has probably been a band of grit or coarse sandstone which has been crushed and impregnated with graphite. Only poor sections can be seen of the phyllites or finer sedimentary bands. As a rule, the only specimens obtainable are small fragments scat-

tered on the surface. In most instances they are found to contain andalusite crystals similar to those in the southern areas.* From their persistent occurrence at the surface there is every reason to

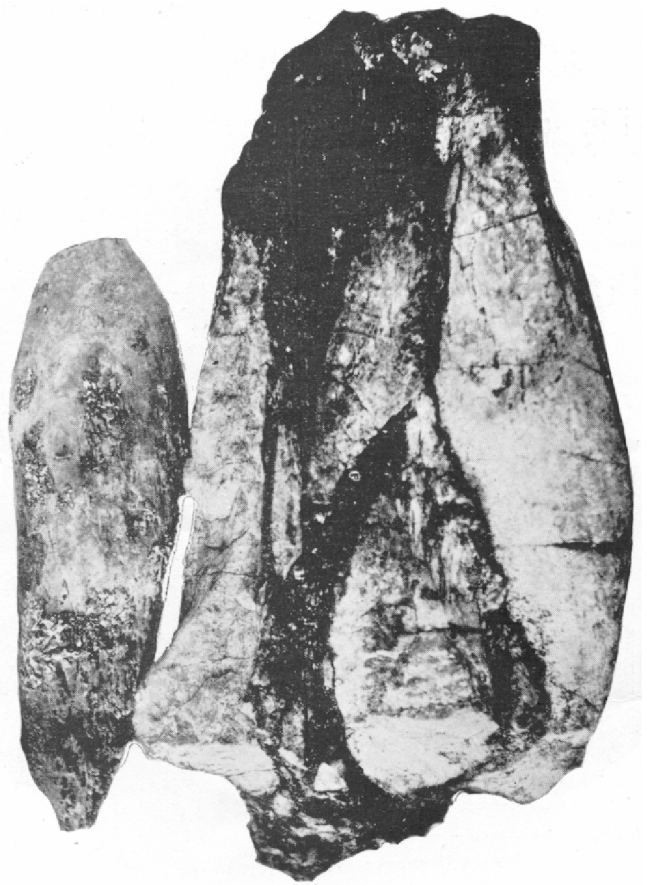

Fig. 4. Elongated quartz pebbles from quartz conglomerate. Neg. 1341.
Photo: R. H. Irwin.

believe that they form the major portion of the sedimentary deposits. The beds have a vertical dip with a general north-west south-east strike.

From an economic point they are of no importance, as in no single instance has gold been found in them in payable quantities, neither do they contain any of the base commercial minerals in such quantities as to warrant exploiting.

* Bull. 63, p. 38. Perth: By Authority, 1915.

Certainly, in some instances, narrow bands of ironstone are seen outcropping along the strike of the beds, but these have been proved to be of such low grade in gold contents as to be worthless, and the iron contents are also poor and the tonnage insignificant for practical purposes.

The beds have a certain amount of importance purely in a geological sense, as they probably represent some of the oldest rock formations of the State, certainly of the Yilgarn Goldfield.

GREENSTONES (amphibolites).

The greenstones or basic igneous rocks of the Bullfinch belt are a continuation of the main rock-mass which passes through and extends southward past Southern Cross.

As several writers have already described the Southern Cross section of this belt, a *résumé* of their various opinions will be stated here, the reader being referred to the several publications in which the reports are to be found, for the detailed descriptions. Gibson,* who was the first to deal with the classification of the basic igneous rocks of the Southern Cross type, divided them into two classes:—

(a) The schists, (b) the massive and foliated variety.—Between these there is no hard and fast boundary, the former gradually passing into and being merely a highly altered form of the latter; moreover, it is often difficult to distinguish between them owing to the fact that at the surface the foliated variety often weathers into the form of schists, this weathering, as a rule, only reaching a few feet below the surface.

The schists are for the most part found in juxtaposition to the granite and evidently owe their existence to the presence of the latter.

The massive and foliated variety form the more western portion of the belt, and occupy a far greater area than do the schists, being generally prominent in the south-western portion of the district examined, where they form a series of low ridges having a general trend slightly west of north. These massive rocks vary considerably in their microscopic properties, passing in all stages from an exceedingly coarse-grained hornblende rock into fine-grained chlorite schists mentioned above.

Saint Smith† divides the basic rocks into two classes, the "older" and the "newer," regarding the former as "metamorphosed rocks, tuffs, etc."

Farquharson‡ divides the rocks into two main classes, subdividing each class into several groups, thus:—

Class I.—Rocks composed of ferro-magnesian minerals without felspar or quartz.

A.—Those consisting of pale-coloured hornblende occurring in confused aggregates.

B.—Those in which hornblende occurs in compact grains —several are intermediate between A. and B., with both fibrous and compact forms.

C.—Chlorite schists.

* The Geology and Auriferous deposits of Southern Cross., Bull. 17, p. 18. Perth: By Authority, 1904.

† Geology and Mineral Resources of the Yilgarn Goldfield, Part I., by E. C. Saint Smith and R. A. Farquharson, p. 23, *et seq.* Perth: By Authority, 1913.

‡ Geology and Mineral Resources of the Yilgarn Goldfield, Part I., by E. C. Saint Smith and R. A. Farquharson, pp. 68–69. Perth: By Authority, 1913.

Class II.—Rocks in which hornblende is the dominant ferromagnesian—felspar almost always present.

A.—Without quartz, or with it only in small quantity.

1.—Rocks massive or only slightly foliated.

(a) Epidiorites—platy and fibrous.

(b) Garnet amphibolites.

2.—Rocks foliated.

Hornblende schist.

B.—With quartz.

1.—Rocks with hornblende in fibrous or other aggregates.

2.—Rocks with compact hornblende and a granular or granulitic structure.

3.—The contact-altered amphibolite.

In a further report, written in a private capacity for the Bullfinch Proprietary, and handed to the Department by the courtesy of the Directors of the Company, Gibson, in his reference to the greenstones of that particular area divides them into two classes, "the older greenstones" and the "newer greenstones."

The former he considers the oldest rocks of the district and describes them in detail as consisting of:—

Fine-grained rocks which are invariably schistose, the intensity of the schistosity varying considerably. In some cases it is so slight that the rocks appear to be almost massive, whilst at times again it is so marked that they have the appearance almost of fine-grained fissile slates.

Originally these rocks were probably fine-grained diabases, but they have now become, as the result of dynamic metamorphism, fine-grained schistose epidiorites.

The "newer greenstones" represent the newest series of rocks in the field. Unlike the "older greenstones" they are essentially coarse-grained. They are occasionally found massive, the schistosity being usually very pronounced. The massive and incipiently schisted varieties represent merely "eyes" or lenses which have, to a certain extent, resisted the general shearing.

These rocks were originally a coarse-grained pyroxenite, but are now, also as the result of dynamic metamorphism, uralite amphibolites and talc schists, the more massive portions being uralite amphibolites, while the highly schisted areas are talc schists, all gradations between the two being obtainable.

In correlating the evidence set out in the above reports, excepting Gibson's later one, and taking it in conjunction with data gained from a detailed survey of Southern Cross to Cheriton's section, the present author adopted a classification more or less corresponding with Gibson's, and the broader one of Farquharson's, viz.:—

1. The foliated variety merging into massive.
2. A coarse variety of hornblendites, the newer series of Saint Smith's, but probably a variation only of the first class.
3. Later unfoliated and massive.

Microscopic examinations of samples collected on the present survey tend to prove the existence of a variety of greenstones varying from hornblendites to epidiorites in every phase of alteration, but probably genetically connected, or in other words, derivatives of the same rock mass.

This does not necessarily presume they are of the same age, in fact, there is evidence against such being the case. But when it is evident that the main mass consists of bands or lenses of rock so intermingled as to be inseparable, and yet varying from one consisting almost entirely of one mineral hornblende to one in which felspar and hornblende are almost in equal proportions, there seems to be little doubt of their once being genetically connected, though subsequently by differentiation, now separated out as apparently different types. Presuming this to be the case, one would naturally expect to find the weathered products of such a rock mass, which had in the meantime been subjected to intense regional metamorphism, occurring in all the possible variations which could arise. A list of the prevailing varieties may be found in Saint Smith's report, above referred to. For the microscopic determinations of some of the rocks collected, *vide* appendices. For a fuller description of the field relationships, what has been written in Bulletin 63 stands for the Bullfinch belt.*

GRANITES.

The granites of the northern area of the Yilgarn belt form the eastern and western boundaries of the Bullfinch greenstones.

As a general rule, on the western side the contact is not visible, being for the most part overlain with sand. Where the rocks do outcrop, and they seldom do, is either in the "breakaways," in which case, as would be expected, the rock is seldom, if ever, not highly weathered,† or in the form of prominent knobs, good examples of which are Baladjie, Karolin, etc. The "knobs" are usually more or less unweathered. When thus seen the granite is found to be of a rather coarse-grained biotite microcline variety, in which occur frequent patches of very coarse aggregates of felspar and mica. The really unweathered portions are mottled black and white or grey. Coarse pegmatite dykes are of frequent occurrence.

Outcrops of granite on the eastern side are very rare. The contact with the greenstones has, however, been exposed in some of the mine workings, notably at Corinthian North and the Bullfinch mines. In each instance it is seen to be distinctly gneissic in character, the banding being fairly perfect. The bands consist of alternate layers of muscovite and biotite with quartz. The felspar is much decomposed and so cannot be identified with any degree of

* The Geology and Mineral Resources of the Yilgarn Goldfield, Part II. The Gold belt south of Southern Cross, by T. Blatchford. Perth: By Authority, 1915.
† Fig. 5.

accuracy. How far this gneissic structure extends is not ascertainable definitely, but it is of no great extent.

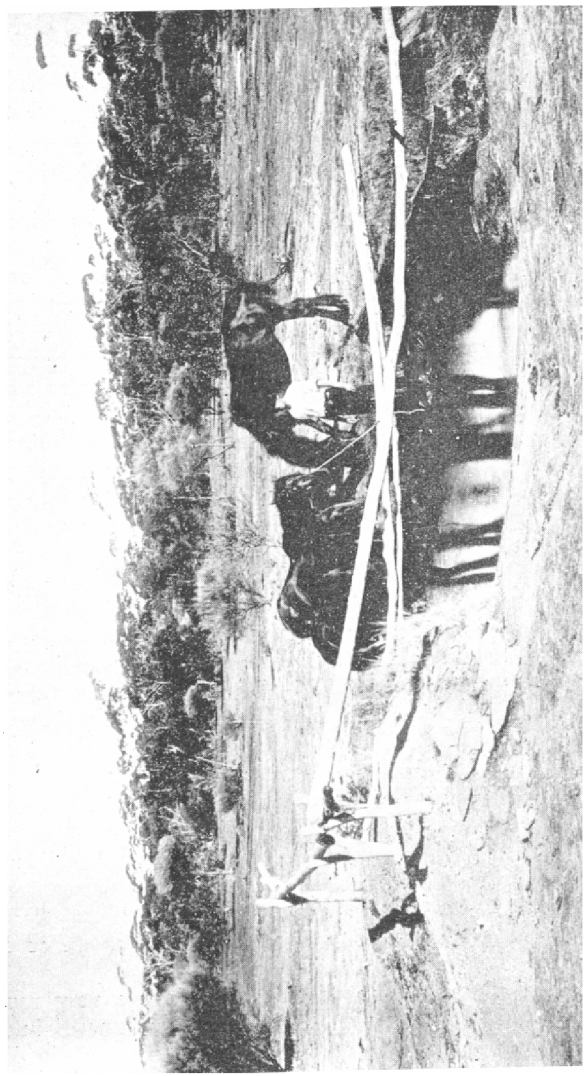

Fig. 5. **Granite rock hole, Deviation Well.** Photo: T. Blatchford. Neg. 1308.

A fresh sample of granite collected from the Government Tank at Ennuin was examined and revealed the following characteristics under the microscope:—

[$\frac{1}{7\frac{1}{2}0}$.] This is a very coarse-grained grey granite rock with occasional large semi-porphyritic scales, crystals and books of biotite. In

section there are very large platy and tabular crystals of partially kaolinised and partially micacised microcline felspar and less common plates of a plagioclase with albite twinning, with aggregations of irregular plates of quartz and occasional flakes of brown biotite, in places chloritic. Wedge-shaped crystals of sphene also occur, sometimes of considerable size. Some vermicular intergrowth appears in places, and an approach to zonary banding is noticeable in some of the felspar plates. Some of the most kaolinised felspars are quite turbid and enclose small grains of epidote. A few grains of black iron ore (ilmenite) appear sporadically. The rock is a very coarse-grained semi-porphyritic microcline biotite granite.*

Though far removed from this locality samples taken from Mount Gibbs, eight miles south of Hatter's Hill, and from near the 128-mile post on the Burracoppin-Starvation Boat Harbour section of the Rabbit-proof Fence, gave practically the same microscopic results. The latter are, therefore, cited for comparison in the appendices.

In summing up the microscopic evidence Farquharson states:—

It is very evident that these three specimens, though collected from points many miles apart, all are so closely similar both in appearance, structure, and composition that they must be regarded as portions of the same, or a genetically similar mass.

It has generally been accepted by previous writers that the Southern Cross massive granite is of a later age and has intruded the greenstones. Saint Smith† has drawn a section showing the intrusive nature near Lake Polaris, but refers to such as "a tongue of granite of a fine-grained acidic type." Since both fine-grained aplites, as well as coarse pegmatites, are found invading the massive granite, this evidence as to the intrusive nature of the massive granite is not at all conclusive. However, apart from the evidence of the schisting of the greenstones near the granite contact, there is at least one definite and conclusive instance in the field where the granite in its massive form may be seen invading the greenstone belt.

This locality is situated some five miles south of Currajong, on the Southern Cross-Jackson road.‡

The granite occurs here, as the mapping shows, in the form of an extensive boss forming an inlier wholly surrounded by the greenstones.

This granite has the same characteristics as the massive granite and must be considered as a portion of the same mass.

It might be mentioned here that a similar occurrence illustrating the intrusive nature of the granite into the greenstones occurs too at Boodalin Soak, in the Westonia district. Furthermore, in this latter case, small areas of the greenstone are to be found in the granite mass as a further illustration of the intrusive nature of the granite.

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* Petrological determination, by R. A. Farquharson.
† Bulletin 49, G.S.W.A., p. 32. Perth: By Authority, 1913.
‡ Plates III. and VI.

There is, of course, no doubt as to the intrusive nature of the granite dykes, for such are repeatedly seen breaking through all the rock series, with the exception probably of a few later dolerite dykes.

As can be readily seen on the frontispiece and Plate I., the major portion of the field is occupied by granite. Unfortunately this vast area of rock does not contain lodes carrying either gold or the baser metals in commercial quantities. Certainly much of the surface is masked by recent superficial deposits of unknown depths. What lies under this cover is, for the present, uncertain. The prospects, however, of finding payable gold or mineral deposits is so remote that it is doubtful if they ever will be exploited, except perhaps in the vicinity of the greenstone contacts.

Referring to these superficial deposits, which are usually sandy or lateritic, one sometimes sees a small area of dark or red loam occurring as an isolated patch. It has been found that these patches are usually due to the disintegration of dolerite dykes, which represent probably the last stage of volcanic action. Further reference to these dykes will be made when dealing with the area at Mid Ironcap, where they are particularly frequent in occurrence.

QUARTZ-HAEMATITE SCHISTS.

This class of rock is well developed in the Bullfinch belt.* As a general rule it occurs in elongated lenses which run parallel to the eastern contact of the greenstones and granite, and usually at no great distance from the latter. On Plate VI., where the greenstones branch at Farren's Rock, this characteristic is very pronounced. The greatest developments of quartz-haematite schists occur in the Golden Valley district. Here parallel bands of the rock are seen practically right across the greenstone area. Quartz-haematite schists do not occur in the granite areas. At Corinthian they abut on the granite, which in this particular instance is distinctly gneissic, but do not intrude into the granite. The granite here merely forms the eastern wall for the deposit.

Throughout, the quartz-haematite schists exhibit a marked banded structure similar in every respect to those in the southern area of which they are an undoubted continuation. Their composition varies from massive haematite to a typical banded jasper rock. In addition to the foliation the rock is often found to be twisted and contorted and fractured to a marked degree. These contortions are sometimes found in only one section of the band, and this is no doubt due to lateral pressure combined with shearing in the rock mass before replacement by the iron and silica, and also to one portion of the rock being rigid enough to resist the shearing that has been induced in the weaker member. In several instances the lenses of quartz-haematite schists have been noticed to branch. Such

* *Vide* Plates VI., VII., and VIII.

is evident in the Violet, Bell Bird, and other mines, which makes it difficult to accept a sedimentary origin for the deposits which has been ascribed to them by some observers.

Opportunities have been forthcoming in some of the mine workings for observing the occurrence of the quartz-haematite schists at depths, and in such a marked change from the surface has been apparent. Thus in the Corinthian mine at the 200ft. level the haematite has been replaced largely by pyrrhotite, and in the Bullfinch mine at the 300ft. level both marcasite and pyrrhotite occur.

The structure of the rock also changes, the planes of foliation becoming less apparent in proportion to the depth. In general there is evidence of the quartz haematite schist gradually changing into the country rock. It should be noted, however, that both in the Bullfinch and Corinthian mines there has been a considerable amount of leaching and redistribution of mineral contents in both the encasing country rock and quartz haematite schists, and thus both these instances, where the subject can be best studied, may still prove to be exceptions to the general occurrence of the rock under review. There is undoubtedly a lack of definite information regarding the occurrence of these deposits at depth. So the conclusions arrived at can only be regarded as tentative.

As the occurrence is of importance from both a mining and geological standpoint, the following extracts have been taken from the writings of other observers both in the Yilgarn and other fields. Woodward, in his description of the Nemesis mine states*:—

> The origin of one of these banded ferruginous quartzite bars is clearly demonstrated since the passage from the comparatively unaltered schist below the 250ft. level can be traced upwards through the pyritic quartz schists to its present oxidised form.

Farquharson's determination of a sample of rock taken from the bottom of this mine is as follows [12074]:—

> A heavy black rock with numerous fine bands of iron ore. Between the leaves in nearly all cases is a layer of rather large crystals of pyrites. Under the microscope the rock is seen to consist of quartz in polygonal plates with scattered grains and crystals of magnetite with small colourless plates of a green, slightly pleochroic hornblende. The latter bands are more densely charged with magnetite and contain frequently, besides, the ferro-magnesian shapeless patches of calcite. Round the border of the plates of hornblende, moreover, is a fringe of almost colourless needles of actinolite projecting at right angles to the rim into the surrounding quartz. A few large and small crystals of pyrites are to be observed. In several instances hornblende, that had almost completely lost its characteristic optical properties, is bordered by magnetite and closely associated with calcite which, indeed, is only to be found in the ferro-magnesian bands, and would, therefore, appear to be a decomposed product. Some brown iron staining is also to be seen in the green mineral.

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* Bulletin 48, p. 100, *et seq.*

Woodward's conclusions on the subject are definite, for he goes on to state:—

It is apparent from the above that the rock composing these bars results from the alteration of ferro-magnesian minerals, and was of a similar character to the enclosing country.

In his report on the banded quartzites in the Murchison Goldfield,* at Lennonville, Mount Magnet, and Boogardie, Gibson divides the quartz schists into two classes—"the haematite" and the "non-haematite," the former being the more prevalent type, and in summing up the occurrences and origin he says:—

The main bands of quartzites appear to have been old fault lines or joints, along which the original greenstones have been highly foliated parallel to the line of faulting or jointing, and thus form zones of weakness along which thermal solutions containing silica, iron, etc., have forced their way to the surface and gradually converted the original foliated greenstones into their present form. This appears to be borne out by the fact that they almost invariably run with the general strike of the country, viz., about north-north-west and south-south-east, and also that in several places they can be seen to tail out and invisibly pass into foliated greenstones.

In Maitland's description of the Mount Millicent quartzites in the Edjudina District,† he states:—

All the available evidence seems to indicate that these lines or bands of quartzite have been found along shear planes, and that faulting took place subsequently to the deposition of the iron ores themselves.

and further on in a summary:—

Analyses of the typical varieties of the different classes of ore showed that, contrary to their general appearance, they all contain a high percentage of silica and a relatively low percentage of iron. They are evidently not of clastic origin, occurring as they invariably do in the greenstone schists; these have invariably been subject to a great amount of bleaching and decomposition in close proximity to the deposits. The greenstone schists contain a certain proportion of iron compounds in their composition, and the bleaching action in proximity to the quartzites would seem to imply that these form the source of the iron ore and possibly that of the silica, with which these ores are invariably associated. The iron-bearing quartzites occur in the form of alternated overlapping lenses along what are evidently shear planes of remarkable persistence which, by virtue of the lamination, have formed channels for the more or less free circulation of mineral bearing solutions.

Gibson, in a report on the Murchison Goldfield, makes further reference to the banded quartzites of that district‡:—

In no single instance have they been found in granite country.

They (the quartzites) appear to be merely highly altered bands of foliated greenstone, and in some places can be seen to tail out imperceptibly into the latter. They are older than the quartz reefs. Their appearance at a depth is exactly similar to that at the surface, except in one case, where the hornblendite appears to be dying out and its place taken by blue quartz.

* Bulletin 8, p. 16. Perth: By Authority, 1903.
† Bulletin 11, pages 28 and 58. Perth: By Authority, 1913.
‡ Bulletin 14, G.S.W.A., Perth: By Authority, 1904.

The same author, in writing about the haematite quartzites of Southern Cross, says:—

> These are similar to the haematite bearing quartzites of the Murchison and other parts of Western Australia, which have already been described in detail as "old faults or joint lines along which the greenstones have been highly foliated, and by a gradual lode forming process been converted into their present state."*

Jackson, in his description of the Mount Morgan's lode,† considers that:—

> Apart from its size and irregular nature it has many points of interest, not the least being its similarity of origin to the banded and haematite bearing quartz lodes which, though elsewhere frequently associated with auriferous deposits, are not themselves generally highly gold-bearing.

In a description of the Craiggiemore G.M., at Laverton,‡ he states that:—

> The ore bodies worked on this property are in every way similar to the haematite bearing quartzites. The whole country is very soft and rotten all through the present workings, and just begins to get hard and settled at the 300ft. level, at which point a fair amount of sulphide begins to make its appearance in the stone.

Saint-Smith,§ in describing the jasper bars or quartz haematite schists of Southern Cross, divides them into three classes in accordance with the percentage of silica present, with a possible fourth class "of subsidiary importance, which latter may represent the transition stage from normal greenstones to one or other of the three main classes of jasper." It is evident the author holds the prevailing idea that they are derived from the alteration or replacement of greenstones.

Farquharson, in dealing with the probable genesis of quartz haematite schists, is inclined to treat them as similar to the Lake Superior and Cuyuna deposits in America. It seems probable that his deductions were drawn from evidence derived from samples only of the bore cores of the Mount Caudan lode, which, without doubt, is of sedimentary origin ‖ and quite distinct in origin from typical examples of the class of rock under discussion. His petrological notes on the ore from the Nemesis mine read distinctly in favour of the general theory of replacement in crushed zones or fissures.

From the foregoing it would appear, therefore, that there is practically a consensus of opinion amongst observers as to the genesis of these deposits, viz., that they have been formed in the crushed zones of the foliated greenstones only, the main constituents, silica and iron, in the various forms of oxide, being derived, partly at least, from the basic rock.

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* Bulletin 17, G.S.W.A., Perth: By Authority, 1904.
† Bulletin 18, G.S.W.A., Perth: By Authority, 1905.
‡ Bulletin 24, G.S.W.A., Perth: By Authority, 1906.
§ Bulletin 49, G.S.W.A., Perth: By Authority, 1913.
‖ Bulletin 63, p. 65, *et seq.* Perth: By Authority, 1915.

It has been further noticed that where observed at depth in the mines there is a tendency for the gradual change or merging of the ferro-siliceous quartzite into the country rock. Furthermore, it has been observed in several instances that the iron oxides are replaced by pyrrhotite, marcasite, and pyrites in the deeper mine workings.

From an economic and mining point of view, considerable importance is attached to the occurrence of this class of rocks in the Yilgarn Goldfield.

Firstly because, in some instances, the quartz haematite schists have been themselves productive of highly payable gold ore.

Secondly, because gold-bearing quartz reefs are often found closely associated with them.

The best instance of payable ore being won from the lodes themselves is to be seen in the Bullfinch mine itself, a fuller description of which will be given under the heading of mines.

A glance at Plates VI., VII., and VIII. demonstrate that most of the mines and mine workings are at no great distance from the quartz haematite schist belts, which is evidence sufficient for the assumption that there is a close connection between them and the gold-bearing reefs and quartz leaders.

As a matter of fact, traces of gold can almost invariably be found in the quartz haematite lodes themselves, but, unfortunately, seldom in sufficient quantity to be of payable value. The Bullfinch mine is an exception, and the higher gold values found there are unmistakably due to severe faultings and subsequent local enrichments.

In the Violet mine, at Golden Valley, a pipe of ore of payable value has been opened out in a large haematite formation, but the gold values occur where an arm branches off the main body, and not in the main body itself.

At Ennuin gold has been won from the Marionette lease, but here again there has probably been local enrichment, due to the ironstone body being impregnated with auriferous quartz veins.

Of the associated quartz reefs, the best examples are the Corinthian and Corinthian North, Marie's Find, and several rich but small reefs at Ennuin.

QUARTZ REEFS.

Quartz reefs occur throughout both the greenstone and granite areas. In the latter rock they are usually of the massive type, non-auriferous, and probably of pegmatitic origin. Those found in the greenstone area may be classified under two headings, in accordance with their origin; but they likewise belong to two epochs when referred to their relative ages. As a general rule, quartz reefs have been found to be of a pre-pegmatite age, but in two instances there is undoubted evidence of the occurrence of a quartz vein after the granite dykes had intruded and cooled down,

Further reference will be made to this exception in describing the Glideaway mine.

Another example is found in the same locality, where two quartz veins are being worked in a granitic dyke itself.

These, apparently, are exceptions, the general rule being that granite dykes intrude quartz reefs, thereby establishing the fact that they are of a later age. Of the hundreds of instances of this, the two instances mentioned above are the only exceptions which have been noticed. Classified according to their origin, the reefs in the greenstones come under two headings:—

(a) Ordinary quartz veins whose origin is undoubtedly connected with ordinary fissure-filling from circulating solutions.

(b) The pegmatitic type originating from fissure-filling by granitic ultra-acid residuum.

Veins of the first type are by far the most important, and the auriferous members of this class seem to be particularly associated with the quartz haematite lodes, or, in other words, they lie in or near the main fracture zone of the greenstones, and more particularly are they found where the granitic dykes are in evidence. Good examples of this are to be seen at Marie's Find, Manxman, Eenuin and Golden Valley. Everything tends to the one conclusion—that where the country rock has been fractured and undergone the most alteration there will be the most favourable areas for mineral deposition and concentration. My frequent reply to the prospector who is often found speaking disparagingly of the granite "bars" is, "Where you do not find those, you won't find gold; so you must take the two together or none at all." Of all the payable mines in the Southern Cross belt, the writer knows of three only in which granitic dykes do not occur; and two of these, the Victoria and Broncho, are in a class of their own, and unlike any others in the above goldfield, whilst the other is the Bullfinch Proprietary, another more or less exceptional case.

The second class, probably derived from the granite magma direct, is not very pronounced, but is represented in one or two instances by conspicuous outcrops. They are usually known by the prospectors as "Buck" reefs. There is no instance on record in the Bullfinch belt in which they have proved of any value as gold bearers.

Quartz reefs in the Bullfinch belt proper do not play the same important part as they do in the southern area, whether viewed from a geological or mining aspect. As a matter of fact, their occurrence, as a whole, is not only less frequent but the auriferous ores may be said to be comparatively scarce.

However, there is always a likelihood of discovering fresh auriferous quartz veins in the vicinity of or connected with the quartz haematite schists, though away from such the chances of

success seem fairly remote—for, while considerable prospecting has been done outside the zone of the quartz haematites, there is no single instance on record where this has led to a successful issue.

This limits the range for prospecting considerably, and really reduces the probable auriferous area to very narrow limits.

Unfortunate as this may be from a mining standpoint, it is nevertheless a fact, though, of course, exceptions may arise in the future, in spite of this rule having held good up to the present date for the Bullfinch, Southern Cross, and Marvel Loch belt.

GRANITIC DYKES.

Throughout the greenstone and granite rocks are numerous more or less narrow dykes of undoubted granitic origin. In the greenstone areas they are extremely common on the eastern contact. To illustrate their frequency, a small area at Marie's Find was taken as an example and each of the dykes mapped.* This illustrates the occurrence, but it will be seen that to have continued mapping on this scale throughout the whole field would have taken far longer than was warranted. For after all, except that the acid dykes occur with persistent frequency in the areas where gold-bearing reefs are found, they have little bearing on the auriferous nature of the quartz vein itself; the chief significance of their association is that both the occurrence of the reefs and dykes point to the fact that the areas in which they are found have probably been suitable for not only circulating solutions, but also the admission of the narrow dykes. In other words, where dykes can invade, there the conditions are suitable also for circulating solutions, and there is a probability of the introduction of minerals from such solutions. The sizes and field relations of the most conspicuous of these dykes can be seen on Plates VI., VII., and VIII.

The granite dykes invade all classes of rock, with the exception of the dolerites, and though they may be of later age even than these they have not been observed passing through them.

In the Glideaway mine an instance of their being of two ages is evident, for the Glideaway reef passes through a series of acid dykes in one part of the mine, whilst in another a rather large granite dyke cuts through the reef.

As far as observed no instance occurred in which base minerals were found in acid dykes. Reference has already been made to gold occurring in two small veins occurring in a granite dyke. This is the one exception in which gold has been directly associated with this class of rock and is almost negligible.

SURFACE DEPOSITS.

For the most part the surface of the country is covered with superficial deposits. These deposits vary in compo-

* *Vide* Plate VI.

ition relatively to the underlying rock. Thus, on the granite areas 're find siliceous laterites and sand to sandy loam, whilst on the reenstone areas one finds isolated patches of ferruginous laterites nd loam.

The deposits in the dry lake areas have already been referred).

Practically little is known about the depth or extent of these urface deposits, as there has been no inducement to exploit them. 'here is no record of any alluvial "leads" being discovered. As a natter of fact, alluvial gold has been conspicuous by its absence hroughout the belt.

Taken as a whole the surface deposits form a mantle, covering nost of the area under review, about which practically nothing is nown.

IX.—GEOLOGY OF THE WESTONIA CENTRE.

The Westonia belt is situated some six miles north of Carrabin, railway station on the Eastern Goldfields line, 195 miles distant 'rom Perth and about 40 miles west of Southern Cross.

EXTENT OF THE BELT.

Compared with the other four greenstone belts, that of Wes- onia is the smallest.

Its total length is some 23 miles, with a maximum width of not nore than five miles. The shape is irregular, the central portion)eing a very narrow neck connecting the northern and southern ends,)oth of which have much greater dimensions.

The southern extremity gradually merges into flat, sand-covered :ountry, presumably granite, but the boundaries here are most in- lefinite.

The same conditions prevail on the northern end, but the coun- ry being of a greater altitude there, makes the boundary somewhat nore definite.*

HISTORY.

The first official notice of the discovery of gold in the Westonia district was the application for a reward claim near Boodalin Soak by A. D. Weston on 20th December, 1910. This lease is now known as Weston's Reward, named after the discoverer, as also is the town- ship Westonia.

Further applications for gold leases soon followed Weston's application, thus we have one by J. Cooke on 30th December of the same year for the Recovery G.M.L. 2097; by E. J. Annear for the Edna May G.M.L. 2180 on 10th January, 1911; by C. Hickey and Asphand for Myrtle Consols G.M.L. 2168, 9th January, 1911; by

* *Vide* Frontispiece.

Tom Duff, Myrtle Consols South G.M.L. 2238, 23rd January, 1911 (these two leases now comprise the Edna May "Deeps" mine); by A. F. Hanks, Myrtle Central G.M.L. 2291, 10th February, 1911 (now the Edna May Central mine); by J. V. Kearney, the M.A.W. lease 2409, afterwards applied for on 5th June as the Myrtle East by R. Holmes, and now part of the Consolidated Gold Mine; and G.M.L. 2617 by Squires and others in March, 1911, afterwards applied for by De Jersoe in 1912, also part of the Consolidated group.

For some considerable time only one of these leases—The Recovery—yielded gold in appreciable quantities, and, in its early stages of development, gave promise of being a high-grade mine. As a matter of fact, it seems quite probable that the first crushings from the Recovery were the means of keeping prospecting alive in the early stages of the field. Certainly it was trying to locate the continuation of the Recovery reef which led to several, if not all, of the above leases being taken up as mining holdings. It is generally understood amongst some of the original prospectors that after the Recovery, gold was next "struck" east of the Recovery in the "water" shaft on G.M.L. 2761 (Edna May Consols), and that the latter find lent colour to the prevailing idea that the Recovery reef extended in that direction. Certainly it was the means of further prospecting between the water shaft and the Recovery, and, therefore, the indirect cause of finding the main Edna May-Central lode, a discovery sufficiently important to lay the foundation of a mining centre of considerable importance. Unfortunately, the Recovery reef proved disappointing, and had it not been for the discovery and proving of the Edna May line probably there would have been a general exodus of the prospector. As it happened, the first crushings from the then Myrtle Central and shortly afterwards the Edna May were such as to give every encouragement to further prospecting. To illustrate the advancement in mining after this period one has only to note the development in mining plants. Up to the end of 1912 there was but one small reduction plant on the Recovery lease. In 1913 the Edna May Company erected a ten-stamp mill, followed by the Central in 1915 and in 1916 by the "Deeps" and "Battler," with mills of a similar number of stamps.

In addition, several mines, chiefly the Edna May, expended considerable amounts of money in pumping and winding plants, air compressors, etc. Up to the present time the Edna May is the only plant equipped with a cyanide plant for treating both sands and slimes. Unfortunately, prospecting during the years 1914 and 1915, apart from the Edna May Central mine, met with little success. Certainly, several small veins carrying high-grade stone were found, but these were unimportant in a true mining sense. The chief mining venture of 1915 was really the attempt to intercept the Edna May line at depth, and with this object in view the owners of the

tle Consols and Myrtle Consols South floated a company, vn as the Edna May "Deeps," to raise sufficient capital to n this objective, which resolved itself into sinking a vertical t from 500 to 600 feet in depth.

It was whilst sinking this shaft that heavy water difficulties : met with and overcome by a cementing process, which is well hy of notice and redounds to the credit of N. Stuckey, the mana- in charge.

In brief, the *modus operandi* adopted was as follows:—A trial was always bored well ahead in the bottom of the shaft. When y water was struck a force pump was connected to the bore by a suitable wooden plug fitted with a pipe valve and hose, liquid cement was then pumped into the hole until the pressure to the limit of the pump (from 300 to 500 lbs. to square inch). hose was then disconnected after the valve had been closed; a several holes had been treated in this way, in the bottom and s of the shaft it was found that, due time for the setting of the ent, of course, having been given, the water was held back and bottom of the shaft could be fired out as usual and be practic- free from water, thus demonstrating that small open fissures ning water channels could be definitely cemented up and perma- ly sealed, at least in unweathered rock. The process is new aining operations in this State and, in the writer's opinion, ld be of use where the conditions are similar to those which e in the "Deeps" mine. The Edna May reef was eventually ck in a drive from this shaft at the 480 feet level. The result an important one in that it proved not only the existence of main reef at this depth, but also that the gold values likewise inued.

GEOLOGY.

The rocks of the Westonia Boodalin belt resolve themselves the following groups, which are placed in relative chronological er commencing with the oldest:—

Sedimentary metamorphics.—Non-auriferous.
Basic Rocks (greenstones), plutonic.—Auriferous.
Gneiss—Edna May Gneiss, intrusive.—Auriferous.
Granites, massive plutonic.—Non-auriferous.
Ultra Acid pegmatites (lodes).—Auriferous.
Basic (greenstone dykes).—Non-auriferous.
Quartz reefs.—Auriferous.
Granitic intrusive pegmatites, aplites.—Non-auriferous.
Recent superficial deposits.—Rarely auriferous.

Probably the oldest rocks of the field are the sedimentary series ıd near Boodalin railway siding. There is a very marked re- blance between these sediments and those of Parker's Range, vel Loch,* Bullfinch and Eenuin, so marked, in fact, that it

*Bull. 63, G.S.W.A., p. 29. Perth: By Authority, 1917.

is only reasonable to suggest that they formed at one time a continuous series, lying horizontally on a fundamental gneissic floor. Subsequent earth movements buckled these beds into folds with axes striking north-west south-east; at the same time basic rocks were intruded. Later on these basic rocks, in turn, were intruded by magma of an acid character, which latter resulted in the formation of the gneissic belt, called in the following pages the Edna May gneiss.

Following these early earth movements comes the intrusion by the Southern Cross granite, the result of which was not only the taking up of the major portion of the area with one prevailing type of granite, but also the introduction of different characteristics to the whole of the then existing rocks both in the rearrangement of their minerals and the introduction of different physical features.

Hence we find the coarser sediments crushed and foliated with extensive developments of fresh minerals such as andalusite, garnets, etc., in the finer varieties.

In the basic rocks hornblendes have changed largely to mica, etc., and both the basic rocks and Edna May gneiss have been highly foliated. On the cooling and consequent contracting of this complex, extensive faulting took place, followed by injections of both an acid and basic character.

Apparently the first of these injections were acid and resulted in the formation of the ultra acid dykes now worked as highly profitable gold-bearing lodes.

These were followed by basic intrusions which passed through the former and were afterwards subjected to the same treatment, for we find further acid intrusions which passed through one and all the members of the plutonic and volcanic series. The injection of these acid dykes is the last evidence of volcanic action in the district. Though there must needs have been extensive faulting in the rock complex there has apparently been little other movement as, with one exception, there is no evidence of throw in any of the faults.

SEDIMENTS (METAMORPHIC).

The sedimentary series in the Westonia section is but poorly represented, and is only found outcropping in one locality, viz., north of the railway line at Boodalin.

A group of leases known as the Comstock embrace most of this area.

On the surface the rocks have weathered considerably, the result being a mixed ferruginous coating resembling the prevailing ferruginous laterite deposits in appearance. In one instance only was there any semblance of this ironstone being the capping of a lode such as found in the corresponding sedimentary areas of Marvel Loch or Parker's Range.*

* Bull. 63, G.S.W.A., p. 64. Perth: By Authority.

It would appear from the shallow workings that gold has been found by prospectors, but not in sufficient quantity to warrant any extensive development.

Where the original rock could be seen, samples were taken and such have been examined by the Petrologist, with the following results:—

G.M.L. 1117:

[⅛]. This is a very fine-grained dirty greyish-black somewhat porous graphitic rock, the numerous minute white scales or rods all arranged with the long axes parallel. There is a suggestion of shearing in the specimen, and the specific gravity is light. Owing to the denseness of grain, the rather soft nature of the specimen and the graphitic content, it is very difficult to obtain a section of the rock of any value. It is possible, however, to make out that the body of the rock is composed of small quartz grains heavily charged with a black dust, of which some particles have the appearance in reflected light of graphite scales. Doubtless there is a considerable amount of amorphous graphite as well. In addition to these constituents there are occasional pale yellow fibrous flakes, resembling decomposed mica and, rarely, rather large areas of minute scales of mica heavily charged with the black dust. These large micaceous aggregates are of obscure origin, but are consistent with a derivation from original chiastolite. From the character of the rock and from comparison with undoubted chiastolite shales from the same field, it is probably a sheared, much altered, graphitic shale of the chiastolite-shale series.

[¼]. An extremely decomposed rock, apparently sheared or indistinctly laminated, somewhat porous, extremely ferruginous, and of a brick-red colour, with numerous pale slate-blue rounded forms that are soft and granular, and in places blackish. The rock is too much altered for sectioning, but appears to be slightly graphitic. The bluish forms were at first sight thought to be flinty, but their soft nature indicates that they are probably decomposition products. Tests, however, with the blow-pipe failed to reveal a strongly aluminous character, but this may have been due to the presence of carbon, and it is probable they are decomposition products of andalusite.

The rock is of doubtful origin, but it is classed as a weather ferruginous clayey product of an *andalusite shale.*

In both instances the rocks have proved to be closely allied to shales much altered and impregnated with graphite, a frequent characteristic of the sediments in the Bullfinch belt. Careful investigation of these beds is impossible owing to the paucity of outcrops and mine workings. They are unimportant from a mining point of view, for, as a general rule, throughout the Yilgarn goldfield they have been proved to be non-auriferous except in rare instances, along their contact with the greenstones.*

GREENSTONES (plutonic).

Next in importance to the Edna May gneiss, especially from an economic or mining point of view, are the greenstones.

* For further reference to Occurrences of Sedimentary Rocks, *vide* Bull. 63, G.S.W.A., p. 20, *et seq.* Perth: by Authority, 1915.

As previously mentioned, the greenstones form a more or less narrow belt, extending through Boodalin railway siding, north-west past Weston's and Boodalin soak. In the centre of this belt is a pronounced necking.*

Under existing conditions it is an impossibility to map the boundaries accurately, as the contacts are almost invariably covered with surface detritus. The boundaries, therfore, as shown on Plate IX. and frontispiece, must be considered as approximate only. Furthermore, this prevailing overburden has so seriously interfered with the possibility of mapping the various rock types, that detailed work in this direction was almost futile.

However, wherever outcrops or mine workings were available, samples were taken and examined, and by this means sufficient information was obtained to admit of a general classification of the rock matrix being made. Several bore cores, too, were carefully sampled, and these were found extremely useful in the investigations.

In an interim report on the Westonia district by the present writer in the year 1914, the greenstones were subdivided into three main groups (1) Diorites; (2) Amphibolites, and (3) Peridotites.

The diorites were further subdivided into four types, the classification being made with reference to structure and composition.

A. Normal diorites.—A rock in which the hornblende and plagioclase (felspar) are in approximately equal proportions.

B. Fine-grained felspathic diorites, in which the felspar predominates.

C. Fine-grained hornblendic diorites, in which the hornblende predominates.

D. A distinctly gneissic variety.

The last of these it was found possible to isolate within moderately definite boundaries.

The above classification was only a tentative one and drawn up from hand specimens and a few rock sections cut in the field.

Since the issuing of the above report, a considerable amount of detailed work has been done by Farquharson† on specimens collected from the surface, mine workings, and bore cores. Whilst recognising numerous facies, in that writer's opinion the whole of the greenstone types may be resolved into two main groups. The following is a list of the types, with a brief summary of their relationships, as written by the observer† :—

1. A foliated hornblende gneiss occurring in a thin lenticular mass from the Junction lease to the western boundary of the Elsie lease. The rock is in places quite coarse-grained and dioritic in appear-

* Frontispiece.
† R. A. Farquharson, Petrologist, G.S.W.A.

ance, in places quite fine-grained, while in some rock specimens felspar is equally developed with the hornblende; in others, hornblende is much in excess of the felspar.

2. The granulitic hornblende schist. This occurs in the Elsie lease in shafts south of the point at which the hornblende gneiss disappears.* It occurs at the south-west corner of G.M.L. 2079; it is found in shafts at the eastern margin of the Myrtle lease, and is predominant in Nos. 2 and 3 bores, Edna May mine.*

Further, both the hornblendic gneiss and the granulitic hornblende schist occur in a shaft at the south-west corner of G.M.L. 2762, though specimens of the former are much decomposed.

Finally, a foliated fine-grained hornblende gneiss or granular quartz amphibolite, and a fine-grained prismatic hornblende schist occur in the Lloyd George mine.*

3. A foliated pyroxene-hornblende-felspar rock occurring at the old townsite.*

4. A foliated hornblende-schist or epidiorite at Bodallin soak. This is virtually identical with the granulitic hornblende schist.*

5. An acicular hornblende schist verging on a granulitic hornblende gneiss, and a fine-grained foliated prismatic or roddy hornblende schist with lenticles of pyroxene, found in the Battler lease.

6. A foliated amphibolite or diorite occurring near the bottom of Duff's bore at about 785ft.,† and a coarse platy diorite at 438ft. in the bore at Weston's Reward.

7. An actinolitic chloritic hornblendite, occurring at the plat in the Edna May shaft 300ft. level, and at a depth of 427ft. in Duff's bore.†

8. Finally, a tremolitic serpentinous rock found at 466ft. and greater depths in Duff's bore, also the plat in the Edna May shaft, and, judging from weathered clayey specimens, in shafts near the western margin of G.M.L. 2617.

These facies are ultimately reducible to two groups:—

(a.) Foliated felspar-hornblende rocks. These include rocks with quartz such as the foliated hornblende gneisses or quartz diorites, and those without quartz or with it in such small amount, such as the granulitic hornblende schists and foliated epidiorite and the foliated pyroxene hornblende schist.

(b.) The non-felspathic hornblendic rocks. Included amongst these are the actinolitic chlorite hornblendite and the tremolitic serpentinous facies.

The mutual relations of the rocks:—

Owing to the impracticability of observing rock junctions, to the paucity and scattered nature of the exposures, most of which are confined to shafts or to the mine workings, and to the absence of any decisive field evidence, the mutual relations of the rocks are very difficult to make out.

The chief facies are undoubtedly the granulitic hornblende schist and the hornblende gneiss, and of these the former certainly appears to have the wider distribution, and is probably the chief member of the country rock.

In this connection, the inliers of greenstone at Boodalin soak must, from their occurrence, be regarded as representative of the country rock, and these, as has been shown, are foliated hornblende schists or epidiorites closely resembling in structure and composition the horn-

* Plate IX.
† Edna May "Deeps."

blende schist from No. 2 and No. 3 bores (Edna May mine)* and other exposures of this rock in the various shafts and the dumps. Moreover, the foliated pyroxene hornblende felspar rock of the old townsite, though apparently different from the hornblende schists, has been shown to consist of hornblende portions microscopically very similar to the latter, and since it is plain in the slides that the hornblendic portions have been derived from the pyroxenic, there is little doubt that the hornblende schists have been derived ultimately from a rock similar to this and from the old townsite, and that this pyroxene rock must be included, from the point of view of origin and affinities, with the hornblende schists.

The relationship of the hornblende gneiss, however, to these hornblende schists is by no means clear. It apparently occurs mostly as a band or strip more or less surrounded by hornblende schists, and since some varieties of it differ only from the presence of a little quartz, while exhibiting the same appearance and structure, it might be regarded as a derivative of a more quartzose modification of the original of the schists. On the other hand, from the characters of [13996], and of the bore core from about 785ft. in Duff's bore, it certainly appears to have been formerly a quartz diorite, and as such may have been a more acid dioritic intrusion into the original pyroxene-felspar rock that subsequently gave rise to the hornblende schists.

Though both the hornblende gneiss and the hornblende schist occur in a shaft at the south-west corner of G.M.L. 2763 and also in the Lloyd George lease, no evidence is obtainable of their mutual relation, and the evidence afforded by the bore cores is inconclusive. For the present, therefore, their relation must remain doubtful.

In the case of the actinolitic hornblendite and the tremolitic serpentinous facies, there is even less evidence of the relation of one to the other or either to the surrounding rocks. All that is known of the hornblendite is that it occurs in two places:—

(a.) Duff's bore at 427ft. At that point there is a clean break between it and the granitic gneiss that extends off and on from the 180ft., and at about 466ft. it passes into the tremolite serpentinous rock.

(b.) In the plats in the shaft at 225ft. and 300ft. level, Edna May mine.

In these localities it occurs again in association with the tremolitic serpentinous rock, but again the relation of the two rocks to each other and to the granitic gneiss is obscure. Subsequent investigations afford evidence suggesting that the hornblendite and the tremolitic serpentinous rock are but facies of one ultra-basic type.

Whether they are ultra-basic dykes and only magmatic modifications one of the other, whether they are separate dykes of different age, or whether the hornblendite at least is a basic modification of the hornblende schist—these questions owing to the lack of exposures and evidence generally—cannot but remain unsettled.

The major portion of the greenstone complex may, therefore, be considered in broad terms as one consisting essentially of hornblende and felspar in varying proportions, the hornblende predominating at times to the almost total absence of felspar. Frequently the hornblende is found almost completely changed to biotite, the intermediate stage chlorite being relatively of common occurrence. Quartz, in small quantities, is frequent whilst

* Plate IX.

sphene is not at all an uncommon accessory. Taken as a whole, the rock mass is foliated. It is highly probable that this foliation is due to the invasion of the main granite mass, which completely surrounds the greenstone belt. The foliation planes are not always visible to the naked eye in the finer-grained forms, but in the weathered, coarse-grained rocks they are readily discernible. Under the microscope in thin sections, however, and without exception, the rocks are seen to be foliated. The planes of foliation run approximately parallel with the granite contact.

In the mapping, one section of the greenstones has been separated from the remainder. This consists of a narrow belt of a rather conspicuous white mottled rock, which strikes northwest through the Recovery, Myrtle, and Advance leases.

Petrographically, this rock does not differ to any great degree from the main mass and might easily be placed as a variation of the latter. However, in the field its general appearance is so marked in comparison to the immediately surrounding rocks that one is inclined to the alternative that it is a probable intrusion. The attenuated shape lends weight to this decision.

Furthermore, there are characteristics from a mining point of view, which also add weight to this decision, for it is found that several small quartz veins worked in this coarser-grained rock do not, apparently, pass into the finer-grained encasing rocks; such quartz leaders have been proved to contain gold in payable quantities, though the reverse applies to veins immediately outside this belt. Otherwise, there is no strong field evidence to support the differentiation of this small lens-shaped belt from the main mass.

In the Edna May shaft, and in "Duff's" bore, a band of rock classified as a hornblendite, has been pierced, which is distinctly more basic in character than the main mass. Unfortunately, this band does not outcrop at the surface and has not been intersected in the mine workings elsewhere. Its origin is, therefore, obscure. However, if the theory be accepted that the main greenstone belt was invaded and foliated by the massive granite and that this took place after the greenstones were invaded by the Edna May gneiss, it follows that the basic rock in question is, in all probability, an intrusive into the main greenstones. For in the Edna May gneiss are found basic dykes, so closely allied to this hornblendite, both in lithological and petrographical characteristics, that it would be difficult to conceive that they were not genetically connected, and, therefore, necessarily of a later age than the main greenstones and Edna May gneiss. They are, likewise, probably of a more recent age than the main granite as their planes of foliation are not parallel to those of the Edna May gneiss.

Further reference will be made to the basic dykes later on in this report.

For more complete and detailed descriptions of the various basic rock specimens, refer to appendices.

EDNA MAY GNEISS.

The belt of rock referred to in the pages of this report as the Edna May gneiss is the most important and interesting of the rock species in the district. Important, because in it occur the principal gold-bearing lodes, and interesting because it represents a class of rock not commonly found in the Westralian goldfields.

The rock does not outcrop at the surface, but is persistently covered with an overburden of recent deposits, varying in thickness from eight to certainly 75 feet, probably more. However, the boundaries of the belt have been defined with a fair degree of accuracy in the various mine workings. On account of the overburden, these boundaries have been plotted on Plate IX., at a depth of 73 feet in preference to projecting them to the present surface level.

This plotting shows that the rock occurs as an elongated lens passing at a depth of 73 feet through leases 2168, 2238, 2180, 2291, and 2570, and terminating, apparently, in the eastern end in lease 2167, and in the western in lease 2088.

The maximum width of the lens is 410 feet, the greatest developments being in leases 2180, 2291, and 2570. To a vertical depth of 400 feet, the footwall of the lens has a persistent dip to the north of an average angle of 58 degrees. The lens will, therefore dip into leases 2168, 2585, 2615, and 2644 at a comparatively shallow depth. Unfortunately, there is no evidence available as to the dip of the hanging wall or northern side; the only two places where this wall can be seen are at the 73-feet level in the Edna May Central mine north crosscut, and at a depth of 46 feet in No. 5 shaft in "Deeps" G.M.L. 2238. The dip of the hanging wall is, therefore, not known, but it is certainly towards the north.

As far as can be ascertained, the encasing rock of this lens is hornblendite. As has already been stated, this hornblendite is probably a later rock than the foliated felspar hornblende rock which is the prevailing type of the district; any relationship which may exist between the lens and this latter rock series is, therefore, masked. The lens of gneiss consists of a foliated quartz mica hornblende rock, which on petrological and chemical examination has proved to be intermediate between a quartz diorite or granodiorite and a basic granite. Farquharson, though inclined to the granodiorite classification, writes with an open mind on the subject and states that the rock may be one of three classes:—(a) a differential product of the foliated horn-

blende gneiss (the prevailing greenstone of the district); (b) a granodiorite; and (c) a foliated basic hornblende granite.

In the upper mine workings, where the rock is seen in its weathered condition, the planes of foliation are still clearly marked. The felspars, as a rule, have been completely kaolinised; mica still exists, but more in the secondary form of sericite. When broken in the hand, the rock is distinctly gritty and is thus easily distinguishable from the weathered products of the basic rocks. In colour, the decomposed rock varies from a grey to a reddish-brown, but at times is almost white. This latter form is due probably to the excess and total weathering and bleaching of the felspar. In the undecomposed zone the planes of foliation are very evident, and the general structure of the rock is gneissic.

The strike of the planes of foliation is, approximately, east and west with a general variation of usually not more than 10 degrees from this bearing, with exceptional cases only of a greater angle.

As a general rule, the oxidised zone reaches a vertical depth of about 130 feet, or some considerable depth below the present water level, which stands at about 75 feet. Portions of the rock, however, are weathered to a depth of 200-250 feet, but this is only along the contacts and not in the main mass. On the south side of the lens a small band of the gneiss is found passing through the greenstones, which probably represents an arm of the main mass. It certainly has the same lithological characteristics. Throughout the gneiss occur dykes of basic rock, pegmatites, and, later, aplites; also innumerable quartz veinlets which are, at least in numerous instances, probably segregation veins.

The nature of these intrusions has already been dealt with under their various headings.

Returning to the question of origin, there are certain points which arise from observations in the field which may be taken with or treated separately from the microscopic evidence, but still have an importance which must not be neglected. For instance, in the Edna May gneiss certain pegmatites occur which are undoubtedly closely associated to the containing rock. Furthermore, as any known granite mass has always accompanying apophyses, it is only natural when granite apophyses are found to look for the parent granite. In the present case it would be most unlikely that the origin of the pegmatites in the gneiss could be traced to the outside granite. There seems no possibility of this being the case. If the gneiss be accepted as a differentiated portion of a granite magma, in which hornblende, though present, be considered as an accessory mineral, the subject of origin could be easily cleared up; otherwise, from whence do the pegmatites arise and whence the gneiss? In certain phases the difference between a granodiorite and basic granite is so small

that the nomenclature is merely a matter of opinion. The chemical analysis of the Edna May gneiss is certainly, as Farquharson points out, very similar to that of certain recognised granodiorites. It must be recognised, however, that in a much altered rock mass, as the gneiss apparently is, the original rock may have undergone considerable chemical change, sufficient to turn the balance either way. Taking the evidence as it stands, it seems more than probable, and certainly more satisfactory, to couple the gneiss and auriferous pegmatites as one pair and the granites and aplites as another, with distinct ages, though, possibly, genetically connected. The occurrence of gold-bearing lodes in an acid rock is not unique in Western Australian mining, as commonly believed and reported. For example, the principal mines of the Cue district are in a granodiorite, the Cosmopolitan mine at Kookynie in granite, and the principal mines of Quinn's in a granodiorite.

Two other instances of acid gneisses occur in the district, one in the Battler gold mine, the other in the Hill End gold mine, in the same vicinity. There is a striking similarity between these two rocks and in some respects they resemble the Edna May gneiss, though in composition and structure there are various differences between the two classes. Farquharson is inclined to the idea that they are representatives of different magmas, but implies the possibility of their being apophyses of the intrusion, which gave rise to the Edna May rock. Certainly, they are intrusive into the greenstones, and are seen in the field occurring as narrow dykes. Unfortunately, except where opened out in the mines, they are not visible, except as decomposed fragments on the surface. However, their importance is evident in that they contain lodes which, though small, are distinctly auriferous, and for this reason attention should be drawn to their occurrence in case similar occurrences are found in the ordinary course of prospecting. A full description of the nature and composition of these rocks, also of samples taken from the Edna May gneiss, are to be seen in the appendices.

GRANITES (massive plutonic).

The granites of Westonia bear so strong a resemblance to those of the Southern Cross-Bullfinch area, that they must be classified as probably the same rock mass.

Setting apart the numerous acid aplites and pegmatitic dykes, they can be classed under two headings:—

1. Massive varieties.
2. Extensive tongues and bosses, portions of the massive portion.

Outcrops of the first class are rare, with the exception of the granite knobs found in the country lying between the Rabbit Proof Fence and Bullfinch.

In the vicinity of Westonia there are three outcrops, one at Boodalin soak, one at Yorkrakine, and the other near the magazine at Westonia.

In the first are numerous examples of the greenstones having been caught up in the granite mass, as can be seen on Plate IX. The granite here is a biotite microcline variety, similar in every respect to the Southern Cross varieties.

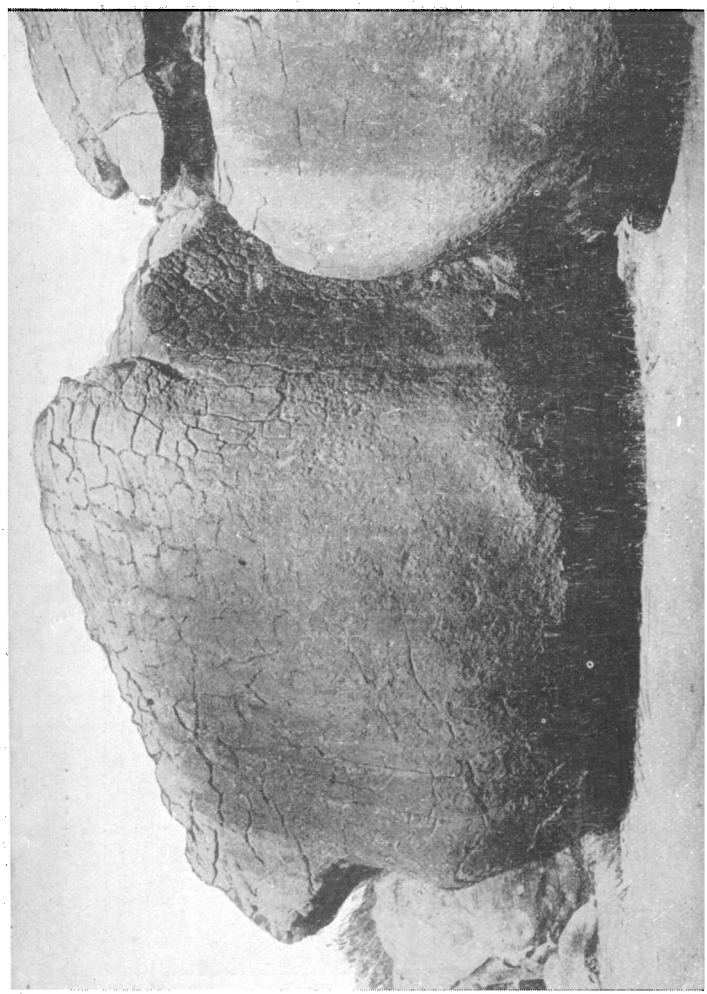


Fig. 6. Photo: T. Blatchford. Neg. 1314.

Granite "Tor," Boodalin Soak, showing surface weathering.

Some of the "Tors" show a marked weathering, which is illustrated in Fig. 6. Otherwise there is nothing of significance to note about the occurrence.

The Yorkrakine rocks stand out as prominent landmarks and afford a good opportunity for the observance of several characteristics of the granite of the area.

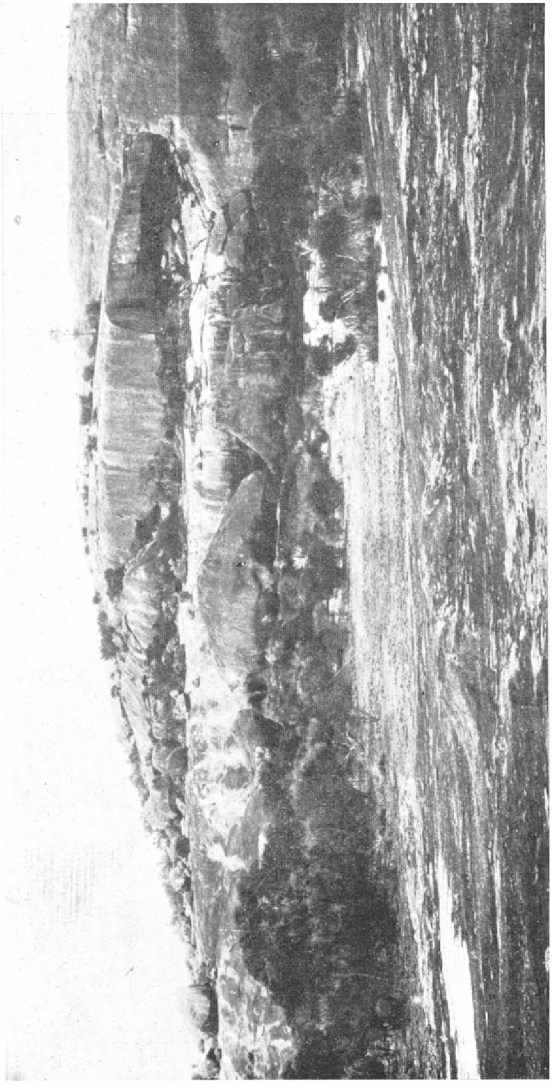


Fig. 7. Photo: T. Blatchford. Neg. 1310.

Yorkrakine granite—illustrating surface scaling.

Fig. 8.

One of the most noticeable features to be observed is the weathering.

Huge flakes of the rock are seen cracked from the main mass on curved faces, and, in many cases, have slipped and fallen from the tops to the base; Figures 7, 8, 9, 10, illustrate this better than a written description.

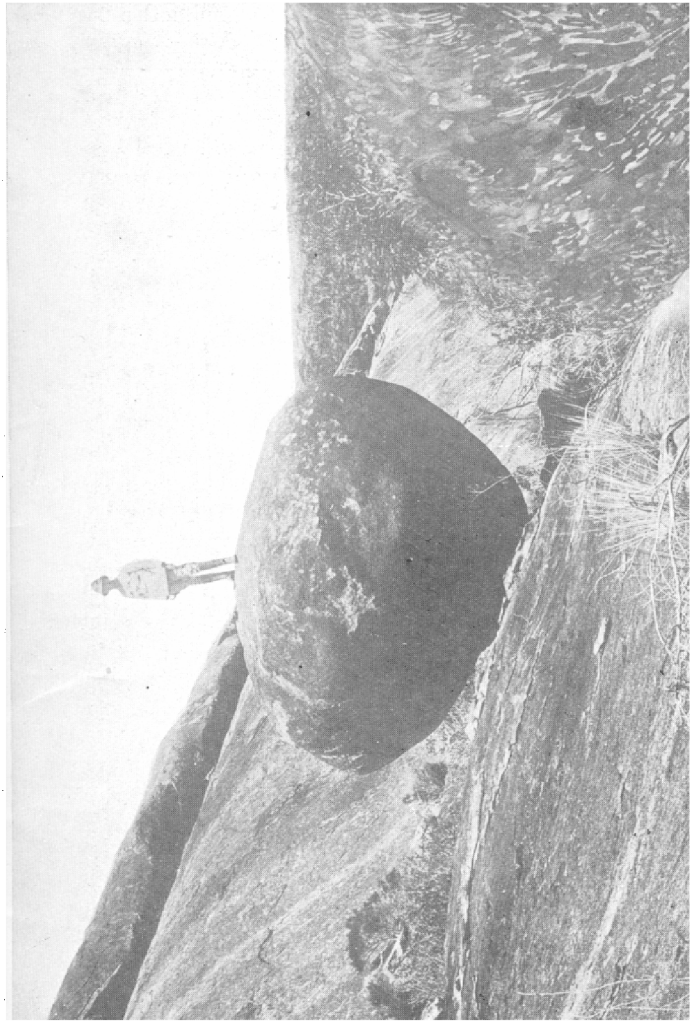


Fig. 8. Detached granite boulder, Yorkrakine rocks. Photo: T. Blatchford. Neg. 1311.

Throughout the mass patches of felspar and mica aggregates occur, which are disconnected and apparently segregations only. In one instance in particular, a coarse-grained pegmatite dyke is seen cutting through the mass in almost a mathematically

straight line. In two places this dyke is faulted (*vide* Fig. 11). Basic patches, probably representing caught up fragments of the

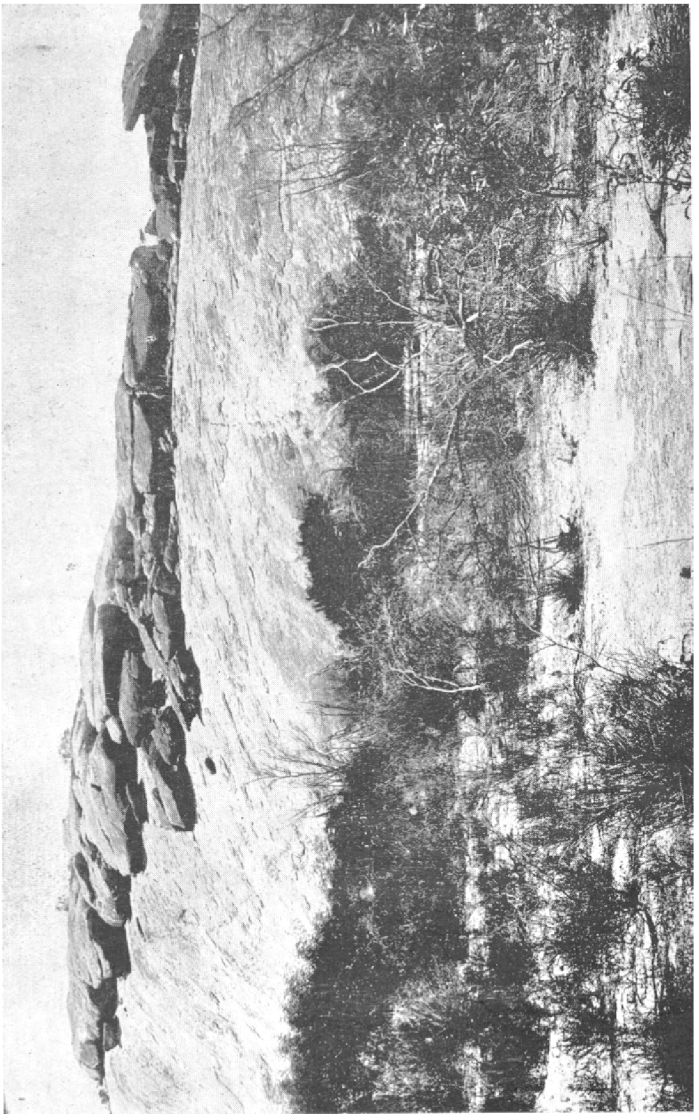


Fig. 3.

greenstones are not uncommon. The granite is of the biotite microcline variety, the minerals being fairly uniformly distributed. In texture there is considerable variation, the felspars in places almost giving the rock a porphyritic appearance, otherwise

the rock may be classed as a typical, fairly coarse-grained grey granite.

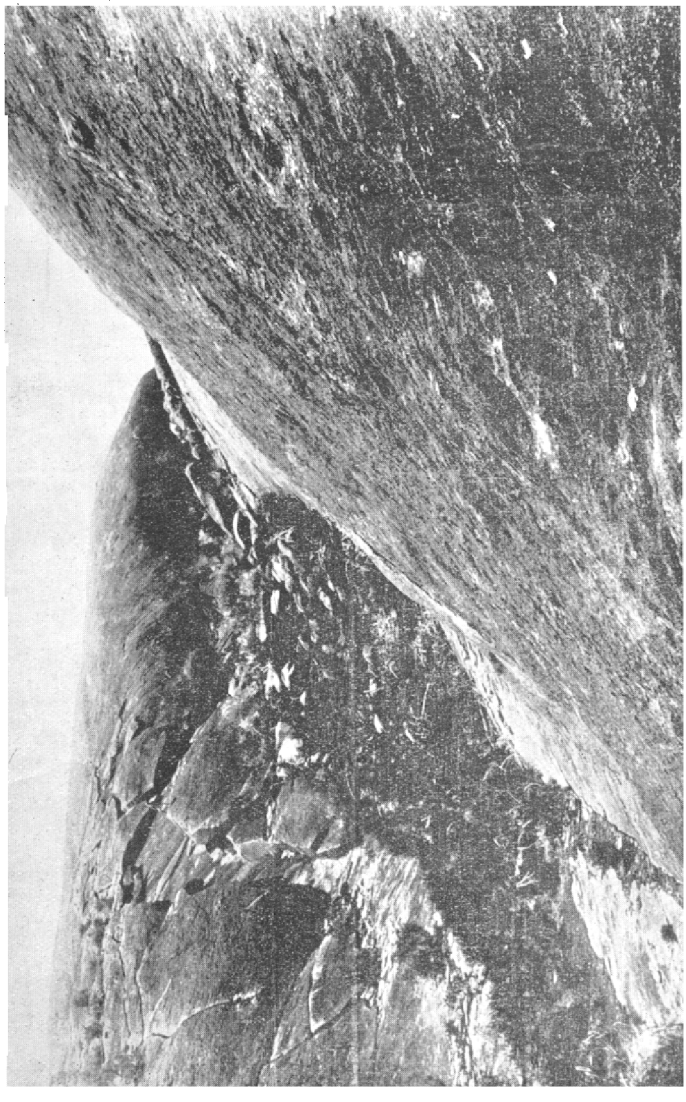


Fig. 10. Yorkrakine granite—block weathering. Photo: T. Blatchford. Neg. 1313.

In summing up the evidence from the various granitic rock specimens submitted, Farquharson remarks as follows:—

"In external appearance the two groups are, as already stated, undoubtedly separable. When, however, attention is directed to the

composition and structure of the two, a very marked similarity becomes at once apparent. Both groups are microcline biotite granite; in both the main constituents are the same, viz., quartz, microcline, and biotite, and in both the same peculiarities are manifested, viz., vermicular micro-pegmatite areas and inclusions or intergrowths of quartz in the

Fig. 11.

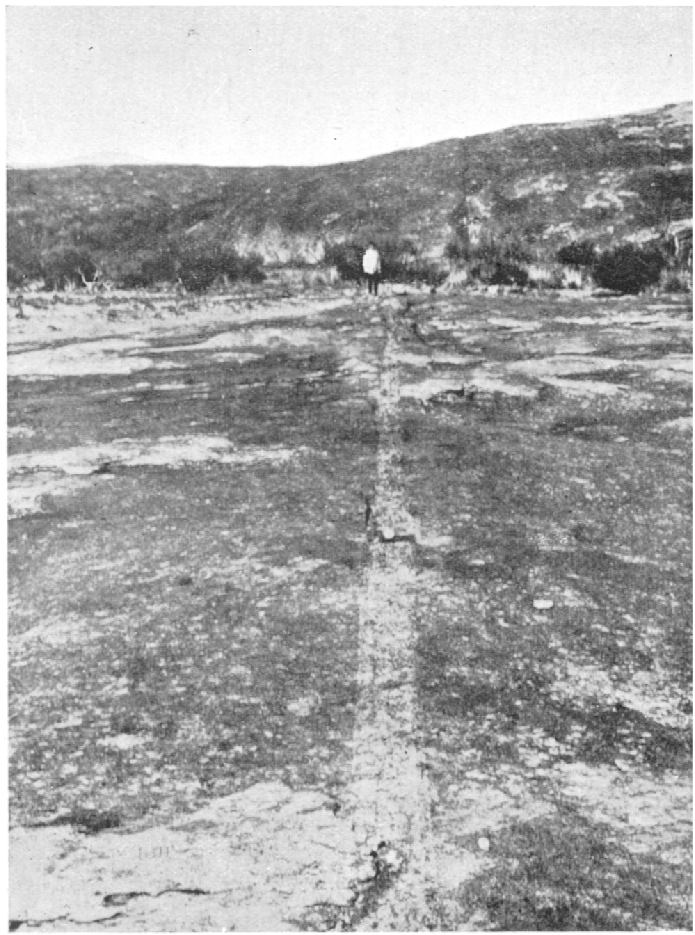


Photo: T. Blatchford. Neg. 1312.

Pegmatite dyke, Yorkrakine rocks.

felspar. There are differences between the group, but these, such as the presence of semi-porphyritic structure, the presence of green chloritic flakes, and the presence of sphene crystals in group (1), are of minor importance.

With regard to sphene, this mineral has not been observed in group (2), but, on the other hand, it is not observable in all specimens of group (1). Again, specimens like [illegible], which, according to field evidence, are dykes and are connected with the granites of group (2) are, both in external appearance and in composition, strikingly similar to [illegible]. Since, therefore, the mapping shows the rocks of group (2) to occur as veins or apophyses, it is probable that the yellow specimens are but apophysal varieties of a main mass of which the rocks of group (1) are specimens. This being the case it would appear, further, that the quartz and quartz-felspar pegmatite that form the ore bodies of the main lode (Edna May) are genetically connected with the magma which gave rise to the grey granite (group 1). Owing, however, to the impossibility of obtaining further field evidence on this point, no positive assertion to this effect can be made.

GRANITIC BOSSES AND DYKES.

In the Westonia belt, apart from the massive granite, granitic rocks are well represented by bosses, dykes, pegmatites, etc. Owing to the frequency of occurrence, and to the fact that one variety is highly auriferous, the granite dykes have an important bearing in mining operations. It has been noted by the writer from personal conversations with mining men in general, on the field, that there is a great diversity of opinion as to what these granitic dykes really are and what their relationship is to the other members of the rock series. On this account, it is considered expedient to give here a résumé of the modern conception of their origin, with special reference to the more important pegmatitic forms.

In the area under review there are several distinct forms of granitic rock, the more important being:—

1. Bosses and arms of practically normal granite.
2. Coarse-grained pegmatites in which mica, felspar and quartz are in usual proportions.
3. Aplites, fine-grained granites, in which mica is absent, and in which the felspar is sometimes very coarse; in other cases, the quartz and felspar is scarcely separable in hand specimens.
4. A very acid form of pegmatite in which the felspar and mica are wholly, or almost wholly, absent, the dyke assuming the character of a quartz reef.

Of the first class, the best example of a boss is to be found at the back of the old townsite. Here we find a large conspicuous outcrop of normal granite which, with its arms, are wholly surrounded by greenstone. This boss is, without doubt, a portion of the main granite mass, which has broken up as an isolated mass in the greenstones. The tongues or arms branching from this mass are usually seen to be of the same nature as the main boss, though some of the smaller dykes are distinctly coarse-grained and pegmatitic in character.

On the main granite-greenstone contacts, numerous massive dykes of normal granite are found, which again must be placed as arms of granite directly connected to the main body.

These do not, as a rule, extend any great distance into the greenstones in the form of normal granite.

PEGMATITES AND APLITES.

These rocks, which occur more or less as narrow dykes, breaking through all the other types, with probably the exception of the sedimentary metamorphic series,* represent the last phase of intrusive activity in the Westonia district.

At the surface they are comparatively seldom seen outcropping for any great length but can, nevertheless, be often traced by scattered fragments for considerable distances. Sometimes areas are met with where the surface is littered with fragments of these rocks, and these are probably due to the disintegration of a dyke which has been lying more or less parallel to the surface, since it is found in the mine workings that many instances occur in which the dykes are almost horizontal.

That they are numerous is evidenced by their frequent occurrence in mine workings and bore cores.

They vary in size from thin veins one to two inches thick up to massive dykes of 20 to 30 feet in thickness.

In composition and texture there is also a wide range of variation, from coarse-grained pegmatites in which mica and felspar are both present or the mica absent, to fine-grained aplites almost felsitic and a combination of both in the one dyke, the felsitic portion forming the marginal facies. This variation in texture and composition is often coincident with the thickness of the vein.

Thus we find the thin dykes almost invariably aplitic and frequently felsitic in structure, and though certainly at times they are coarse-grained, in such instances mica is almost wholly absent, whilst the thicker dykes are persistently more regular in grain and the minerals more uniformly distributed. The latter are more closely allied to a normal granite in structure and composition, though the mica is always below the normal quantity. In several instances sections have shown the dyke rock with inclusions of the invaded rock thus proving the intrusive nature of the former. As regards the strike and dip of the acid dykes there is no general rule.

Certainly in the Edna May and Central mines several of the main dykes have a general north-east, south-west strike with a variable dip to the south-east, but when followed any distance even these dykes often vary in direction and dip considerably in a few feet. In the granitic areas where the massive granite comes to the surface such as at Yorkrakine rocks, etc., the pegmatitic structure of portions of the granite can be well observed. At Yorkrakine, in particular, one can see irregular masses of felspar and quartz with

* They have not been observed in the sedimentary area.

patches of biotite scattered throughout the rock mass. Such have not had the opportunity, when forming, of filling a crack and thereby forming a vein, but have crystallised out in the rock mass in irregular masses. However, in some cases such residuals have found a way into fissures, and are then seen as normal dykes. A photograph of one of these illustrates this point clearly*.

The chief point to note about their occurrence is their comparatively negative effect on the rocks they pierce. As has already been stated, they invade all the plutonic and intrusive rocks, also the quartz veins and lodes. It has been stated by some of the mine managers that local enrichments occur in the lodes near the position at which the dyke passes through the latter. Certainly in one portion of the Edna May lode this seems to be the case, but, as a general rule, this enrichment, if existing, is not so apparent as in other localities in the Yilgarn goldfield and, from a mining point, is almost negligible. With one exception faulting along the plane of the dyke is absent and, even in this exception, the throw of the fault is insignificant and has not caused the mining complications which have occurred under similar conditions for example, in the Marvel Loch district. In no instance are the acid dykes foliated.

The acid dykes in the Edna May, Central, and Deeps mines have nevertheless been, or will be probably, the cause of serious water troubles to mining operations. This question will be dealt with when writing about the mines themselves. Other than this, the acid dykes are of no significance from a mining point of view, for though they have been found carrying traces of gold, probably original, the gold has occurred in such small quantities as not to warrant serious consideration.

Farquharson, in summing up the white granites and aplites refers to them in the following terms:—

> In general, therefore, the rocks are white in colour, vary in grain from fairly coarse to a fineness which is almost felsitic. They consist of felspar and quartz, the former being, in places largely microcline, but in places orthoclase, and another acid plagioclase. Only rarely do a few scales of brown biotite and green chlorite appear. In one instance, *i.e.*, at 243ft.-251ft. in the No. 3 bore (Edna May), the granite or aplite contains small red garnets.

For detailed references see appendices.

The local names for these dykes is legion. For example, when mica is conspicuous in a dyke it is designated a "mica bar," aplites when fine-grained are often known as "quartzites," whilst if the felspar in the coarse varieties is at all conspicuous "limestone" is not at all an uncommon name. It is evident, therefore, that in some cases at least, there is a rather weird conception as to the nature and origin of pegmatites and their allied forms.

The fourth and most important variety of pegmatites is the ultra acid or quartz form, the quartz reefs of the Edna May group which are the important lodes of the district.

* Fig. 11.

It will be patent to any reader that the bosses and normal granite arms are merely portions of the main granite mass which have broken through the greenstones in the ordinary well-known manner of invading rocks. The occurrence is simple and the rocks easy of recognition.

This does not hold for the pegmatites which vary so much in texture and composition, especially in the extreme phases. For many years the origin of pegmatites, and incidentally of the ultra acid or quartz varieties, has been the subject of much controversy amongst numerous writers on the subject. In fact, the literature on this topic is so extensive that it is impossible to more than briefly summarise the individual theories. Taken collectively, there seems to be a consensus of opinion, especially amongst modern writers on the subject, that in any rock mass, before solidification, the component minerals are liable to separate more or less one from the other, and thus form zones in which certain minerals are predominant. This is known as differential crystallisation. On cooling, these segregated products crystallise out or solidify in certain order, the more acid constituents being the last to solidify. Such is termed magmatic segregation. Hence in a granite magma or molten mass the acid or quartz portion would be the last to solidify. Furthermore, an important factor in the solidifying of any rock mass is the casting off by the portion solidifying of surplus water vapour which, mixing with the siliceous or quartz residuum, makes the latter more mobile.

Vogt,* in criticising this process, writes:—

By reason of the greater superior mobility of the aqueous solutions as compared with the magma, these segregations may send out branches in the form of the finest apophyses;

A second theory, which has few supporters, as to the origin of pegmatites has been advanced by Williams† from his study of the occurrences in Maryland. These investigations led him to the conclusion

that both segregation and intrusive pegmatites quite similar in appearance appear side by side.

Crosby and Fuller‡ disagree with Williams, and consider but one origin "the end product of differentiation"; further, that

In every pegmatitic district there is one normal plutonic rock of essentially similar, but slightly less, acid composition, and with which the pegmatite is most intimately associated, into which it may be traced, and from which it has evidently been derived

Spurr§ states that

the modern conception is that, in a broad sense, the pegmatites are igneous rocks, but it is the part which water has played in their formation that has so strongly differentiated them from other igneous types.

* Problems in the geology of ore deposits, Trans. XXXI., p. 133, 1901.
† General relations of the granitic rocks in the Middle Atlantic Plateau. 15th Ann. Rep., U.S. Geol. Surv., pp. 657–684 (1893–4).
‡ Origin of pegmatites Technology, Quart. Vol IX., pp. 326–356 (1896).
§ U.S. Geol. Surv., Prof. Paper 55, pp. 327 (1906).

The same author, in summing up the evidence as to the origin of quartz veins of magmatic origin, contends that:—

Pegmatites are coarsely crystalline rocks which show close relationships with ordinary igneous rocks, such as granites on the one hand, and with veins, such as are known to be due to precipitation from aqueous solution, on the other. Hence there has been much perplexity and contention, some referring them to the igneous rocks and calling them dykes, others insisting that they are aqueous and true veins. But the latest essays on the subject agree that pegmatites are formed intermediate between those which govern the formation of siliceous "igneous" rocks like granite, and those under which quartz veins are formed. There is, in short, no line of demarcation in nature corresponding to our artificial and arbitrary one between igneous rocks and certain aqueous veins, between granite and certain masses of quartz.*

In support of the above theory it may be well to note here that, in certain cases, granitic dykes have been definitely followed through the successive stages to pure quartz.

One local example of this has been already noted by the writer in the Londonderry district.†

Apart from the foregoing classification of the various granitic dykes, bosses, etc., according to their composition and physical characteristics, a further and fairly definite separation may be made when their relative geological ages are considered.

Considered from this point of view they naturally resolve themselves into two, probably three, series.

Of these, the oldest would be those belonging to the bosses and granite dykes, and arms contemporaneous with the formation of the main granite mass.

Probably later, and certainly not earlier than this, the formation of the pegmatitic quartz reefs in the Edna May gneiss took place, whilst at a much later date we have most of the aplites and pegmatites which are found passing through all the other rock formations and thereby representing the last stages of intrusive activity on the field.

Microscopic descriptions of samples taken from the individual rock types are to be found in the appendices.

Further details of the occurrences of the aplites and quartz reefs will be given in discussing the individual mines.

BASIC DYKES.

In the Edna May group of mines several basic dykes have been intersected in the various underground workings and bore cores. Furthermore, in several instances basic rocks have been encountered and partially, but not completely pierced, thus leaving it in doubt as to whether such occurrences are of the dyke class as in the first case, or whether they represent portions of the main basic rock. In each instance when a sample of basic rock was obtainable

* Spurr–Igneous rocks as related to occurrence of ores. Transactions Am. Institute, M.E., Vol. 33, pp. 312.
† Bull. 53, G.S.W.A., p. 17. Perth: by Authority, 1913.

it was microscopically examined, and this has led to the following classification of two distinct varieties, with a possible but doubtful third:—

Type 1:

Under the heading of basic rocks reference was made to a band of hornblendite lying on the footwall of the Edna May gneiss.

Type 1 represents a similar class of rock in the form of (A)* an undoubted dyke, (B) several intersections of basic rock which are probably portions of the hornblendite band.

The dyke lies in the south-eastern portion of the Edna May mine, at the end of the main lode.

It has been intersected in the following mine workings:—

Edna May:

150ft. level—Number 3 south crosscut, and south crosscut near main shaft.

225ft. level—South-west crosscut and south-east crosscut.

300ft. level—At end of main crosscut.

Edna May Deeps:

485ft. level—in No. 1 winze, near main shaft.

In no case has the thickness of this dyke been greater than 4-5 feet, while at the 300ft. in the Edna May it is not more than two feet.

The rock throughout is slightly foliated, the planes of foliation being parallel to its walls. This is probably due to shearing.

At the 485ft. level in the "Deeps" the rock is comparatively fresh, but from the 300ft. upwards is patchy, some portions being friable to the touch.

So far, this dyke has been an important factor in both mines, as it apparently controls the south-western extension of the main lode.

In the ends of the west drive and main crosscut in the Edna May at the 150ft. level, the depressed bore 300ft. level Edna May, the depressed bore in Deeps from the 240ft. level and the footwall of the 485ft. level Deeps, a similar rock to that of the dyke rock has been cut but not passed through.

Some doubt exists, of course, as to whether such occurrences may not be dykes, but, in the writer's opinion, they will probably prove to be the intersections of the hornblendite band previously referred to. There is so strong a resemblance between the rock at these intersections, the dyke and the hornblendite, that they must all be classed as one and the same rock and, therefore, as different from the prevailing foliated hornblende-felspar types. As regards the age of the hornblendites, there is no doubt that they are later than the Edna May gneiss and the Edna May Central

* Plates XV. and XVI.

Deeps lode, for the dyke can be seen in its passage through both of these rocks. They are, however, older than the aplites, for the latter clearly pass through the hornblendites.

Further reference will be made in the descriptions of the individual mines as to their possible influence over the lodes.

TYPE 2:

This class is represented by one dyke which is found in the depressed bore in "Deeps" at a vertical depth of 344 feet, in the Edna May "Deeps" shaft at 344 feet, and Duff's bore at a depth of 304 feet.

According to the depths at which this dyke has been cut, it follows that it must be approximately horizontal with a slight dip to the north-west. A good section is to be found in "Deeps" shaft, where its intrusive nature is clearly seen, the planes of foliation of the dyke being at an angle readily distinguishable from those of the gneissic granite (Edna May gneiss).

Apparently the average thickness is from two to four feet. As far as is known, it is unimportant from a mining standpoint. The rock has been classified as a variety of amphibolite in which the felspar and hornblende occur in varying proportions.

TYPE 3 (doubtful):

Passing through the Edna May lode is a narrow, extremely weathered basic band of rock, an undoubted basic dyke. Unfortunately in no case could specimens be gathered from its intersections, which were sufficiently fresh for decisive microscopic diagnosis. The dyke is unimportant, and passes out of the mine workings at the 245ft. level.

In the appendices full microscopic descriptions are to be found, whilst in the plans and sections the course of the dykes, etc., have been portrayed.

In addition, the official numbers thus [$\frac{1}{8\,7\,2}$] have been placed on the plans, and these will be found to correspond with those in the appendices.

SUPERFICIAL DEPOSITS.

Scattered over the greater portion of the field are deposits of "cement," loose loam, sand, etc., the result of the wearing away of underlying rocks by comparatively dry denudation. At times these take the form of lateritic deposits, both the siliceous and ferruginous varieties being represented. Laterites are, however, comparatively rare and, when found, usually occur in isolated patches on the higher ground, and represent the remnants of probably very much more extensive beds.

Little is known about the depth or character of the superficials. It is characteristic of the siliceous laterites to overlie granite, and almost equally so for the ferruginous varieties to be found on the

top of the more basic rocks. However, the resorting and redistribution of the laterites and the formation thus of the lower level lateritic deposits from their original formations often tends to these general rules being broken.

The auriferous nature of surface deposits has already been referred to in a report on the southern area of the Yilgarn goldfield at Marvel Loch.*

The one instance in which payable gold has been discovered in an alluvial deposit at Westonia occurs in the Edna May Central mine. Reference to the extent and nature of this deposit will be found included in the detailed description of that mine. Suffice it to say here, the evidence is such as to demonstrate that the detritus in the deposits has not travelled any great distance or been subject to any definite sorting, for in no instance were the pebbles found to be anything much more than sub-angular, and they were invariably intermixed with the kaolin and ferruginous material, forming an indefinite mixed deposit. Gold is found both in the quartz pebbles and cementing material, the richer sections being where the quartz pebbles predominate.

X.—MINES OF THE BULLFINCH BELT.

The mines of the Bullfinch belt may be classified under three headings, according to the nature of the ore-bodies being worked:—

(1.) Those containing quartz-haematite schists.
(2.) Those containing dolomitic lodes.
(3.) Those containing quartz reefs and veins.

QUARTZ-HAEMATITE SCHISTS.

On plates 6, 7, and 8 it is evident that this class of lodes extends throughout the whole length of the northern portion of the Yilgarn goldfield, and continues southward as far as Cheriton's.†

The series, with minor exceptions, persistently hugs the eastern granite contact. Though, as a general rule, auriferous, the deposits seldom contain sufficient gold to be payable as mining ventures. Certainly the Bullfinch "main" and "southern series" of lodes have been profitably worked, but these are exceptions to the rule, the enrichment being due to extensive local faulting.‡

This faulting has rendered it possible for solutions to circulate through the original ore-bodies, and by this agency certain zones in the lodes have been considerably altered. Incidentally, during this process the gold contents have been concentrated.

Like conditions have not been noted in any other area than the Bullfinch along this extended zone in which the quartz-haematite schists occur. Certainly, in some of the blanks on the plates referred to, similar conditions may exist and be still covered over, but

* Bull. 63, p. 101. Perth: by Authority, 1915.
† Bull. 63. ‡ *Vide* Plate XI.

such are not evident at the surface. In fact, rather the reverse was noticeable, the regularity of the deposits being most pronounced.

DOLOMITIC LODES.

Of the dolomitic deposits one only has been worked, viz., the "northern series" of the Bullfinch mine. This lode has been the mainstay of the mine and has been developed to a vertical depth of 500 feet. The lode is a typical example of replacement, and although the gold contents are largely dependant on a secondary enrichment, due to the introduction of quartz veins, the deposit as a whole is an important addition to the other varieties of gold-bearing lodes of the district.

QUARTZ REEFS AND VEINS.

There are three varieties of quartz reefs represented.

First there are the large low-grade quartz reefs, such as at Hope's Hill, Corinthian, etc. Associated with these are narrow quartz veins usually carrying higher gold values, but small and usually erratic in habit. Closely allied to these are the quartz veins so common in the southern areas and invariably found associated with the quartz-haematite schists. The occurrence of these in the northern area is not nearly so common as in the southern portion of the belt; yet they are of extreme importance to the prospector, producing at times considerable quantities of remunerative milling stone. One or two minor examples of quartz veins in acid dykes have been noted but are not of any great importance.

The following are detailed descriptions of the mines which were accessible for inspection. Unfortunately, these were few in number, most of the old workings opened up in the boom days having been abandoned.

It should be noted that, without exception, all the gold-producing lodes and veins lie in or near the zone in which occur the quartz-haematite schists. Furthermore, the only rocks which carry gold-bearing lodes are the greenstones, and in one instance an acid dyke, the massive granite and sedimentary series so far being proved to be barren.

CORINTHIAN AND CORINTHIAN NORTH GOLD MINE, G.M.Ls. 896, 893.

Location.—This mine is situated at a distance of 11 miles north of Southern Cross and lies one mile to the west of the Bullfinch-Southern Cross main road.

Geologically, its position is on the contact of the main massive granite and the greenstones.

Geology.—Several distinct groups of rock occur on the above leases.*

* *Vide* Plate X.

(a.) Granite.—Massive granite of a distinctly gneissic type lies to the immediate east of the main workings and forms the footwall of the lodes. The gneiss is probably the selvedge of the main Southern Cross granite.

(b.) Foliated amphibolites (greenstones) form the western or hanging wall rock. This rock has been fully described in the previous pages of the present report under the heading "greenstones."

Occurring as they do on the Corinthian leases, the rock presents the phase of extreme foliation, especially in the immediate vicinity of the lodes.

(c.) Granite dykes.—These are represented by two narrow dykes in the 100ft. workings. The felspars have been completely weathered and the rock is only recognised by the disintegrated grains of quartz. Mica is almost wholly absent, minute traces alone remaining.

(d.) Dolerites.—Fairly fresh examples of this rock occur as dykes. Of these the main one is found outcropping to the east of the main shaft. It is also seen in No. 5 shaft at the 100ft. level, and in the main shaft at 200ft. level, where it attains a thickness of 24 feet. Four other dykes of a similar character are intersected in the main south drive at the 100ft. level. The general strike of all is north-west south-east with a dip to the south-west at a fairly steep angle. There is little doubt that these dykes are the newest rock of the series and will be found invading all other members.*

Lodes.—Sandwiched between the granite and amphibolites are extensive lenses of quartz and quartz-haematite schists.

Quartz-haematite Schists.—The quartz-haematite schists, which have the prevailing lens shape, represent a portion of the main series found in an almost continuous line from Cheritons to the northern extremity of the Bullfinch belt. Although classified here as a lode on account of the presence of gold and gold-bearing minerals, the rock is not being worked as such, being too low grade to be profitably treated.

The origin and nature of quartz-haematite schists has already been fully discussed.

Locally the rock is known as "biscuit rock" on account of the colour and the fact that in and near the surface the weathered portions break into flat yellow-coloured pieces, supposed by some to resemble certain forms of edible biscuits.

Quartz lodes.—These come under two headings—(a) the massive or main lodes; (b) smaller quartz veins or laterals.

Main Quartz lodes.—There are two main quartz lenses, striking approximately parallel to the granite greenstone contact and underlying very slightly from the vertical towards the west.

Of the two the northern is by far the most important and in it the main workings occur.

* For further details *see* appendices.

Practically all the quartz for that portion of the lode in lease 896 and partly in the northern end of lease 893 has been open-cut to the 100ft. level and sent to the mill. The width taken in places was as great as 25 feet.

All this ore was oxidised. As the accompanying returns show, the gold contents were extremely low, yet payable. Unfortunately, sulphides made their appearance in the northern end of the drive at the 100ft. level, and although the top of the sulphide zone pitched away to the south, the stock of payable oxidised ore was thereby diminished, contrary to original expectations.

It seems possible that the zone of oxidation was influenced by the main dolerite dyke, and it will probably be found that the top of the sulphide zone is parallel to this dyke.

Below the 100ft. level in the sulphide zone, the gold values were found to be erratic in occurrence. At first it seemed as if they were also pitching south, but mine developments did not substantiate this idea, but rather tended to prove that the gold occurred irregularly in more or less flat indefinite zones. Unfortunately, before a conclusion could be arrived at on this point, the mine closed down. Even in the upper levels the southern portion of the main levels did not yield payable stone in any quantities under existing mining conditions.

For the most part the main quartz lens is a solid compact body of stone, but in certain zones, especially near the boundary between the two leases, it is much broken. As this particular spot is not far removed from the four dolerite dykes previously referred to, it is scarcely to be wondered at. There is no sign of local enrichment in this vicinity.

Marcasite, pyrrhotite, and ordinary pyrites are the principal sulphide minerals in the sulphide ore.

Pyrrhotite occurs in such quantities as to seriously hamper the extraction of the gold by direct cyanide treatment. The minerals are, as a rule, fairly well distributed throughout and occur in small veins and bunches.

Quartz veins.—Several quartz veins have been found on the western side of the main channel. Two at least of these are probably connected directly with the main lens, but the others are parallel veins filling minor shear planes in the adjacent greenstone. Though of a higher grade in gold they are too small to be of any intrinsic value to a large low-grade mining concern.

Treatment.—The oxidised ore was rough crushed in an ordinary wet stamp mill, fine ground in two tube mills 16 feet by four feet, then direct cyanided and finally treated in an improved Ridgeway filter.

When it became necessary to treat the sulphide ore, two Newell No. 8 ball mills were installed, the ore dry ground, and roasted in two Edwards' furnaces having a length of 149 feet with 60 rabbles each. The after treatment of the sulphide ore is similar to that of the oxidised portion.

That this venture was not a success is regrettable from several standpoints, one amongst others being that the proposition was one of the lowest-grade mines of its class in the State. Had it been successful it would certainly have given encouragement to prospect and develop similar deposits elsewhere.

Table showing the Yield of the Corinthian Reef.

Year.	Name and Number of Lease.	Ore Crushed.	Gold therefrom.	Total.	
				Ore Crushed.	Gold therefrom.
		tons.	ozs.	tons.	ozs.
1909 ..	Corinthian, 893	42·00	30·86	..	..
1910 ..	Do.	145·00	138·65	..	..
1911 ..	Do.	1,075·00	597·50	..	..
1912 ..	Do.	..	..	..	..
1913 ..	Do.	1,422·50	386·79	..	..
1914 ..	Do.	..	..	..	..
1915 ..	Do.	..	..	..	..
1916 ..	Do.	..	..	2,694·50	1,123·80
1913 ..	Corinthian North G.M., Ltd., 896, 934, 946	18,713·00	4,320·01	..	..
1914 ..	Do. do. ..	48,730·00	10,149·25	..	..
1915 ..	Do. do. do.	47,147·00	9,218·17	..	..
1916 ..	Do. do. do.	16,632·00	3,876·89	131,222·00	27,564·32
	Total	..	..	133,906·50	28,688·12

BULLFINCH PROPRIETARY GOLD MINE, G.M.Ls. 960, 916, 915, 926, 928, 914, 942.

Location.—The Bullfinch Proprietary gold mines are situated near the township of Bullfinch, which lies near the Southern Cross-Jackson road at a distance of 22 miles north of Southern Cross.

History.—Gold was first reported as having been discovered in the locality by C. Jones, the working partner of a syndicate formed by D. L. Doolette and others to prospect the country north of Southern Cross.

Jones' application for a mining leases was lodged at the Warden's Court, Southern Cross, on 29th December, 1909. As the first parcels of ore yielded extremely high returns a phenomenal boom in mining occurred throughout the whole district, the far-reaching effects of which have already been referred to. Shortly after the leases were pegged a company was floated and mining operations commenced on a systematic scale, the mine eventually turning out to be an extensive and consistent producer though, unfortunately, the grade proved to be much lower than originally anticipated.

Geology.—Two distinct series of rocks are represented, the one granitic the other basic.

Of these the former is represented by the main Southern Cross granite. As at the Corinthian, this granite is gneissic and probably represents the foliated selvedge of the main mass. Narrow granite dykes, so common in other places, are absent in this locality.

Basic Rocks.—The basic rocks, commonly known as greenstones, contain the lodes.

There are various points at issue as to the age, origin, and classification of these basic rocks. Gibson, whose private report on the mine has been kindly lent to the department, divides the basic rocks into two—a "newer" and "older" series—the former having intruded the latter.

The "older" he classes as being originally fine-grained diabases, now in the form of schistose epidiorites as the result of dynamic metamorphism.

The "newer," which is essentially coarse-grained, uralite amphibolites and talc schists sometimes massive but usually schistose, he considers the resultant of a coarse-grained pyroxenite.

Farquharson, dealing with the same rock specimens, classifies them as fibrous epidiorites or hornbendites, all of which have been derived from gabbro or pyroxenites.

Certainly in the main crosscuts of the mine in the deeper levels where the rock mass can be best studied, there seems to be no apparent demarcation between the various forms, the one merging into the other and repeating in the same section as if they were altered portions of one rock mass. Near the "northern series" lode there is certainly a narrow band of fresh epidiorites which may be of later age than the rest of the complex, though on the other hand

it may be an unsheared portion of the main mass; the latter case being the more probable. For a fuller discussion on the subject, *vide* Appendices. The greenstones have been mapped on Plates VII. and XI. as derivatives from the same magma.

Lodes.—The lodes of the Bullfinch mine come readily under two general headings:—

A.—Quartz-haematite schists and their equivalents.

B.—Dolomite lodes.

A. *Quartz-haematite Schists, etc.*—The origin of the quartz-haematite schist deposits has already been fully discussed and need only be briefly referred to here. They represent the altered product of crushed zones in the greenstones by replacement with silica and various iron oxides.

In the Bullfinch series several distinct forms of these lodes occur varying from the typical haematite variety to one consisting of silica with a very small percentage of iron.

Of these, the three best defined groups in the mine are locally known as the "Discovery lode" or "Southern series," "The Main Lode," and the "Water shaft" lode. In addition, there are certain "pipes" of gold-bearing ore to which no name has been given but which are genetically connected to the above.

The extent and position of the various lodes may be seen on Plat VI., where a plan of each level from the 100ft. downwards has been drawn. On the surface little of the lodes can be seen at present as the outcrops are partially or completely covered with surface detritus.

Faults.—At the 100 feet level in particular, a main fault plane is seen striking north-east, south-west through leases 914 and 915, the dip being to the north-west. Past this fault plane the southern series has not been found extending to the south-east. The same fault plane is found near the eastern end of the "main lode."

It is probable, but not certain, that this fault plane extends past the eastern end of the northern series.

Minor faults are found cutting the main series off at the eastern end (No. 1 fault), whilst between this and a second fault (No. 2) a short lode occurs which is probably a faulted portion of the main series. Between the main fault and No. 3 fault another similar lode, probably a faulted piece from the northern end of the main series, occurs.

Faults 1, 2, and 3 have a general north by east strike with a dip to the west by south. The water-shaft lode is cut off by fault No. 4, which strikes north-west and dips south-west. Besides these, there are several minor faults, as shown on Plate XI.

The Discovery Lode.—This consists of an extensive series of parallel lodes occurring in bands of a varying composition, but which in a geological sense, must be considered as one deposit. On account of the variation in gold values, however, only certain por-

tions are mined and, for this reason, the series, for convenience sake, has been divided into two, the "southern series" and "yellow lode."

The Yellow Lode.—In the upper levels this consists of a band of hard, yellowish, laminated quartz. Evidence of brecciation in places is well marked.

At the 100ft. level the yellow lode has not been developed to any extent. A crosscut in the eastern end shows a width of lode of 21 feet. The lode here has been driven on for a total length of some 100 feet.

200*ft. Level.*—The lode here has been driven on for a considerable distance. In the crosscut the width is some 15 feet. The ore is oxidised still, but sulphides are just making their appearance.

300*ft. Level.*—The lode at this level contains a fair percentage of sulphides and is well in the sulphide zone. Where intersected in a crosscut the thickness of the ore has been proved to be about the same as in the upper levels.

Southern Series proper.—This series consists of parallel bands of iron-bearing quartz schists, separated by layers of soft clay schists, which are also more or less ferruginous. Of these, the most southern portion is a compact hæmatite-bearing lode, a typical example of the quartz-hæmatite variety. Except that the iron contents are not so pronounced the other portions of the southern series are of a similar character. They consist mainly of a sintery, crushed, and at times brecciated laminated quartz. At the 200ft. level iron sulphides make their appearance, but even at the 300ft. level the iron oxides are not wholly replaced by such. The sulphides occur in patches, some portions of the rock being highly charged with them, whilst in other places the lode is, apparently, still practically in an oxidised state.

There is a pronounced falling away in the silica contents of the lode in the lower levels, and one forms the impression that the percentage of the country rock constituents is gradually increasing.

At the 100ft. level extensive stoping has taken place on the main fault. Here stopes are seen with dimensions of 120 feet by 170 feet; they are irregular, however, and will probably not average more than 40 feet. There is a gradual falling away in gold values in direct ratio to the distance from the main fault.

200*ft. Level.*—At the 200ft. level no stoping has been done. The lode here has a width of 90 feet. Sulphides make their appearance at this level.

300*ft. Level.*—As at the 200ft. level nothing but development has been done here. The lode has the same thickness and is partially oxidised still, though sulphides are more prevalent.

Owing to the great size and irregular nature of the ore body, the pronounced pitch of the fault plane and consequently the stopes, to the north-west, square setting in the stopes was the form of timbering resorted to and has been used throughout this section.

Water-shaft Lode.—This was a narrow pipe of ore stoped down on No. 4 fault plane to the 100ft. level, the dimensions of the stope being 40 feet by 50 feet. Below the 100ft. level no work has been done on this ore body. At the surface the fault plane (No. 4) is represented by a narrow band of quartz-hæmatite schist, which does not contain appreciable gold values. This band is visible on the north-western side of the open cut.

Main Series.—At the surface this lode outcrops as a quartz-hæmatite schist, the eastern extension of which has been faulted on fault plane No. 1; this faulted portion is low-grade. The main series, otherwise known as the rich shoot, is a band of altered quartz-hæmatite schist about 130 feet in length and worked for a width of from 15 to 20 feet. It lies between the main and No. 1 fault planes. The fault plane (No. 1) is now represented by a narrow band of very ferruginous quartz-hæmatite schist. Especially in the upper levels the lode is much shattered and altered, the fracturing being no doubt caused by earth movements along the fault planes.

This shattering made the lode pervious to circulating solutions, which not only removed the soluble portions of the lode but, at the same time, replaced such with silica and iron compounds in the form, probably, of sulphides.

The sulphides thus introduced contained gold and have since been oxidised and leached away, leaving in places an almost pure sintery quartz and the gold in a free state. In appearance some of this quartz resembles closely that found in the upper levels of the Mount Morgan's mine in Queensland. It is extremely porous and resembles a pumice or sponge in structure, in many instances being easily crushed in the naked hand.

Gibson, who reported on the lode in its early stages, describes it thus:—

> In its present highly oxidised state the lode (rich portion) consists of an irregular, more or less rubbly mixture of quartz, ironstone, and clay schists, the ironstone predominating. Occasionally it is hard and compact, consisting of brecciated portions of the original lode cemented together with secondary or "jasperoid" quartz. There are no defined walls, and irregular veins of quartz and ironstone run out into the shattered country on either side, the latter often carrying fairly high gold values.

The lode underlies to the south-west slightly but pitches to the north-west on the fault plane at an angle of about 45 degrees. Stopes extend from the 100ft. to the surface. The two faulted ends, *vide* Plate XI., have not been mined.

200ft. Level.—The "rich shoot" is 130 feet long at this level and has a stoping width of 15-20 feet. A fair amount of iron sulphides make their appearance in a winze at the 235ft. level.

In composition the lode is similar between the 200ft. and 100ft. levels to that at the 100ft. level, with the exception of the sintery quartz which is, apparently, not so pronounced.

300ft. Level.—The structure of the lode here is similar to that above. Sulphides are pronounced throughout the ore body. The

length of the ore body is 150 feet, with stoping values over a width of from 12 to 15 feet.

400*ft. Level.*—At the time of inspection the lode had only been partially opened out at this level. The characteristics were very similar to those of the 300ft. level.

Immediately under the main fault plane the country rock is much weathered and, apparently, in the initial stages of the formation into a quartz-hæmatite schist. As a whole, this impregnated zone does not contain sufficient gold to render it milling ore; pipes of ore occur in it, which have, however, proved payable.

Starting from No. 10 shaft, one of these pipes has been stoped for a length of 70 feet by 25 feet. This pipe dips to the south-east and comes into the 200ft. level in the east drive, where the stoping width is 70 feet by 30 to 40 feet.

The same pipe has, apparently, been intersected in the South cross-cut at the 300ft. level and risen on in No. 8 rise. The stoping dimensions at this level are 40 to 50 feet by 8 to 10 feet. The dip of this pipe can be seen on the accompanying plans.

Another similar pipe of ore, 20 feet by four feet, has been followed from the 300ft. level in No. 4 rise up under the west branch drive at the 210ft. level.

It is probable that if this pipe be followed it will remain under the main fault plane and come up into No. 2 level with the lode found at the east end of west branch drive. This pipe is heavily charged with sulphides.

Summary.—The main and southern series may all be classified as or modifications of the quartz-hæmatite variety of lodes. As such the general tendency is that the lodes contain less gold as greater depths are reached. There is no direct evidence to hand regarding the exact nature of these deposits at depths exceeding 400 feet, but the general tendency is for the lodes to lose their characteristics and, presumably, gradually merge into the country rock. The Bullfinch mine, being one of the best examples opened up, should be carefully studied in the future if development be carried to deeper levels.

Northern Series.—The northern series is a lode unique in character as regards the mines of the Yilgarn Goldfield in that, below the oxidised zone, it consists almost entirely of dolomite.

This lode does not outcrop at the surface. At a vertical depth of about 120 to 130 feet there is a sudden change in the lode from a siliceous to one of a dolomitic character. At the same level the sulphide zone is reached.

100*ft. level.*—At this level the lode consists of one ore-body striking north-west-south-east with an underlie to the south-west.

The south-eastern end apparently lies on the main fault of the southern and main series and pitches to the north-west. Whether the north-western end has gradually ended in a feather edge has not been proved.

In the lower levels an eastern "leg" was discovered. To ascertain whether such occurred in the 100ft. level a crosscut was driven north-east to intercept this "leg," but was unsuccessful.

From the 100ft. level stopes have been extended to a height of 45 feet, when the ore-body cut out.

The lode from the 100ft. upwards, and to a depth of 20 to 30 feet below the level, consists of a mixture of ferruginous clayey lode material partially cemented together, with irregular masses of jasper, the whole ore-body being traversed by narrow quartz veins. These veins are comparatively flat with a general north-west south-east strike and an underlie to the north-east.

The hanging wall is much decomposed, and consists of a highly schisted rock, the weathered product of an epidiorite or allied rock. In places the demarcation between the hanging wall and the lode is not too distinct, the same remarks applying to the footwall, though not to the same extent.

The stopes are kept open by square setting.

200ft. level.—In the 200ft. level the lode assumes a horseshoe shape, the longer arm of which is the western.

Throughout both arms the lode consists of a compact dolomite, which the flat quartz veins pass as in the oxidised portions of the lode. An analysis of the dolomitic portion gave the following results:—

G.S.M. 1/826. G.S.L. 8886D.

SiO_2	15.83
Al_2O_3	.29
Fe_2O_3	.11
FeO	4.86
MnO	.27
MgO	17.21
CaO	27.64
Na_2O	.18
K_2O	.06
H_2O hyg.	.06
H_2O comb.	.80
TiO_2	.02
CO_2	31.99
P_2O_5	.07
Fe_7S_8	.48
Cr_2O_3	nil
V_2O_3	.04
	99.91

Gold—15 grs. per ton. Sp. gr.—2.94. Analyst, H. Bowley.

The chief constituents are dolomite, about 55.2 per cent.; calcite, about 14.3 per cent.; actinolite, about 25 per cent., with smaller amounts of pyrrhotite and probably serpentine, albite and quartz.

The above analysis tends to prove that the lode is a replacement ore in a probably partially closed fissure, the foreign minerals, actinolite, etc., representing the remnants of the original rock.

There is no hard and fast line between the portion of the lode being mined and the walls of the country rock, the carbonation having extended a much greater distance into the latter than indicated on the plans on Plate XI. In many instances the quartz veins also extend beyond the zone of mining operations into the walls. From the 200ft. level downwards the walls are solid and comparatively not been subjected to surface weathering. Hence the trouble experienced in mining the lode in the upper levels is greatly diminished.

300*ft. level.*—There is practically no change in the nature of the lode or walls at this level from that below the 200ft. level. Stopes extend on both legs upwards.

400*ft level.*—In the western leg of this level a split in the lode is noticeable, a "horse" of country rock coming into the channel. This horse may also be seen in the stopes above the level.

510*ft. level.*—The ore-body had been cut but not opened out to any extent. Except that the quartz veins and sulphides were not so pronounced, there is no other change from the 300ft. and 400ft. levels.

General distribution of Gold and Mineral Contents.—There is no doubt that the gold and mineral contents are closely associated with the quartz veins. Both in the oxidised and sulphide zones it is very apparent that at the junction of the quartz veins with the lode proper, and extending into the walls of the veins, the greater portion of the mineral exists. It is also apparent that the quartz veins are of a later age than the main ore body. In the oxidised portions of the lodes there is an abundance of iron oxides scattered throughout, with isolated concentrated patches of a more or less siliceous nature. In these concentrations, which are uually associated with quartz veins, carbonates of copper are not infrequent, and, in isolated cases, native silver is present. Carbonates or sulphates of lead were not noticed, though it is almost certain that the silver has been liberated from the oxidation of galena, which is a common occurring mineral in the sulphide zone. In the sulphide zone the iron and lead minerals appear as streaks and bunches chiefly, as already stated, on the contact of and in the walls of the quartz veins. The dolomitic portion of the lode has usually a greenish tinge, which is due either to the ferrous iron or vanadium, possibly both.

Closely associated with the galena are various sulphides of iron, chiefly pyrites; probably marcasite and pyrrhotite.

No doubt the gold is associated with the basic minerals, for it is a general maxim on the mine that where there is no quartz showing, and mineral contents scarce, the gold values are low.

Unfortunately, figures regarding the gold from the various lodes cannot be obtained.

The mine's total production, taken from official returns, is:—

Tons (2,240lbs.).	Gold (fine ounces).	Silver.
24,842.94	117,404.26	16,442.43

Of the above amount, the first 1,027.52 tons produced 10,958.88 ounces of fine gold. This ore was taken from the main series in the early stages of development and speaks for itself as regards the richness of the first ore won from the mine.

Table showing the Yield of the Bullfinch Proprietary.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1910	Bullfinch leases, 914/6, 926, 928, 942, 960	1,027·52	10,958·88
1911	Bullfinch Proprietary (W.A.), Ltd., 914/6, 926, 928, 930, 942, 960 ..	653·42	5,544·42
1912	Do.	..	..
1913	Do.	47,959·00	33,760·96
1914	Do.	66,430·00	25,682·98
1915	Do.	68,636·00	23,631·17
1916	Do.	63,715·00	17,825·85
	Total	**248,420·94**	**117,404·26**

In conclusion I wish to acknowledge the courtesy and help shown me by J. Morgan, underground manager, and J. V. Rowe, surveyor. The accuracy of the fault plan is largely due to the latter, and may be rightly looked upon as a result of our combined efforts.

GLIDEAWAY AND NEW GREEN HARP GOLD MINES, G.M.Ls. 2272 and 2948.—As these two mines are on the same line of reef they can be conveniently described as one.

Geology.—Foliated greenstones and granitic dykes are the only two varieties of rock represented.

The lode, which does not outcrop at the surface but is overlain with about four to eight feet of surface soil, consists of a quartz reef lying between two perfect greenstone walls. The strike of the reef is some 30 degrees east of north with an underlie east of about 45 to 50 degrees. The width of the reef varies from a few inches to four feet. It has produced payable stone for a distance of 140 feet in the Glideaway, and about the same distance in the Green Harp. A main level at the 60ft. on the underlie passes through both mines. Most of the stone has been stoped above this level for a distance of 280 feet. In the Glideaway some stoping has also been carried on near the shaft below the 60ft. level, but these workings were under water on date of inspection, so dimensions

were not procurable. The sinking of a main shaft on the Glideaway was the only work in course of progress on that mine. On the Green Harp a little work was being done to try and prove whether the reef was faulted or not in the south end.

As can be seen on plate (13) these mines are of interest from a geological point of view, in that the reef, contrary to the usual habit for the Yilgarn Goldfield, passes through numerous aplite and pegmatitic dykes, and is not invaded by them except, perhaps, in one instance.

In the Green Harp, in the southern end of the main reef, a large granitic dyke was met with. Whether this dyke has cut through the reef or not has not been proved. A parallel reef lying to the east has been worked, and it would seem that this second reef is the faulted end. On the other hand, there is no evidence of faulting in any other workings, or are there any indications of such movements at the surface.

It is therefore possible that the main reef extends southward past this dyke and that the eastern reef has no connection with the main reef, in which case the dyke would be of a later age than the reef and the main series of pegmatites.

The eastern reef has been opened out at the 50ft. level by a drive 45 feet south and a few feet north. Practically all the stone above the 50ft. level has been stoped, and the shaft filled in below. The strike of the reef is practically the same as the main reef, but the underlie is considerably steeper though in the same direction, viz., towards the east, at an angle of 55 to 60 degrees.

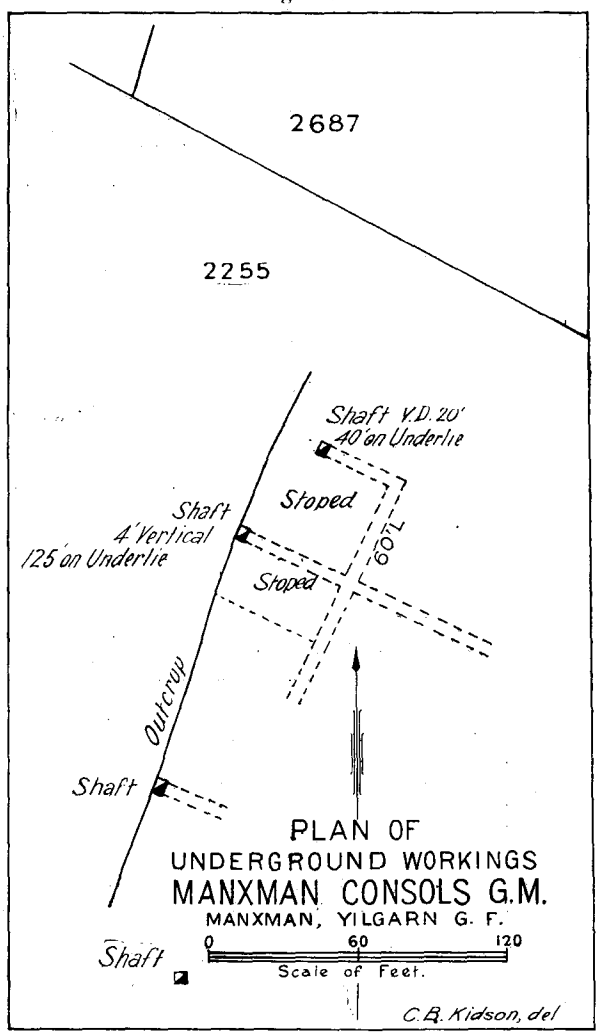
Table showing the Yield of the Glideaway, New Green Harp, and Green Harp Reef.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
	Glideaway 2272	..	..
1912	Do.	254	360·52
1913	Do.	364	309·99
1914	Do.	233	331·32
1915	Do.	..	..
1916	Do.	..	..
1915	Green Harp, New, 2948	14	11·40
1916	Do.	..	..
1912	New Green Harp leases {2541, 2542}	230·00	184·39
1913	Do.	379·90	211·13
1914	Do.	39·00	25·87
1915	Do.	17·00	9·31
1911	Green Harp 2297	46·00	53·21
	Total	**1,576·90**	**1,497·14**

MANXMAN CONSOLS, G.M.L. 2790, Manxman Group (Plate VII.), Yilgarn Goldfield.

Geology.—The country rock is similar to that of the Glideaway and Rosalie gold mines, and consists of foliated greenstone in which are numerous granitic dykes.

Fig. 12.



Plan of workings, Manxman Consols.

The workings * of the Manxman Consols are in one of these dykes. Two small parallel quartz veins, known as the hanging and

* Fig. 12.

footwall "leaders," have been followed for a horizontal distance of about 70 feet and to a depth on the underlie of 125 feet.

The dip of the veins is from 45 to 55 degrees towards the east. A distance of from one to four feet separates the two veins. Throughout the workings the walls of the veins are very regular, particularly the footwall. The walls consist of a very fine-grained aplite, not oxidised to any great depth, and extremely hard to mine. It is difficult to form an idea of the average thickness of the quartz veins as the variation is from two inches to thirty inches in places. Where the vein increases in thickness the gold contents are said to be lower. Apparently the same granitic dyke in which the veins occur has been followed into leases 2296 on the south and 2687 on the north. Gold has been found in a small vein in G.M.L. 2296, which has not been opened out to any extent, but was still being worked by prospectors with encouraging results.

Table showing the Yield of the Manxman Consols.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1914	Manxman Consols, 2790	4·35	6·98
1915	Do.	28·65	29·97
1916	Do.	8·00	12·36
	Total	41·00	49·31

ROSALIE G.M.L. 2739, Manxman Group, Plate VII., Yilgarn Goldfield.

Geology.—The Rosalie gold mine lies in the greenstones, which are much foliated and contain a network of acid dykes.

Mine Workings.—There are three main shafts on the lease.

South or No. 1 shaft.—This is an underlie shaft with a depth of about 90 feet. The inclination of the shaft is from 45 to 55 degrees to the east. At the bottom of the shaft there are no workings but 60 feet from the surface drives extend north and south. In the south end the reef is broken and small. The north drive has a length of 50 feet and follows the reef, which has a width of four feet at the shaft and about two feet at end of drive.

The end of this drive is about 15 feet from the central or vertical shaft.

The footwall of the reef is a very siliceous rock, probably one of the acid dykes. At times it is so siliceous as to be almost pure quartz. The hanging wall is greenstone, very schistose. A barren quartz vein occurs between the hanging wall and the payable lode. This barren vein is, in all probability, an acid pegmatite.

In the south end of south drive the footwall is greenstone.

No. 3 (*northern shaft*).—This shaft is also on the underlie at an angle of about 50deg. Depth on underlie, 105 feet.

At the bottom of the shaft the reef is six feet in thickness.

The strike of the reef is a few degrees to the east of north.

No. 2 *or Central shaft.*—This is a vertical shaft in greenstone, depth 40 feet.

From the north-west peg a narrow quartz vein has been traced on the surface and is said to contain payable gold values, but has not been developed except by costeans. This vein runs parallel with the main vein.

Table showing the Yield of the Rosalie Reef.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.	Total.	
				Ore crushed.	Gold therefrom.
		tons.	ozs.	tons.	ozs.
1912	Rosalie, 2391	23·00	23·98	23·00	23·98
1913	Rosalie, 2595	46·00	92·63	..	..
1914	Do.	18·00	33·94	64·00	126·57
1915	Rosalie, 2739	30·00	33·62	..	..
1916	Do.	90·75	88·65	120·75	122·27
	Total	..	..	**207·75**	**272·82**

VIOLET, G.M.L. 2653.—This mine is situated at a short distance to the north-east of the Golden Valley townsite.

Geologically, it lies in the main quartz-haematite schist series.

The main workings consist of an underlie shaft the vertical depth of which is 100 feet. At the 70 feet level drives extend 30 feet north and 26 feet south. This level is at the junction of the oxidised and sulphide zones. From the sides of the shaft oxidised ore has been stripped for a width of some twelve feet for a length of about 20 feet from the 70ft. level to near the surface.

The shaft is placed near the junction of a spur with a large quartz haematite lens which is not of any value itself as a gold producer.

Below the 70ft. level the spur lode, as seen in the shaft, contains sulphides, the quartz-haematite bands being highly charged with antimonial and arsenical sulphides.

A pronounced band of sulphide ore at the bottom of the shaft is visible, the thickness of this band being about 24 inches.

The sulphide body is said to contain highly payable gold values.

The gold-bearing formation has the appearance of being a pipe at the junction of the spur of the quartz-haematite schist with the much larger lens of the same nature. There is insufficient development to enable a definite opinion to be formed on this point.

It is evident that a considerable amount of crushing has taken place as the lode is fractured horizontally into a series of flat floors. This fracturing has possibly led to local enrichment.

Table showing the Yield of the Violet Reef.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	*ozs.*
1909	Violet, 835	65·00	133·26
1910	Do.	125·00	88·47
1911	Do.	50·00	45·31
1912	Do.	490·00	167·81
1913	Violet, 2653	60·00	12·80
1914	Do.	..	..
1915	Do.	23·64	43·32
1916	Do.	..	..
	Total	**813·64**	**490·97**

MARIONETTE, G.M.L. 2999.

Locality.—This mine is situated about 42 chains north of Trig. HK48, which lies immediately to the north of Lake Deborah.

Geology.—The mine is in one of the quartz-haematite lenses of the main series. On both sides this lens is encased with foliated amphibolite.

The main workings consist of a vertical shaft, 60 feet deep. From the bottom of the shaft a short crosscut connects with two main drives extended 30ft. north and 40ft. south. For the whole distance the drives are in quartz-haematite schists.

Crosscuts from the north and south ends and one opposite the shaft have been driven for a few feet towards the east.

In the one opposite the shaft and from the end of the south drive a mixed quartz reef and quartz-haematite schist lode has been cut. From the first an inclined rise has been worked to the surface, and a winze extended 12 feet below the level. From the latter a winze has been sunk a distance of 15 feet, presumably on the same quartz formation which has a thickness here of from four to five feet. Sulphides show their presence in this winze. A series of

partings occur in the quartz lode; these partings underlie to the east at a low angle.

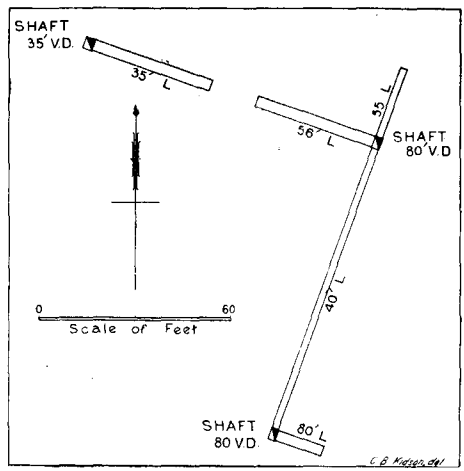
Gold is said to occur in payable quantities across the whole formation, but it is evident that considerably more stoping has been done in the quartz body than in the quartz-haematite portion of the lode. Official returns show a return only of 14 tons crushed for 11.97 ounces of fine gold.

Table showing the Yield of the Marionette.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1912	Marionette, 1848 (2999)	14·00	11·95
	Total ..	**14·00**	**11·95**

GRACE'S MINE, G.M.L. 1961.—This mine is situated at a distance of about one mile north of the Marionette.

Fig. 13.



Plan of workings, Grace's mine.

Three shafts* have been sunk on the lease, two to a vertical depth of 80 feet and one 35 feet. The first two are connected by a drive 100 feet in length at the 40 feet level. In this drive two

* Fig. 13.

quartz veins were followed; from the north shaft they ran parallel for a considerable distance, but eventually united near the south shaft. When separate their thickness varied from one to six inches, but formed in the south shaft a body of stone the full width of the shaft. The eastern of the two veins was by far the richer in gold contents. The eastern wall consisted of ironstone whilst the western or hanging wall was a rather massive, fine-grained amphibolite.

A crosscut from the north shaft at the 55ft. level intersected ironstone and quartz leaders for a distance of 40 feet.

From the south shaft a crosscut east from the bottom of the shaft 15 feet in length passed through "blocky" hard fine-grained greenstone. A small quantity of galena was broken from the reef in this shaft at the 40ft. level.

The western shaft has been sunk to a vertical depth of 35 feet and a crosscut put in eastwards a distance of 40 feet. In this crosscut are numerous small quartz veins which carry traces of gold. Twenty-five tons of ore crushed from the workings at the 40ft. level produced by battery treatment 17½dwts. of gold per ton.

One or two quartz veins were being opened out on leases between the Marionette and the Trig. Station HK 48. They are excellent examples of the laterial quartz veins found so often associated with the quartz-haematite schists.

Since my last visit Messrs. Hefferman & Cox, on the Star of Ennuin G.M.L. 2803, have crushed ore from one of these veins, the official record being 118.16 tons of ore treated for a return of 342.89 ounces fine gold. As has already been pointed out, some of these quartz veins produce extensively high-grade ore of which the above is another example.

Table showing the Yield of the Star of Ennuin Reef.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1915	Star of Ennuin, 2803	45·50	125·93
1916	Do.	72·66	216·96
	Total	**118·16**	**342·89**

Marie's Find.—A little work was in progress here on some very small quartz veins associated with the quartz-haematite schists. The workings were in no instance carried to an appreciable depth below the surface.

Marie's Find mine itself was flooded on both occasions when visited, and an inspection was therefore impossible.

Table showing the Yield of the Marie's Find Reef, 2389 ; New Marie's Find, 2389, 2390.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1912	Marie's Find, 2389	252·00	317·66
1913	Do.	40·00	57·16
1914	Do.	44·00	85·69
1915	Do.	..	..
1916	New Marie's Find G.Ms., 2389, 2390 N.L.	226·00	144·35
	Total	**562·00**	**604·86**

XI.—WESTONIA GROUP OF MINES.

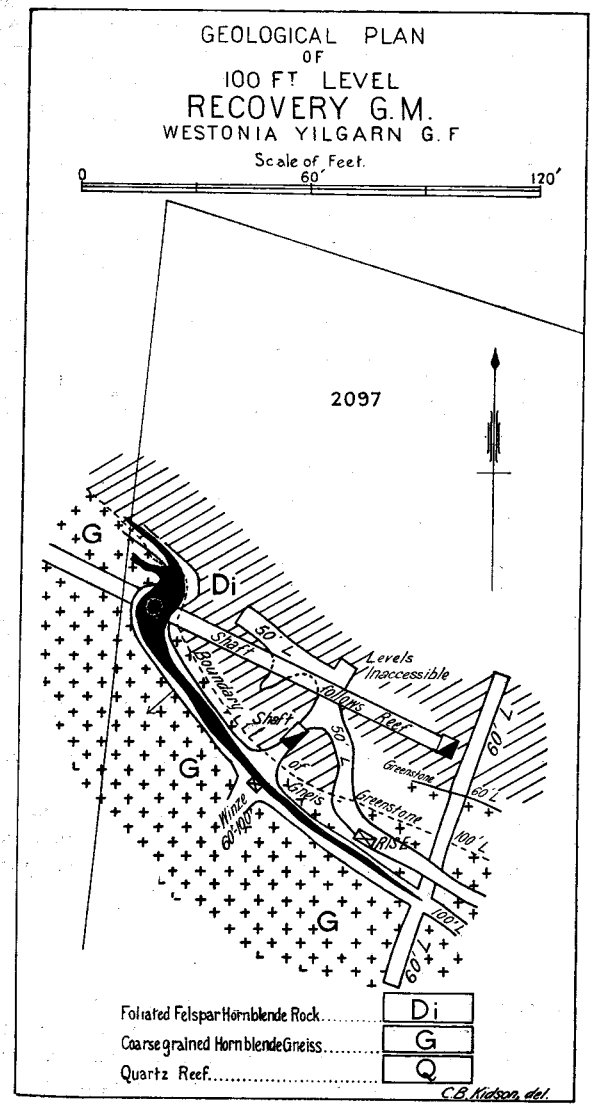
The principal mines of the Westonia group proper are confined within the limits of the Edna May gneissic belt. Outside of these boundaries no lode of any appreciable size or gold contents has been found. In the immediate vicinity of this limited area, especially on the north, south, and eastern boundaries, a considerable amount of prospecting has been done, at shallow levels certainly, but deep enough to intersect any lodes which are likely to exist. Up to the present this development tends, therefore, to prove that outside the gneissic belt it is improbable that extensive or payable lodes will be discovered. Veins of quartz have been intersected, but with unfavourable results, both as regards size and gold values. There is no apparent reason why this should be except that the chief gold-bearing lodes are pegmatitic in origin and have not extended beyond the gneiss, the pegmatites in the greenstone areas belonging to a different age and, possibly, not derived from the same magma.

High gold values were certainly found in the Recovery lode but not for any great length in the reef. Small veins have also been located and worked successfully in the greenstone by the prospectors, but such have invariably been proved to be erratic and small. There is no reason, however, why a repetition of the gneissic belt should not exist on the low-lying ground to the east of the main belt but, owing to the surface being covered up by a considerable overburden, it would be impossible to form any but the vaguest idea where to search for such an occurrence. However, the likelihood should be noted and any loose floaters or rock examined in case fragments came to the surface which would indicate the existence of another covered up gneissic belt.

The mines of the gneissic belt have been described in detail. Not so all the surrounding leases whose workings are in the decomposed greenstones, and do not exhibit any data which would be worthy of record.

Recovery Gold Mine, G.M.Ls. 2087, 2088. (Greenfinch Prop. N.L. G.M.)

Fig. 14.



Geological plan of workings, Recovery Gold Mine.

Location.—The Recovery gold mine lies some short distance north of the main Edna May group.

Geology.—Attention has been drawn to the geology of the country rock under the heading of greenstones. The main lode in the lease lies in the coarse hornblende gneiss which is bordered by a much finer foliated hornblende felspar rock.*

With the exception of the main reef, the leaders or quartz veins worked in this band, though of fairly high gold contents, were too small to yield much tonnage. The main lode has been followed to a vertical depth of 100 feet by an underlay shaft. All the stone from this level to the surface has been stoped. A section of the reef is shown in Fig. 14. Most of the gold shown in the returns was obtained from the wide portion of the reef, the legs not only being smaller but also contained considerably less gold.

Sulphides showed in the stone in the bottom of the level.

The underlay shaft has been sunk some few feet below the 100ft. level but was full of water on date of inspection.

Table showing the Yield of the (Greenfinch Prop.), Recovery Gold Mine.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		Tons.	Ozs.
1911	Greenfinch Proprietary G.M., N.L. .. 2086, 2087, 2088, 2635	472·00	478·93
1912	Do.	3,450·00	1,547·93
1913	Do.	2,878·00	585·82
1914	Do.	776·00	171·05
1915	Do.	240·00	43·30
1916	Do.	59·00	26·92
	Total	**7,875·00**	**2,853·95**

Myrtle Consols South (Edna May Deeps Mine) G.M.Ls. 2238, 2168, *etc.*

Situation.—The lease is located to the north of the Edna May gold mine.

Geology.—Three distinct classes of rock are found in the mine —the Edna May gneiss and the greenstones surrounding this belt, through which pass narrow granitic dykes, the offshoots of the massive granite. In addition to the above, basic dykes, probably directly connected with the encasing greenstones, occur.

The nature of these various forms of rock types have already been discussed.

The principal mine workings are as follows:—†

1. Main Shaft in south-east corner of lease 2238.

The vertical depth of this shaft is approximately 500 feet A short crosscut was started at the 240 feet level, but discontinued.

* Fig. 14.
† Plate XIV.

A main drive has been opened out at the 485 feet level on the Edna May lode. The direction of this drive and width of ore body as far as has been exploited, may be seen on Plate 15.

In the description of the Edna May mine, reference has been made to certain basic dykes. One of these plays an important factor in the limitations of the south-west end of the Edna May lode. In the "Deeps," the same conditions exist, for though the basic dyke A is not clearly distinguishable at the end of the lode in the "Deeps" ground, there is every reason to believe it will be found on further development in the south-western end of the mine. The tongue of greenstone found in the 385 feet level in Edna May ground on the footwall of the lode is clearly seen (on the footwall of the lode) in a corresponding portion in the 485 feet level in "Deeps." A winze connecting the shaft to the 485 feet level follows this greenstone. In it are seen numerous quartz veins of a lenticular nature, which were at first taken locally for a south-western continuation of the main lode, but which, in the writer's opinion, are distinct from the main ore body. It appears to be highly probable that a south-western extension of the main lode will, therefore, not be found. There is, however, or should be, a considerable area of gneissic rock still south-west of the main shaft for, in the deep bore, the greenstone was not intersected until a vertical depth of 427 feet was reached. Such being the case,* there is a possibility of exploiting payable quartz veins in this direction.

The various granite dykes and quartz veins which were intersected in sinking the shaft, have been plotted on the sections, and further reference is unnecessary here, as they have already been fully described in the previous pages of the present report.‡

Water.—Owing to the presence of heavy underground water in certain zones, considerable difficulty was experienced in sinking this shaft. The first water met with was undoubtedly due to surface water soaking through and accumulating in the decomposed country rock and surface beds. These conditions prevailed from the natural water level, 75 feet, to a depth of 200 feet. The flow of water between these levels was not abnormally heavy, but made shaft sinking difficult, more particularly on account of the saturated nature of the rock, which was soft and spongy. Very heavy underground water was first struck in the depressed bore in the 236 feet level, but accurate details of this flow are not obtainable.

At varying intervals in the shaft, flows of water were struck but were held back by filling the water channels with cement pumped in under pressure.†

* This does not allow for bore deflection, about which there has been much local controversy. For position of bore see Plate XXI.
† Particulars given on page 47.
‡ Particulars given on page 64.

The most serious of these flows occurred at the 423 feet level. After this one had been cemented back, a seam of cement in the sides of the shaft could be seen at least one inch wide, dipping slightly to the south-east.

From the evidence collected, it seems almost certain that the presence of these various water zones is due to the horizontal fissuring of the gneiss. Sometimes these fissures have been filled with dyke material, sometimes they occur as open cracks. The prevailing dip of both dykes and fissures is to the south or south-west, therefore, they should link up with the main fault plane, described when dealing with the faults and dykes in the Edna May. Further evidence of the horizontal fissuring is evidenced in the Edna May lode itself, and the dykes which have been traced through the various levels in the Edna May and Central mines. On the other hand, at times dykes are found which do not conform with this rule, but having a steeper angle of dip, and consequently cross the horizontal channels. Such form natural independent water reservoirs, the best example of which is the one which was intersected at the 300 feet level in the Edna May. If the water question be considered under the following headings, it should be easily grasped:—

(1.) A main fissured, partly open channel, running parallel to the junction of the Edna May gneiss and greenstone on the footwall or southern side of the gneiss.

(2.) More or less horizontal fissures, open or filled with dyke material, connecting to the first zone and acting as feeders into the same, and finally dykes, which cross the first two zones and thereby divide the water system up, forming underground water reservoirs. The reasons for drawing these conclusions may be more readily followed by perusing the sections on Plate XV.

Unfortunately, complete and accurate data of the pressures and flows encountered was not recorded, though there is little doubt that the pressures correspond more or less closely with the hydrostatic head. Furthermore, it is evident that continual pumping is lessening the underground water-flow, and has lowered the natural water level considerably.

No. 5 Shaft.—Vertical depth 76 feet. Crosscuts extend 70 feet north 20 degrees east, and 80 feet south 20 degrees west from bottom of shaft.

In the northern crosscut, 30 feet from shaft, a small quartz leader and several smaller veins of quartz have been followed for a distance of eight feet west and 12 feet east. The general strike of these leaders is N. 20deg. west and south 20deg. east with a dip to the north-east. The country rock in the north crosscut is

gneissic granite. In the eastern drive off north crosscut, a granite dyke is seen in the face, but is not pierced.

In the northern end of crosscut another dyke is seen. This dyke is flat and dips slightly to the south, as it is seen passing out of the bottom of the south crosscut at a distance of 40 feet south of the shaft.

The strike is apparently north-west south-east, with a slight underlie to the south-west; its thickness is about four feet.

In the south crosscut the country rock is also gneissic granite. In both crosscuts small quartz veinlets are common. In the south crosscut there is rather a marked distinction in the colouration of the gneiss. The first half starting from the shaft is dark and perfectly banded, whereas the latter half, though gneissic in structure, is yellow, due to the greater portion of muscovite mica as compared with biotite.

Twelve feet above the level are two small stopes on the side of shaft, strike about north 40° west. The amount of stone taken out of the small reef here is about eight or ten tons.

Gold values and reef cut out in the north end owing to the intersection of a small granite dyke some two feet thick. This dyke underlies to the west at an unknown angle.

Shafts 3 and 4.

In the first place the shafts are connected at the 36ft. level, and a drive extended north-east a further 70 feet past No. 3 shaft.

Thirty feet north-east from No. 3 shaft the contact of the greenstone and gneiss is clearly seen.

From this junction south to No. 4 shaft the rock is gneissic granite, highly decomposed and containing innumerable quartz veinlets which persistently underlie to the north-east.

The strike of these veins varies from north 50° to north 80° west.

From No. 4 shaft a drive extends some 180 feet south-west at the 51ft. level (vertical). In this distance 136 feet is in gneissic rock, when the change to much weathered greenstone takes place.

At a distance of 72 feet from the shaft a reef, four inches wide, was cut and driven on for short distances east and west. This reef dips to the north and strikes approximately east and west. Small quantities of wolfram were found in this reef. Thirty-six feet further south in the crosscut another quartz vein was cut, striking west 20° north and dipping to the north-east.

Another level has been opened out at the vertical depth of 77 feet in this shaft, and a short one at the 83 feet. The first one extends southward a distance of 121 feet, the latter 50 feet northward. In the south drive the greenstone is intersected at the end of the drive. Sixty-two feet from the shaft, the reef seen in the 50ft. level (72 feet from the shaft) is intersected. Here it is four feet wide, but dwindles out in the east drive, which follows its course a dis-

tance of some 50 feet. Small quantities of wolfram are found in this lode.

Forty feet south of shaft a vein striking north 70° west and underlying north-east, has been driven on for a distance of 18 feet west. This vein is 18 inches thick in the crosscut, but diminishes to one of eight inches in the drive.

A small dyke of coarse pegmatite, striking east and west through the shaft just above the level, disappears under this crosscut. Another dyke, with similar dip and strike, is seen in the north face of the north crosscut at the 83ft. level. This dyke, which has a thickness of 24 inches, rises from floor of crosscut up to the north face; it is practically horizontal. The level has a length of 54 feet only. At a distance of 35 feet from the shaft two short drives have been put in from this crosscut on a broken vein of quartz, which strikes in the direction of the drives and underlies to the north-east. A considerable amount of wulfenite is present in this vein.

There is little to see in shaft No. 2 as the drives are for the most part filled in. The shaft has a vertical depth of 77 feet, with two east and west drives of 60 feet east and 70 west, connected at the bottom by a short crosscut. From the 40 feet to the bottom of the shaft a coarse granite dyke is the rock passed through. The footwall of this dyke can be seen in the crosscut.* The western drive was filled in and inaccessible. A large quartz vein may be seen in the eastern drive. This is said to be 13 feet in thickness, but the walls were not discernible owing to the ground having fallen in. It appears as if this quartz is striking at a slight angle across the planes of foliation of the gneiss, but such cannot be definitely stated until further work be done. If such be the case it is certainly worthy of extensive exploitation.

Table showing the Yield of the Myrtle Consols South (Edna May Deeps).

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		Tons.	Ozs.
1912	Myrtle Consols leases 2168, 2238 ..	41·00	22·81
1913	Do.	71·00	35·22
1914	Do.	..	..
1915	Do.	..	..
1916	Do.	1,140·00	1,146·32
	Total	**1,252·00**	**1,204·35**

Edna May Gold Mine G.M.L. 2180:

History.—An application for the right to mine on G.M.L. 2180 was lodged by J. Annear and party on 20th December, 1910. The

* Plate XIV.

first returns came from that portion of the lode lying near the eastern boundary of the lease, and were, therefore, not sensational. It was not until the present company opened up the 73ft. level for

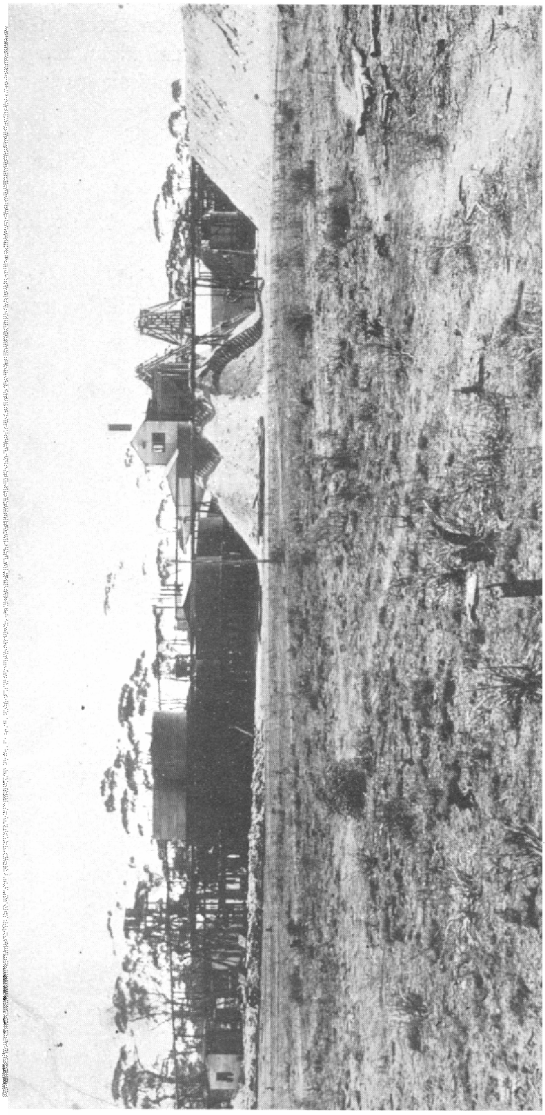


Fig. 15. **General view Edna May Gold Mine.** Neg. 1309.

Photo: T. Blatchford.

a length of over 200 feet in ounce ore that serious attention was drawn to the value of this mine. This development occurred in 1913.

Geology.—The Edna May lodes lie in the rock known as the Edna May gneiss (granitic), though the major portion of the lease is in the foliated hornblende felspar rock and hornblendite, both of which will be referred to as greenstones.

A considerable amount of prospecting has been done by boring and shallow mine workings in the greenstone areas without success. No values of any importance have been found on the lease outside the gneissic area. The greenstones and gneissic rock have already been described.

Dykes.—In the gneissic area several basic dykes occur which can be traced throughout the mine workings.

Dyke A.—It is evident in section (C-D)* that the south-western end of the main lode pitches to the north-east. The evident cause of this is—

(1.) That the gneiss was sheared at right angles to the main lode channel, that is, approximately parallel to the contact of the gneiss and greenstones.

(2.) That the main lode channel did not extend past this series of shear planes which, in consequence, mark the south-western termination of the lode.

(3.) That as these cross shear planes dip to the north-east the end of the lode has a corresponding dip.

The massive greenstone does not actually form a footwall to the end of the lode.

The dip of the cross shear planes varies, hence we find a different pitch for the end of the lode between the 150ft. level and the surface to that between the 225ft. and 485ft. levels (Deeps).

The shear plane from the 225ft. downwards has been subsequently opened and filled with dyke material (Dyke A),* and this fault plane can, in consequence, be easily traced in the mine workings. That this dyke is of later age than the lode is evidenced by the presence of fragments of the lode quartz in the dyke.

Dyke (B), which is an extremely decomposed one, is first seen at the back of the 73ft. level, and passes through the main lode in which it has been traced to the south winze between the 225ft. to the 300ft. level; after this being reached, it is not seen again.

Dyke (C).—This dyke is found in the Edna May Deeps shaft at 344 feet, and probably in the Edna May Central main shaft at 295 feet. It should occur somewhere not far above the 385ft. level in the Edna May mine. This dyke apparently dips west to south-west at a small angle from the horizontal. Both B and C dykes are important from a mining point of view.

Throughout the mines in the gneissic area are numerous granitic dykes which cut through all the other rocks. These are important factors in the mining operations for several reasons, the chief of which are: (1) They deplete the stopes of the ore in the direct

* Plate XV.

ratio of their thickness. (2) The lodes, when faulted, usually fault along them invariably as overthrust faults, and (3) They act as water carriers or bank the water up forming thereby, at times, extensive reservoirs, which have considerably hampered mining operations.*

The thickness of these dykes varies considerably, from two to three inches to 20 or more feet.

As a prevailing rule they dip to the south-west and have a tendency to get smaller as they proceed north-east, thereby showing that the intrusions have emanated from the granite on the south or west side of the belt.

Before leaving the subject of dykes reference must be made to the greenstone found on the footwall side of the No. 2 Edna May lode. At the 73ft. level this greenstone was intersected but not passed through by a crosscut from the No. 2 reef. The main crosscut at the 150ft. level also revealed the occurrence of greenstone in a corresponding position but not its thickness.

In the depressed bore in Edna May from the 300ft. level the bore ended in greenstone. It was not until the boring for the lode in "Deeps" by a depressed bore was completed that any light was thrown as to the extent of this greenstone belt. This bore, after passing through the lode, passed through eight feet of greenstone on into gneissic rock. Sections cut of the basic rock at the above intersections tend to a general classification of all the samples as one rock. The inference is then, that a tongue or dyke of greenstone forms a footwall for the No. 2 lode. No. 2 lode joins the main lode just above the 300ft. level, and as greenstone of a similar nature as the suggested dyke forms the footwall of the main lode at 485ft. level in "Deeps," and also in the depressed bore in "Deeps," it follows that this assumed dyke or tongue forms the footwall of the main lode from somewhere near the 300ft. level downwards. This will probably account for the slight narrowing of the lode in "Deeps," but whether the narrowing continues upwards to the 300ft. level in Edna May is not yet known, though it appears highly probable it will.

Lodes.—In the Edna May lease there is one main lode and several smaller veins, the most important of which are known as the Footwall or No. 2 reef, and the hanging-wall reef. The main body, as seen on Plate 15, strikes perceptibly across the planes of foliation in the southern portion, but gradually turns round to a more or less east and west course and follows the planes of foliation of gneiss just after the lode crosses the eastern boundary of the lease; without doubt the richer portion of the lode is the first. From the surface to the 200ft. level there is an extension of the main lode in an easterly direction along the shear plane extending from this level

* A full description of the nature of the above rocks is to be found in the pages of the present report, and the petrological descriptions in Section D.

to the surface already referred to. This portion underlies north by east, whilst the other portion of the lode has an underlie varying from west by north to north by west.

It will be seen that the smaller veins have a prevailing strike approximately to east and west with a persistent underlie to the north, or, in other words, they follow the planes of foliation and do not, as the main lode does in the southern portion, cut across the combs of the gneiss. In several instances such veins are found to be joined to the main ore bodies, and may therefore be considered as offshoots or laterals of the latter.

On the other hand, there are numerous smaller veins whose origin is doubtful. These have no direct connection apparently with the main ore bodies. As far as can be seen their origin is different and they will probably be found to be merely quartz fillings from siliceous-bearing waters of foreign origin, or segregation products of the gneiss itself. So far they have been proved to be, comparatively speaking, non-auriferous, certainly they are not payable veins under existing conditions. Their number, however, is legion, and in certain portions of the gneiss would form an appreciable proportion of the whole rock.

A good example of this form of quartz vein is to be seen in the north crosscut from the 73ft. level in the Edna May Central. The main lodes are interesting in that, though they represent a form of occurrence commonly found in the Eastern Goldfields, yet, as a rule such have not proved to be gold producers of a payable nature.

The Main Lodes.—In the upper levels of the Edna May the main lode had several characteristics which made it appear as if the formation was due to ordinary replacement of a partially closed fissure. Throughout the quartz were remnants of the walls, and the colour and texture of the quartz itself seemed to be variable at different points. Owing to the crushed nature of the lode and the form of mining adopted, investigation was difficult. It may be noted here that seldom, if ever, could more than a small section of the lode be seen at one time owing to the fact that it was fractured horizontally and, in consequence, it was necessary to stope in sections, the roofs of the sections being held up by "false" sets and head boards. However, in the lower levels, conditions for investigation were more favourable, and the rock forms being undecomposed gave more satisfactory and conclusive results.

Petrological examinations of typical samples of the lode taken between the oxidised zone show that the quartz is of a granitic character. Rows of fluid inclusions are constantly present. Felspar is almost invariably present and constantly associated with the quartz plates, being either contained in or containing this mineral, thereby proving a more or less contemporaneous solidification of the two. Throughout the lode wolfram is of common occurrence especially on the footwall side. This mineral usually occurs in bunches, but

sometimes in elongated flat lenses on the footwall. Galena is found sometimes in fine grains or crystals, at others in bunches. Wulfenite* and crocosite† are occasionally found, more particularly where the quartz is at all inclined to be vughy. In the oxidised zone scheelite was said to be present and concentrating tables were used to recover this mineral; unfortunately samples of the concentrate were not procurable, and there is some doubt as to whether the supposed scheelite was not really wulfenite. Molybdenite is not at all infrequent and is found not only in the lode itself but also in the gneiss. Pyrites and marcasite are found in bunches and minute specks scattered irregularly throughout both lodes and walls. All the metallic minerals taken together, however, form a very small percentage of the whole, and concentration was found to be unprofitable and in consequence was not continued.

In the upper levels the quartz was variable in general appearance, being sometimes a milky white, sometimes clear and glassy, and at others glassy but either coloured brown or yellow. As a general rule traces of kaolin were found throughout. On account of the fractured nature of the quartz, the presence of the kaolin appeared to be due more likely to the filtering of the mineral into the cracks than the decomposition of an original felspar. In the unaltered zone, however, felspar is readily seen throughout the stone, more particularly in the southern end, where the pegmatite structure is very evident; in fact at times, the lode resembles coarse-grained granite more than anything else.

From the above evidence there seems to be no reason to doubt that the nature of the lode is granitic, and that it represents the acid residuum of a quartz felspar pegmatite.

The occurrence of such lodes is frequent, but the high gold contents such as the Edna May lode possesses is unique for Western Australian mining.

In the Southern Cross area numerous similar lodes occur, but the gold contained does not amount to any appreciable quantity. Molybdenite is frequently found in small quantities associated with this class of lode throughout that area. One striking feature in the gold occurrence in the Edna May series of lodes is, that where the lode crosses the planes of foliation of the gneiss, there it is that the high gold values occur, whereas when the lode is found running parallel with the planes of foliation the gold values are invariably low and inclined to be erratic.

Naturally the laterals, if this rule holds, will be found to be low-grade and patchy. It is well known that the mineral distribution in pegmatites, or any dykes of granitic character, is usually, if not invariably, irregular.

In the Edna May lode the highest values are found at the extreme southern end of the lode in the two lower levels, and in

* Tungstiferous molybdate of lead.
† Chromate of lead.

the 75ft. and 100ft. levels at the southern bend. These values, though not quite so high, extend along the lode to where it forms a big bulge, when they diminish materially, becoming again perceptibly less a short distance after this bulge is passed to the eastward.

The gold is disseminated throughout the quartz as a rule in the finest of patches, very coarse gold being a more or less rare occurrence in any part of the mine.* It is found in close association at times with the wolfram, molybdenite and wulfenite, more particularly the first material. In one or two instances gold was found well embedded in felspar crystals, and in the wolfram.

There is no evidence of any extensive secondary segregation of the gold in the lode; what data there is rather points to the conclusion that the gold was formed contemporaneously with the lode material.

It is difficult to fix a vertical depth for a sulphide zone as there is no definite line between oxidised and sulphide ore.

Galena was obtained from the back of No. 1 stope in the 225ft. level, *i.e.*, a vertical depth from the surface of 208 feet. Certainly oxidation did not reach the 225ft. level. On the other hand, as the lode is traversed eastward the sulphide zone seems to be rising but, nevertheless, is irregular.

The natural water level of the gneiss was originally about 75 feet. Below this, to a depth of about 200 feet or more, the drainage from the weathered portion of the gneiss was comparatively heavy. This was undoubtedly due to the weathered rock being saturated from surface soakage which, on continuous pumping, was eventually drained.

A far greater volume of water than the above was encountered in the main crosscut at the 300ft. level, the first water pressures in the drill holes showing 82lbs. to the square inch. Even when pumping a volume of 60,000 gallons† per hour, the pressure did not fall below 30lbs. to the square inch for some considerable time.

It has already been noted that the eastern extremity of the lode ends at a shear plane which strikes approximately east and west and dips to the north. Also that most of the granite dykes dip at varying, but low angles to the west or south-west, and are continuous through the lode and various rock formations. When the crosscut at the 300ft. level was opened up it was found that the water was confined behind one of these granite dykes, and that the country was heavily charged with water from this point, which was 40 feet on the footwall side of the shear plane above referred to, and the water zone extended for a further distance of 40 feet on the hanging wall side of the lode.

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* Coarser gold has been since found in the "Deeps" and 385ft. level, Edna May
† According to estimate of management.

The evidence seems conclusive that this is the main water zone in the mine and is partly supplied by water permeating along the dyke channels, but probably the main supply is from parallel open fissures or cracks, such as have been cut in the "Deeps" main shaft. Furthermore, it is evident that the granite dykes have cut this water zone up into sections, the water of each section being more or less isolated from the other.

Owing to the irregularity in occurrence of both the dykes and open water channels, it is impossible to supply accurate plans or sections of their position or extent, but the above data should be of use in mining operations, the obvious course being to keep bore holes well beyond the working faces and be always prepared for heavy flows of water, especially when piercing one of the dykes.

Faulting.—With the exception of a small fault above the 225ft. level, there is no evidence of faulting in the mine. In the exception cited above, the changing wall lode has been overthrust on a granite dyke a distance of some nine feet.* This fault will probably be found extending through the other lodes. A similar faulting is found at about the same level in the Central mine, but whether the two are connected has not been proved. There is certainly a strong probability of such being the case, as both faults are approximately horizontal with a throw in the same direction.

Table showing the Yield of the Edna May.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1912	Edna May, 2180	581·00	919·27
1913	Edna May G.M. Co., N.L., 2180, 2605	9,119·00	8,975·21
1914	Do.	28,998·00	28,755·69
1915	Do.	35,743·00	35,468·83
1916	Do.	36,623·00	36,821·40
	Total	**111,064·00**	**110,940·40**

Myrtle Central (*Edna May Central*) *Mine, G.M.Ls.* 2291, 2585, 2615.

History.—The Myrtle Central lease 2291 was applied for by F. Hanks and party on 10th February, 1911. From hearsay evidence, it appears that gold was discovered on this lease shortly after the Recovery lode was found. The first crushings obtained were not high-grade, but led to the development of the rich portion of the lode in the adjoining Edna May lease. The lease was held under option by the Edna May company during part of the year 1913, but the option was not executed. Shortly afterwards a company was formed under the name of the Edna May Central, and included leases 2585, 2615.

* *Vide* Section, Plate XV.

The mine was soon equipped with a ten-head stamp mill which has run continuously since. During the development of the main lode a deposit of gold-bearing alluvial was discovered overlying the eastern portion of the lode. Ore won from this deposit enabled

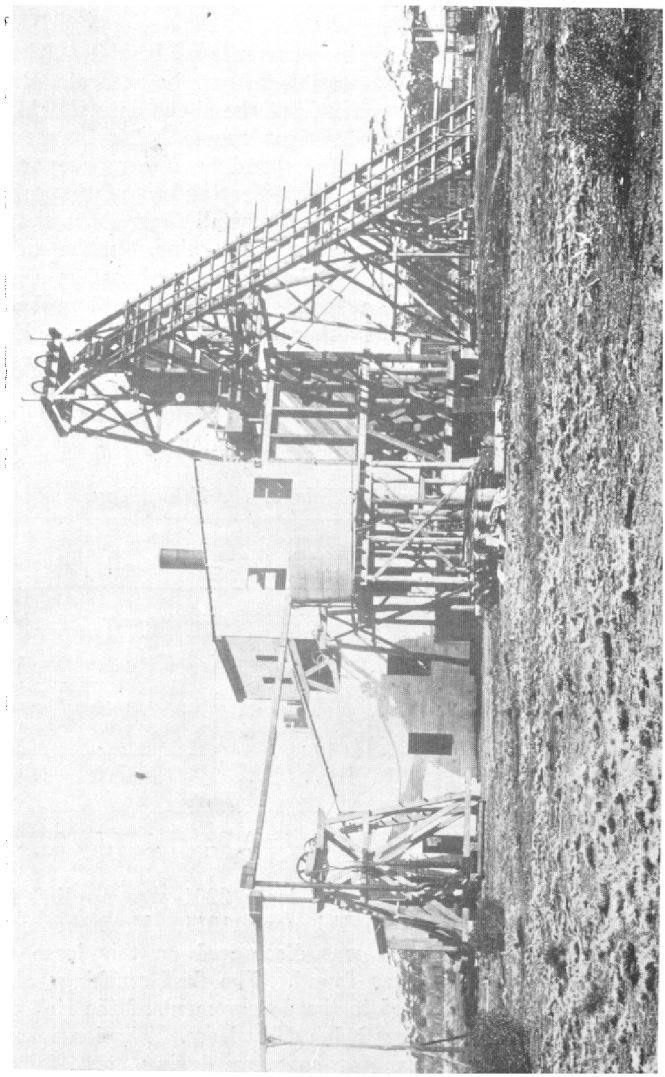


Fig. 16. **General view Myrtle Central Battery.** Neg. 1307.

Photo: T. Blatchford.

the mine to continue working and, furthermore, led to the discovery of a second lode which is now the mainstay of the company. This discovery was made in December, 1915.

During the early part of the year 1916, owing to the publication of phenomenally high assay values from this lode, the shares rose far beyond their intrinsic value. As the crushing returns did not respond to these values there was the inevitable slump in the market, with the usual result.

Geology.—The whole surface of the three leases is covered with superficial deposits of varying thickness. The geology is best studied by examining the 73ft. level which has been extensively exposed by numerous mine workings.* At this level the major portion of lease 2291 is found to be in gneissic rock, the southern portion and the north-east being in greenstone.

Fig. 17. Photo: R. H. Irwin. Neg. 1492.

Molybdenite in quartz, Myrtle Central Gold Mine.

As the gneiss underlies north it should pass under the greenstones in leases 2585 and 2615 at no great depth.

* Plates XIV. and XV.

The general features of the greenstones and gneiss have already been discussed.

Dykes.—The granite dykes are similar in every respect to those in the Edna May, and, in some instances, are continuations of the same.

Only one basic dyke has been intersected in the mine, which is probably the dyke C* found in the "Deeps" shaft and Duff's bore. This dyke was intersected in the main underlying shaft at the 295ft. level.

Lodes.—There are two main lodes in the property: one the continuation of the Edna May line; the other, known as the "new" lode, a replica in many respects of number one. Both have been mined to a vertical depth of 225 feet.

Edna May Lode.—After passing into Central ground, this lode lost its gold values to a considerable extent. It also became smaller, lenticular, and more irregular in habit. Apart from these features, the general geological characteristics are similar. Wolfram and molybdenite have both been found in isolated patches in this portion of the main lode.*

Edna May Central New Lode.—In the latter part of the year 1915, whilst working an alluvial deposit, a large body of quartz was cut by the merest chance. On development, this quartz proved to be a body of stone similar in many characteristics to the main lode. As a matter of fact, the two lodes appear to be directly connected by the No. 2 (Edna May), No. 3 (Central) reef. A plan of the 73ft. level workings show a marked parallelism of the two bodies. Further, the reversal of dip in the south-eastern end is common to both. Both lodes, when crossing the plane of foliation, bulge, and the gold values, though not proportional, yet are higher in each at the bends than elsewhere.

The distribution of the gold in the quartz is similar, and there is even a strong resemblance in the quartz itself.

The occurrence of felspar and the characteristic pegmatitic minerals, however, are not so pronounced; neither were they in the upper levels in the Edna May lode. The new lode seems particularly free from base minerals, a small amount of iron sulphides and galena being the only ones visible. The hanging wall "leg" is different in form to an ordinary lateral, but is comparable with the hanging wall reef of the main lode.

Geologically, the chief difference in the two is that the south-western end abuts on the greenstone proper and does not end on a shear plane as in the main lode.

A very interesting mining as well as geological problem arises as to what will happen to these lodes at depth, and as this subject concerns the Central mine more closely than the others, it may be as well to discuss it here.

* Fig. 17.

The data gained from the present survey point to the following conclusions:—

(1) That the lodes are of pegmatitic origin, and as they have no extensions beyond the gneissic belt they must necessarily have come from a deep-seated magma. Their permanency at depth should therefore be assured, though, of course, the size of the veins or their mineral contents is still a matter of conjecture.

(2) At the 73ft. level there seems no doubt that the system of main lodes at least is a connected one. The hanging wall reef in the Edna May, the footwall reef, Edna May, or No. 3 in Central, undoubtedly connect, as also does the hanging wall leg of the Central new reef.

(3) As the footwall reef in the Edna May gradually inclined towards the main lode and eventually connected with it above the 300ft. level, so the new reef is gradually approaching the main lode, and, furthermore, it must be noted that the west end of the main lode is also moving towards the west end of the new reef. Under normal conditions this intersection should take place in "Deeps" ground at some 700 to 800 feet, the major portion of the reef being in the deep blocks of Central ground.

The whole system of quartz reefs in the gneissic belt appear to be converging to a common source, a parent dyke, the extent and mineral contents of which it is impossible to foretell.

To enumerate the details as regards the extent, dip, etc., of the various quartz reefs and lenses in the mine is unnecessary, as they are produced on the accompanying plans drawn to scale.

East of the main underlay shaft and just above the 73ft. level an alluvial deposit was intersected which was distinctly auriferous. The extent to which this deposit has been worked may be seen on plate 15. What the real width is cannot be stated, as only that portion which was considered milling dirt has been taken out. The thickness thus worked varied from about 4 feet 6 inches to 8 feet; the average being between six to seven feet. The deposit consists of sub-angular quartz pebbles and boulders, cemented together with a ferruginous clay. Gold was visible in some of the pebbles, also in the cementing material. At times the pebbles were found with patches of plate gold on the outside, the plates having an area of a halfpenny piece. The strike of the auriferous portion of this deposit is north-east south-west with a gradual dip to the north-east.

The south-west end is apparently striking towards the outcrop of the south-west end of the main lode (Edna May). There seems no doubt that the "lead" has been formed partly from the weathered portions of the main lode and largely from that of the new lode. Specimens of some of the boulders in the south-west end are identical in nature to the stone of the main lode. On the other hand, there is a class of boulder which seems foreign to both of

the main lodes, and thereby points to the possibility of a third reef which at present has not been discovered. If such be the case, it should be found north-west of the Edna May main shaft. Probably this block of ground, viz., between the Edna May main shaft and "Deeps" No. 2, will demand more attention in the near future; it certainly warrants prospecting.

The gold is distinctly of two classes—reef and precipitated gold. Some of the pebbles have fine gold scattered throughout them and resemble so closely the main reef stone that it would be impossible to doubt their common origin.

The plate gold round the pebbles and in the cementing material is undoubtedly precipitated gold; such is of common occurrence in the alluvial deposits of Western Australia.

There is no data available whereby the gold won from the different lodes and alluvial can be tabulated separately.

Table showing the Yield of the Myrtle Central (Edna May Central).

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1912	Myrtle Central, 2291	595·00	190·38
1913	Do.	156·00	53·58
1914	Edna May Central G.Ms., N.L. ..	7,029·00	1,446·23
1915	Do. 2291, 2585, 2615	25,027·00	5,424·47
1916	Do.	32,062·00	11,811·79
	Total	**64,869·00**	**19,926·45**

Edna May Consolidated Gold Mine, N.L., G.M.Ls. 2570, 2617, and 2644.—This mine now embraces the two following leases: Myrtle East G.M.L. 2570 and Edna May East G.M.L. 2617.

Most of the mining operations have been carried on in the former, the old Myrtle East lease, which joins on the western boundary to the Edna May Central mine.

Five shafts have been sunk on this lease, four varying from a vertical depth of 60 to 75 feet, and one, the main shaft, has reached a level of 210 feet below the surface.

Main Shaft, 210 feet.—This shaft, after passing through overlying superficial deposits of a thickness of some 50 feet, entered the gneissic granite zone and remained in same for a vertical depth of 180 feet, after which it entered the underlying greenstones and remained in the latter rock to the bottom of the shaft.

From the 210ft. level crosscuts were extended north-east 200 feet and south-west 80 feet.

In the north-east crosscut the gneiss was intersected at a distance of 40 feet from the shaft, and the crosscut remained in this

class of rock to the end. A small quartz leader was passed through at a distance of 75 feet from the shaft, the vein having a north-west south-east strike; this vein was followed for some distance to the north-west,* but was of little mining importance as far as the development showed. Further than the intersection of a few mining quartz seams and very small pegmatite veins, the crosscut did not reveal any other feature worthy of notice.

The south-western crosscut is in the typical greenstones described in the previous pages of this report.

In the early stages of the mining the water level was between the 65ft. and 70ft. levels, but was gradually lowered by the drainage from the lower workings of the deeper adjacent mines. The hourly output from the bottom of the shaft was officially given as under 5,000 gallons.

Shafts numbered 1 to 5 on accompanying plan are of comparatively shallow depth, the maximum being 75 feet.

From No. 1 shaft crosscuts extend north-east and south-west, the former intersecting No. 2 shaft.

In the southern crosscut a band of granitic rock was intersected. This may be a corresponding or the same band to that found in the plat of the 300ft. level in the Edna May mine, but is so weathered here as not to be readily classified. The remainder of the southern crosscut is in highly altered greenstone. The north-eastern crosscut from No. 1 shaft is in soft decomposed greenstone for a distance of 60 feet, beyond which point gneissic granite is the prevailing rock in all the workings.

There is a marked difference in the colouring in the greenstone in this crosscut. For a distance of 30 feet back from the gneiss the rock is of a dark-brown appearance and much iron-stained. From this point to No. 1 shaft the brown is replaced by a pale to dark-green colouration with dark-green or brown bands. A similar rock is found in the north crosscut from No. 4 shaft in the Golden Point G.M.L. 260S, and at about the same distance from the contact of the gneiss and greenstones.

There are strong reasons to suggest that this rock is produced by the decomposition *in situ* of some rock rich in magnesian-bearing minerals, such as a peridotite. The green colouring is due to chromic oxide.

From No. 2 shaft, drives and crosscuts extend north and eventually connect with No. 3 shaft.

In the drive immediately east of the shaft a vein varying in thickness from a few inches to four feet, but yielding payable gold values, has been opened out for some considerable distance. Stoping for a width of from two to three feet has been commenced a short distance north of No. 2 shaft.

* Plate XIV.

A rise connects the 75ft. levels of No. 5 shaft to the above drive.

As may be readily seen from the accompanying plan, numerous quartz veins have been intersected, some of which contain sufficient gold to go to the battery. Of these, there seems little doubt that the reef worked in No. 4 shaft is the same as the one worked in the 60ft. and 75ft. levels north of No. 5 shaft, and is probably a continuation of the "new reef" in the Edna May Central mine.

Most of the veins run east and west approximately, *i.e.*, parallel with the planes of foliation of the gneiss. It has already been pointed out in the previous pages of this report that such veins are usually lenticular and irregular in both occurrence and gold contents. On the other hand, the vein in the workings to the east of No. 2 shaft strikes across the planes of foliation, and this vein should be worthy of further exploitation. The same applies to a reef being opened out in the winze north of the rise from the 75ft. to the 60ft. levels, and between No. 2 and 5 shafts.

There is also a large area of gneissic rock in the eastern area of lease 2570 still unexploited. This area is well worthy of development on the chance of cutting a similar deposit to the Edna May Central main lode and the Central "new reef."*

Table showing the Yield of the Edna May Consolidated G.M.Ls. 2570, 2617, 2644.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons	ozs.
1916	Edna May Consolidated, 2570, 2617, 2644	668·00	261·16
	Total	**668·00**	**261·16**

Golden Point Gold Mine G.M.L. 2608.

Location.—The Golden Point mine lies to the immediate south of the Consolidated and Edna May Central gold mines.

Geologically it is situated in the main greenstones.

Geology.—In no instance does the country rock outcrop, the whole surface being overlain with a mantle of debris the maximum thickness of which is about 65 to 70 feet.

The country rock is highly weathered foliated greenstone of the prevailing hornblende-felspar type. Possibly the hornblendite extends through the lease in the end of the north crosscut from No. 4 shaft, but the rock is so highly weathered as not to be definitely

* Since writing the above a new quartz reef has been cut in a north-west cross-cut from the main north-east cross-cut, which has every appearance of being a similar lode to the "new reef" in the Edna May Central mine, *vide* Plate XIV.

determinable. Throughout the workings numerous quartz veinlets and pegmatitic dykes have been cut.

The quartz veins have not proved in any instance to contain payable gold, neither do they in any instance attain sufficient thickness to be even treated as low-grade mining propositions.

The principal veins are found in shaft No. 6 at the 92ft. level. Here two irregular quartz seams were cut, and the western one followed in a drive for a considerable distance. The stone was following the planes of foliation, but was too low-grade for mill treatment and scarcely warranted prospecting at a greater depth.

Both veins in their south-eastern end extend into the Edna May Consols, where they maintain the same characteristics.

XII.—BATTLEFIELD CENTRE.

The mines of this centre belong to three distinct classes—

(a.) Reefs occurring in an acid gneiss.

(b.) Reefs occurring in the foliated greenstones.

(c.) Pegmatite dykes of a recent age occurring in the foliated greenstones.

Of the first class there are two examples—the Hill End and Battler-cum-Great Battler. Of these the former has not been developed to any great extent owing to the extremely hard nature of the encasing rock. The reef, however, is well defined and the gold contents encouraging.

A fairly long quartz vein has been opened up in the Battler group for a vertical depth of over 100 feet. In this case, the encasing gneiss was soft and the mining conditions comparatively favourable. The reef, though extremely narrow, contained fairly high gold contents. Of the second class there are many examples but, with one exception, the veins are either small and comparatively rich in gold or large and extremely low-grade.

The Pertha M. reef, which belongs to the second class, has been worked to a depth of over 100 feet vertical, and though the reef in the shaft is large and high-grade, it has not been opened out horizontally, so it is problematical whether the reef will be of sufficient length to form a permanent mine.

Of the third class, there are one or two cases in which pegmatite veins, of an age later than the main Edna May lodes, have been found, carrying free gold, but it is extremely doubtful whether they will ever be exploited to any extent.

In all three cases the reefs are closely associated with the occurrence of granitic dykes, a fact which tends to prove the disturbed nature of the country rock in which they occur.

The following are descriptions of the mines which were open for inspection.

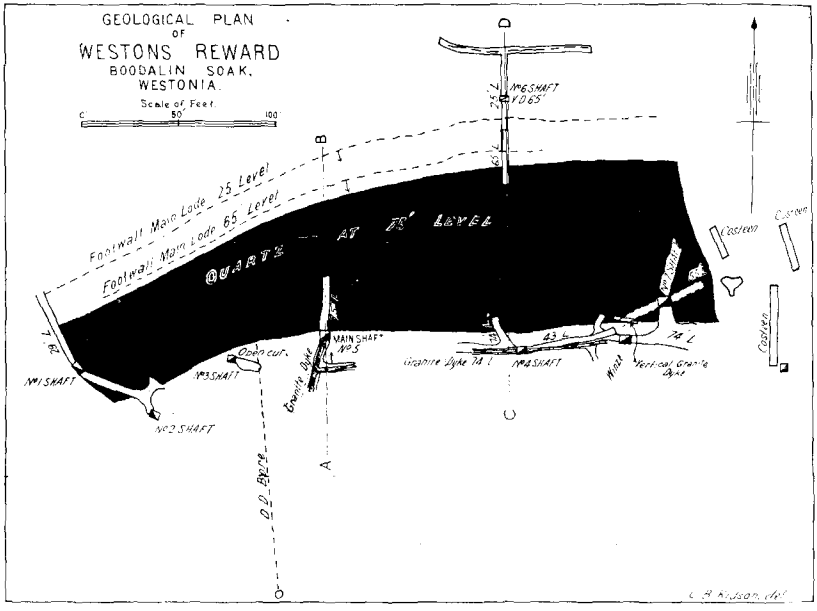
Weston's Reward Gold Mine 2724.—Gold was first discovered in the Westonia district by A. D. Weston, his application for a Reward Claim being lodged on 20th December, 1910.

The lease, which now bears the discoverer's name, is situated near Boodalin Soak. Geologically, its position is close to the junction of the greenstones and the granites which outcrop in a conspicuous line to the east of the "soak."

On the surface of the lease a rather conspicuous quartz outcrop* is seen striking east and west. The gold was found in the vicinity of this outcrop.

In all, seven shafts have been sunk, and a certain amount of driving and crosscutting done at levels varying in vertical depths from 25 to 75 feet. The extent of these may be seen in Fig. 18 and Fig. 19 which shows the sections across the lode.

Fig. 18.



Geological plan, Weston's Reward Gold Mine.

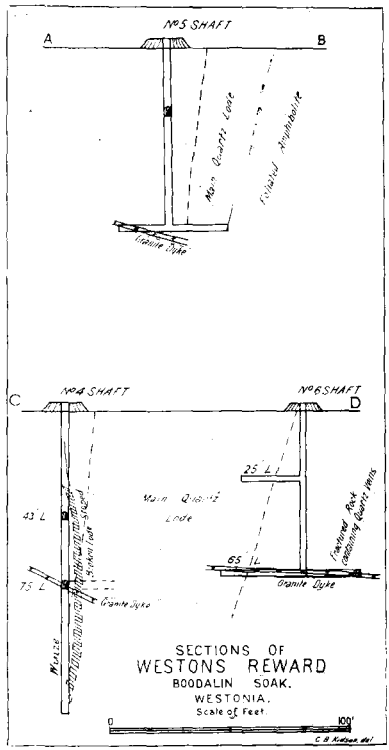
The reef itself is a large one, being as much as 90 feet across one of its widest portions. In the upper levels, particularly in the eastern end, a considerable amount of iron oxide is mixed with the quartz, but this is soon replaced by sulphides. The amount of gold estimated from bulk samples of the lode proper is low and not payable.

In sinking No. 4 shaft payable gold values were encountered to about the 46ft. level, but these were passed through and missed

* Figs. 18 and 19.

in the drive at the 73ft. level. However, they were subsequently found and stoped out for a distance of 35 feet east of No. 4 shaft, between the 73ft. and 46ft. levels. The width of ore broken was

Fig. 19.



Geological sections, Weston's Reward Gold Mine.

about 20 feet to 24 feet, the tonnage represented being 150 to 170 tons. From the 46ft. level a stope was run 20 feet west and 35 feet east from the shaft, the highest point being 10 feet up from the 46ft. level. The total tonnage from these two stopes was about 200 tons, and gave a return of 28 dwts. total gold per ton. The stone broken consisted of small vein quartz and gangue. It would appear that the gold is a local enrichment in the crushed greenstone forming the hanging wall of the main lode, and does not give the appearance of a permanent ore channel. Shaft 7 was sunk to a vertical depth of 55 feet and then on the underlie to the 73ft. level. Drives were put in 32 feet south-east and 35 feet north-east from the shaft at the 55ft. level.

In the western drive a small pegmatite dyke was cut in which free gold was noticeable.

The rock in these drives is much broken and contains a variable amount of auriferous quartz veins. Immediately under the level is the main quartz body, which has not been prospected at this point.

At a distance of 40 feet west from the bottom of the shaft a winze has been sunk to a depth of 50 feet in the sulphide zone. The country is hard and the veins irregular in size and values.

From the winze to the shaft another stope had been taken out, producing about 80 tons of crushing stone similar in nature to that already referred to. Several pegmatite dykes pass through the workings in the directions indicated on the sections.

From No. 6 shaft, at a depth of 65 feet from the surface, a crosscut has been driven 43 feet south, for the most part in the main lode. In the north crosscut, at a distance of 22 feet from the shaft, broken country containing quartz leaders was driven on east and west for distances of 43 and 30 feet respectively. The gold values were low in these drives. In the drives the country rock, which, like the footwall rock, is a foliated felspar-hornblende gneiss, is much broken and crushed.

Taken as a whole, the workings reveal the presence of a rather large body of quartz on both sides of which the containing rock has been crushed, and in these fissured zones smaller veins of quartz occur which contain payable gold. The main body, so far, has not been proved sufficiently high grade to warrant further development. An attempt was made, by boring, to intersect the main lode at a vertical depth of 500 feet; unfortunately, this bore did not meet with the success anticipated, the site of the bore hole being apparently too far to the west.

Table showing the Yield of the Weston's Reward.

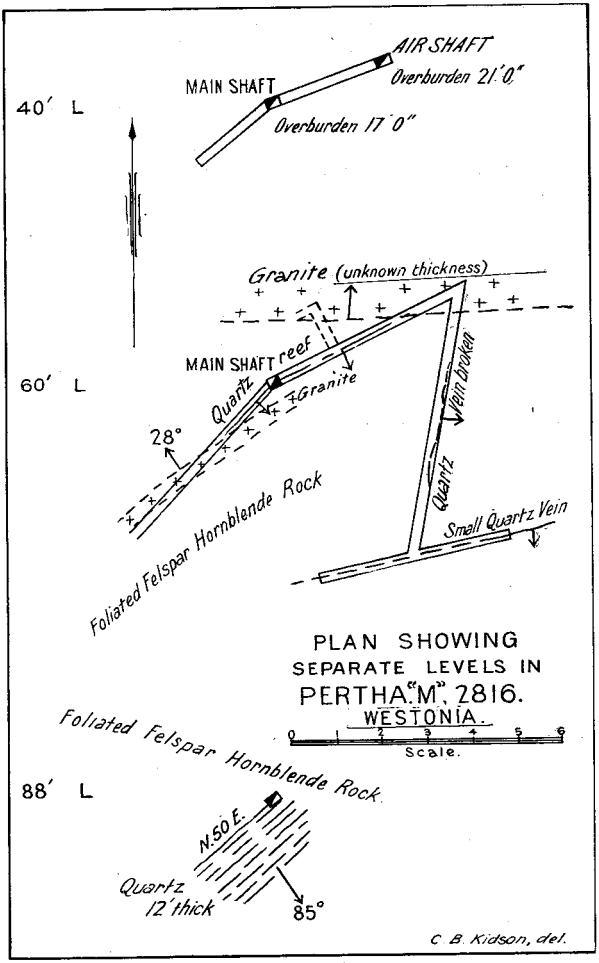
Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1915	Weston's Reward, 2724	35·00	57·24
1915	Weston's Reward G.Ms. N.L., 2724, 2761	418·00	384·56
1916	Do.	55·50	40·10
	Total	**508·50**	**481·90**

PERTHA M. GOLD MINE, G.M.L. 2816.—This mine is situated about 25 chains to the south of Boddalin Soak, and lies almost adjacent to the Lloyd George G.M.L. 2259.

The main workings consist of one shaft sunk to a vertical depth of 88 feet. Further sinking was being carried on with the

intention of reaching water level before opening out on the reef again.

Fig. 20.



Geological plan, Pertha M. Gold Mine.

40ft. Level.—At the 40ft. level the reef was followed in a drive starting north 70 degrees east for a distance of 27 feet, and south 51 degrees west at a distance of 21 feet.

Most of the stone from the back of these levels has been taken out up to the over-burden, which, in this particular locality, has a thickness of some 17 to 21 feet. There was still stone of a thickness of four feet showing in the western face. The underlie of the reef is slightly to the south, but for practical purposes the angle is negligible.

60ft. Level.—At this level a serious mistake was made in not sinking deeper before opening out on the reef, for as it is, the workings are immediately over a granitic dyke, and though there is a well-defined reef beneath this granite "bar," immediately above it the country is much disturbed and the reef with it.

The extent of the workings at this level may be seen on the accompanying plan.

In the western drive the dyke above referred to has taken possession of the drive. This dyke is comparatively flat, underlying slightly towards the north at an angle approximately 28 degrees from the horizontal. The dyke in the drive has a thickness varying from three to four feet, and passes through the shaft immediately below the level. In the back of the level little, if any, stone can be seen, and what stone there is shows signs of being much broken and mixed with the encasing rock.

In the eastern drive another granite intrusion has been intersected in two places, viz., at the end of the north-eastern drive and at the end of a short crosscut branching from the drive north-westward at a distance of 20 feet from the shaft. This granite may be a tongue of the main mass, but possibly is the western wall of the massive granite outcropping at Boddalin Soak. Certainly the contact cannot be far distant.

In the south crosscut from the end of the eastern drive there is little to be seen. A small quartz vein was followed for some considerable distance, but this soon vanished.

At the end of the crosscut another small vein, carrying gold in appreciable quantities in places only, was followed east and west. This vein dips to the south.

When the mine was last visited the prospectors had opened out the main reef at the bottom of the shaft, the reef here having a width of some 12 feet. A crushing from the stone broken at this spot yielded highly payable gold values. The policy decided on at this time was to continue sinking to water level rather than attempt to open out the reef at such a shallow depth.

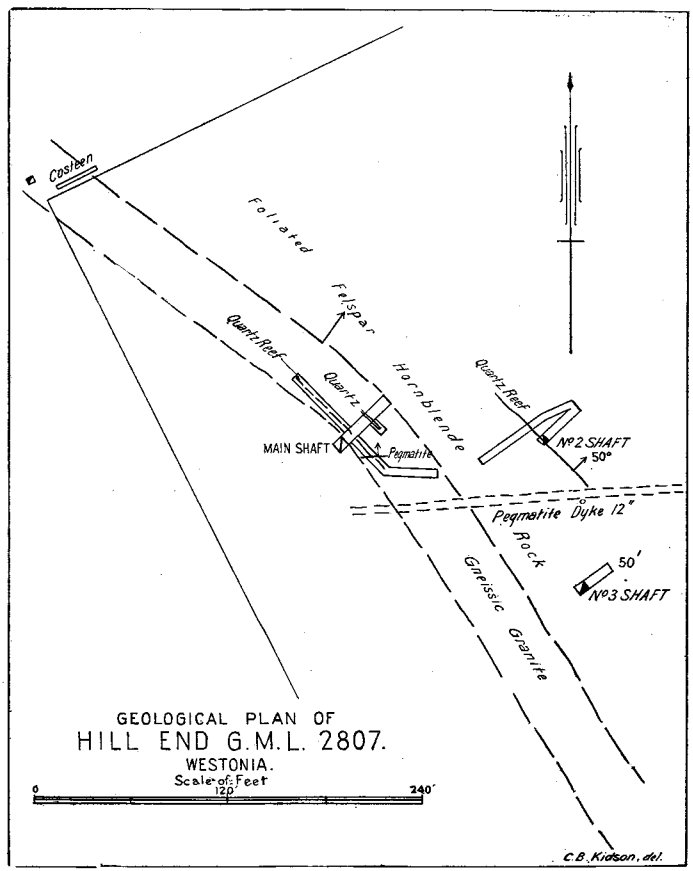
The mine is situated in greenstone country, and lies near or at the contact of this rock and the massive granite seen outcropping at Boodalin Soak. Owing to its proximity to the granite it may reasonably be expected that other granite dykes will be encountered in subsequent development.

Table showing the Yield of the Pertha M G.M.L. 2816.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1916	Pertha M., 2816	392·00	263·41
	Total	**392·00**	**263·41**

HILL END MINE, G.M.L. 2807.—The work on this lease (Fig. 21) has been chiefly confined to the exploiting from a shaft (main shaft) of a quartz vein running in and parallel to the sides of a narrow belt of gneissic granite.

Fig. 21.



Geological plan, Hill End Gold Mine.

This gneissic granite is similar to the Edna May belt. There is no reason to doubt its intrusive nature, also its age being greater than the pegmatite epoch.

The underlie of the shaft is 60 degrees, which represents the dip of the reef.

At a depth of 45 feet vertical the reef has been opened out with a drive going south-east for a distance of 27 feet. In this drive the reef averages probably 18 inches. In the north-western drive the reef is not so well defined. Immediately below this level the sulphides appear. The shaft has been sunk to a depth on the underlie of 72 feet.

About 12 feet below the 45ft. level a drive has been put in south in the sulphide zone. Here an excellent hanging wall is seen, and a regular reef heavily charged with pyrites. Visible gold is common in this stone, and the owners showed me some excellent pan prospects.

The country here is very hard. One or two very small pegmatite dykes are seen crossing the reef, but appear to have no effect on either its continuity or gold contents.

Hill End No. 2 Shaft.—This shaft has been sunk 60 feet on the underlie, following a more or less irregular body of quartz of an average width of some 36 inches. At the bottom of the shaft a crosscut was started on a bearing of 238 degrees, and extends for a distance of 70 feet. As may be seen on the plan* the end of this crosscut is trending towards the end of the crosscut in the main shaft. Except for a few small quartz veins, nothing of importance was intercepted in this crosscut. The prevailing rock was greenstone in a more or less altered form; mica is common, being derived from the decomposition of the hornblende. This is more conspicuous near the lode than elsewhere.

No. 3 Shaft.—This shaft has been sunk 50 feet on the underlie. A crosscut 17 feet in length has been put out to intercept the gneiss, but was not continued a sufficient distance to effect this object. The country intercepted was greenstone, in which the mica was replacing the hornblende. These workings are all in the oxidised zone.

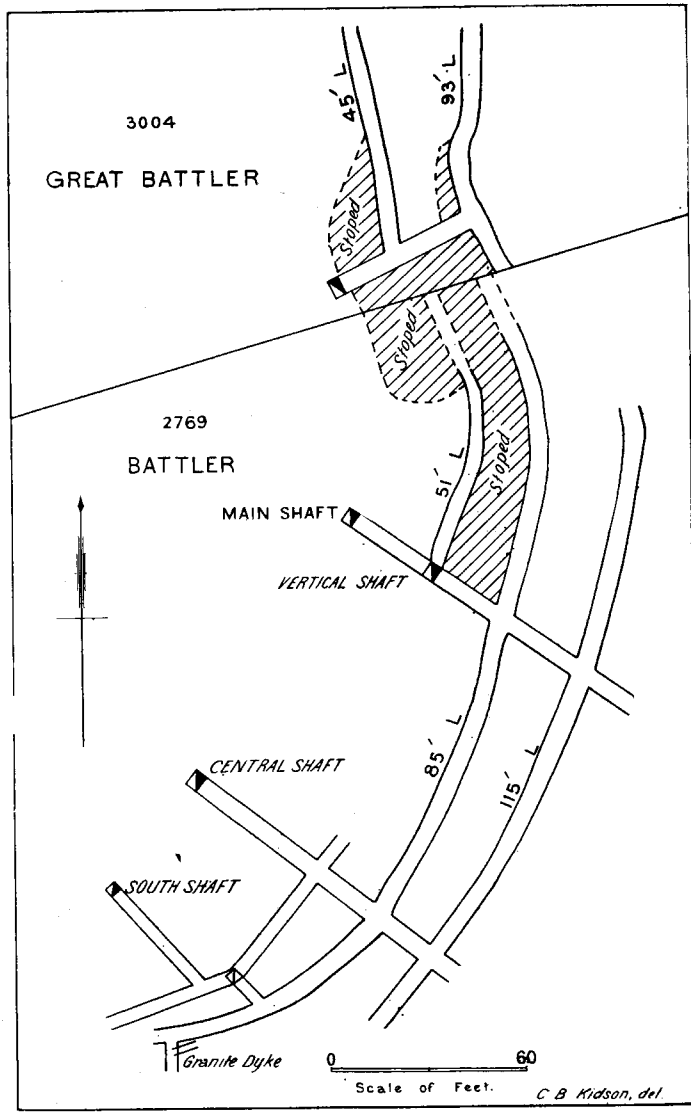
Table showing the Yield of the Hill End G.M.L.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		tons.	ozs.
1915	Hill End, 2807	126·00	93·44
1916	Do.	68·00	43·43
	Total	**194·00**	**136·87**

* Fig. 21.

BATTLER (G.M.L. 2769) and GREAT BATTLER (G.M.L. 3004) MINES.—These mines are situated near the townsite of Battlefield, west of Boodalin Soak.

Fig. 22.



Plan of workings, Battler and Great Battler Gold Mines.

Geology.—Three classes of rock are represented.

First, a narrow band of granitic gneiss in which the quartz vein or lode occurs. This band is surrounded by the prevailing greenstone. In both the above are typical pegmatite dykes.

The gneiss, which is but a narrow dyke mass, highly foliated, has been already fully described both in the text and appendices.

*Mine Workings, Battler.**—The principle mine workings are connected to a main underlie shaft.

No. 1 Level.—This level extends north from the shaft into the Great Battler and a short distance south of the shaft. The vertical depth is 51 feet, and on the underlie 59 feet.

A stope has been taken along the whole level, so width of stone not ascertainable. The south face was blocked and not accessible.

No. 2 Level.—Vertical depth 85 feet. From shaft to boundary the ore has been broken to the 51ft. level. Southward the level extends past the south shaft.

Between the main and central shafts the quartz vein is very small, except for a length of about 20 feet, when it is seen to have a thickness of from six to eight inches. The reef has practically vanished south of the central shaft.

In the extreme south of this level a pegmatite dyke is seen crossing the south face. The strike of this dyke, though uncertain is north of east, with a dip to the west.

No. 3 Level.—Vertical depth 115 feet. A drive at this level connects the central and main shafts. It also extends some 20 feet south of the central shaft and 60 feet north of the main underlie shaft.

Between the two shafts the thickness of the quartz vein is variable, but in no instance was it more than 12 inches thick and often only three to four inches.

A stope was started 60 feet south of the main shaft, where the stone was about 10 inches wide.

North of the main shaft, for the 60 feet driven, the average thickness of the vein was about six inches.

Throughout the mine the quartz vein is small and irregular. The encasing gneiss is not payably auriferous.†

As greater depths are being reached the encasing rock is getting perceptibly harder. The mine is a comparatively dry one, water being almost absent.

The Great Battler.—The quartz vein being worked in this mine is a continuation of the one in the Battler.

Two short levels have been opened from an underlie shaft situated close to the southern boundary.

From the first of these, the 45ft. level, a stope, some 60 feet in length, has been carried up to the surface.

North of this stope the vein had practically vanished.

In the shaft the vein appears to be not more than four to six inches wide.

* Fig. 22. † Manager's word for this statement.

The second level has a vertical depth of 93 feet. Some 25 feet north of the shaft the reef makes a sudden bend, and in this bend a nice body of stone was found. Unfortunately, however, it soon cut out into a mere thread.

The walls of the lode in the Great Battler are similar to those in the Great Battler, viz., gneiss, and as this band is found on the surface some considerable distance north of the present workings there is still a chance of finding more stone by driving north in this ore channel, otherwise the mine must be considered as one containing a very small tonnage of fairly high-grade ore as the following official returns show.

Table showing the Yield of The Battler and Great Battler Reefs.

Year.	Name and Number of Lease.	Ore crushed.	Gold therefrom.
		Tons.	Ozs.
1915	Battler, 2769	115·00	170·64
1915	Edna May Battler G.M. Co., N.L., 2769	243·00	195·97
1916	Do.	1,745·00	1,713·39
1916	Great Battler, 3004	50·50	68·86
	Total	**2,153·50**	**2,148·86**

Violet May Mine G.M.L. 2878.—On the south-western boundary of this lease are two shafts sunk to develop some irregular quartz veins in a very coarse pegmatite dyke.

The underlay, or northern shaft, has a vertical depth of six feet, and then on the underlie for a distance of 27 feet at an angle of 55° towards the north-east.

The dyke is in the footwall of the shaft. At the bottom, the hanging wall is exposed. A small hole in the footwall of the shaft exposes the footwall of the dyke, which has a thickness here of eight feet six inches. The quartz veins being worked are irregular, both in size, shape, and direction. In some places the dyke is highly felspathic, in others extremely acid. This latter phase is particularly noticeable in the southern shaft. This shaft has a vertical depth of 28 feet and has just struck the granite in the bottom.

It is asserted by the owners, Messrs. Hansen Bros., that gold is found in appreciable quantities in the dyke itself. It is probable that the same dyke extends into lease 2879. A lot of dry-blowing and costeening has been done near this boundary, which would indicate that some lode or other is shedding gold. There are indications of other dykes being present in this vicinity, but they have not been exposed sufficiently to map.

XIII.—CONCLUSIONS.

The Westonia belt consists of a series of rocks comprising sediments (metamorphic) and intrusives of both a basic and acid character. Surrounding this complex is the massive granite.

The sediments, from a mining point of view, are not an important type of rock, for they are neither metalliferous nor auriferous.

Of the intrusives the principal types, taken in order of age, are the following:—

A.—The prevailing foliated hornblende felspar series, the typical greenstones of the area.

B.—Acid gneisses. Of these the best example is the Edna May lens, with the subordinate equivalents at the Battler and Hill End mines. These are, from a mining standpoint, the important rocks in that they contain, with minor exceptions, the payable lodes of the district.

C.—Basic igneous rocks. These occur as intrusives into classes A and B in the form usually of narrow dykes. They are of an extremely basic character, and are technically termed hornblendites.

D.—A double series of acid dykes or apophyses.

I. An ultra acid variety, highly auriferous and of a greater age than Class C. Of this variety the main lodes of the Edna May consist.

II. A later, in fact the latest, series of intrusives occurring in the form of normal pegmatites and white aplites, both essentially non-auriferous.

Recent surface deposits, the partially stratified talus of the country rocks, payably auriferous in one instance, were traced in the vicinity of the outcrops of the main lodes of the Edna May group.

Reviewed from a mining standpoint, the facts obtained point strongly to the following conclusions:—

(1) That the gneissic areas, though very limited, have up to the present only been partially prospected, also, it is evident that the main gold-bearing lodes occur in those areas.

(2.) Outside the gneissic zones the quartz veins which have been found have proved very small and erratic, with two doubtful exceptions, the Recovery and Pertha M. lodes.

The possibilities, therefore, are that new lodes will be found in the main gneissic area (in particular), and minor veins of a payable nature in the surrounding greenstones.

The longevity of the main lode is extremely probable, though, of course, the gold contents at depth will be problematical.

There is no reason why fresh gneissic areas should not be located, but prospecting for such would be extremely difficult and their discovery merely fortuitous.

It might certainly benefit prospectors to look out for gneissic rock first, in their pursuit of gold-bearing lodes, searching carefully in any areas of this class of rock they may locate; it would certainly enhance their chances of success.

XIV.—COUNTRY SOUTH OF CHERITON'S.

GENERAL DESCRIPTION.

After travelling southwards from Cheriton's along the beaten track, for a distance of above four miles a noticeable change takes place in the vegetation, surface rocks, and surface configuration. In place of the morrell forests and gimlet wood thickets one sees only stunted vegetation, with an occasional clump of gums, and in the spring time an abundant variety of wild flowers noticeably different from those of the northern portions of the field. The rocks here exposed are either granite or remnants of an extensive sedimentary series.

The surface instead of being hilly and rough, is undulating, with occasional elevations which have the appearance of hills when viewed from a distance, but do not rise to any appreciable altitude.

There is little if any change from this class of country till Mount Holland is reached, when similar country to the Parker's Range district is encountered. A narrow strip of greenstone country, running more or less parallel to the road as far south as Hatter's Hill, is responsible for this change.

Hugging this greenstone belt on the west from Mount Holland to Mid-Ironcap is a belt of sediments resembling closely those to the west of Parker's Range and Cheriton's.

The North Ironcap is a conspicuous land mark in this series.

Passing through the Mid and South Ironcap, both of which are also conspicuous landmarks, is a similar belt of sedimentary rocks, with identical lithological characteristics.

From Hatter's Hill to Cowjenup plain country is the prevailing type, in which are occasional granite knobs, conspicuous amongst which is Mount Gibbs.

Just visible to the east or north-east from the highest points above-mentioned the tops of the hills of Bremer Range can be seen in the far distance, with occasional glimpses of the intervening lake country; the south-western extension of the Johnstone lake series.

From Iron Cap to Bremer Range the country presents little, if any, change.

At Cowjenup a tributary of the Oldfield River has cut a deep channel through the surface debris down to the granite, which alters the configuration of the surface slightly, but is not worthy of further notice.

The track of the Rabbit-Proof Fence traverses pronounced undulating country; most of the road is sandy, with occasional ironstone gravel—(laterite)—patches, on the crests of the higher ground. Conspicuous outcrops of granite are common and form the only relief to a most monotonous landscape. Similar country extends westward of the fence as far as the eye can reach.

WATER SUPPLY.

During the winter months of average rainfall there is an abundant supply of water on the granite rocks, but this cannot be counted on during the summer months.

On the main road to Cowjenup from Cheriton's the following waters are more or less permanent:—

Split Rocks—8 miles south of Cheriton's.
Mount Holland—17 miles south of Split Rocks.
Government Tank—18 miles south of Mt. Holland.
Digger Rocks—20 miles south of Government Tank.
Hatter's Hill—12 miles south of Digger Rocks.
Mt. Gibbs—7 miles south of Hatter's Hill.
144-Mile Rabbit-Proof Fence—8 miles south of Mt. Gibbs.
154-Mile Rabbit-Proof Fence—10 miles south of 144-Mile Rabbit-Proof Fence.
170-Mile Rabbit-Proof Fence—16 miles south of 154-Mile Rabbit-Proof Fence.

On the Rabbit-Proof Fence from Burracoppin to Cowjenup, there is a good supply of water at short intervals, but this can only be used by special permission from the Government Inspector.

The track from Forrestania to Bremer Range is not so well watered, but during the wet season the supply is adequate for prospectors.

After leaving Forrestania the first water is reached on a travelling distance of 10 miles; this is known as Allen's soak. There is plenty of water here but it is more suitable for stock than drinking purposes, the water being very dark, due to decaying vegetation.

After rain, water can be obtained in abundance at distances of 17 and 26 miles east from Allen's soak. At a distance of nine miles from the last, that is 36 miles from Allen's soak, there is another soak which yields a good supply of water but is decidedly brackish owing to its proximity to a salt lake.

However, six miles east from this is what is likely to be a very permanent supply of good drinking water. This is also a soak from granite rocks. Considerable quantities of water were drawn here without exhausting the supply. In the summer months this is the only known permanent water supply for Bremer Range, and, by the road, is 17 miles west from Mount Gordon.

A new tank has been excavated near the leases at Forrestania which with a natural clay-pan catchment should yield a more or

less permanent supply when once filled, unless very extensively drawn upon.

There is usually water at Native Rock, immediately to the south of North Ironcap.

With these exceptions, the water supplies can only be relied upon during the winter months, or a short time after rain for, as a general rule, the clay-pans and rock-holes are too shallow even when completely filled to last any appreciable time during the summer months.

One main cut track extends from Southern Cross southwards to the Rabbit-Proof Fence, intersecting the fence at the 144-Mile post.

For the most part, from Cheriton's the track is sandy and only partially cleared of stumps and roots, but has, nevertheless, been traversed successfully by teams and several motor cars.

The track on the Fence itself, though sandy in places, has been well cleared for vehicular traffic, but can only be used, as already stated, by special permission.

The other routes marked on the maps are merely bush tracks and usually very rough and heavy, notably the one from Forrestania to Bremer Range.

TIMBER.

Taking the area as a whole, timber is scarce, though there are occasional small belts of gum and gimlet wood suitable for mining purposes. The best supply is, without doubt, on the greenstone belt lying between Mt. Holland and Mid Ironcap.

GEOLOGICAL FEATURES.

The rock types of the area under review may readily be classed in four groups:—

(1.) Granites and their apophyses.
(2.) Greenstones—(a) Older series.
(b.) Later series, dolerites.
(3.) Sedimentary rocks.
(4.) Superficial deposits.

Taking the area as a whole, considerable difficulties present themselves in the mapping of these rock types, as is generally the case on the Eastern fields, but more particularly so in this area, as the greater portion of the surface is not only masked by superficial deposits but often by dense scrub.

In the granite areas the overlying debris is chiefly sand or loam with not infrequent patches of siliceous and less common ferruginous laterites.

These deposits are derived from the disintegration of the granite itself, the breaking up of the remnants of a once extensive sedimentary deposit and, in a lesser degree, to the waste from the massive greenstones and recent dolerite dykes. In consequence, many

square miles of the surface present nothing else to the observer than sand-plains, with very occasional outcrops of granite, and more rarely, isolated patches of highly altered sedimentaries.

In addition, except where bush fires have lent a helping hand, much of the surface—and this applies to the greenstone areas as well—is overgrown with thick scrub matted with fallen timber and vines. These surface conditions, together with the scarcity of water, the abundance of poison plants, etc., make the accurate mapping of this area extremely difficult, and only possible by prolonged work and an expensive and complete outfit.

The boundaries, as delineated on Plate V., must, therefore, only be taken in a broad sense and as a reconnaissance survey only.

SUPERFICIAL DEPOSITS.

Scattered almost universally over the underlying rocks is a mantle of debris varying in thickness from a few inches to several feet; the composition of which varies almost as much, if not more, than the thickness.

Typical sections, however, often show the upper layers to be loose, incoherent sand and ironstone nodules overlying a mixture of sand and loam, in which are numerous rock fragments. Still deeper the mixture is often cemented with a hard compact conglomerate rock, the cementing material being either lime and iron oxides or silica, or a combination of all. In other instances, clay beds have been cut under the overlying sand, which, being impervious to water, are found extremely useful in the formation of water reservoirs. A less frequent covering are the ferruginous and siliceous laterites, the latter, as a general rule, being indicative of underlying granite.

There is little doubt that the lake beds are built up to a considerable depth with recent deposits, but there was no opportunity of studying their composition. The upper layers are composed of very fine sediment impregnated with magnesium and sodium chlorides, and in which gypsum is commonly found.

Scattered through the sand-plains are numerous small belts of red soil. It seems more than probable that these patches are derived from the washing away of basic dykes, the dykes being probably dolerites of a later age than the granites. This is certainly the case in some instances.

SEDIMENTARY ROCKS.

With two exceptions the rocks of this class are only represented by scattered remnants.

After leaving Cheriton's, as already related, the greenstone belt ceases and the country opens out into more or less undulating plains, with occasional rises and granite knobs to break the monotony.

On the higher ground it is not at all uncommon to find remnants of rocks resembling in many lithological details the beds of sedimentary origin found in the Parker's Range and Marvel Loch, which have been fully described in a previous report.*

It has been found impossible to map these isolated patches in detail, but general boundaries have been fixed to embrace that portion of the surface where such outcrops predominate.†

South of Mount Holland, however, a belt of this class of rock is fairly well defined and continuous, and extends to the west of Mid Ironcap.

Another well-defined belt, and probably a continuation of the first, extends further south with the same strike, but with a reversed dip through both the Mid and South Ironcaps.

On the three "Ironcaps" which form the highest points of the district, portions of these beds are well exposed. In each instance they are found to consist of well-banded quartzites; in most instances highly ferruginous.

The iron occurs in the form of limonite and haematite. In places the beds are decidedly magnetic.

Folding in the strata is of common occurrence. The strike varies from north to north by west or east with a dip at a high angle to the west in the southern belt, but slightly to the east at north Ironcap, and also near Mt. Holland.

It seems probable that these beds form the southern continuation of the series found in the mid and northern portions of the Yilgarn Goldfield, and may be related to the Stirling Range beds.

As regards their age, there is no doubt in the writer's mind that they are older than the greenstones and have been intruded by the latter. Hence they are probably the oldest rocks of the district. From an absence of fossil remains their geological age is not determinable, but they are probably Pre-Cambrian.

From an economic point of view they are, so far, of no value, as they do not carry minerals of commercial value and have not proved to include auriferous quartz veins, or carry self-contained gold in payable quantities.

GREENSTONES.

These are readily divisible into two classes:—

A. A massive variety of the Marvel Loch type.

B. Dolerites.

A. *Massive Greenstones.*—Where exposed, in the areas under immediate review, the rocks of the massive variety are found in the foliated, massive fine-grained and massive coarse-grained forms, the first usually occurring as a selvedge to the two latter.

There is such a close similiarity of these types to those of the Bullfinch-Southern Cross-Marvel Loch that a detailed description

* Bulletin 63, page 29, *et seq.*
† Plate V.

is unnecessary here, as the reader can refer to the previous pages of the present bulletin, and also Bulletin 63 for further details.

B. *Dolerites.*—Numerous intrusive dykes of an apparently fresh rock are met with in the working of the Forrestania field. Further reference will be made to these dykes in the descriptions of the mine workings. Petrological examinations of samples broken from the rock in the underground workings are to be found in the Appendices.

GRANITES.

In mapping the granite, as a general rule, any area covered with sand or siliceous laterite was included under this class of rock. The granite rock itself comparatively seldom comes to the surface, and, when it does, usually occurs in irregular masses outcropping on the crests of the higher ground, forming in many instances a conspicuous landmark. Specimens taken from some of these masses have been described by the Petrologist, and in each case have proved to be microcline biotite granite, closely resembling the granite of the Southern Cross type. (See appendices.)

In the Forrestania area the main rock mass is a granite highly decomposed near the surface. The rock, even in this weathered condition, has a distinctly gneissic appearance, the planes of foliation apparently running east and west with a general dip to the north.

Descriptions of the Mining Centres in the Southern Area.

XV.—FORRESTANIA.

The following report was made on 27th July, 1915:—

Location.—The new field is situated in the extreme south of the Yilgarn Goldfield at a distance of eight miles north 60 degrees east from the Mid Ironcap, and 13 miles due east of the 95-mile post on the Rabbit Proof Fence.

ROADS.

There are two main tracks leading to the field from the Eastern Railway. Of these, the better is the one passing through Parker's Range, Cheriton's, and Mount Holland. This track is in fair order as far as Cheriton's, and though cleared of timber is very rough for general traffic for the remainder of the distance. The other route turns off the Rabbit Proof Fence from either the 79 or 88 mile post. The one followed was the former, and it is extremely heavy as far as Wattle rock, where the other from the 88 mile joins. From here the route passes by the north Ironcap and connects with the Ravensthorpe track about five miles to the north of the Government Tank. The road down the fence is very heavy, the sand having filled in the wheel ruts during the recent wet season.

From Southern Cross by the first route the total distance is 108 miles, and by the Rabbit Proof Fence 124 miles to the Central leases. A somewhat shorter route from the railway line would be from Yelladine, a railway siding 20 miles east of Southern Cross.

GEOLOGY OF THE FIELD.

The leases are situated in granitic country, apparently a portion of the main granite belt. Unfortunately, the underlying rocks are almost completely covered with an overburden of sand and ferruginous gravel, but there are sufficient outcrops of the decomposed rock to verify the above statement. Lying to the north-west of the lease is rather an extensive belt of greenstone of the Marvel Loch type and, probably, a continuation of the same belt. Another small belt of similar rock outcrops about four miles south of the Reward lease.

LEASES.

Unfortunately, very little development work has been done on any of the leases and, to date, only one reef can be positively said to exist.

The indications from quartz floaters, however, would point to the possibility of other veins being exposed at an early date. There is a marked parallelism of the fine lines of floaters, the general strike being north 70 degrees west.

On account of the parallelism it seems more than likely that the granite will be found to be gneissic in character, the quartz veins following the planes of foliation.

On the Reward lease two costeans, about 200 feet apart, reveal a reef at least seven feet wide in one place, and three feet in the western end.

The floaters extend over a distance of some 700 feet. Carefully broken samples of the reef exposed in these costeans gave a result in each case of slightly under 3 dwts. of fine gold per ton.

Samples from the floaters on the Premier, Commonwealth, Potosi, and Allen's Find were crushed and panned off in the field, and the stone was found to be gold-bearing, but, in the writer's opinion, the values obtained were low, and scarcely payable. It seems probable that higher values than justifiable have been given by prospectors on account of the low value of the gold not being taken into account. This should be guarded against in the future. Taken as a whole, the reports of the field have been very much exaggerated, and against such the people should be warned. On the other hand, gold has been found over an extensive area in new country and, as practically no development has been done, the expenditure of a limited amount of capital is justifiable.

WATER SUPPLY.

Both tracks are supplied with water at intervals sufficiently short to accommodate the travelling public. Appended is a list of the supplies and distances. The main supply for the field itself would be obtained from a Government tank, 20,000 gallons capacity, on the Ravensthorpe road, and situated about six or seven miles, as the crow flies, from the leases. At present there is no direct route, and the distance by a bush track is at least 10 miles. Owing to the late rains surface soak water is being obtained in shallow holes in the sand close to the leases. This supply should be exploited further, as little expense would be entailed, and, if successful, would be extremely useful to augment the permanent supply. With economy, there would be sufficient water to prove whether the field warrants further permanent water conservation. A justifiable expense would be incurred in cutting a direct track from the Government tank to the leases, and it would undoubtedly be much appreciated if the track from Cheriton's to the field was cleared of mallee roots and stumps.

The following is a list of water tanks, etc., with distances from Southern Cross to the new find:—

——	Distance in miles.	Nature of Supply.
Southern Cross to Marvel Loch	22	Scheme water.
Marvel Loch to Parker's Range	14	Parker's Range Government tank. Dingo tank, 50,000 gals., full.
Parker's Range to Dulcie Jean	10	Dulcie Jean tank, 50,000 gals., full.
Dulcie Jean to Split Rock ..	16	Split Rock well, 8,000 gals., not permanent in summer.
Split Rock to Mount Holland ..	16½	Mount Holland tank, 12,000 gals.; 6,000 gals. at present.
Mount Holland to Government tank, five miles north of turn off W. the field	20	Government tank, 100,000 gals., full.

On the Rabbit Proof Fence there is sufficient water (surface) at the rocks marked on accompanying plan for travellers, but such is not permanent during the summer months.

MINES.

Since the above report was written a limited amount of mining development has been done to a vertical depth below the surface not exceeding 60 feet. A detailed account of the individual mines will be found in the following pages of this report under the heading of Mines.

Geologically there are a few points of interest brought to light which were not too apparent at the surface. In the first place the country rock has proved to be a highly kaolinised rock, through which are distributed quartz veins of uniform size having the appearance of primary quartz. Fine grains of mica are also common throughout, though apparently this is only the residual of a much greater amount. There seems no doubt as to the rock being a highly kaolinised biotite granite. Lines of foliation in the rock mass, which are not always too apparent, tend to point to a more or less original gneissic structure. In several of the mines narrow basic dykes were encountered. So far these have been proved to have no great thickness and, as a general rule, conform with the prevailing strike of the reefs and lines of foliation in the granite, *i.e.*, a general east and west trend with a prevailing dip to the north. The occurrence of these dykes and their relationship to the granite and quartz reefs is clearly set out in Figs. 23, 24, 25, and 26.

The following are two petrological descriptions of samples collected from the basic dykes found in the Reward and Commonwealth leases:—

REWARD LEASE, G.M.L. 2909.

The rock is a fine-grained amphibolite derived from a dolerite or fine-grained gabbro, and is similar to specimens from the Canning River bores, and consequently to some of the Darling Range greenstones. It is not, however, the same rock as the Corinthian dyke, which is a fresh augite dolerite, and probably later in age.*

COMMONWEALTH MINE, G.M.L. 2916.

The rock is a fine-grained, partially chloritised amphibolite with the hornblende in great excess over the colourless constituents. These consist of felspar and a little quartz. Shearing was not noticed in the sections nor any gneissic structure. It is doubtless derived from a fine-grained dolerite similar to sample from the Reward lease.*

With regard to the quartz reefs, as can be observed from the description of the individual mines, they have so far proved, under existing conditions, to be unpayable as gold producers; also, as a general rule where opened out, they have proved to be smaller and of lower grade at depth than at or near the surface.

Furthermore, that where payable values have been formed at a depth the gold occurred near faults which points to the higher values being probably due to secondary enrichment.

Development work has also shown in several instances that the quartz bodies are apparently much larger at the surface than in the solid country below. This is particularly noticeable in Smith's, G.M.L. 2970, and the Great Southern No. 1, G.M.L. 2911.

Careful observation shows this is apparently due to the disintegration of the original reef outcrop and the accumulation and burying of the debris. "Surface creep" probably played an active part also in this concentration of the quartz in the surface rock.

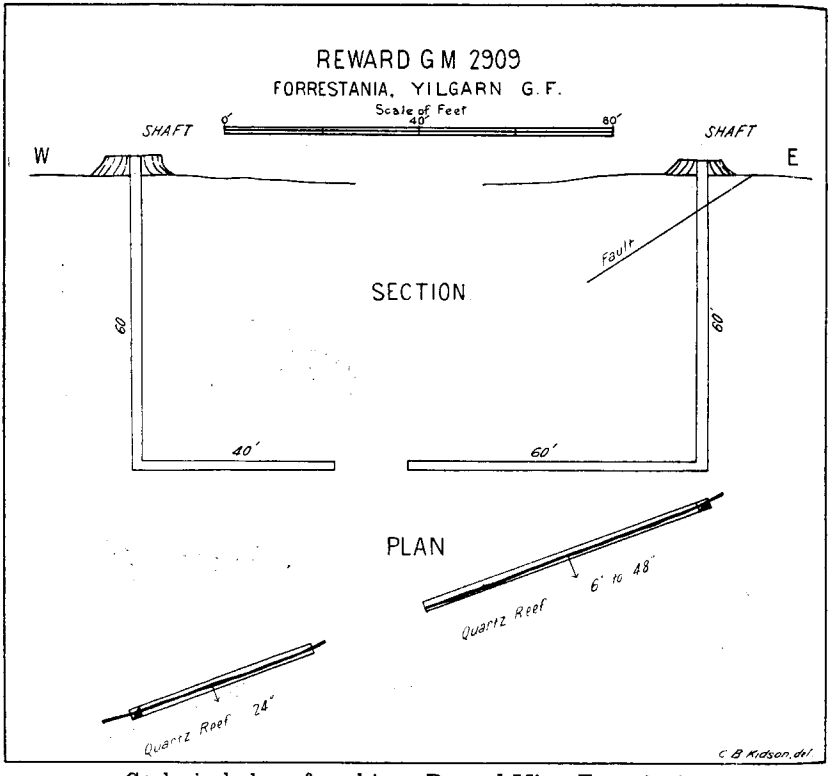
* R. A. Farquharson, Petrologist.

REWARD MINE, G.M.L. 2909.

Two shafts (Fig. 23) situated approximately in the centre of the lease and 400 feet apart, have been sunk to vertical depths of 60 feet.

The western shaft was sunk on the reef which has an average thickness of about two feet. A drive east for 40 feet on the reef

Fig. 23.



Geological plan of workings, Reward Mine, Forrestania.

proved the reef to be continuous for this distance with approximately the same thickness, but reported low-grade values.

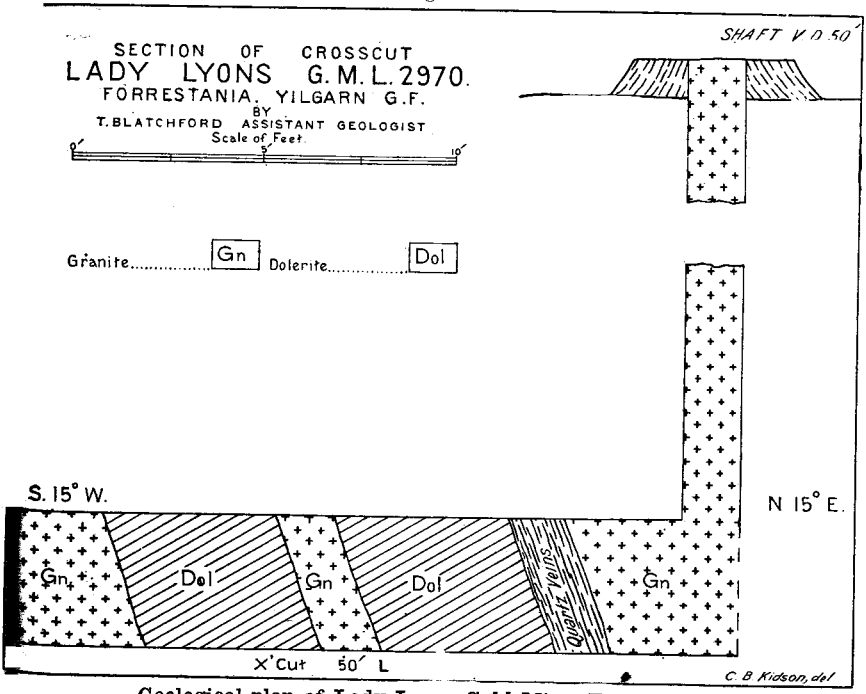
The western shaft intersected the reef at a depth of 33 feet and passed through same at the bottom of the shaft. A drive has been made on the footwall of the reef 40 feet west. From this drive, boreholes pierced the reef at regular intervals, and the manager informed me that the average thickness of the reef varied from six inches to four feet, with low gold values. At the bottom of the shaft the reef is probably six feet thick at least. Twenty feet down the shaft the reef has been intersected on the south side of the shaft. At this

point the reef is faulted; the fault plane dips to the south-west. Above this fault gold values are higher. Insufficient work had been done to take exact measurement of the precise amount of faulting, but it is evident the reef has been moved only an inconsiderable distance.

On the surface immediately east of the east shaft the outcrop has been costeaned and some of the stone contains coarse, visible gold, the extent of which is uncertain; probably it will be found to have some connection with the fault which could easily come up about this point, and, if so, the increased gold value may be secondary enrichment only. The outcrop north and south of this point certainly does not contain high or even payable values.

The strike of the reef on the surface is north 70deg. west with an underlie at a steep angle to the north.

Fig. 24.



Geological plan of Lady Lyons Gold Mine, Forrestania.

LADY LYONS MINE, G.M.L. 2970.

This mine was formerly known as Smith's show.

On the surface there is no doubt that floaters could be picked up which would yield appreciable amounts of gold when concentrated by crushing and by panning off with water.

However, a shaft was sunk (Fig. 24) and a crosscut driven south for a distance of 30 feet. with the result as shown on section.

The occurrence of the dolerite dykes in this crosscut are interesting, and clearly show that their strike corresponds to the prevailing strike of the quartz reefs, or, in other words, that there is a prevailing parallelism of the two. Comparing the two rocks, the dolerite and granite, there is a marked difference in their relative decomposition. For the most part the dolerite may be considered only partially weathered, the weathering becoming perceptibly less as greater depths are attained. On the other hand, the granite is highly decomposed and still friable to the touch of even the hand, and shows no sign of becoming harder and massive. There is no doubt in the writer's mind that the dolerites are intrusive and of a much later age than the granite, also that the quartz reefs are associated with the occurrence of the greenstone intrusives and are of later age than the prevailing quartz reefs of other portions of the Yilgarn Goldfield. Furthermore, in this and other mines the quartz veins are seen to occur in the granite and near the junction of the dyke and running parallel with the latter rock.

In no instance was there any indication of the dolerite dykes attaining any great thickness, the two in this mine being approximately nine feet each.

GREAT SOUTHERN No. 1 MINE, G.M.L. 2911.

One shaft (Fig. 25) has been sunk on this lease to a vertical depth of 50 feet, from the bottom of which a crosscut has been driven in for a distance of eight feet south. In the end of the crosscut the reef was intersected, also a dolerite dyke. The reef is at the junction of the dyke and the country rock pierced by the shaft, which is highly decomposed granite. Drives were made four feet east and six feet west on the course of this reef. The thickness of the reef intersected is but a few inches and is unpayable. On the surface the reef had every appearance of considerable size and gave promising gold prospects.

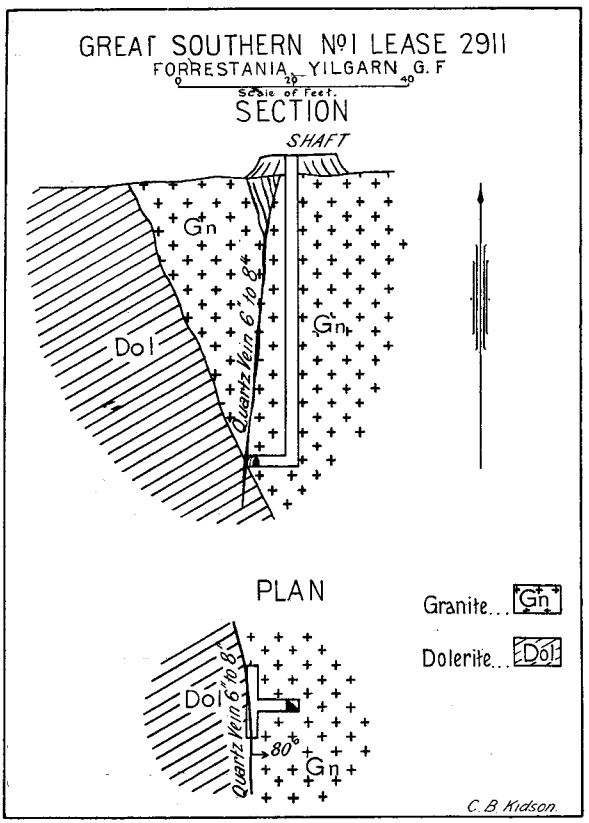
COMMONWEALTH MINE, G.M.L. 2916.

As may be observed on the accompanying plan and section (Fig. 26), development work on this lease has been carried on from two shafts at vertical depths of 60 feet.

Taking the western shaft first, crosscuts were made from the bottom of the shaft 15 feet north and south. In the northern crosscut a greenstone dyke was pierced but no lode found. In the southern crosscut a small vein of quartz was found at the end of the crosscut, and on the junction between the greenstone dyke and granite. The reef was too small and too low in gold contents to be of any commercial value.

In the eastern shaft the country pierced was granite, and a crosscut south 40 feet in length revealed the same rock for the whole distance. If the line of "floaters" on the surface were indications of a permanent reef it should have been, under normal conditions, intersected in these workings.

Fig. 25.



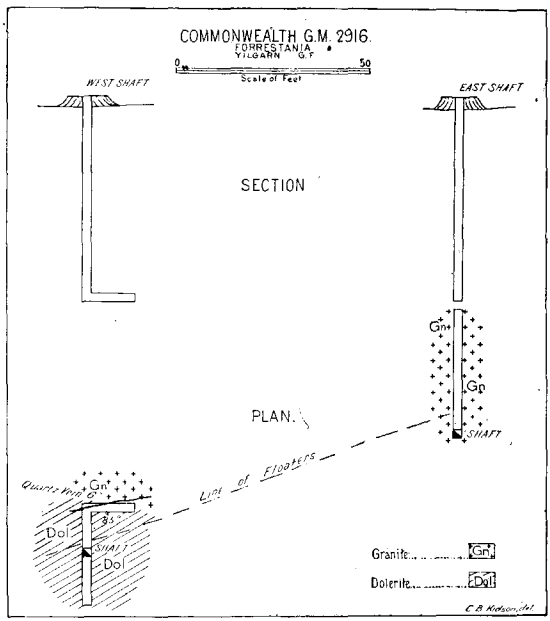
Geological plan of Great Southern Gold Mine, Forrestania.

PREMIER MINE, G.M.L. 2913.

Only a limited amount of prospecting has been done on this lease. Except for a few very shallow costeans, the development consists of one shaft at present eleven feet deep, where it is boarded over. The total depth is a few feet greater than this. This shaft has been sunk on the reef, which is much broken up near the sur-

face. At the depth of eleven feet it was covered over and a small drive made on the west side. There is apparently a fissure in the reef at this point, which pitches to the west at a fairly low angle. Out of this small drive, which runs north 60deg. west, a crushing of five tons was taken which gave a reported result of 13dwts. of gold per ton, the exact value of which was not stated. In the face of the drive above-mentioned the quartz had a thickness of at least three feet.

Fig. 26.



Geological plan of Commonwealth Gold Mine, Forrestania.

The country rock on the south side is granite, but that on the north side is doubtful, the rock here being too decomposed for a definite determination.

BLACK PRINCE MINE, G.M.L. 2961.

Only one shaft has been sunk, on a reef some two feet wide, to a vertical depth of 11 feet. At the bottom of this shaft the reef was 20 inches thick. A sample of the reef broken from the sides of the shaft returned 10dwts. to the ton by fire assay, over a width of 20 inches. The strike of the reef is north 70deg. west with an underlie of 85deg. north.

Since the date of my inspection the owner told me that they had continued the shaft and the reef had become smaller and the values lower.

Near the surface the owners proved that payable gold occurs in the seamy portions of the reef. These seams consist of almost pure clay with a little iron intermixed. The gold in the seams is inclined to be of a coarse nature and readily separates from the gangue. Hence, in taking samples from the bottom of the shaft there is a likelihood of the sample being enriched from the gold loosened from the clay by repeated firing.

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PART B.

MOUNT JACKSON AND MARDA CENTRES.

By

C. S. HONMAN, B.M.E.

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I.—INTRODUCTION.

The field work in this region was commenced towards the end of July, 1914, and continued until the end of January, 1915. The area mapped and described below covers about 4,500 square miles; includes the country between the Mt. Jackson-Southern Cross road and the Rabbit-Proof Fence from the 35-mile to the 126-mile post on the latter; and between Mt. Jackson and the eastern boundary of the Yilgarn Goldfield, including Pigeon Rock, the Die Harty and Bungalbin Ranges.

The mining centres of Jackson, Marda, Koolyanobbing, and Yarbu have been examined in greater detail than the intervening tracts of country.

I am indebted to Mr. Simpson for the determination of a number of minerals and Mr. Farquharson for the petrological examination of rock specimens, also to the mine managers and prospectors of the district for facilitating in every possible way the examination of their mines and claims.

Mr. Woodward has previously reported on this area on a reconnaissance trip through the North Yilgarn and southern portion of the North Coolgardie Goldfield, which he describes in Bulletin 46. The broad outlines of Mr. Woodward's mapping of the district was of great assistance as a basis for the more detailed work described in this report.

Except for the mining districts of Jackson and Marda the mapping has been done on a scale of 300 chains to the inch and reproduced on a scale of four miles to the inch. (Plate 1.)

Greater detail is shown on the maps of the Jackson and Marda mining centres for which a scale of 20 chains to the inch has been used in the field. They are reproduced herewith (Plates 17 and 18) on that scale.

A number of plans and cross-sections of the various mines accompany this report.

The usual difficulties which attend field mapping in the Eastern Goldfields, viz., relative scarcity of outcrops and the large extent of overburden represented by sand plains and salt lake country, were encountered in this district.

The geology of the district is of more than ordinary scientific interest on account of the occurrence of a group of sedimentary

rocks of younger age than the greenstone series, and resting unconformably on the latter. Owing to the strong lithological resemblance of these younger rocks to the Kurrawang Series in the Kalgoorlie district, it follows that an unconformity exists also in the latter district where, owing to the parallelism of the strike of all the rocks, no unconformity is actually visible.

II.—PHYSICAL FEATURES.

TOPOGRAPHY.

The topography of the region is typical of the Eastern Goldfields of Western Australia, and is that of a tract of country whose surface has been sculptured by a process of desert erosion. (See Plate 17.)

This area belongs to the topographical division described by Mr. Jutson in his work on the Physiography of Western Australia, Bulletin 61, as the Central or Salt Lake Division which, according to that author, is an elevated plateau of arid erosion.

The land forms in this region, as is generally the case in the Eastern Goldfields area, are not very diverse.

By far the most prominent land marks are the greenstone ranges at Mt. Jackson, around Pigeon Rock, Bungalbin, and at Koolyanobbing. These constitute the "higher land." Below this there is a vast tract of country which may generally be described as "sandy plain," and in the depressions of which occur strings of large salt lakes.

The "sandy plains" occupy by far the greatest area of the whole country.

Mr. Jutson has subdivided the Central or Salt Lake Division into a "new" and "old" plateau, which are chiefly divided from one another by breakaways of which the long line running east and west about 15 miles south of the Mt. Jackson ranges is an instance.

In the Mt. Jackson district the higher land attains an elevation of many hundreds of feet above the old plateau and probably represents the remnants of a still older land surface.

Whilst the higher land appears to be representative of an earlier cycle of erosion on the "old plateau," the salt lakes represent on the other hand, a later cycle of erosion on the new plateau, or a wide valley of mature erosion on the new plateau. (Fig. 27.)

There are several levels of breakaways though not as well defined as the main line that separates the old and new plateaux. For instance, there are cases of breakaways on the higher portions of the granite country. These are very disconnected and local and often below the level of large granite bosses. These higher level breakaways are probably the remnants af an older system of breakaways. This is very clearly shown by the mapping between Kalgoorlie and Coolgardie* where the new line of breakaways borders

* Bull. No. 56.—The Geology of country between Coolgardie and Kalgoorlie, by C. S. Honman.

the lake, and remnants of the old line occur some miles behind the former.

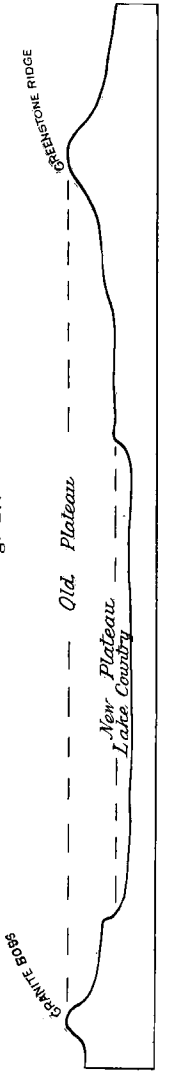


Fig. 27. Diagrammatic section showing relation of old and new plateau.

The highest country is that around Pigeon Rock from which there is a decided fall to the south-west to the lakes at Yacke Yackine. This high country falls again to the north towards Lake

Barlee and apparently forms a dividing range between the Barlee and Southern Cross Lake system.

The ranges have a sinuous course corresponding with the trend of the ferruginous quartzites (Jaspers) in the greenstone series, and in fact owe their existence to the resistance to weathering offered by the quartzites.

When one considers that all the prominent peaks and ranges are composed of combs of ferruginous quartzites (Jaspers), it becomes evident what a very marked effect these banded quartzites have had on the natural relief of the region.

The ranges consist of razor-backed ridges which practically envelope the inlier of granite at Pigeon Rocks and are there known as the Die Harty Ranges. The northern portion of these ranges strikes north, and to the south divides into two arms, one trending to the south-east and culminating in a prominent peak called Mt. King; the other arm to the west crosses the greenstone belt south of Pigeon Rock and turns again to the south and follows the western boundary of the greenstone through Jackson.

At Jackson a number of parallel bands of ferruginous quartzite occur forming parallel ridges which turn again to the east-south-east, and passing south of Marda as one ridge, where its highest point is Mount Jackson Trigonometrical Station (2,200 feet by aneroid).

From Mt. Jackson Trigonometrical Station the range continues for over 20 miles to Bungalbin Trigonometrical Station, where it forms a group of steep ridges turning abruptly to the north-east.

The slopes of these ranges are steep, and rise from a gently undulating plateau of greenstone, which at no considerable distance from the ridges passes into sand plain which stretches as far as the eye can see, and whose monotony is only emphasised by the strings of salt lakes in the lower parts of the sand plains. When approached from the south the Bungalbin Ranges have a very imposing and rugged appearance.

The ranges around Pigeon Rock and the Mt. Jackson-Bungalbin range constitute in every sense of the term a "Divide" separating the Barlee lakes from the lakes of the Yilgarn. It may be termed the "Jackson Dividing Plateau."

Another range of mountains also corresponding with the ferruginous quartzites (jaspers) in a greenstone belt occurs striking north-west through Koolyanobbing Trigonometrical Station, which is, if not the highest, the most rugged peak in the range. The Koolyanobbing Ranges, as has been pointed out by Mr. Woodward,* occur in an area of depression, and are partially surrounded by salt lakes.

A characteristic and frequently occurring feature of the granite table-lands which occupy the north-west portion of the Yilgarn

* Bulletin 46, G.S.W.A., p. 20.

are the large bosses of bare granite, which have a very imposing appearance, and in some cases represent monadnocks of an earlier cycle of errosion on the old plateau. Examples of such bosses are Pigeon Rock, Elachbutting, Kurrakoppin, Walyahmoning, Barcooting, and many others, especially along the Rabbit Proof Fence.

The salt lakes form a connected drainage system with an irregular trend, and agree in this connection with Professor Gregory's idea of their being a dead river system. The direction of fall of the lakes is not certain without levels being taken; the main course being probably Lake Seabrook, which meanders about the Koolyanobbing ranges and connects with Lake Deborah, which has forced its way through the greenstone ranges just above Mt. Woodward, and is connected with Lake Brown.

Yacke Yackine Lake has a southerly trend, and has its source near Windarling Peak, at the foot of the Die Harty Ranges. It breaks through the Mt. Jackson ridges near Athlone and turns to the south past Yacke Yackine, where it spreads itself to the east and, finally taking a southerly course, joins the main line of lakes at Lake Deborah.

A line of lake connects the Koolyanobbing lakes (Lake Seabrook) to Lake Koorkordine at Southern Cross, and the latter falls slightly to the north-east, as proved by a topographical survey of Southern Cross.

The lowest level of the lakes is a little over 1,000 feet, and the highest peaks around Pigeon Rock, according to aneroid measurements, are not higher than 2,500 feet above sea-level. The majority of the country is a great undulating plain, varying in elevation between 1,000 feet and 1,500 feet above sea-level.

VEGETATION.

The vegetation of this country may be divided into two classes, according as it occurs on the north or south side of the Jackson Dividing Plateau. Thus we have two different types of vegetation.

(1) The Yilgarn or Coolgardie Type. South of Jackson.

(2) The Barlee Type. North of Jackson.

The Yilgarn or Coolgardie Type.—South of the Jackson Dividing Plateau the vegetation may be roughly subdivided into three groups, according as it grows on:—

(1) Greenstone country.

(2) Granite country.

(3) Lake country.

On the greenstone country we find different varieties of gum trees, viz., morrell gum, salmon gum, gimlet-wood, with an undergrowth of salt bush and stunted shrubs.

On the granite country there occurs mostly dense thickets of the jam-wood type, with patches of white gums and mallee on the higher portions.

On the lake country there is a comparative absence of the extensive salt-bush flats that characterise the Barlee country, and they become more scarce the farther south you go.

The timber country is much closer to the lake shore. Samphire is commonly found along the lake margins.

South of the divide large forests of good timber occur, whereas north the only timber is mulga and mallee.

The Barlee Type.—North of the Jackson Dividing Plateau the vegetation may also be roughly subdivided into the same three groups, but each having different characteristics to the corresponding groups north of the Plateau.

On the greenstone country we find mulga and an absence of gum trees of any description.

On the granite country, spinifex and mallee scrub. A species of desert pine is found growing on both greenstone and granite country, but is most abundant on the sandhills at the edges of the lake country.

On the lake country there is generally a fringe of samphire bush in immediate proximity to the dry salt lakes. This is followed by wide flats of salt bush, with occasional patches of quandong or native peach and sandalwood extending sometimes for a couple of miles inland from the lake shore. Outside the salt bush you find sandhills covered with desert pines and then, as the lake country is left behind, spinifex and mallee or mulga, according as the underlying rock is granite or greenstone.

Sandalwood is fairly evenly distributed on both types of country, though it is more noticeable around the dry lakes north of the divide.

WATER SUPPLY AND TRACKS.

The average annual rainfall of this region is below ten inches, and the scarcity of water is one of the great drawbacks that the prospector and pastoralist have to contend with.

There is no permanent natural water supply in the district. The pioneer had to depend on the catchments in rock holes of small capacity and hastily dug soaks.

These difficulties have been overcome as far as Jackson and Marda are concerned by the splendid work of the Water Supply Department by the building of large tanks in suitable catchment areas.

These artificial supplies are large earthen tanks dug in suitable position to catch the drainage from a group of hills, or are blown out of solid rock at the foot of large bosses of granite which serve as splendid natural catchments, supplying very clear water.

At Marda there is a tank roofed with galvanised iron and having a capacity of 500,000 gallons of water. The tank is excavated in decomposed greenstone and lined with asphalt. The catchment area is protected by three miles of fencing.

Along the Bullfinch-Jackson Road there are tanks at Golden Valley (30 miles from Southern Cross), 40,000 gallons; the 40-mile post small tank, blown out of granite; Ennuin, 200,000 gallons;

Fig. 28. Photo: C. S. Honman. Neg. 1351.

Clay pan filled after heavy rain—three miles south-east of Koolyanobbing.

Trough Well (48M.), small tank in granite; Currajong (61½M.), 200,000 gallons; Yacke Yackine (75½M.), 123,000 gallons; and at Jackson (85M.), 250,000 gallons. All these tanks are lined, roofed, provided with pump and trough, and the catchments protected by fencing.

The new track to Jackson is shorter than the surveyed road, but this is discounted by the much heavier and more sandy nature of the track and the scarcity of water, the only dependable supply being at the Native Well about 28 miles south of Jackson, which is a roofed, excavated tank in granite of 3,500 gallons capacity. Glasse's Well, which is about five miles to the north-west, is a shallow stone-lined well at the foot of a flat granite rock.

The surveyed road is, however, an excellent track, except a sandy stretch beyond Golden Valley, and one beyond Currajong.

From Jackson there are two tracks to Marda—one to the Government tank, and one at Allen's Find.

From both Jackson and Marda there are tracks to Pigeon Rock, where there is a permanent well.

All the tracks and water-holes are marked on the accompanying map (Plate 17).

From Marda an old track goes out to the north-east to Mulline through Chalarie Rocks (small gnamma hole) and Dooling Soak. From Pigeon Rock there is also a track to Chalarie Rocks, through Olby Rock (three covered rock holes).

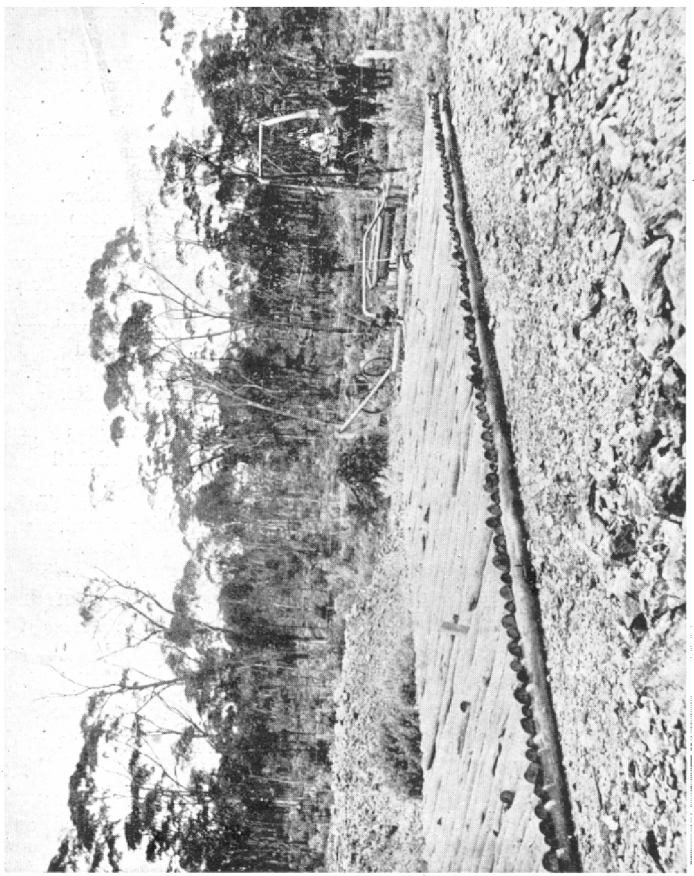


Fig. 29. Government tank north of Koolyanobbing. Photo: C. S. Honman. Neg. 1352.

From Ennuin a very old track goes through the Native Well and passes to the north of Bungalbin towards Mulline.

At Koolyanobbing there is a covered and cemented tank of 50,000 gallons capacity (Fig. 29).

III.—GENERAL GEOLOGY.

The rocks of this country may be roughly divided into three series, viz., granite and greenstones, and sedimentary, and by far the greater portion of the area is represented by granite. With the exception of the superficial deposits of sand, laterite, and alluvium, all the rocks have so far proved destitute of fossil remains, and for that reason, and their lithological resemblance to certain rocks in other parts of the world, they are at present classed as of Pre-Cambrian age. They belong to the same age as all the Eastern Goldfields rocks, and can be classified on the same lines.

The general succession is as follows:-

Recent			Superficial	Laterite.
				Alluvium.
				Dry Lake deposits.
Pre-Cambrian (Proterozoic)	Greenstone Series		Kurrawang Series	Conglomerates.
				Sandstone.
				Slates.
		Intrusive		Newer Granite.
				Pegmatite.
				Porphyry.
				Amphibolite.
		Sedimentary		Ferruginous quartzite (Jasper)
		Volcanic	Acid	Rhyolite Porphyry.
				Rhyolite Porphyry Breccia.
				Quartz Porphyry.
			Basic	Carbonated Ultra-basic rock.
				Amphibolite.
				Dolerite.
				Fine-grained gabbro.
				Amygdaloidal Dolerite.
				Ophite and Tuffs.
Archæozoic				Older Granite and gneiss.

Generally, the rocks of the area are composed of an ancient granite complex, containing remnants of a volcanic series which probably originally covered the whole area. Tremendous orogenic movements resulted in severe folding and consequent tilting.

By denudation the geo-anticlinal portions of the volcanic rocks were worn away and the synclinal portions left as remnants in deep folds of the granite complex. The pressures generated by the orogenic movement have resulted in the formation of plutonic granite masses, which have imposed thermal metamorphic effects upon the dynamic metamorphism of the volcanic series.

The volcanic series was originally composed of horizontal sheets of lavas and tuffs, both of acid and basic composition.

The tilted beds have been squeezed and metamorphosed to such an extent as to appear from a superficial examination to be com-

posed of a solid mass of amphibolite and dolerite. Intercalated in the volcanic series are beds of sediments, laid down conformably with the former, probably during a period of volcanic quiescence. These sediments have been, of course, tilted with the rest of the rocks, and are now represented by almost vertically banded ferruginous quartzites.

In the Jackson greenstone belt the amphibolites appear to occupy the margins adjoining the granite, and have probably been formed from volcanic rocks similar to the dolerites and gabbros of Marda, by contact metamorphism.

IV.—DESCRIPTIVE GEOLOGY.

Treating the different rocks individually in their historical order, the first to be described should be the ancient basement which is probably now represented by the many scattered outcrops of gneiss and gneissic granite. The plutonic granite, being of later origin and formed by the absorption of the gneissic basement, will be treated later.

GNEISS AND GRANITE (ARCHÆOZOIC).

The gneiss is most usually found close to the boundaries of the greenstone and forms a border round the greenstone belts, separating the more massive granite from the greenstone. But it is undoubtedly true that the former has in many places broken through the barrier of gneiss and invaded the greenstone, as can be clearly seen around the Koolyanobbing Ranges, where a number of granite dykes occur in the greenstone. On the western contact of the Koolyanobbing greenstone belt the gneissic border can be distinctly seen outcropping about 1½ miles south of Chadwick's Reward Claim. Here the gneiss contains the oval remains of felspars, which look like stretched pebbles in a conglomerate. But the gneissic bands can be seen bending round the felspar giving them a typical eye structure. It has probably been formed by the crushing of a coarsely porphyritic granite.

On the east of the range there is also a fairly wide development of gneiss, some miles in width. To the south-west of Jackson numbers of the large granite bosses have a banded structure, which is parallel to the usual north-north-west strike of the rocks of the Eastern Goldfields.

At Elachbutting Rock alternating bands of coarse and fine-grained granite succeed one another. The coarse bands contain porphyritic crystals of felspar, with their longer axes parallel to the strike of the bands. They have a rough bedded appearance.

The best outcrop of distinctly fundamental gneissic granite showing distinct sharp bands of different texture and giving a banded appearance, suggestive of a sedimentary origin, occurs at the Native Well on the new Southern Cross-Mt. Jackson track. This

outcrop is in a direct line with the western contact of the Koolyanobbing Range, and of the western elbow of the Jackson greenstones belt, which also has a margin of gneiss. As opposed to a sedimentary origin for the gneiss it is possible that the banded and gneissic structure has been produced in plutonic granite by lateral pressure, in which case the "eyes" of felspar in the gneiss at Koolyanobbing are accounted for by the foliation of a coarse porphyritic granite.

The large masses of plutonic granite now represented by the frequently occurring bosses and tors and covering large tracts of country were probably formed by the absorption of the gneiss.

GREENSTONE SERIES.

Basic Volcanic Rocks.—Generally speaking the basic volcanic rocks are composed of massive dolerites and fine-grained gabbros, or massive to schistose amphibolites, according as they occur away from or close to the granite contact.

Three belts of greenstone occur in the area, viz.:—

(1.) Extending from Diemels and Die Harty Ranges through Jackson, where a bend in the belt occurs, and passing through the Bungalbin Ranges to the eastern boundary of the Yilgarn Goldfield.

(2.) Embracing the Koolyanobbing Ranges.

(3.) The Ennuin belt, which does not extend beyond 10 miles north of Currajong. Taking the Jackson belt as typical, and which has been examined more particularly, it is described below in detail.

The Dolerites in the Jackson belt are fine-grained, massive rocks and cover large tracts of country. The following is a description by Mr. Farquharson of typical specimens:—

[13914.] Country rock from the Butcher Bird Mine. A somewhat dull, greyish-green, fine-grained rock with a yellowish tinge in the more decomposed portions and showing minute reflecting surfaces and dull green spots.

In section the rock is in great part opaque, grey granular with short and long columnar and platy crystals of a colourless mineral, with high refractive index and birefringence, and referable mostly, if not wholly, to colourless epidote. There are also pale green patches enclosing aggregates of epidote plates, with somewhat opaque rims, occasional curious greyish patches resembling kaolinised felspars, and dark-walled almost skeletal crystals, of which the walls are in great part composed of chloritic scales or with associated epidote. Some greenish grey granular patches usually opaque, and white by incident light, also occur.

In polarised light, the slide is almost wholly of uniform low birefringence. There are, however, occasional short and columnar crystals,

some of which are epidote, others probably epidote but closely resmbling augite, since optical extinction was indefinite; there are many small plates and platy aggregates of almost colourless epidote and zoisite, occasional areas of almost isotropic chloritic material with associated epidote, in columnar form representing either felspar or augite (probably the latter). There are, moreover, platy crystals of low birefringence which are felspar, and in places can be seen thin columnar or broad lath-shaped and quite opaque crystals projecting into shapeless areas of clear quartz and referable with little doubt to remains of felspar crystals similar to those in some altered dolerites. The alteration of the felspars appears in part to result in the production of kaolin, in part of epidote, but is in all cases sub-microscopical. The forms seen seem to indicate a kind of ophitic (sub-ophitic) structure in the rock. There are some shapeless areas of clear interstitial quartz.

Most curious of all, however, are occasional areas of greyish clear material, which in polarised light and with high powers proves to be distinctly spherulitic in places. There are in some instances clear quartz crystals even with pointed ends and with straight uniform lines in the interior of these areas, and round them is a rim of clear fibrous plates, the plates set at right angles to the rim; beyond these occur either isolated spherulites with well-marked radial extinction, or small aggregates of them in the greyish mass. This latter seems in places to give rise to spherulitic aggregates. In any case, it is not isotropic, but distinctly depolarises and exhibits a wavy extinction. The spherulites and the fibrous fringe, as well as the whole greyish mass, indicate that the mineral is chalcedony and is not a glass. Now chalcedony can appear as an original constituent of the ground-mass of very siliceous-prophyritic eruptive rocks or as a decomposition product in all kinds of rocks. It is unlikely, seeing that interstitial quartz occurs in the rock, that it is original, though it is fairly prevalent in small areas in the rock slide. On the other hand, if it is secondary, there must have been cavities in the rock-mass in which it could have been formed and in which the enclosed quartz crystals could have been produced (probably by the action of alkaline silicate solutions). It would appear, then, that either the rock has been subjected to great leaching and decomposition, or has been of a vesicular nature, and the vesicles have become filled. The rock betrays marked evidence of alteration, chemical and mineralogical. The presence of epidote, of chlorite, the loss of much of the optical effects in the slide, and the opacity of the felspars all evidence the alteration, so that the rock in any case is largely the product of decomposition. The sub-ophite structure noticeable in places suggests a dolerite origin. The rock is, in its altered form, difficult to name, but it appears to be most probably an epidotised and chloritised basic igneous rock, probably originally a dolerite.

[13913.] Between the Marda dam and the Standard Mine.

An exceedingly fine-grained dark-green rock.

In ordinary light there are numerous small imperfect rods of a green slightly pleochroic scaly mineral and grains of iron ores, in an almost clear but slightly greyish granular mass. In polarised light, the greenish forms are seen to consist mostly of isotropic chlorite associated often with much granular epidote and occasionally with granular calcite. They have the appearance of the columnar felspars that have been partially or wholly chloritised and epidotised, for in some cases portions of the original felspar substance still remain. In addition, there are some indefinitely columnar and platy felspar forms, with characters, however, much obscured. Grains of epidote and calcite are scattered

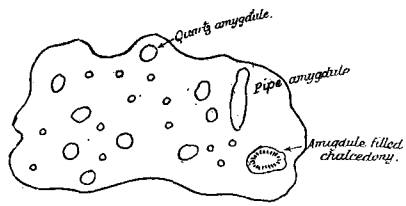
all over the slide, and some shapeless plates of quartz are identifiable. The character of some of the larger greenish chloritic forms suggests an origin for them from hornblende or augite. The rock is much weathered, and indefinitely characterised both mineralogically and structurally, but an indistinct ophitic structure appears to be present.

The rock is classed as a fine-grained chloritised dolerite.

The specimens submitted were as fresh as could be obtained. The determinations, however, sufficiently establish them as dolerite and one as an amygdaloidal dolerite.

The amygdaloidal structure is plainly visible in hand specimens in the field, the amygdules being now filled with quartz. These quartz fillings weather out as perfectly rounded pebbles. The amygdules vary in size from almost microscopic size up to ¼ inch in diameter. The amygdaloidal structure is visible in both the acid and basic rocks. Of the basic amygdaloids the best outcrops are in the vicinity of the Butcher Bird Mine, and the acid representatives occur between Bulgine and Mt. Jackson Trigonometrical Stations. (See Fig. 30.)

Fig. 30.



Showing vesicular structure in decomposed porphyry near Mount Jackson Trig.

A specimen of greenstone from south of the Butcher Bird mine has been described by Mr. Farquharson as a porphyritic vesicular basalt or augite andesite. This rock contains radial spherulitic chorlite, which is a typical component of a vesicular lava flow. An extensive development of this rock may be traced between the more acid lavas and the dolerite, and probably represents a transition from basic to acid flows.

Another interesting variety of the greenstone occurs east of the Marda tank. This has in places a peculiar pisolitic structure and weathers with a roughened spherulitically pitted surface. The size of the spherules are uniform in individual specimens, but vary at different places from pea-size up to ½ inch in diameter. This rock is probably a variolite or ophite and resembles rocks of volcanic

origin in the Lake Superior region in America, which are named "ophites" by the Michigan Geological Survey and "variolites" by the United States Geological Survey.

The following is a description of a specimen of tuff associated with the ophites examined microscopically by Mr. Farquharson.

[13938.] Surface outcrops between the Marda Tank and the Standard Mine.

Specimens vary from a minutely grained almost flinty type with small rounded quartz nodules, through a nodular flinty type to a coarse-grained greenish-grey but still almost aphanitic rock.

In section, the rock proves much too weathered for definite determination, having been altered by exposure as a capping, but a few points can be made out. It appears to be of fragmental origin. There are small angular pieces of kaolinised felspar, grains of epidote occurring sporadically and in aggregates, opaque grey granular forms of doubtful character but in part chloritic and kaolinic, small grains of quartz—in one case almost hexagonal—and occasional peculiar rounded concretionary forms. In places are what appears to be the remains of large completely weathered crystals. There is an almost uniform low birefringence throughout the slide almost amounting to isotropism. In the finer grained type the slide is a minutely grained yellowish-grey mass of almost isotropic character; but here and there, especially in the nodular variety, are rounded quartz patches resembling quartz vesicles, and occasional angular or fragmental patches of quartzose mosaic which probably represent completely weathered felspar fragments. The nodular variety also exhibits strings of yellowish green chloritic material sometimes surrounding smaller nodular forms.

The structure of the rocks is very indefinite, due to advanced alteration, but it appears to be of fragmental origin, and is put down with doubt as a much altered, fine-grained volcanic tuff.

Between Marda and Jackson and to the north of Curragibbin Trigonometrical Station the greenstones are more basic. In hand specimens they are a fine-grained dark green rock which under the microscope is seen to be a gabbro or basic dolerite. This has the same field relations as the amygdaloidal dolerite and is probably a more basic variety of the same volcanic series.

CARBONATED ULTRA-BASIC ROCK.

In the Great Unknown Mine at Marda the country rock is a carbonated rock which corresponds in composition with a peridotite. The carbonated peridotites of Kalgoorlie have been so far recognised as being of intrusive origin. The presence in the carbonated rock at Marda of a banded quartzite cannot, however, be reconciled to an intrusive origin for this rock, especially as a shear zone in the rock is later than the banded quartzite. Owing to the sedimentary origin for the quartzites put forward later this carbonated rock is apparently interbedded with a volcanic sediment (viz., banded quartzite), and therefore must be a volcanic rock itself, therefore a carbonated ultra-basic lava flow. This view I think is most consistent with all the facts discovered in the district.

An analysis of the country rock of the Great Unknown Mine and the shear zone in which the quartz occurs gives the following composition:—

	(1.)	(2.)
SiO_2	41·95	33·04
Al_2O_3	7·05	8·63
Fe_2O_3	·31	·29
FeO	11·22	13·22
MnO	·26	·16
MgO	16·97	14·99
CaO	·64	·77
Na_2O	·10	·14
K_2O	·83	·76
H_2O —	·06	·08
H_2O +	3·66	3·49
TiO_2	·32	·71
CO_2	16·20	13·07
P_2O_5	·15	·10
FeS_2	·09	10·21
Cr_2O_3	·34	·18
V_2O_3	trace	·01
C	*Nil*	·12
	100·15	99·97
Sp. Gr.	2·91	3·09
Analyst	E. S. Simpson	H. Bowley.

(1.) G.S.M. $\frac{1}{60}$. G.S.L. 6761D.—Country rock of Great Unknown, Marda.

(2,) G.S.M. $\frac{1}{77}$. G.S.L. 6762D.—Shear zone of Great Unknown, Marda.

The presence of chromite is confirmed by the analysis giving .34 per cent. of Cr_2O_3.

Amphibolite.—At Jackson all the country rock with the exception of the quartzites and ferruginous quartzites (jaspers) is composed of fine-grained amphibolite of varying textures, the coarsest being in the minority and of medium grain.

The amphibolites at Jackson have the same field relations to the ferruginous quartzites (jaspers) as the dolerites have at Marda. The quartzites are less contorted and more ferruginous than at Marda.

Owing to their proximity to the granite to the west, their relations to the banded ferruginous quartzites (jaspers) and their variation in texture, the amphibolites are most probably derivatives of the dolerites by metamorphic action and uralitisation. There is no evidence of an intrusive origin for the amphibolites.

ACID VOLCANIC ROCKS.

These consist of different kinds of porphyry, which vary from fine-grained almost felsitic porphyry to a coarse-grained rhyolite porphyry.

Three developments of porphyry occur at Marda, one on the northern boundary of the greenstone (see Fig. 31); one on Allen's Find; and one in the Mt. Jackson ranges.

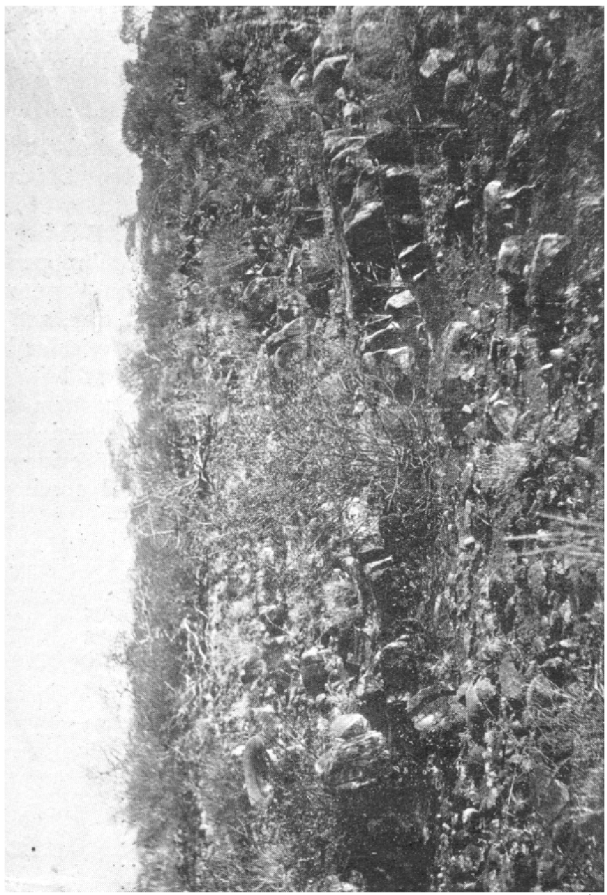


Fig. 31. Photo: C. S. Honman. Neg. 1355.
Outcrop of rhyolite porphyry north of Butcher Bird Gold Mine.

The northern occurrence consists of a large development of rhyolite porphyry which is in places decidedly fragmentary, and which changes to the north into a pink felspar porphyry very similar to the felspar porphyry at Binduli near Kalgoorlie.

At Allen's Find the country rock is very decomposed and its composition is not clear, though it is an acid rock of some description and contains remains of porphyritic felspar.

The southern occurrence of porphyry outcrops three miles south of the Marda Tank, and is of much more limited development than the northern occurrence. This porphyry is almost felsitic,

showing faint outlines of felspar phenocrysts, and also rounded phenocrysts of quartz. In hand specimens it is a pale pink colour to almost white. Interbedded in it there occur a number of parallel bands of ferruginous quartzite (jasper) similar in every respect to the quartzites in the basic series, and striking parallel with them. This is significant as correlating the porphyry with the basic volcanic rocks and placing them also as volcanic rocks, viz., acid lavas. This is supported by the fragmental bands in the Rhyolitic porphyry north of the Butcher Bird No. 1

Associated with the southern band of porphyry in a gully between Bulgine and Mount Jackson Trigonometrical Stations, there occurs a decomposed rock which has the appearance of being derived from, and is on the same strike, as the felsitic porphyry on the southern slope and summit of Bulgine Trigonometrical Station. This decomposed rock contains perfectly round inclusions of quartz which in distribution and appearance are similar to the vesicles formed in a lava flow, or slag, and have exactly similar characteristics as the vesicles in the vesicular basalt near the Butcher Bird. Some of the cavities instead of being completely filled with quartz, have a concentric ring of quartz with a hollow centre, the growth of quartz being from the periphery of the cavity inwards as in Fig. 30, which is distinct evidence of amygdaloidal structure. An analysis of a weathered specimen of the felsitic porphyry gives the following results:—

G.S.M. $\frac{1}{6^{2}}$, G.S.L. 6763D.

SiO_2	81·00	80·05
Al_2O_3	15·09	9·73
Fe_2O_3	0·25	1·72
FeO	0·20	0·18
MgO	0·10	*Nil*
CaO	*Nil*	0·83
Na_2O	0·04	2·19
K_2O	0·14	4·43
TiO_2	0·61	..
P_2O_5	0·07	..
CO_2	*Nil*	..
SO_3	trace	..
MnO	*Nil*	..
H_2O —	0·20	..
H_2O +	2·92	..
	100·62	

Analyst: .. .. D. G. Murray.

(1.) Weathered felsite porphyry from Creek between Bulgine and Mount Jackson Trigonometrical Stations.

(2.) Quartz porphyry Mount Haughton, Michigan, U.S.A.

Although No. 1 specimen from Marda is much weathered, it can be seen that its composition is sufficiently close to No. 2 (an

undoubted felsite porphyry of effusive origin) to establish its identity as such, especially with supporting field evidence.

This is important on account of the amygdules only being found in the weathered rock. The low percentage of soda and potash in the Marda rock (No. 1) may easily be accounted for by weathering. It is therefore evident that these rocks represent a series of acid amygdaloids, lavas and tuffs.

The rhyolite porphyry, of which there is a prominent outcrop north of the Butcher Bird Mine, is a dark bluish-grey rock showing numerous white phenocrysts of felspar in a dark aphanitic ground mass. In places it is a distinct breccia which is, however, never very coarse. On weathered surfaces the fragmental character of certain bands is obvious.

About four miles north of Marda, on the Pigeon Rock track, there is another bold outcrop of a banded rhyolite porphyry with a selvage of black glassy rhyolite. In hand specimens it looks like a black chert, but its field relations place it as a phase of the rhyolite porphyry.

An analysis of the rhyolite porphyry gives the rock the following composition:—

G.S.M. $\frac{1}{59}$. G.S.L. 6760D.—Rhyolite porphyry 20 chains north of the Butcher Bird Mine.

SiO_2	69·93
Al_2O_3	13·92
Fe_2O_3	1·04
FeO	2·80
MnO	·26
MgO	1·02
CaO	2·21
Na_2O	3·87
K_2O	3·18
H_2O —	·04
H_2O +	1·16
TiO_2	·28
CO_2	·16
P_2O_5	·15
FeS_2	·02
	100·04
Sp., Gr.	2·72
Analyst	E. S. Simpson.

Unfortunately, owing to the scarcity of outcrops and exposures of dips, no measurements of the lava beds and dips can be given, though the dips of the jaspers should correspond with them.

The dips are, however, roughly vertical in the southern porphyry and owing to the much greater horizontal distribution of the

northern porphyry the dips of the latter are probably fairly shallow.

FERRUGINOUS QUARTZITES (JASPERS).

The ferruginous quartzites occur exclusively in the greenstone series and appear to be interbedded with fine-grained greenstones and felsite porphyry. These rocks are locally known as "jaspers" by miners and prospectors.

Their extensive and continuous distribution in the greenstone belts is brought out by the mapping shown on Plate I. This shows only the most prominent exposures and there are many minor exposures which, owing to the broad nature of the work, could not be delineated.

The most prominent exposures are in the Die Harty Ranges, east of Pigeon Rock, at Jackson and Marda, and at Bungalbin. Exposures can be traced between these points and are sufficient to show the complete continuity of the bands.

The "Jaspers" also form a backbone to the Koolyanobbing and Ennuin greenstone belts.

Dips are determinable in most of the outcrops and show the steep angle at which the rocks are tilted, the lowest recorded dip being 35deg. east at Athlone, where an anticlinal formation can be seen about a mile north of the workings. Around Pigeon Rock the dips are mostly to the west at varying angles; at Mt. King to the west; the Die Harty ranges and Windarling Peak to the south; at Jackson to the east with a much gentler dip; and at Marda the beds are almost vertical with a general inclination to the north. They appear, therefore, to form a huge syncline pitching to the east.

The quartzites are in all cases extremely evenly banded and considerably contorted in places (Figs. 32 and 33). They are composed of alternating bands of ferruginous and quartzose material. The ferruginous bands are composed of hematite and magnetite in varying proportions and sometimes limonite. In hand specimens they are composed of alternating bands of light and dark colour, varying from bluish-black, through all shades of red to white (Fig. 33).

Three chief varieties occur according to which coloured bands predominate—

(1) Blue-black banded variety;

(2) Red banded variety;

(3) White banded variety.

The blue-black and white banded varieties are most prominently represented near the granite contacts at Jackson and around the inlier at Pigeon Rock.

Photo: R. H. Irwin. Neg. 1321.

Fig. 32.

Contorted Jasper, ½ mile west of Great Unknown Gold Mine, Marda.

Photo: R. H. Irwin. Neg. 1322.

Fig. 33.

Contorted Jasper, ½ mile west of Great Unknown Gold Mine, Marda.

The red banded variety, which commonly has a brilliant vermilion hue, occurs at Marda and Bungalbin where huge cliffs showing several hundreds of feet of vermilion quartzites occur among the ranges.

There is a cherty variety of "Jasper" which is not evenly banded, but appears to be a secondary deposition of quartz along cracks and fissures in the contorted banded rock. This cherty material is often accompanied by quartz veinlets.

The ferruginous quartzites (jaspers) of Marda are apparently of sedimentary origin. But rocks of similar character have, in other districts, been described as shear zones in greenstone, and in the southern portion of the Yilgarn Goldfield, Mr. Blatchford favours such an origin for certain ferruginous quartzites occurring there. These, however, according to Mr. Blatchford's report * have characters distinct from the Marda quartzites.

The siliceous and ferruginous character of the quartzites in general is probably of secondary origin and such an impregnation would be found to occur both along lines of shearing or schistose zones and sedimentary beds; in fact, along any rock capable of providing a free circulation for underground waters. If such is the case the resulting rock, whether an impregnated shear zone, schist or sediment, would be hard to distinguish in hand specimens.

The banding of the Marda quartzites (jaspers), however, appears to me to be too uniform and regular to be caused by shearing or schistosity, and has a strong resemblance to that of sedimentary beds, both in appearance and structure, for example, the anticline occurring north of the Athlone leases. Their contact with both the massive and schistose greenstones is invariably perfectly sharp, especially at Marda. At Jackson, however, when a schistose wall occurs it sometimes has an appearance of being either a schist impregnated with iron oxides or *vice versa,* a ferruginous quartzite impregnated with hornblende.

The Marda quartzites have also been subjected to all the dynamic forces that have acted on the greenstones, such as fissuring and shearing. In the Great Unknown mine at Marda a shear zone in the greenstone actually passes through the banded quartzite, and has formed a shear breccia composed of fragments of banded quartzites.

The following chief characteristics of the Marda "Jaspers" strongly suggest that they are of sedimentary origin:—

(1.) The remarkable and persistent evenness of the banding, many hundreds of feet in thickness, more even than known shear zones and just as even as any series of sediments.

* Bull. No. 63.—The Geology and Mineral Resource of South Yilgarn, by T. Blatchford.

(2.) The proved continuous occurrence of the evenly banded structure for 70 miles in length in the greenstone belt, and perhaps much longer. This is a structure undoubtedly produced by sedimentation, a process which takes place under such uniform conditions as would produce a great persistence of even banding.

(3.) Variation in dip from 30deg. to vertical and the presence of anticlinal folds.

(4.) The association with volcanic rocks at Marda with which they are interbedded. It would be most unusual to have a big development of volcanic rocks without sediments of some kind interbedded with them. The ferruginous character of the quartzites would be consistent with volcanic sediments as indicating an original basic composition.

(5.) If the "Jaspers" represented shear zones then owing to their great length they could only have been formed by regional movements. In which case it would be only reasonable to expect to find an equivalent effect on some of the gneisses and granites which are devoid of anything approaching a similar character. But the porphyries in the greenstone series which have a very similar chemical composition to granite do contain banded quartzites.

(6.) Distortion, faulting and brecciation of the quartzites by the same earth movements which have formed shear zones in a direction across their strike showing that the quartzites existed before the shear zones were formed in the rocks.

(7.) The general ferruginous character of the beds would be accounted for by the basic composition that volcanic sediments usually have when associated with basic volcanics. It is interesting to note that the quartzites occurring in the porphyries are non-ferruginous, which is consistent with the above views.

The other belts of greenstone have not been examined in the same detail as the Jackson belt, but generally they are composed of fine-grained greenstone and jasper.

The Koolyanobbing belt is about five miles wide and over 30 miles long striking in a north-west direction. It is characterised by the usual hard backbone of ferruginous quartzites which form prominent ridges for its whole length.

INTRUSIVES.

The intrusives at Marda are made conspicuous by their absence. In fact away from the granite contact no decided intrusive rocks were met with, unless some of the coarse amphibolite outcrops represent later intrusive masses, but, unfortunately, no field evidence could be found of the relation of such isolated coarse-grained amphibolite to the fine-grained greenstone.

In the old Mt. Jackson Proprietary workings at the 100ft. level there occurs what appears to be a coarse amphibolite dyke, but owing to the decomposed nature of the ground its relations were not clear. Not having well-defined walls it might be a coarser phase of the fine-grained amphibolite.

In the greenstone belts I saw no undoubted intrusive dykes of dolerites; all the dolerite outcrops seemed to be part of the volcanic series.

In the granite country, however, opposite the 60-Mile post on the Rabbit Proof Fence and about one mile on the south of Geeranning Rock, a dyke of fine-grained dolerite, about two chains wide, strikes almost east and west across the track from Elachbutting. At the southern foot of Geeranning Rock another dyke occurs, also striking east and west, composed of a coarse-grained amphibolised gabbro. This has fine-grained margins and an epidotised phase on one side. They were the only basic dykes met with in the granite areas.

Near the granite contact intrusives of pegmatite and granite are of frequent occurrence, and in most cases have a strike parallel with the contact. Near the northern contact of Koolyanobbing greenstone there are numerous granite intrusions, which have an irregular trend and of considerable width in places. It is on the contact of one of these granite intrusions that the reefs of the Rainbow leases occur (see plate), and in the greenstone schists into which the granite is intrusive there are bands of felsitic porphyry associated with the quartz reefs.

On the north-east contact of Koolyanobbing Range there are many intrusive dykes of granite, also east of Mt. King, and south of Mount Jackson.

THE KURRAWANG SERIES.

The rocks of the series which is correlated with that at Kurrawang rest unconformably on the ancient greenstones, and are composed exclusively of slates, quartzites, and conglomerates of different grades and textures. These beds are sporadically, though widely, distributed over the greenstone belts, and represent remnants of a series that once covered a much greater area.

The chief exposures are on the northern fall of the Mt. Jackson Range at Marda (see Fig. 34), and north of Marda running east and west from the 14-Mile on the Ularring Road, through the old Sweet William, and thence between Allen's Find and the Great Unknown. Not sufficient outcrops occur to correlate the individual beds of the series. Isolated outcrops show one class of bed exposed

at a time, and therefore no accurate section can be drawn of the series.

Fig. 34.

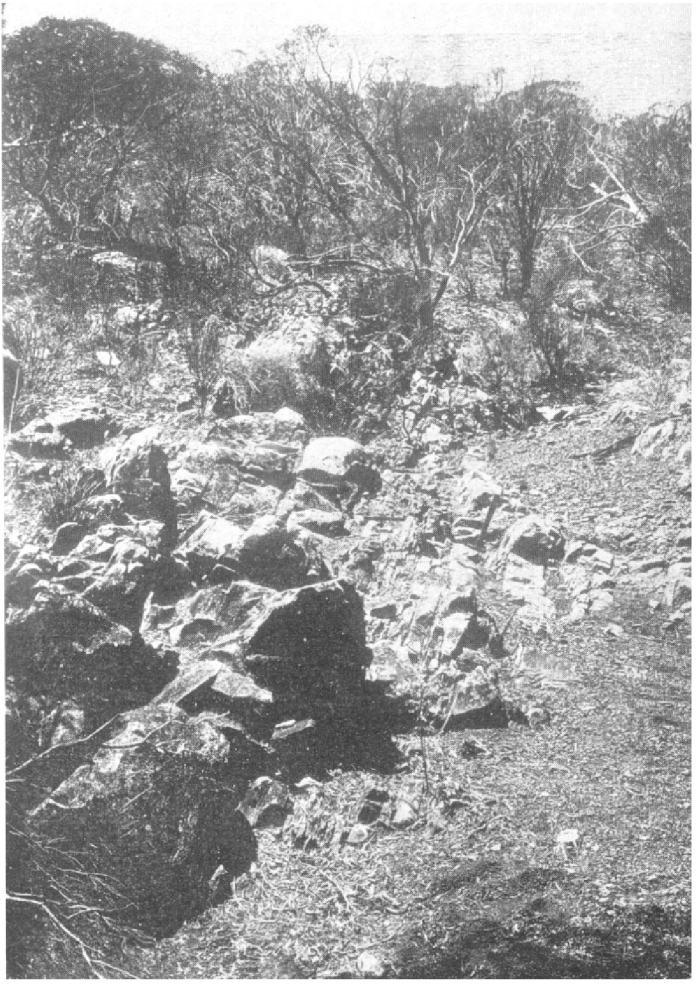
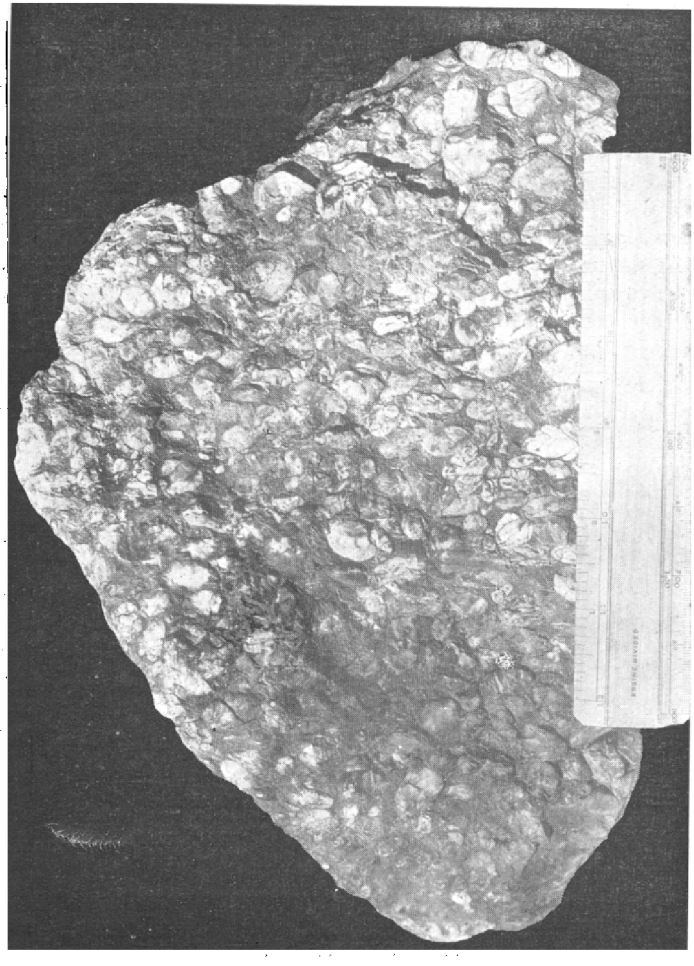


Photo: T. Blatchford. Neg. 1323.

Sediments in creek between Bulgine and Mount Jackson Trigs.

But it is certain that it consists of alternating beds of conglomerates (see Fig. 35), sandstones, and slates. Other outcrops occur on Victoria Trigonometrical Station at Jackson. In a pre-

liminary statement, written for the annual report of 1914, the Victoria Trig. outcrop was correlated with the banded quartzites outcropping around it, but later researches show that these beds belong to the Kurrawang series and are resting on the quartzites (Jaspers). Their association with the older quartzites is merely a coincidence.



Neg. 1304.

Photo: T. Blatchford.

Specimen of conglomerate from south of Allen's Find.

This outcrop shows distinct current bedding. Their strike is north-east and they are sheared in a north-west direction. In hand specimen it is compacted friable quartzite. The following is a description by Mr. Farquharson:—

[13939.] Victoria Trig., west of Jackson Townsite:—

A quartz rock varying from white in colour to yellowish white, and in hand specimen consisting of angular or irregularly banded grains of quartz. The yellowish variety has a somewhat friable structure.

In section, the rock consists of large and small interlocking and irregularly outlined grains of quartz, the boundaries clearly marked by dust particles, and with a small amount of silicious cement developed. The structure of the rock is that of an Itacolumite, and the rock is a quartzite formed from loose grains of quartz compacted by pressure and to a certain extent by development of secondary quartz. It is of clastic origin.

Another outcrop very similar to that at Victoria Trig., but of coarser grain, occurs 2¾ miles north-east of Buddarning Trigonometrical Station. This is probably a continuation of the Marda occurrence.

West of Pigeon Rock, there is a belt of conglomerates striking in a north-west direction. This can be seen outcropping on the Yarbu track and on a hill to the east-north-east of Yarbu. In the latter place the adjoining bands of sediments are very much indurated and are in places impregnated with tourmaline.

At the northern extremity of the Ennuin belt of greenstone and about five miles north of Currajong there is an outcrop of indurated sandstone that greatly resembles the current bedded rock at Victoria Trig., and probably representing another outlier of the Kurrawang series.

The proof of unconformity is based on the following facts:—

(1.) Presence in the conglomerates of pebbles of banded quartzite and vermilion quartzites (Jaspers) and of quartz porphyry, which are identical with the rocks of the greenstone series.

(2.) Great lithological difference between the beds of the two series.

(3.) Actual exposure of the younger series resting on the upturned edges of the older series with the beds of either series dipping in opposite directions. This can be seen on the western spur of the Bulgine Trigonometrical Station, three miles south of Marda Tank.

These beds have been undoubtedly laid down in running water, the pebbles being well rounded and such as would be found in the lower reaches of a large river.

An analysis of a quartzite from the creek bed between the Mt. Jackson and Bulgine Trigonometrical Stations shows the following composition:—

G.S.L. 7470D.

SiO_2	86·96
Al_2O_3	10·24
Fe_2O_3	·82
CaO	trace
MgO	·09
H_2O+	1·96
H_2O-	·06
	100·13
Sp. Gr.	2·65
Analyst	H. Bowley.

The conglomerates at Marda are not crushed like those at Kurrawang, near Kalgoorlie. This is probably owing to their occurring in a zone in which the older series strikes east and west, and so offers sufficient resistance to protect the later series from shearing forces.

Both Messrs. Maitland and Blatchford, who made an inspection of the area towards the end of the field season, were struck with the resemblance of the conglomerates to the Nullagine series in the Pilbara Goldfield.

In the Kurrawang series some interesting nodules occur, which are chiefly spherical in shape and reach up to three inches in diameter. They are mostly composed of flinty material and have apparently grown from a nucleus. There are also concretions of calcite which take most fantastic shapes, and have a form so symmetrical as to suggest their derivation from fossil remains. These flint and calcite nodules occur near the contact of the older and younger rocks and in the younger series.

RECENT DEPOSITS.

The superficial deposits consist of the laterite cappings to the more decomposed portions of the rocks of the highlands and plateaux. The highest portions of the ranges consist of hard, unweathered rock, while the laterite chiefly covers the foothills of the greenstone ridges, and large areas of the granite plateau.

Amongst the ranges there are extensive deposits of alluvium, and the plains are covered with sand for many square miles without the sign of an outcrop.

It is not known to what depth the alluvium extends in the lake country. It is probable, however, except where the lakes hug the greenstone belts that many hundreds of feet of alluvium exist. Close to the ranges the lakes are shallow, bed rock often corresponding with the surface of the lake. This is probably due to the migration of lakes described by Mr. Jutson,* and only extends for a short distance from the shore towards which the lake migrates.

No deep leads or auriferous alluvial patches have been discovered in the Jackson District, though there is no reason why they should not exist.

V.—STRUCTURAL GEOLOGY.

FOLDING.

The broader structural features of the district are brought out by an accurate delineation of the ferruginous quartzites (jaspers), showing the dips of the beds where possible. This shows that there are a series of closely compacted folds where the dips are very steep. At Athlone, Buddarning, and Windarling

* Bulletin 61, G.S.,W.A., p. 156.

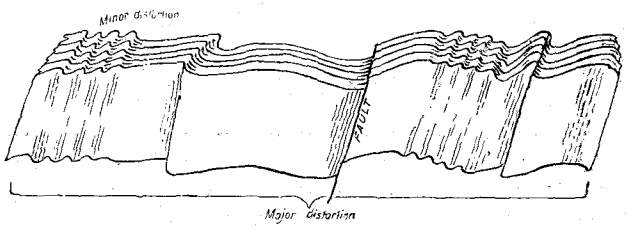
Peak the dips are from 35° to 45°, showing that the folding was less intense inside this area. At Wundarling Peak the rocks dip to the south, and at Athlone and Buddarning to the north-east, hence forming a syncline pitching to the south-east. North of Pigeon Rocks shallow dips are again recorded dipping to the west, showing that the beds are less tilted in that locality also.

DISTORTION.

The jaspers have been distorted by pressure exerted parallel to their strike. This effect is always greater when the beds strike east and west than when they strike north and south. This distortion takes place on a large scale, resulting in a sinuous course being given to the beds over some miles along their strike. This is accompanied by fracturing and faulting. On a minor scale the distortion can be seen even in hand specimens (see Figs. 32 and 33).

The following diagram is a rough representation of the distortion in the ridge of Jaspers at Marda on a number of leases known as the Bergoose Group (Fig. 36).

Fig. 36.



Diagrammatic sketch of contortions in the Bergoose jaspers, Marda.

FAULTING.

Major faulting has taken place at Marda, and a series of major steps faults appear to have taken place at Koolyanobbing.

At Marda the principal major fault passes through a break in the greenstone ridges east of the 10-mile soak on the new Southern Cross track. This break is in line with the course of the undoubted rupture in the Mt. Jackson ranges passing through Boondine to the south-west of Mt. Jackson Trigonometrical Station. Further, this is in the same line as a break in the Rhyolite Porphyry west of the Butcher Bird Mine. Owing to a shortening of the width of the greenstone west of the fault line and a displacement of the south-dipping Jaspers to the south the fault is probably an overthrust from the west. This would result in a narrowing of the synclines

and a widening of anticlines west of the fault line, which is what actually occurs (Fig. 37).

Fig. 37. Photo: C. S. Honman. Neg. 1353.
Contorted jasper half mile west of the Great Unknown Gold Mine, Marda.

Faulting on a minor scale is very common in the whole field (see Fig. 37), some very good instances of step faulting occurring at Jackson, where a quartz reef can be seen faulted twice with a total displacement of 58 feet within a distance of one chain.

Of the minor faults, two kinds are observable:—

(1) Reversed Dip Faults striking north-east and at right angles to the schistose structure of the region.

(2) Strike faults parallel to the schistosity. The latter type of faulting is not easily seen, as the fault plane becomes confused with planes of shearing. It is generally accompanied by slickensiding.

In the two principal mining centres of the district the structural features are quite distinct, chiefly owing—

(a) to the difference in strike of the rocks in the two centres, and

(b) to the greater metamorphism that has occurred at Jackson, owing to its proximity to the granite contact.

Since the rocks at Marda strike practically at right angles to the shearing and foliating forces, they have been protected to a great extent from those forces and still retain their original structures, but the strains set up have resulted in the formation of an irregular system of fractures.

At Jackson, owing to the line of least resistance, viz., the bedding, corresponding with planes along which shearing and foliation took place, the fissuring has had a longitudinal trend not very far from parallel with strike of the schists.

SHEARING AND FOLIATION

is characteristic of the country close to the granite contact, but towards the centre of the belts the schistose structure is practically absent, except for local shear zones such as occur in the Great Unknown Mine.

PLANES OF PARTING (HEADS)

are very well defined in the Marda rocks, large blocks of stone being easily separated from the massive greenstones owing to the presence of two well-defined series of parting planes.

VI.—ECONOMIC GEOLOGY.

GOLD.

Although the discovery of gold at Jackson was first officially reported as late as 1894, this centre is situated only 40 miles north of Ennuin, where Mr. Harry Anstey's party in 1887 made the first sensational discovery of the precious metal in the eastern goldfields of Western Australia.

The official report on Jackson showed that in October, 1894, two mines had started operations, and that the Nil Desperandum had 150 tons of ore at grass from a number of reefs on which an incline shaft of 46 feet deep and 60° underlay, and a vertical shaft 72 feet deep, had been sunk. These are probably the original workings of the Mt. Jackson Gold Mines, Ltd. One mile north of the Nil Desperandum the Victoria gold mine had a main shaft down 70 feet on an easterly dipping reef, besides three prospecting shafts, and had 50 tons of ore at grass.

At the end of 1895 an official report stated that a new centre had been opened up at Mt. Jackson, and that a battery was in the course of erection. In that year it supported a population of 60 people.

Warden Victor Black, in 1896, reported that the development at Mt. Jackson had been remarkable, and that the population had reached 120 people. In that year a new track was cut from Southern Cross to Jackson.

A quiet year was experienced at Jackson in 1897, though crushings were averaging over an ounce to the ton. For reasons not stated the work was temporarily suspended in 1900, and exemption granted the following year. In 1902 the mines were reported to be again working vigorously, and consistent returns were obtained until 1907, from when mining has been almost extinct.

A revival took place in the district in 1910 following on the discovery of payable reefs 10 miles east of Jackson, at Marda, since when, in spite of poor crushing facilities and other difficulties attendant on its isolated position, Marda has supported a number of prospecting parties who have met with varying degrees of success. Some of the shows now opened up show great promise.

Jackson and Marda, though both occurring in the same belt of greenstones, are essentially different in geological characteristics. In both centres the ore deposits may be divided into—

(1) Quartz reefs,

(2) Ferruginous quartzite lodes.

By far the most important are the quartz reefs, on the successful working of which the future prosperity of the field will depend. At Jackson the country rock is almost universally composed of amphibolite schist striking north-north-west, and the quartz reefs appear to follow definite trend lines.

At Marda the country rock consists of massive volcanics ranging from quartz porphyries to dolerites and ultra-basic rocks, whose strike is almost east and west, and in which the reefs have no regularity in strike or dip.

JACKSON CENTRE.

This centre occurs on the western boundary of a large greenstone belt extending from Diemels to Bungalbin. The principal workings are situated a mile to the east of the granite contact. There are two principal series of reefs represented:—

(1) Striking north-west and dipping east.

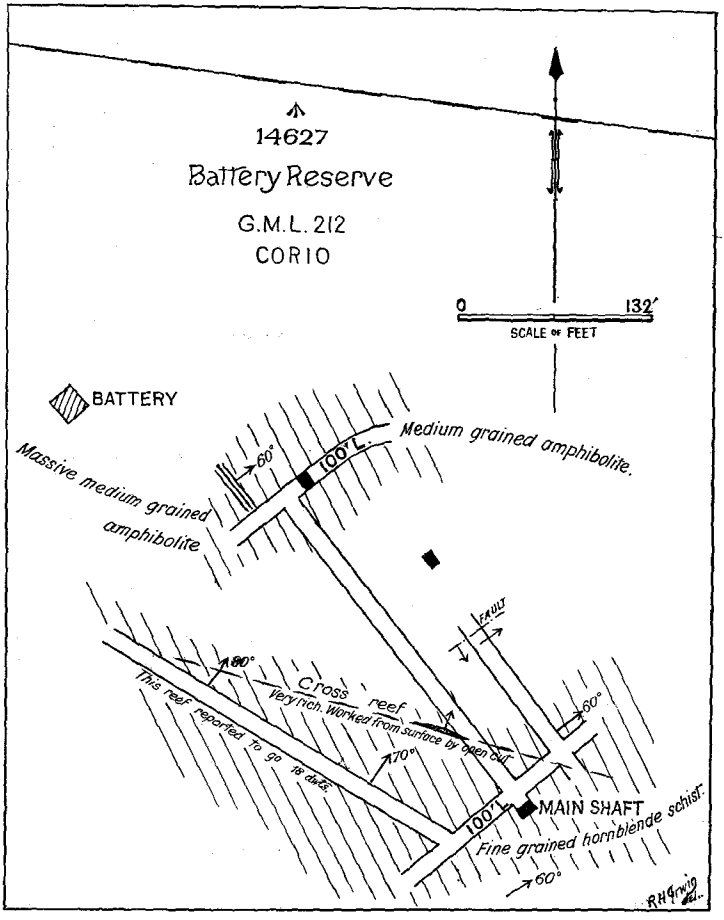
(2) Striking north and dipping west.

Both have been worked, but the principal workings occur on the first class of reef. Besides these two there is on the Mt. Jackson Gold Mine an east-and-west reef dipping north, which crosses the north-west and south-east reefs, and is said to have been very rich. All the reefs occur in amphibolite schist, and are associated with ferruginous quartzite, but in what relation to the latter cannot be seen in any of the workings, except that in the Associated Mine the reef appears to be deflected by the footwall of the ferruginous quartzite, showing that the reefs are younger than the banded

quartzites (Jaspers), which, of course, they must be if the latter are of sedimentary origin.

Faulting on this field is due either to overthrusting from the north or normal faulting to the south. There is not sufficient evidence to show which. Hence westerly dipping reefs are displaced to the left and easterly dipping reefs and ferruginous quartzites to the right. This may be taken as a rule for the district in locating the displaced continuation of a reef.

Fig. 38.



Sketch plan of 100ft. level, Mt. Jackson Gold Mines, Ltd., G.M.L. 2752.

As all the mines are closed down, and only the upper levels accessible, only such descriptions can be given as the circumstances would permit, and are therefore necessarily incomplete.

MT. JACKSON GOLD MINES, LTD.—This company owned at different times G.M.Ls. 212, 217, 233, 397, 462, 658, and 659. The principal workings are on G.L.L. (212) 2752. All the workings below 100ft. level were under water. Fig. 38 is a sketch plan of the 100ft. level. There are no records of the workings below 100 feet.

The country rock is a fine-grained to medium-grained amphibolite schist, with foliation planes striking north-north-west parallel with the ferruginous quartzites and dipping 60° east. From the main cross-cut on 100ft. level three drives running north-west show roughly parallel reefs dipping 60°-70° north-east. About 50 feet north-west of the main shaft in the main drive an east-and-west reef dipping north cuts the north-west reefs. This cross reef has been stoped to the surface, and is said to be very rich.

The Battery on this lease was taken over by the Government in 1912 and crushings put through for the prospectors at Marda until the Butcher Bird mill at Marda was subsidised in 1914.

The following are the gold returns of this mine taken from the statistics of the Mines Department:—

Table showing the Yield of the Mt. Jackson G.M.

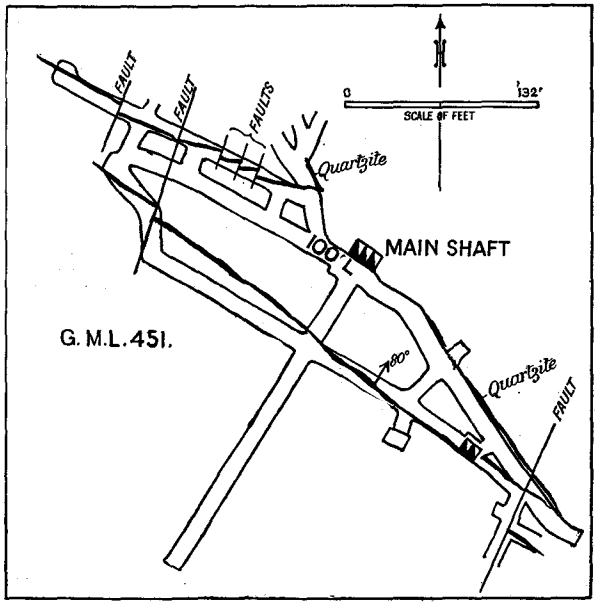
Year.	Ore treated.	Gold therefrom	Silver.
	tons.	fine ozs.	fine tozs.
Prior to 1897	1,514·00	720·06	..
1897	361·00	286·52	..
1898	1,255·00	716·66	..
1899	4,252·00	2,963·83	..
1900	2,155·00	1,219·42	..
1901	..	*10·17	..
1902	..	..	..
1903	..	† 449·86	..
1904	7,844·00	5,723·95	998·00
1905	5,390·00	3,329·09	997·50
1906	1,820·00	597·27	50·00
1906	1,992·00	1,045·99	..
1907	2,514·00	2,251·26	259·78
1908	100·00	31·53	..
1909	150·00	88·02	..
Total ..	**29,347·00**	**19,433·63**	**2,305·28**

* From plates. † By cyaniding.

ASSOCIATED MT. JACKSON GOLD MINES, LTD., G.M.Ls. 246, 450, 451, 459, and 460.—The principal workings are on G.M.L. 451, but only the 100ft. level was accessible for examination. Fig. 39 shows a sketch plan of the 100 feet level. The country rock is a decomposed amphibolite schist striking 340deg. and dipping to the east.

On the hanging wall of the eastern workings a banded quartzite strikes parallel to the schists and also dips east forming a barrier to the quartz reefs which, as soon as they meet the quartzites,

Fig. 39.



Sketch plan of 100ft. level, Associated Mount Jackson Gold Mines, Ltd., G.M.L. 451.

are diverted and follow the footwall of the latter. The quartzites are here non-ferruginous but very evenly banded. Two parallel reefs have been driven on, on a bearing of 300deg. or roughly N.W. The main cross-cut has been run out for 170 feet beyond the west reef without showing any development of importance except a 6in. quartz reef dipping 30deg. to the S.W.

The main reefs are steeply inclined at 80deg. to the N.E. North of the main shaft minor faults are very common, giving displacements up to three feet. They are all right-handed faults.

A dismantled 10-head battery is on the mine, and no work has been done for years.

On G.M.L. 246 and 450, known as the Golden Lady Hay and the Alpha respectively, there is a large reef striking north and dipping to the west between 50deg. and 60deg. This is faulted in places with a total displacement up to 57 feet, but to the left hand, which

would be accounted for by the opposite character of the dip to other reefs in the district. The reef abuts against banded quartzites dipping E., but in what relation is not shown in the workings.

A number of shafts have been put down on the Lady Hay line of reef, and the workings, though inaccessible, have not been carried to any depth. Judging by the Mines Department statistics the work on this company's properties has not proved satisfactory.

The following are returns supplied from Mines Department's statistics:—

Table showing the Yield.

Year.	Tonnage.	Gold in fine ozs.
1900 ..	76.00 ..	73.95
1902 ..	725.50 ..	150.76
	801·50	**224·71**

VICTORIA REEF MINE, G.M.L. 2564.—On this lease there is a dismantled 5-head battery. The workings are in a state of collapse and could not be inspected.

The mine is in a direct line of strike with the reefs of the Mt. Jackson Gold Mines, Ltd., and is probably a continuation of the same kind of reef. Not much ore has been crushed from this mine, as is shown by a yield of only 5.14ozs. from 27 tons of ore in 1912.

MT. JACKSON WONDER MINE, G.M.L. 2397.—This mine is situated about two miles south of Jackson townsite and was abandoned at the time of my visit. It was described as follows by Mr. H. P. Woodward after a tour of inspection of the district in 1911:—

A formation 30 feet in width containing small veins of quartz has been developed by means of a 40ft. shaft, with a drive 20ft. north and 27ft. south, and crosscutting 35ft. east with a drive 10ft. north at the end of it. This formation has a general strike of north and south, with perhaps a slight dip to the east, but upon this point it is at present impossible to make a definite statement.

A number of pits have been sunk upon rich quartz leaders, which are usually ferruginous although occasionally quite white. Upon one of these a small shaft has been sunk to a depth of 15 feet, from which some very rich stone was raised.

The gold is mainly carried in the small irregular leaders, but the formation is said also to yield appreciable quantities upon assay, although it is impossible for me to make a definite statement on this point without systematic sampling.

The mine gave a return of 44.27ozs. from 120 tons of ore in 1912.

ATHLONE MINE, five miles north of Jackson. There are some workings which are now flooded and known as the Athlone.

These workings and those on the General Roberts were also visited by Mr. Woodward in 1911, when he reported as follows:—

To the northward of the old mines a new discovery has been made at a distance of five miles, known as the Athlone, from the name given to the first lease pegged, upon which a reef striking N.N.E. and S.S.W. with an almost vertical dip has been sunk upon to a depth of 30 feet, but since a heavy body of salt water was encountered at a depth of 25 feet it was driven on at this depth.

In this level, to the northward of the shaft, the reef forms into a solid body of quartz for a distance of 10 feet, when it pinches clean out. Its largest dimensions in this distance is 2ft. 6in.

In the south level a broken mass of stone about two feet in width was met with for a distance of 20 feet, at which point it is cut clean off by a solid quartz reef which only carries values at its point of contact with the auriferous body.

This reef did not outcrop and was not encountered until eight feet had been sunk; it was generally small and much broken in the shaft, but forms into a solid body at the shaft bottom. Judging from appearance it is of a pipe-like form with a pitch to the northward, the length of the shoot being 30 feet, and its average width about two feet. There is every possibility of this shoot lengthening with depth, whilst so far the size promises to increase.

The stone is of a banded cherty character showing a considerable quantity of gold, whilst it yields an excellent prospect of fine gold when apparently barren stone is dollied. There is a small quartz vein which contains a considerable quantity of hornblende and prospects well exposed in a trench to the east of the shaft, but no traces of this were met with in the workings.

About 30 feet west a parallel reef about nine inches in width with a westerly dip has been sunk upon to a depth of 30 feet by means of a shaft, in which the volume of water was considerably less than in the other.

Still further is another reef upon which the original discovery was made. This outcrops for a length of 40 feet, and has been sunk upon to a depth of 25 feet.

The stone is about three feet in the widest part, and is more iron-stained and sugary in character than the eastern reefs, but is not so rich.

The water is extremely salt, the yield from the first shaft being 6,000 gallons per day and the second 1,200 gallons.

The General Roberts is north of the Athlone, and upon it a shaft has been sunk to a depth of 20 feet upon a small vein of stone which is exposed in a series of trenches for a distance of five chains. Upon the other leases of this group no work has been done.

The returns for the Athlone mine in the mining statistics are as follows:—

	Tonnage.	Gold therefrom, fine ozs.
1911—Athlone Reward Leases 2284, 2285	5.00	22.20
1912—Athlone Reward Leases 2284, 2285	100.00	82.61
	105·00	**104·81**

The average is 1oz. per ton.

There do not appear to be any lode formations associated with the ferruginous quartzites at Jackson, probably owing to the parallelism of their strike with the foliation of the schists.

MARDA.

This centre is situated 10 miles due east of Jackson townsite, and towards the centre of the greenstone belt. The geological features are essentially different to those at Jackson, the chief difference being in the E. and W. strike of the rocks and the absence of schistosity at Marda. The rocks are composed of a series of tilted and metamorphosed acid and basic lava flows. The ore deposits are confined to these, none being so far found in the sedimentary series that caps them at various places.

QUARTZ REEFS.

The quartz reefs are irregularly distributed in both the acid and basic rocks of the series and strike and dip in almost any direction. There are, however, three directions in which they occur most commonly, viz.:—

(1) North-west and south-east, dipping to the north-east.
(2) North-east and south-west, dipping to the north-west.
(3) North and south, dipping to the west.

These probably represent three directions of fissuring in a massive rock due to strain induced by great earth movements. It will be noticed that two of these directions correspond with those at Jackson. At Marda, however, the reefs are not so regularly distributed nor so persistent in outcrop.

This field is different from any other goldfield owing to the irregular trend of the reefs, an irregularity due to the rocks being massive and not fissured and sheared in the usual north-north-westerly direction. The reason for this is obviously because the series strike almost east and west, namely, at right angles to the great lateral pressures to which they have been subjected in common with all the rocks of the eastern goldfields.

The result is contorted quartzites and irregularly fissured rocks, with an absence of schistose structure and regular shear zones; hence the irregular form and distribution of the quartz reefs. The gold occurs in the reefs as short rich shoots, generally at the intersection of another reef, or alongside a brecciated pipe or zone in the ore channel. In most cases the reefs are short and lens shaped. and some difficulty is entailed in locating fresh chutes of gold, sometimes necessitating a great amount of dead work which eats up the profit earned from the last chute.

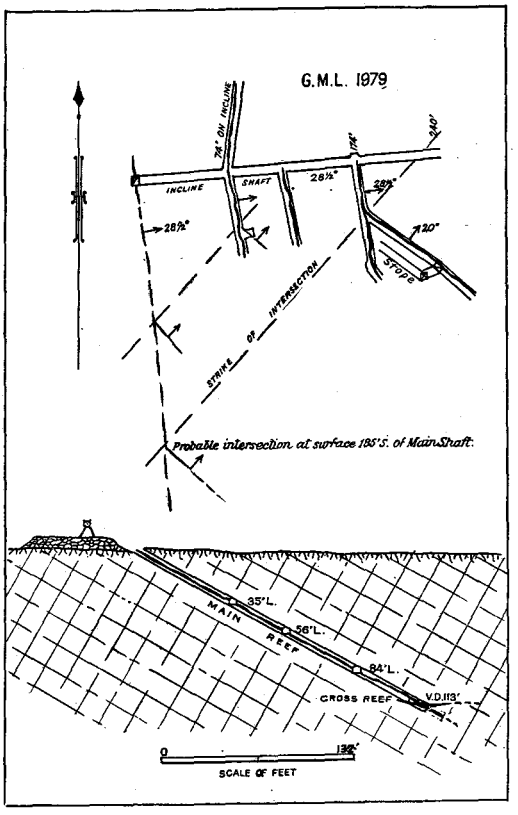
The principal mines are:—

Allen's Find.
The Great Unknown.
The Butcher Bird.
The Standard.

ALLEN'S FIND MINE, G.M.L. 1979.—Since writing the preliminary report which appeared in the Annual Report for 1914, it has been undoubtedly proved on further careful examination of specimens that Allen's Find occurs in a decomposed acid igneous rock, probably a quartz porphyry belonging to the volcanic series.

The country rock on this mine is very decomposed and in hand specimens is a soft greenish white rock composed of kaolin and quartz and traversed by veinlets of quartz. The main reef strikes a little west of north and dips to the east at 28°.

Fig. 40.



Sketch plan and cross section, Allen's Find, G.M.L. 1979.

An inclined shaft has been sunk on the reef to 240 or to a vertical depth of 113 feet. At a depth 74 feet on the incline (33 feet vertical), levels are driven north and south on the reef for 65 feet

and 55 feet respectively. At 116 feet on the incline (56 feet vertical), a level has been driven south for 50 feet, and at 174 feet incline (82 feet vertical), a level south for 80 feet, with a drive off it at 35 feet from the shaft on a cross reef for 100 feet. The main reef varies in width from two to five feet and is a uniform body of stone. The cross reef that cuts it at the lowest level is also a well formed reef of from two to three feet in width, but has a shallow dip of only 20° to the north-east. There is another parallel cross reef cutting the main reef at the first level. The main reef has been stoped to the north of the shaft from the surface to the first level, and to the south of the shaft from the first level to the bottom level. The gold appears to occur at the intersections of the main reef and cross reefs. There should, therefore, be about 200 feet of backs along the intersection from the bottom level. The calculated intersection of the two reefs pitches to the north-east, and should cut the outcrop of the main reef on the surface at about 160 feet south of the mouth of the shaft. There is a dark seam of pug, a fraction of an inch thick, which can be seen following the footwall of the reef in the shaft. At the bottom of the shaft there is a big body of stone completely filling the face, and probably the continuation of the junction which occurs in the bottom level. At the junction of the main reef and the cross reef the quartz is brecciated and cemented by opaque to black quartz, caused by either a ferruginous or manganous staining.

This brecciation seems to be a characteristic of the intersection, but not sufficient stone was exposed to show which reef cut the other. The following is a plan and section of the mine workings:—

Statistics from the Mines Department's reports give the following gold yields:—

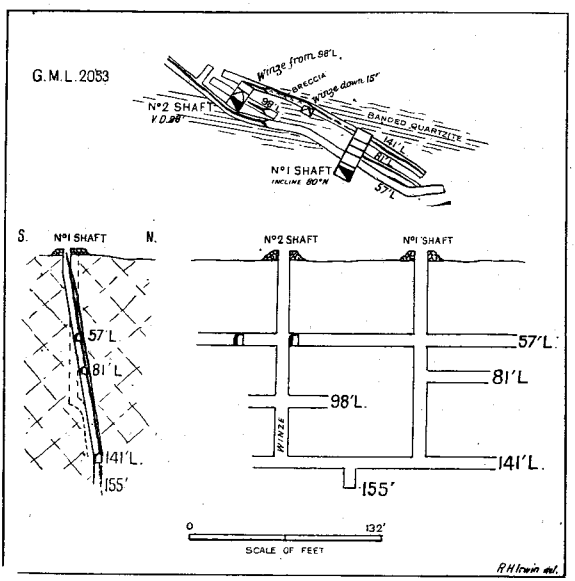
Year.	Tonnage.	Gold therefrom.
		Fine ozs.
1912	139·30	106·23
1913	199·25	213·76
1914	300·00	174·87
1915	553·50	223·81
1916	319·00	59·15
Total	**1,511·05**	**777·82**

The first two years give an average of 19 dwts. per ton. In 1914 the average has fallen considerably below that figure, but should be high enough to pay expenses. At the intersection of the two reefs there is a big body of stone. This mine shows great promise, with a chance of enrichment as the sulphide zone is approached. I should recommend sinking a vertical shaft to the east

so as to cut the reef at about 200 to 250 feet vertical depth. This would test the reef at the least cost and ensure economical working.

THE GREAT UNKNOWN MINE, G.M.L. 2053.—This mine is situated 1½ miles north-west of the Marda Tank and one mile a little east of south of Allen's Find. Two shafts have been sunk on a reef

Fig. 41.



Sketch plan and longitudinal section of Great Unknown Gold Mine, G.M.L. 2053.

striking 300°. No. 1 or east shaft is sunk on an inclination of 80° to the east. No. 2 or west shaft has been sunk through the reef to a depth of 98 feet, from which level a winze is sunk on the reef to 141 feet.

There are levels at 57 feet, 81 feet, and 141 feet, and the greatest length of reef driven on is 225 feet on the 57 feet level, and 170 feet on the 141 feet level. The greatest depth attained is 155 feet in a winze sunk on the eastern edge of a pipe of breccia. Fig. 41 is a Plan, Cross and Longitudinal section of this mine.

The country rock in the Great Unknown mine is a totally different rock to that on Allen's Find, though belonging to the same series. It is a carbonated ultra-basic igneous rock, and its chemical composition corresponds with a carbonated peridotite. The ore body is a quartz reef in a chloritic shear zone of about four feet wide in the carbonated country rock.

Unlike Allen's Reef it is practically vertical with an underlay of 80° to the east. The reef varies from six inches to three feet and averages about 18 inches. It takes an irregular course in the shear zone and is generally near the centre though in places follows either wall of the shear zone. In the country rock there is a band of quartzite, similar to the banded ferruginous quartzites in the neighbourhood and parallel to them. This quartzite strikes almost east and west, and is cut by the reef which strikes 300° at a very acute angle. The shear zone has sheared the quartzite into a breccia which has formed an obstruction in the ore channel, causing the reef to bifurcate and envelope the breccia connecting on the other side forming a solid reef again in the shear zone. The contact line of the reef and quartzite (jasper) is vertical, and therefore the horse of breccia forms a vertical pipe enclosed in the quartz reef. In the neighbourhood of either side of this breccia there is, according to the owners, an enrichment of gold.

The ore shoots are also vertical and therefore parallel to the pipe of breccia. There are three ore shoots according to information obtained from the prospectors of the mine. One on either side of the pipe of breccia, and one at the eastern end of the workings which as far as could be seen was unconnected with any structural feature. The quartz is heavily mineralised and frequently shows coarse gold. The returns from this mine give the stone a high average value, though probably the richest portions only of the reef have so far been treated. There is a large quantity of stone at grass which is expected to crush an ounce to the ton. The statistics are as follows:—

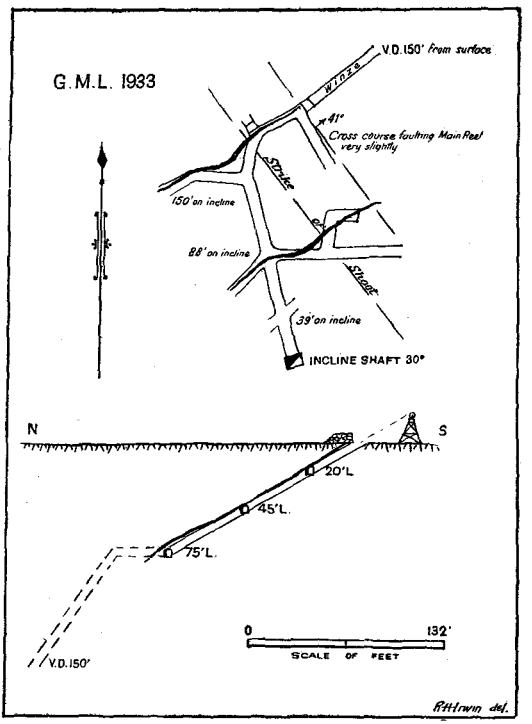
Year.	Tonnage.	Gold therefrom.
		Fine ozs.
1911	37·88	267·09
		Dollied 37·22
1912	411·05	1,374·63
1913	306·00	1,094·05
1914	123·00	393·36
1915	180·50	199·81
1916	167·00	140·98
Total	**1,225·43**	**3,507·14**

Average 2·86ozs. per ton.

Butcher Bird Mine, G.M.L. 1933 (Atkinson's), is situated 2¼ miles slightly east of north of the Marda Tank. The reef has a general strike of 65° and dips 30° to the north-north-west. An incline shaft has been sunk on the reef for 150 feet, passing into the footwall near the bottom which has a vertical depth of 75 feet. At 88 feet on the incline there is another level. Down to 40 feet

there is an irregular network of workings. About 60 feet east of the main shaft on the 75 feet level there is a winze sunk on a fault plane dipping 40° east to a depth of 90 feet. The water level is 63 feet below the 75 feet level, making a total vertical depth of

Fig. 42.



Sketch plan and cross section, Butcher Bird No. 1 Gold Mine, G.M.L. 1933.

138 feet below the surface. At the time of my visit there was not sufficient water to work the mill, but an adequate supply should be assured by further sinking. The mill has since been supplied with water by a pipe-line from the Marda dam.

In the west end of the drive, in the 75 feet level, the reef is still big and strong, but is said to be poor in value. In the east end the fault plane on which the winze is sunk cuts the reef off, though not altogether, as the fissure line corresponding with the reef can be seen east of the fault line (Fig. 42).

The country rock on this mine is a decomposed dolerite and is intermediate in composition between the more acid rock on Allen's

Find and the more basic on the Great Unknown. The reef also differs from both the above mines, being less regular in trend, and having a wavy course. The wave or roll in the reef determines the position of the ore shoot which seems to follow the pitch of the eastern fold of the wave. The reef ranges in width from 1 foot to 5 feet. Just overhead on the 75 feet level, near the winze, and on the footwall of the reef, there is a patch of arsenates of iron, including scorodite and pharmacosiderite. The former is a pale green granular mineral and the latter occurs as bright emerald green cubic crystals. Associated with these is arsenical pyrites and pyrites, and the green minerals have no doubt been formed by the oxidation of the arsenical pyrites. Gold is freely distributed in both the mineral and the quartz.

A specimen from this occurrence is fully described by Mr. Simpson below (pp. 181-183).

Gold mining statistics show the following yield from this mine:—

Year.	Tonnage.	Gold therefrom.
		Fine ozs.
1912	288·00	266·70
1913	215·00	160·01
1914	60·00	50·07
	563·00	**476·78**

Average—17dwts. per ton.

The following notes on the minerals in the gold ore from the Butcher Bird Mine have been supplied by Mr. E. S. Simpson, the Mineralogist and Chemist:—

THE MINERALS IN GOLD ORE FROM THE BUTCHER BIRD G.M., MARDA.

By E. S. Simpson, Mineralogist and Chemist.

"An examination of the specimens of gold ore collected by Mr. Honman at the Butcher Bird G.M., Marda, reveals the presence of six minerals, viz., in relative order of frequency:—

Quartz, Scorodite, Pharmacosiderite, Arsenopyrite, Pyrite, and Gold.

"*Quartz.*—Milky white quartz forms the main gangue.

"*Scorodite.*—Hydrated arsenate of iron, $Fe_2O_3.As_2O_5+4H_2O$. After quartz, this is the commonest mineral present. It forms large and small irregularly shaped masses, not visibly crystallised, but indistinctly granular in structure. It is pale grey-green in colour.

Like pharmacosiderite it is composed of ferric oxide, arsenic oxide, and water, but its individuality is established by its much higher specific gravity, in this case 3.26, and by its proving to be anisotropic between crossed nicols.

"Scorodite has previously been observed in this State at Federal Downs (Kimberley) in tin ore, with cassiterite and quartz; and at Warriedar (Murchison) in gold ore at the Porcupine G.M., with jasper, arsenopyrite, and a copper arsenate (erinite?).

"Scorodite is somewhat widely distributed in Australia, having been recorded from numerous mines in Queensland, Victoria, Northern Territory, and Tasmania, and from two localities in New South Wales.

"*Pharmacosiderite* (hydrated basic arsenate of iron, with potash (?), formula uncertain, perhaps "$FeAsO_4.Fe[O(H,K)]_3.5H_2O$").* This is the most striking constituent of the ore, occurring in well formed crystals of a rich green colour, ranging in size from 1mm. to 4mm. The crystals are developed either as a partial filling of cavities in quartz, which were once filled with arsenopyrite, or embedded singly or in groups in the centre of masses of scorodite. The common form is the simple cube of the isometric system, but occasional crystals are seen in which half the corners of the cube are truncated by the faces of the tetrahedron, or by oscillatory combination of the cube and tetrahedron. Interpenetration twins resembling those of fluorite are fairly common.

"The specific gravity of small crystals was proved to be 2.85. This figure, as also that for the scorodite, was obtained by interpolation in the following series, using methylene iodide as the suspending fluid:—

Olivine, Navajo Reserve, U.S.A.	3.32
Spodumene, Ravensthorpe, W.A.	3.14
Rubellite, Elba, It.	3.01
Aragonite, Melbourne, Vic.	2.93
Calcite, Coolgardie, W.A.	2.71

"Pharmacosiderite is a somewhat rare mineral, and there is no record of any other locality for it in this State. It is, however, reported to occur in several localities in Victoria, as well as two in New South Wales, and two in Tasmania.

"*Arsenopyrite.*—This is abundant in one of the two specimens collected by Mr. Honman, and is present in small amounts in the second. It is plainly the mineral from which both the arsenates have been derived.

"*Pyrite.*—A few small crystals (cubes and pyritohedrons) of this mineral occur in the solid quartz, where weathering agencies have not been able to reach them.

"*Gold.*—Free gold in fine to moderately coarse particles is freely distributed through the ore. It is seen attached to the sides

* E. G. J. Hartley, Min. Mag. XII., 157.

of cavities from which arsenopyrite has weathered out, as well as embedded in unweathered arsenopyrite and in quartz and covering fracture faces.

"*Occurrence.*—Mr. Honman informs me that the specimens were taken from a small patch of similar material occurring on the footwall side of the reef at a depth of 75 feet.

"*Paragenesis.*—A study of the ore and its occurrence points to the primary minerals being quartz, with a minor amount of arsenopyrite in irregular masses and bunches of various sizes embedded in it. The greater part of the gold, too, I am inclined to consider as primary, having originally been embedded either in quartz or in arsenopyrite. In the latter case it now mostly appears either embedded in scorodite or attached to the walls of empty or partially filled cavities left by the solution of arsenopyrite.

"The co-existence of two different arsenates of ferric iron is interesting, and a study of it is likely to shed light upon the general question of the weathering of sulphide ores.

"The mineral pharmacosiderite which appears so freely in the specimens is of unusual interest in view of the complete uncertainty regarding its exact chemical composition. Only two analyses have ever been made of it, viz., one in Sweden in 1824, one in England in 1899. There are serious and inexplicable differences between these, the two formulæ deduced from them being

$4Fe_2O_3.3As_2O_5.15H_2O$ (Berzelius), and
$2FeAsO_4.FeO_3(H.K)_3.5H_2O$ (Hartley).

"In view of these facts I would urge that every effort be made to secure for detailed examinations some further specimens from Marda, particularly of material containing well defined crystals."

STANDARD MINE, G.M.L. 2548.—Garrett and party and subsequently Saunders & Don:

This mine is situated one mile a little south of east of the Marda tank.

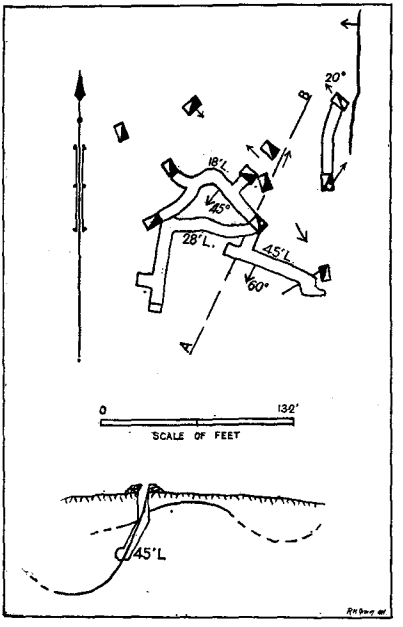
The workings of this mine are such a ramification of shafts, drives, cross-cuts, and stopes that an intelligible pen description is made extremely difficult. This is owing to the irregular course of the reefs, there being apparently a number of wavy reefs that cross and twist in a most remarkable manner. Eleven prospecting shafts have been put down within an area of one-third of an acre.

The main shaft is sunk vertically for 18 feet, and then on the incline at 60° to 45 feet on a reef dipping 60° south to the east of the shaft and 45° south-west to the west of the shaft. North of the main shaft the cap of dome-shaped reef comes within a few feet of the surface. This reef dips away in all directions and cuts the reef in the main shaft at 18 feet.

There is a north and south reef dipping 20° west, which is poor in value, and other narrow reefs are cut in the shafts dipping in all directions. The deepest workings are not more than 60 feet.

The country rock is decomposed dolerite and very similar to the Butcher Bird rock. The reefs vary from a few inches up to two or three feet wide, and often tail out to thin veins; judging by the positions of the stopes the ore appears to come from the dome portion

Fig. 43.



Sketch plan and cross section, Standard Gold Mine.

of the reef, at curved portions and close to intersections of two reefs. Fig. 43 shows sketch plan and section of the mine. Some rich crushings have come out of this mine, as the following statistics testify:—

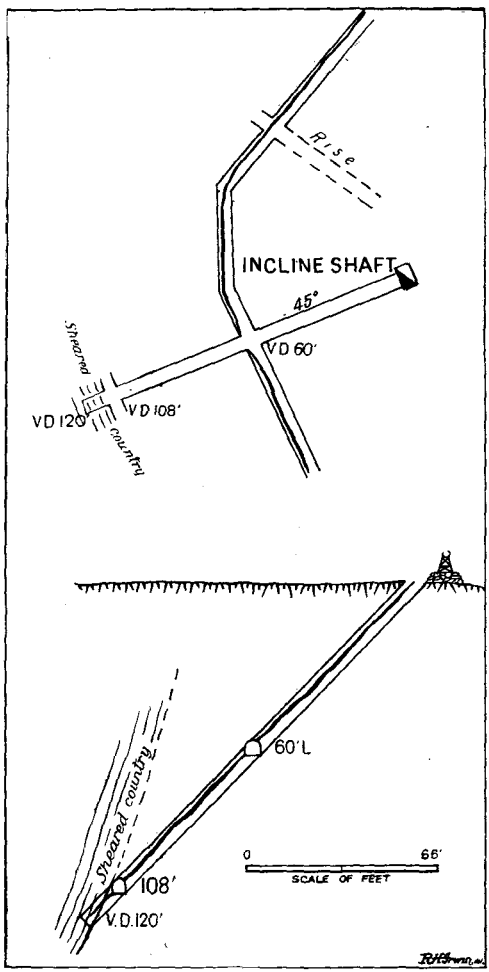
Year.	Tonnage.	Gold therefrom.
		fine ozs.
1912	67·00	355·13
1913	182·00	522·56
	249·00	877·69

Average—3·5 ozs. per ton,

THE MINER'S DREAM MINE, G.M.L. 2190.

Another mine which has been developed systematically but so far with poor results is the Miner's Dream. This is an anticlinal

Fig. 44.



Sketch plan and cross section, Miner's Dream Gold Mine.

reef pitching to the west at 45°. A main shaft has been sunk to 170 feet on the incline of 45° or V.D. 120 feet. There is a level at 80 feet on the incline which has been driven on for 100 feet north and 50 feet south. The ore shoot pitches to the north, on the northern leg of the antidine, but has so far not proved payable.

The country rock is decomposed, kaolinised and white. Near the bottom of the shaft the country is sheared. The reef is a solid body of quartz varying from 12 inches to two or three feet in width. Crushings taken out gave the following results:—

Year.	Tonnage.	Yield, fine ozs.
1912 ..	45.00 ..	16.42
1914 ..	31.00 ..	19.11
1915 ..	349.00 ..	93.81
Total ..	425.00 ..	129.34

Average, 6dwts. to the ton.

The continuation of this line of reef can be followed on the surface for some distance to the northwards. The manager, Mr. Gilbert, intended sinking on the shoot of gold, and it is to be hoped he will have better luck, as it is not unlikely, owing to the decomposed nature of the ground at the bottom of the shaft, that the values will improve at depth. Fig. 44 is a sketch plan and section of the mine.

There are many other shows which are in the early stages of prospecting, some which have been abandoned, but from which, according to report, some rich patches of ore have been obtained. Most of the reefs are highly mineralised and of very promising appearance, but many are small and short.

THE UNKNOWN SOUTH, G.M.L. 2594, is a lease which, from a geological point of view, has possibilities. At the south end of the lease a prospecting shaft is sunk on a reef which is exactly similar to the Great Unknown reef, carrying the same mineral and showing free gold. It is on the continuation of the line of strike of the Unknown reef, and though in unsettled country, appears to occur in a shear zone and possibly the same as the Great Unknown. The reef is certainly in the same ore channel with the same dip and strike, and I am informed that good prospects can be obtained from floaters between this shaft and the Great Unknown mine.

The following sundry returns have been recorded from Marda:—

Year.	Name of Lease.	Tonnage.	Gold therefrom.
			fine ozs.
1911	Effie's Reward, G.M.L. 2271 ..	·25	3·70
1911	Flemington, G.M.L. 2362	..	* 4·36
1911	Marda East, G.M.L. 2387	7·50	12·01
1911	Queen of the Hills, G.M.L. 2300 ..	8·00	20·85
1911	Three Kings, G.M.L. 2157	10·00	12·31
1912	Best Known, G.M.L. 2547	20·80	33·35
1912	General Jackson, G.M.L. 2505 ..	36·00	26·27
1912	Great Unknown North, G.M.L. 2444	11·00	23·07
1913	„ „ „ „	14·50	12·46
1912	Inglewood, G.M.L. 2156	13·50	8·96
1912	Known Best, G.M.L. 2602	12·00	13·93
1912	Persian, G.M.L. 2527	16·00	31·96
1912	Titanic, G.M.L. 2614..	13·50	18·69
1913	„ „ „	12·50	6·23
1913	Well Known, G.M.L. 2569	6·00	6·96
1913	Sundry Claims	208·40	116·70
1913	Just in Time, G.M.L. 2597	10·00	12·20
1913	Lone Chance, G.M.L. 2636	10·00	6·77
1913	Newmarket, G.M.L. 2713	9·00	30·48
1913	„ „ „	..	*42·68
1913	Titanic	12·50	6·23
1913	Sundry Claims	752·10	481·11
1913	„ „	..	*8·92
1914	Sundry Claims	98·00	66·07
		1,281·55	1,006·27
1916	Total, Sundry Claims	359·75	201·85
		1,641·30	**1,208·12**

* Dollied.

FERRUGINOUS QUARTZITE (JASPER) LODES.

This class of lode has so far not proved profitable on this field, and is not likely to be until the field has gone ahead, owing to their being, if payable at all, low grade propositions and therefore necessitating greater facilities for mining than the field at present provides. They consist of lodes in ferruginous quartzite which have been sheared or crushed sufficiently to have formed in them many small cracks which have become filled with quartz. So that you have a quartzite riddled with veinlets of quartz. The gold, according to all accounts, occurs exclusively in the quartz, forming a low grade formation with an irregular distribution of gold owing to the sporadic arrangement of the quartz veins. Typical examples of these lode formations are the Mount Bacon and Burgoose leases, and

the Canopus, G.M.L. 2511. It is only where the ferruginous quartzites are distorted or sheared that they are auriferous, as there are many miles of outcrop of ferruginous quartzite which are perfectly barren of gold. There is, however, every likelihood that payable reefs may be found outside the lodes which may be enriched where they meet or cross the lodes.

YARBU.

Yarbu is situated seven miles west-north-west of Pigeon rocks and is close to the granite contact. The country rock consists of decomposed ancient sediments, being composed of alternating bands of coarse and fine grained schists, which are probably of sedimentary origin. The schists strike north-north-west and dip 70deg. to the east. A number of leases were taken up about the time of the Bullfinch boom. The principal mine was the Bronzewing G.M.L. 2336. Three prospecting shafts have been sunk on this lease to cut a gently inclined narrow reef dipping 15deg. to the south-east. The reef varies from 6in. to 9in. in width and is composed of a clear glassy looking quartz. Mining statistics give the good yield of 60.03 ozs. from 44.5 tons of ore from this show in 1912.

Another show, G.M.L. 2310, gives a yield of 16.42ozs. from 10.00 tons of ore. Other reefs at this centre are generally narrow and composed of glassy quartz. One has a dip as shallow as 10deg. west and others are vertical or steeply inclined. The reefs so far worked appear to be too small to be worked at a profit, and, generally, developments as far as they go are not promising.

There is some country worth prospecting between Yarbu and Jackson near the granite contact. Quartz outcrops are numerous and geological conditions favourable.

KOOLYANOBBING.

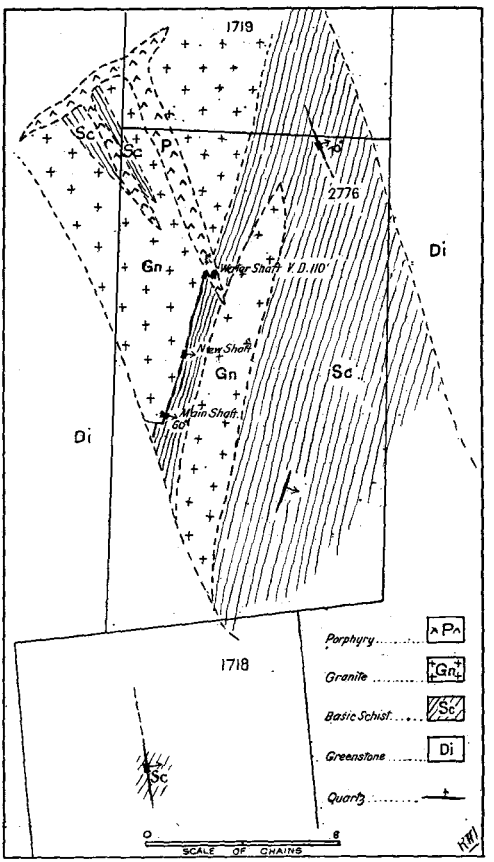
This centre is situated 35 miles north-east of Southern Cross, and occurs in a lens-shaped belt of greenstone 35 miles long, five miles wide, and striking to the north-west. Gold was first discovered here in 1904, and a reward claim was granted to Mr. Chadwick of Southern Cross.

The principal workings are situated on the Rainbow leases, G.M.Ls. 1718, 1719, and 2776, which are situated about 2¾ miles north-east of Koolyanobbing Trigonometrical Station and half a mile south-east of the Government tank.

CLARK'S SYNDICATE MINE, G.M.L. 2776, was being worked at the time of my visit. The main reef is along the contact of granite and a basic schist, strikes north-north-east and 60deg. to the east. It varies in width from six inches to three feet. The reef can be followed on the surface for 500 feet. Most of the work has been done on the south end of the reef, which has been stoped down to 48 feet for a length of, roughly, 50 feet. An incline shaft is sunk on the

reef and at 48 feet the reef is driven on 45 feet to the north and 28 feet to the south. At the south end the reef is faulted to the right which is the same direction of throw as at Jackson. The displacement is eight feet at the bottom of the shaft, the granite intrudes the basic schist hanging wall, and north of this intrusion the ore

Fig. 45.



Geological sketch plan of Rainbow leases.

shoot occurs. Gold shows in the reef three chains north of the main shaft and the present owners are sinking on the reef at this point. At the northern visible extremity of the reef a prospecting pit shows that the reef has straightened up, being almost vertical with a dip to the west. East of the pit a shaft has been sunk to a depth

of 110 feet showing basic schist at the bottom overlying granite, dipping 30 deg. south-east. At 20 feet from the bottom there is a three feet band of basic schist dipping 30deg. south in granite. This shaft passes through a felsitic porphyry but where it cuts the porphyry is hidden by the timbering of the shaft. From the north-west corner of the lease an arm of felsitic porphyry striking south-east cuts the northern end of the main reef.

About six chains east of the main shaft there is a parallel reef dipping east. Near the northern boundary of the lease and a few chains west of the north-east peg there is a reef striking north-north-west and dipping east.

Fig. 45 is a sketch plan of the geology in the vicinity of the workings of the Rainbow leases.

Adjoining the south end of G.M.L. 1718, Prospecting Area 400 has been pegged, and a shaft sunk to about 50 feet on a vertical reef up to 18 in width and striking 18deg. east of north. This reef occurs in the sheared eastern margin of a boss of felsitic porphyry.

About 1½ miles east of the Rainbow lease is an abandoned five-head battery, and 35 chains east again a Government well from which water was obtained for crushing purposes, the water level of which was about 60 feet from the surface, and the total depth of the well about 160 feet.

Chadwick's Reward Mine, G.M.L. 641 (abandoned) is 2¾ miles south-east of Koolyanobbing Trigonometrical Station, and one mile from the main granite contact. Here they have worked a narrow quartz reef, in decomposed fine grained greenstone, but values are reported to be on the low side.

South of Chadwick Reward there are some old workings alongside the granite contact, along which there is a large buck quartz reef (see Fig. 46) which outcrops for miles and can be seen outcropping on the south-east side of Lake Seabrook. The old workings above referred to are on a narrow portion of this buck reef. One wall of the reef carries copper carbonates, but not rich enough to form copper ore.

At these workings some interesting contact rocks occur. The granite does not abut against the greenstone but has a contact margin of gneiss. This gneiss contains large rounded crystals of felspar enveloped by gneiss giving a typical eye structure. The foliation of the gneiss bends round the felspar crystals.

The gneiss becomes more basic near the greenstone, changing into an evenly banded hornblende gneiss. This is followed by amphibolite schist, impregnated with crystals of magnetite and crushed talcose schists.

About two miles north of Chadwick's Reward, on the track to the Rainbow leases, there occurs in greenstone schist a large body of quartz 20 feet wide in places and 500 feet long, and carrying galena and zinc blende. This should be worth sampling.

I have been informed that there is auriferous country about 10 miles north-east of Koolyanobbing, but I did not have an opportunity of visiting it. It is probably part of the belt that crosses

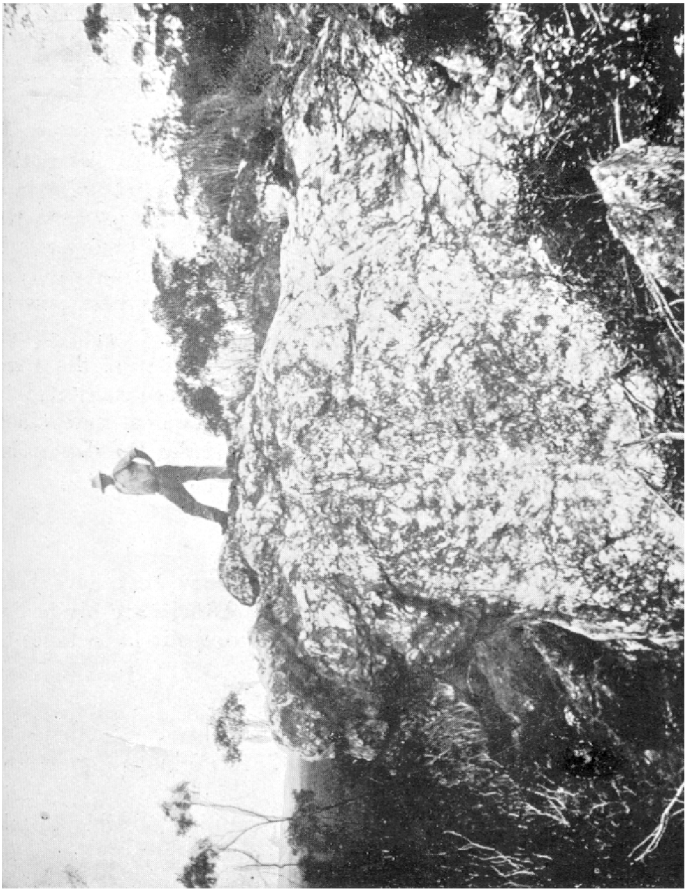


Fig. 46. Photo: C. S. Honman. Neg. 1350.

Quartz blow three miles south-east of Koolyanobbing.

the Glen Rynn track 7½ miles north-north-east of Koolyanobbing Trig. Between this development of greenstone and the Koolyanobbing belt there appears to be an extensive development of gneiss.

The following are the returns for Koolyanobbing:—

Year.	Name of Lease.	Tonnage.	Yield.
			Fine ozs.
1905	Chadwick's Reward	6·00	2·65
1908	St. Clair, No. 2 South G.M.L., 783 ..	23·00	16·07
1910	Jupiter, 909	12·00	9·15
	Saturn	28·00	2·07
	St. Clair, No. 2 South	239·00	86·80
1911	Sundry Claims	55·00	10·40
1912	Sundry Claims	..	·84
	Total	**363·00**	**127·98**

Bungalbin Ranges.

Bungalbin Trigonometrical Station is situated 31 miles north-north-east of Koolyanobbing and is the most prominent point in a rugged range of ferruginous quartzite (Jaspers) rising from the continuation of the Jackson greenstone belt. The greenstone is about 12 miles wide here, and practically no prospecting has been done in spite of the favourable geological conditions that prevail.

Both contacts with the granite to the north and south should be well worth prospecting, especially in the vicinity of the Bungalbin ranges where the rocks appear to have been subjected to great disturbance, and therefore likely to contain a zone along which fractures and fissures have been provided for the deposition of quartz reefs.

IRON.

Of deposits other than gold there are none that have been worked up to the present in this district. Yet there are big bodies of iron ore which may some day be of great economic importance to the country.

Three classes of iron ore exist in the district:—

(1.) Segregations of haematite and magnetite in the folds and fractures of contorted ferruginous quartzites (Jasper). High grade ore.

(2.) Gossans of Goethite forming a capping possibly to sulphide lodes.

(3.) Haematite quartzites. Low grade ore.

The first class of ore is probably very widely represented, and should be found by an exploration of the contorted portions of the jasper ridges. An example occurs on the western slope of Koolyanobbing Trigonometrical Station (*vide* Appendix II.). A sample [$\frac{1}{51}$] of this ore proved to be the purest yet found in the State,

and is described by Mr. Simpson as Micaceous Haematite. The following is its composition:—

Fe_2O_3	98·75 %
SiO_2	1·04
P	·016
S	Trace
Ignition loss	·39

Analyst—D. G. Murray.

The second class of ore (Goethite) is associated with lines of major faulting or shearing in the haematite quartzites. It occurs

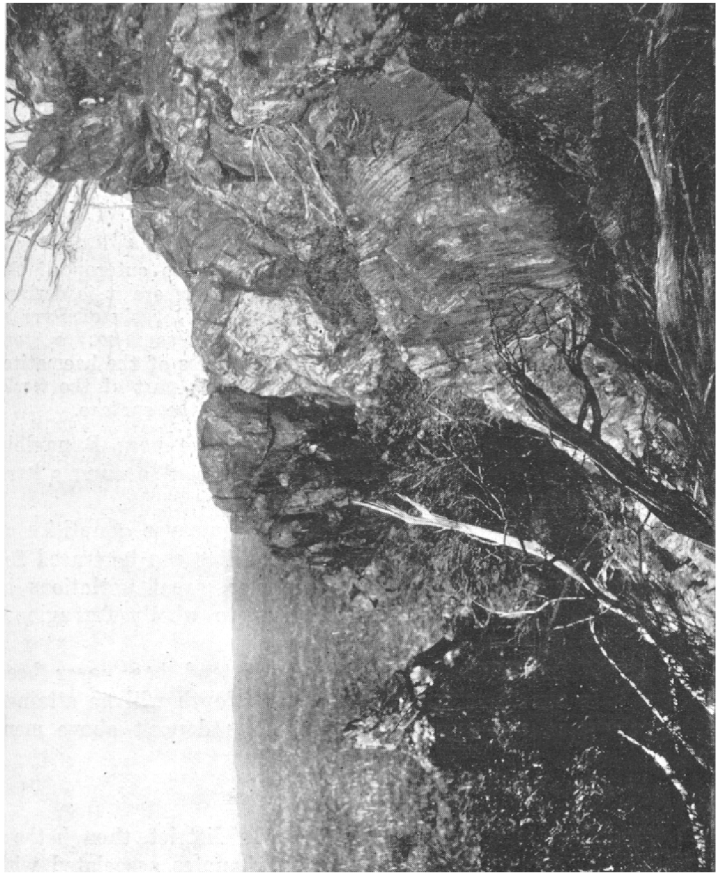


Fig. 47. Photo: C. S. Honman. Neg. 1354.
View from north side Koolyanobbing Trig., looking east.

as a huge mass in a big gap in the Mt. Jackson jasper ridge, extending between Mt. Jackson Trig. and Boondine Trig. for nearly a mile in length. Great buttresses of Goethite occur along the

ridge. (See Fig. 47.) A sample of this class of ore is thus reported on by Mr. Simpson:—

[1/47.] Brown iron ore, near Mt. Jackson.

The brown iron ore collected half-mile south-west of Mt. Jackson appears to the unaided eye to consist of two minerals, viz., a compact structureless mineral of a dark brown colour forming the main mass of the specimen, and a similarly coloured but distinctly fibrous mineral forming crusts on the former. The structure of the fibrous mineral is that of typical Goethite $Fe_2O_3 . H_2O$, and its identity with this mineral is confirmed by a partial analysis.

Picked fragments of the massive mineral had the following composition:—

Fe_2O_3	90.26	(Metallic Iron 63.18.)
H_2O	9.91	
SiO_2	traces	
	100.17	

Typical Goethite contains:—

Fe_2O_3	89.86
H_2O	10.14.
	100.00

The massive mineral is therefore also Goethite.

Massive Goethite forms a large proportion of the outcrop of the immense iron lode of Mt. Caudan, South Yilgarn, where it is derived from the oxidation of a lode which in depth consists largely of Pyrrhotite and magnetite I am of opinion that the present samples are from the outcrop of a similar sulphide lode, since iron lodes of the haematite-jasper type or magnetite-ilmenite type do not in this part of the world appear to give rise to masses of iron hydrates at the surface.

There is also a development of Goethite ore near Bungalbin Trig. At this place it is clearly seen to be a gossan forming a hard capping which has become undermined by caverns.

Of the third class of ore there must be immense quantities of low-grade material, since the haematite quartzites can be traced for a distance of 70 miles. There are, however, great variations in composition—from almost wholly silicious to wholly ferruginous quartzites.

The depth to which these iron ores extend has never been tested, but it is almost certain that no great depth will be attained except perhaps in the case of the first class deposit above mentioned.

COPPER.

No copper ores have been proved in the district, though there are indications such as the presence of carbonates associated with the contact reef, on the western contact of the Koolyanobbing greenstone and in the same line of strike as the western contact of the Jackson belt. At Koolyanobbing the indications are not very promising, but 11 miles south-south-east of Jackson, near the granite contact, there is a quartz reef in the greenstone that runs

parallel with the contact at a few chains from it. This reef crosses the road about one mile north of the soak, and a reef at the same distance from the contact is exposed in a prospecting shaft one mile south and half a mile east of the soak. The latter outcrop shows an abundance of carbonate on one wall of the reef. But no more than what is to be seen in the prospecting pit is exposed, so that it is impossible to say whether it is of economic value or not, yet there are sufficient indications to justify a search being made along the line indicated, viz., the western contacts of the Jackson and Koolyanobbing greenstone belts. In connection with the copper-bearing reef near the 11-mile soak, an extraordinary feature which was pointed out to me by a local prospector was the total absence of vegetation on longitudinal belts of country parallel to the strike of the contact of the greenstone and granite, and starting from the prospecting pit exposing the carbonates of copper. Since these bare patches occur on the slopes of a rise, they could not be caused by swampy conditions, but must owe their origin to the composition of the soil or underlying rock having a deleterious effect on vegetation. The composition of the underlying rock, which is amphibolised dolerite or gabbro, os as follows:—

G.S.M $\frac{1}{5\cdot2}$. G.S.L. 7459D.	
SiO_2	49·17
Al_2O_3	15·39
Fe_2O_3	1·52
FeO	8·73
MnO	·21
MgO	8·29
CaO	11·11
Na_2O	2·22
K_2O	·06
H_2O —	·10
H_2O + ...	2·20
TiO_2	·59
CO_2	·06
P_2O_5	·10
FeS_2	trace
	99·75

Sp. Gr. 2·84.

Analyst .. .. .. H. Bowley.

VII.—ORE GENESIS.

A complete discussion on the origin of the ore deposits of this region would be impossible at the present stage of its development, but certain facts in their relation to ore genesis can be pointed out, and any tentative conclusions drawn therefrom may be of some assistance in suggesting criteria for the location of fresh shoots in an already proved line of reef, and for the prospecting for new fields in the large belts of promising country at Jackson, Bungalbin, and Koolyanobbing.

The reefs of the region occupy zones of fracturing in the greenstone series. In a greenstone belt like the Jackson belt great earth movements have resulted in the weakest portions, or those portions of the belts subjected to the greatest force being fractured, resulting in zones of country riddled with fissures. These fissures will vary in arrangement according as the forces are compression, tension, torsion, or a combination of the three, hence the great variety of arrangement of reefs in different districts. In some fields the reefs are all parallel and dipping in the same direction, this is probably an effect produced by either shearing or tensile forces. In others approximately parallel, but dipping in opposite directions and due to compression. Again we find a most irregular arrangement forming a network of reefs with variable dips, probably due to twisting or torsion. As these forces are combined or superimposed the more complicated is the system of fissures. Now it is only natural that deep-seated solutions and vapours under pressure must take these zones of fractures as a means of escape, and on circulation in the fissures relief of pressure results, and deposition of reefs and minerals in the fissures. Where do these solutions obtain their mineral composition? It has been proved that the basic igneous rocks contain small percentages of base and precious metals, and it is significant that in all the large tracts of acid rocks no gold has been discovered unassociated with basic igneous rocks. If the deposits are not actually in the greenstones when occurring in granite the greenstones are never far distant. It is conceivable, therefore, that the solutions have obtained their metallic contents from the rocks in which they circulate. At Marda the reefs are most irregularly distributed in a block of greenstone country in which later intrusives are scarce, if not almost absent. The reefs occur alike in the acid rocks as well as the basic. In fact, the three principal mines are in three rocks of totally different composition though of contemporaneous origin. Thus:—

Allen's Find—Acid country rock.

Butcher Bird Standard—Basic country rock.

Great Unknown—Ultra basic country rock.

And in these mines the richest reefs are in the basic rocks, in which the quartz shows free gold. In the acid rock gold is not nearly so easily seen in the quartz, nor are the reefs so rich. This may of course be a coincidence, yet it is significant.

It is probable, therefore, that by a process of saturation of the rocks by deep-seated waters, weak metallic solutions have been formed, which, upon the rupture of the containing rock and the formation of open fissures, have ascended these fissures and deposited their mineral and metallic contents as a consequence of the attendant relief of pressure.

As regards the distribution of the gold in the reefs, it is a fact in the Marda field that the ore shoots are always associated with some structural feature, which would have either restricted, enhanced, or diverted the flow of a solution circulating in the fissure now occupied by the reef. In the three principal mines we have an illustration of three such different controlling factors.

(1) Obstruction in the Great Unknown Mine, in the form of a pipe of breccia crossing the ore channel. Result, an ore shoot on either side of the obstruction.

(2) Increase of flow and a meeting of solutions probably different in composition, temperature, and pressure at the junction of two reefs, as in Allen's Find. In this case the space occupied by the reef is greatly increased at the intersection, where two things might have happened: one, a slackening of the rate of flow and an attendant deposition of minerals; two, a reaction between two different solutions meeting. Result: ore shoots in the neighbourhood of the contact of two reefs.

(3) Diversion of flow as in the Butcher Bird Mine by a curvature in the course of the fissure. The shoot of gold in the Butcher Bird Mine, judging by the position of the stopes, corresponds almost exactly with the eastern arm of a pitching syncline in the reef.

The ore shoots in the Standard Mine were probably controlled by a combination of conditions (2) and (3), because the reefs on that mine are curved and also intersect one another.

The moral, therefore, is that prospectors cannot pay too much attention to the structural features on their mines with a view to interpreting their effect on the ore shoots. The reason is obvious in a search for new shoots of ore, as the following of a favourable structural feature will direct the dead work into those portions of the reef most likely to be productive and may sufficiently reduce the exploratory work to change a duffer into a payable concern.

As regards the mineralisation of the reefs, it is generally found that pyrites is most plentiful in the walls and near the walls of the reefs. For instance, in the Great Unknown Mine the chlorite carbonated shear zone contains 10 per cent. of pyrites and traces of gold and silver. In the quartz the most common minerals are galena, zinc blende, and arsenical and cupriferous pyrites.

The gold in many cases occurs intimately associated with any of the above minerals. The minerals are arranged in crudely arranged crusts, which usually succeed one another in the following order:—

(1) Pyrites in walls of reef.
(2) Pyrites in margin of reef.
(3) Calcite.
(4) Galena, Zinc Blende and Arsenopyrite near centre of reef.

This is a typical case of crustification, which is generally admitted to be a characteristic structure of a fissure filled by deposition from circulating solutions.

Secondary enrichment, though not actually observed in this field, is likely to occur in any of the mines, and if so, in the zone of change from oxidised to unoxidised country.

In the Great Unknown Mine the zone of possible enrichment is close to the surface, at about 75 feet, and the workings already extend well into unoxidised country.

The Butcher Bird Mine is still in oxidised country, but not far off the sulphide zone, and values should improve in depth until unoxidised country is struck.

Both Allen's Find and the Standard are still in decidedly oxidised country. It is therefore clear that all these mines have not yet nearly reached the limit of their productive zone in depth, but probably the value of the ore on the Great Unknown will decrease as the sulphide zone is penetrated further.

It should, therefore, be born in mind that if the high values so far obtained are due, to some extent, to secondary enrichment, which is more than likely, the value of the stone will not be so high below the zone of enrichment, though there is every indication that the reefs will be payable for some considerable depth. Past experience in this State has proved that the zone of enrichment may extend for 100 feet above and below the cap of the sulphide zone.

The Marda field, however, has not yet reached that stage at which the value of the ore at depth need cause any anxiety to the mine owners.

VIII.—CONCLUSIONS.

(1) Two series of rocks are represented and separated by an unconformity. The younger series has so far proved unproductive both here and in the Kalgoorlie district.

(2) Marda as a prospective mining field offers great inducements to small parties of prospectors, provided continuous crushing facilities are made available.

Some of the mines show great promise, and deserve the attention of capitalists and large companies. Of these, the Great Unknown and Allen's Find are most promising, especially the former, on account of the possibility of the reef extending through the South Unknown Lease.

(3) The old Jackson centre, though now deserted, is worthy of the attention of capitalists on account of the persistent nature of the reefs and their regular trend.

(4) Koolyanobbing is well worth further prospecting. Its extension northwards appears to have been practically untouched by prospecting parties.

(5) East of Marda there is a large tract of country which deserves more attention from the prospector. From the Marda tank to Bungalbin Range there is a continuous belt of greenstone country 25 miles long and from 10 to 15 miles wide. The intervening country and that around Bungalbin appears to be practically untouched, and new finds will probably be made here as the result of further and more systematic prospecting.

(6) Yarbu is a centre that is not particularly attractive from a mining point of view, though the country along the granite contact between here and Jackson should be worth prospecting.

Table showing the Yield of the Mount Jackson and Koolyanobbing Centres of the Yilgarn Goldfield, up to 30th June, 1915.

Mining Centre.	No. of Lease.	Name of Lease.	Dollied and Specimens.	Ore treated.	Fine Gold therefrom.
			fine ozs.	tons.	fine ozs.
Mt. Jackson	1979	Allen's Find	..	708·55	528·94
Do.	1933	Butcher Bird, No. 1	..	911·00	719·98
Do.	2053	Great Unknown	37·22	877·93	3,129·13
Do.	2190	Miner's Dream	..	76·00	35·53
		Voided Leases.			
Do.	(246), (450), (451), (459), (460), (494)	Associated Mt. Jackson G.M.S. (W.A.), Ltd.	..	801·50	224·71
Do.	(2284), (2285)	Athlone Reward Leases	..	105·00	104·81
Do.	(2547)	Best Known	..	220·80	33·35
Do.	(2336)	Bronzewing	..	44·50	60·03
Do.	(2271)	Effie's Reward	..	·25	3·70
Do.	(2362)	Flemington	4·36	..	..
Do.	(2505)	General Jackson	..	36·00	26·27
Do.	(2444)	Great Unknown, North	30·62	25·50	35·53
Do.	(2156)	Inglewood	..	13·50	8·96
Do.	(2597)	Just in Time	..	10·00	12·20
Do.	(2602)	Known Best	..	12·00	13·93
Do.	(2636)	Lone Chance	..	10·00	6·77
Do.	(2387)	Marda, East	..	7·50	12·01
Do.	(212), (217), (233), (397), (462)	Mt. Jackson G.M.S., Ltd. (1897)	..	9,537·00	6,210·61

Do.	(212), (233), (462)	(217), (397),	(Mt. Jackson G.M.S., Ltd.)	..	15,054·00	*9,806·22
Do.	(212), (397)	(217),	(Mt. Jackson G.M.S., Ltd.)	..	4,506·00	†3,297·25
Do.	(212), (658),	(217), (659)	Mt. Jackson leases	..	250·00	119·55
Do.	(2397) ..	..	Mt. Jackson Wonder	..	120·00	44·27
Do.	(2713) ..	..	Newmarket	42·68	9·00	30·48
Do.	(2527) ..	..	Persian	..	16·00	31·96
Do.	(2300) ..	..	Queen of the Hills	..	8·00	20·85
Do.	(2548) ..	..	Standard	..	249·00	877·69
Do.	(2157) ..	..	Three Kings	..	10·00	12·31
Do.	(2614) ..	..	Titanic	..	26·00	24·92
Do.	(2564) ..	..	Victoria Reef	..	27·00	5·14
Do.	(2569) ..	..	Wellknown	..	6·00	6·96
Do.	(2310) ..	..	Yarbu	..	10·00	16·42
			Total output	**114·88**	**33,488·03**	**25,450·48**
Koolyanobbing ..	(641) ..	..	Chadwick's Reward	..	6·00	2·65
Do.	(909) ..	..	Jupiter	..	12·00	9·15
Do.	(917) ..	..	Saturn	..	28·00	2·07
Do.	(783) ..	..	St. Clair, No. 2 South	..	262·00	102·87
			Total output	..	**308·00**	**116·74**

* Also 2,045·50 ozs. silver.

† Also 259·78 ozs. silver.

APPENDIX I.

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD TO THE END OF THE YEAR 1916.

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.
Blackbourne ..	..	Voided leases	..	..	..	..	..
Do.	302	Royal Victoria South ..	..	..	84·00	43·25	..
Do.	557	King Edward VII... ..	..	..	100·00	3·29	..
Do.	615	Millionaire	..	..	28·00	5·04	..
Do.	696	Blackburn South	..	..	92·00	32·93	..
Do.	671	Blackbourne..	..	..	492·00	142·37	..
Do.	887	Blackbourne..	..	..	486·50	114·49	..
Bullfinch	(2667)	Bullfinch East Extension ..	..	..	1,282·50	341·37	..
Do.	914, 915, 916, 926, 928, 942, 960	(Bullfinch leases)	..	..	16·00	39·20	..
Do.	914, 915, 916, 926, 928, 930, 942, 960	Bullfinch Proprietary (W.A.), Ltd.	..	..	1,027·52	10,958·88	..
Do.	..	Voided leases	..	..	247,393·42	106,445·38	16,442·43
Do.	962	Chaffinch: Great Chaffinch G.M. Co., M.L.	..	..	1·00	6·55	..
Do.	969, 970 ..	Bullfinch East G.M. Co., Ltd.	..	..	22·85	78·60	..
Do.	1263	Bullfinch Great Northern	..	..	16·00	2·91	..
Do.	2325	Golden Area	..	..	12·00	2·11	..

Do.	2337	Illawarra: Cosgrove Prospecting Syndicate	..	..	15·00	5·13	..	
Do.	2494	Lady Agnes	..	..	201·40	184·63	..	
Do.	2579	Derwent Jack	..	..	58·60	38·30	..	
Do.	2779	Bell Bird	..	..	17·80	7·24	..	
Corinthian ..	**893**	Corinthian	..	..	2,684·50	1,123·80	..	
Do.	**896, 934, 946,**	Corinthian North G.Ms., Ltd.	..	..	131,222·00	27,564·32	..	
Do.	..	Sundry claims	..	..	73·50	73·29	..	
Do.	..	Voided leases	..	..	..	..	..	
Do.	955	Pilot	..	..	65·00	10·75	..	
Do.	1092	Corinthian Main Reef South	..	..	12·00	1·34	..	
Do.	1391, 1393 ..	Babylonian G.M. Co., N.L. ..	..	..	72·50	57·96	..	
Do.	1391, 1392, 1393	(Babylonia North leases)	..	..	371·00	312·83	..	
Do.	1589	(Babylonia Extended) ..	..	..	28·00	6·84	..	
Do.	1589, 1590 ..	Babylonian Extended G.M. Co., N.L.	..	..	53·00	16·02	..	
Eenuin	**2803**	Star of Ennuin	..	..	118·16	342·89	..	
Do.	—	Sundry claims	..	..	100·50	60·58	..	
Do.	..	Voided leases	..	..	16·40	18·45	..	
Do.	2865	Trig Hill	..	..	..	..	18·45	
Golden Valley ..	**(2755)** ..	Deborah	..	..	122·50	182·27	2·00	
Do.	**2272**	Glide Away	..	..	851·00	1,001·83	..	
Do.	**2948**	Greenharp, New	..	..	148·50	197·99	..	
Do.	**3039**	Lake View	..	..	34·00	36·50	..	
Do.	**2790**	Manxman Consols	..	..	41·00	49·31	..	
Do.	**2389**	(Marie's Find)	..	..	336·00	460·51	..	
Do.	**(2880)**	Mount Kattrine	..	..	42·85	43·44	..	
Do.	**2389, 2390** ..	New Marie's Find G.Ms., N.L.	..	..	226·00	144·35	..	
Do.	**2994**	Radio	..	..	42·00	244·65	..	
Do.	**2739**	Rosalie	..	..	120·75	122·27	..	
Do.	**2653**	Violet	..	..	83·64	56·12	..	

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.
Golden Valley ..	..	Sundry claims	..	2·75	1,593·57	1,278·26	..
Do.	..	Voided leases	..	..	..	..	..
Do.	193	Kathleen	..	..	130·00	218·32	..
Do.	740	Last Trig	..	..	7·00	2·44	..
Do.	829	(Pioneer)	..	..	102·00	336·35	..
Do.	829, 920, 924, 1043	Pine Hill G.M. Co., N.L. ..	..	..	509·00	487·93	..
Do.	835	Violet	..	..	730·00	434·85	..
Do.	920	(Ada May)	..	..	115·00	179·99	..
Do.	922	Lily of the Valley ..	..	..	117·00	22·70	..
Do.	924	(Mountain Oaks)	..	..	302·50	418·46	..
Do.	927	Baby Queen	..	..	47·00	74·81	..
Do.	1008	Valley Wonder	..	..	14·00	5·36	..
Do.	1337	Golden Crown	..	..	40·00	5·19	..
Do.	1750	Budgeerigah..	..	..	..	1·11	..
Do.	1751	Bullin Bullin	..	..	13·00	5·03	..
Do.	1807	Red Robin	..	..	25·50	11·44	..
Do.	1848	Marionette	..	..	14·00	11·95	..
Do.	2239	Welcome	..	..	89·00	39·77	..
Do.	2240	Sunset: The Sunset G.M. Co., Ltd.	..	..	67·00	14·30	..

Do.	2255	Manxman South Extended	..	..	126·60	412·50	..	
Do.	2296	Manxman Main Lode ..	..	..	20·00	32·35	..	
Do.	2297	Green Harp	..	..	46·00	53·21	..	
Do.	2304	Bullwark	..	..	62·00	85·32	..	
Do.	2357	Light Wing	..	..	4·50	1·75	..	
Do.	2391	Rosalie	..	..	23·00	23·98	..	
Do.	2435	Lady Mollie	..	..	17·25	6·76	..	
Do.	2453	Golden Hole	..	..	19·50	16·24	..	
Do.	2541, 2542 ..	New Green Harp leases	..	..	665·90	430·70	..	
Do.	2553	Wainui	..	..	20·00	22·30	..	
Do.	2559	Golden Valley	..	..	30·00	2·67	..	
Do.	2595	Rosalie	..	..	64·00	126·57	..	
Do.	2658	Lady Ellen	..	..	27·50	49·30	..	
Do.	2690	Two Seas	..	..	79·00	77·92	..	
Do.	2712	Sand King	..	..	66·00	29·12	..	
Greenmount ..	**2992**	Searchlight	..	..	32·00	17·44	..	
Do	**550**	(Sunbeam)	14·00	..	4,472·00	1,427·25	..	
Do.	**550**	Sunbeam	..	..	200·00	100·14	..	
Do.	**550, (585)** ..	(Sunbeam leases)	..	..	3,191·00	816·42	..	
Do.	**2987**	Sunset	..	..	220·00	28·88	..	
Do.	**536**	(Transvaal)	..	..	30,233·00	7,340·62	579·78	
Do.	**536, 1358** ..	Transvaal leases	..	..	78·00	15·37	..	
Do.	..	Sundry claims	..	4·12	632·50	263·70	..	
Do.	..	Voided leases	..	..	..	..	..	
Do.	693	Alligator	..	..	400·00	95·07	..	
Do.	374	Ardath	..	..	75·00	18·37	..	
Do.	694	Bulletin	..	..	440·00	131·12	..	
Do.	793	Bulletin	..	..	42·00	7·42	..	
Do.	603	Excelsior	..	..	18·00	4·90	..	
Do.	580	Federal	..	..	80·00	13·42	..	
Do. ..	684	Gem	..	..	77·00	9·47	..	
Do.	756	Golden Fleece	..	..	355·00	62·50	..	

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons. (2,240lbs.)	Fine ozs.	Fine ozs.
Greenmount ..	604	Great Southern	..	..	135·00	23·48	..
Do.	713	Great Surprise	..	..	..	35·37	..
Do.	503, 535, 555	(Greenmount G.Ms., Ltd.) ..	..	..	5·00	2·11	..
Do.	503, 535, 555	Greenmount Mines, N.L. ..	..	..	64,186·00	15,788·99	..
Do.	591	Imperial	..	..	133·00	30·92	..
Do.	566	Little Wonder	..	..	71·00	19·92	..
Do.	622	Lord Roberts	..	..	237·00	73·11	..
Do.	1220	Lord Roberts	..	..	56·00	9·88	..
Do.	625	Madge	..	..	65·00	16·14	..
Do.	599	Port Royal	..	..	71·00	13·87	..
Do.	590	Rand	..	..	179·00	43·05	..
Do.	640	Rand	..	..	26·00	5·44	..
Do.	565	(Royal George)	..	..	1,806·00	602·41	..
Do.	744	Southern Cross Boulder ..	..	..	214·00	69·76	..
Do.	564	St. George	..	..	204·00	56·43	..
Do.	655	Sunbeam North	..	..	10·00	·87	..
Do.	492, 511 ..	Transvaal	..	..	692·00	198·09	..
Do.	511, 516 ..	Transvaal	..	..	310·00	61·23	..
Do.	503	(United Australia)	..	..	410·00	120·15	..
Hope's Hill ..	**2544**	Colleen Bawn	..	..	287·20	1,119·77	..
Do.	..	Sundry claims	..	25·38	1,317·50	467·40	..

Do.	..	Voided leases	..	..	..	..	..	..
Do.	500	Australia United	..	..	60·00	6·81	..	
Do.	1052	Cross	..	..	15·00	17·45	..	
Do.	932	Debtors Friend	..	..	150·00	29·20	..	
Do.	2502	Great Boulder, No. 2 ..	..	..	58·00	25·42	..	
Do.	1727, 1771 ..	Hopefinch leases	..	..	107·00	10·41	..	
Do.	795	Hope's Hill	..	..	357·00	152·99	..	
Do.	19, 52, 288, 360, 480	Hope's Hill G.M. Co., Ltd. ..	..	..	124,825·00	31,671·83	..	
Do.	880	Hope's Hill North ..	..	..	165·00	31·83	..	
Do.	895	Hope's Hill Perseverance	..	..	426·50	459·37	..	
Do.	809	Hope Still	..	..	38·00	6·17	..	
Do.	814	Lady Kathe..	..	..	30·00	7·97	..	
Do.	2524	Lady Kathe..	..	..	45·00	7·76	..	
Do.	2639	Last Hope	..	..	34·00	7·42	..	
Do.	877	Maud	..	..	228·00	53·01	..	
Do.	703	Mellor's Hill	..	..	90·00	53·14	..	
Do.	661	Mount Victor	..	..	85·00	16·22	..	
Do.	899	Norwood	..	..	40·00	53·41	..	
Do.	2523	Parisian	..	..	797·50	565·74	..	
Do.	1432	Phoenix	..	..	1,442·50	532·93	..	
Do.	2571	Phoenix South	..	..	30·00	3·90	..	
Do.	801	Pryoress	..	..	104·00	67·61	..	
Do.	620	Railway	..	..	81·35	20·41	..	
Do.	628	Railway South	..	..	105·00	22·42	..	
Do.	1288	Red Wings	..	..	8·00	1·19	..	
Do.	2354	Renegade	..	..	123·00	21·85	..	
Do.	815	Reward South	..	..	20·00	2·44	..	
Do.	921	Rodda's Reward	..	..	312·00	42·13	..	
Do.	2906	Try Again	..	..	88·00	12·75	..	
Do.	910	Willbee	..	..	20·00	2·77	..	
Kennyville ..	**776**	Cornishman	..	13·18	2,048·00	1,780·53	..	
Do.	**570**	(Great Leviathan)	..	..	3,821·85	2,948·67	..	

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons. (2,240lbs.)	Fine ozs.	Fine ozs.
Kennyville ..	**570**	Great Leviathan	..	..	4,073·00	3,192·32	..
Do.	**570**	(Great Leviathan: Northern Blocks Syndicate, Ltd.)	..	..	10,705·00	2,974·64	..
Do.	**911**	Trafalgar	..	..	1,337·00	1,111·52	..
Do.	..	Sundry claims	..	..	277·00	151·42	..
Do.	2574	Bournville	..	..	83·00	29·35	..
Do.	813	Catherine	..	..	399·50	161·63	..
Do.	2876	Catherine	..	..	135·00	41·23	..
Do.	828	Croesus	..	..	31·00	5·81	..
Do.	2545	Emperor	..	..	53·00	8·04	..
Do.	856	Glen Dower	..	..	237·00	150·09	..
Do.	2539, 2568 ..	Mornington Prospecting Syndicate, N.L.	..	..	20·00	3·18	..
Do.	683	New Chum	..	..	67·00	6·74	..
Do.	582	Yilgarn Perseverance ..	..	..	158·00	77·40	..
Do.	..	Voided leases	..	..	..	..	..
Koolyanobbing ..	641	Chadwick's Reward ..	..	..	6·00	2·65	..
Do.	909	Jupiter	..	..	12·00	9·15	..
Do. ..	917	Saturn	..	..	28·00	2·07	..
Do. ..	783	St. Clair, No. 2 South ..	..	..	262·00	102·87	..
Marvel Loch ..	**923**	Bohemian	..	17·44	3,349·00	3,263·85	..

Do.	1689	(Bronco)	..	..	217·00	22·17	..	
Do.	1689	Bronco : Bronco Horseshoe Pro-Prietary Mining Co., N.L.	..	..	1,776·00	591·76	..	
Do.	(1465)	Comet	..	..	6,673·00	5,640·34	..	
Do.	(768)	(Donovan's Find)	..	..	1,768·00	1,999·43	..	
Do.	(768)	Donovan's Find : Greenmount Mines, N.L.	..	..	2,276·00	1,117·44	..	
Do.	1463	Eclipse	..	..	2,003·00	1,474·38	..	
Do.	3006	Firelight	..	6·87	15·00	26·20	..	
Do.	(820)	Gentle Annie	..	..	1,627·00	670·64	..	
Do.	(2885)	Golden Cube	..	..	65·00	32·31	..	
Do.	2656	Golden Dream	..	..	40·00	52·65	..	
Do.	719	(Great Victoria)	..	..	1,356·00	281·53	..	
Do.	719, 944, 945, 1227, 1228, 1606	Great Victoria leases ..	..	..	60,988·00	7,056·80	..	
Do.	(2907)	Jacoletti No. 1	..	..	367·00	164·72	..	
Do.	(714)	(Marvel Loch)	..	..	500·00	316·81	..	
Do.	(714), (723), (822), (869)	Marvel Loch G.M. Co., N.L. ..	..	..	49,235·50	18,590·18	379·96	
Do.	852	May Queen	..	4·07	626·50	3,613·48	..	
Do.	(803), (838), (948), (949) (950), (951)	(Mountain Queen leases) ..	..	..	748·00	208·39	..	
Do.	(803) (838), (948), (949), (950), (951), (2543), (2754)	Mountain Queen, Ltd. ..	..	..	103,909·00	29,222·44	376·17	
Do.	(665)	(Never Never)	..	..	29,395·00	7,709·26	..	
Do.	3030	Never Never	..	..	85·00	48·25	..	
Do.	(2979)	Newry	..	..	159·00	27·16	..	
Do.	3017	Pro Patria	..	..	307·00	362·14	..	
Do.	1011	Rising Star	..	..	140·00	11·48	..	

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons	Fine ozs.	Fine ozs.
Marvel Loch ..	2993	Sandfly	..	..	310·00	302·30	..
Do.	2998	St. George	..	..	708·00	294·90	..
Do.	3011	Victory	..	..	145·00	83·63	..
Do.	(665), (765) ..	Yilgarn G.M. Co., Ltd. ..	..	..	4,353·00	749·63	14·90
Do.	..	Sundry claims	7·72	68·81	5,425·75	3,371·26	..
Do.	..	Voided leases					
Do.	2484	Bee	..	..	68·00	36·16	..
Do.	774	Alpha	..	..	34·00	26·19	..
Do.	2530	Beta	..	..	40·00	5·76	..
Do.	2538	Cadonia	..	..	40·00	43·19	..
Do.	R.C. 656 ..	Christmas Gift	..	..	452·00	325·83	..
Do.	819	Christmas Gift	..	..	49·00	16·76	..
Do.	2588	Dalmore	..	..	14·00	38·40	..
Do.	925	Dell	..	..	100·00	62·81	..
Do.	884	Democrat	..	..	289·00	154·50	..
Do.	869	(Evelen's Eden)	..	..	104·00	44·29	..
Do.	717	Evelen's Eden	..	..	622·00	349·17	..
Parker's Range ..	2978	Gift	..	..	96·00	71·39	..
Do.	2656	Golden Dream	..	37·10	366·00	583·20	..
Do.	(2606)	King of the Range ..	..	..	331·00	624·06	..
Do.	(2905)	Lord Kitchener	..	..	16·00	3·11	..

Do.	**2801**	Scots Greys	..	..	10·00	6·25	..
Do.	**2546**	South Side	..	4·82	112·00	42·21	..
Do.	**724**	(Spring Hill)	..	..	3,232·00	607·21	..
Do.	**724, (760)** ..	(Spring Hill leases) ..	..	..	8,910·00	2,215·59	..
Do.	**724, 2633** ..	Spring Hill G.M. Co., N.L. ..	..	..	1,176·00	112·88	..
Do.	**2806**	Star of the Range ..	..	..	92·50	189·21	..
Do.	**2951**	White Horseshoe	..	..	541·75	484·02	..
Do.	..	Sundry claims	..	..	1,576·75	1,030·53	..
		Voided leases	..	..	..	..	..
Do.	485, 508 ..	Australia	..	..	3,218·00	1,666·37	..
Do.	771	Battler's Hill	..	..	6·00	16·89	..
Do.	515	Blue Hill	..	..	80·00	366·47	..
Do.	(515), 520 ..	Blue Hill	..	..	1,071·00	1,627·94	..
Do.	524	Blue Hill No. 1 North ..	..	..	20·00	7·59	..
Do.	830	Brilliant	..	..	278·50	163·22	..
Do.	2785	Briton	..	..	51·00	46·29	..
Do.	216	Passby: Carlyle G.M. Co., Ltd.	..	..	36·00	47·18	..
Do.	746	Dulcie Jean	..	..	108·75	161·35	..
Do.	751	Ell Ess Dee	..	..	26·00	28·61	..
Do.	2128	Ell Ess Dee	..	..	11·00	3·24	..
Do.	491	Enterprise	..	..	750·00	147·15	..
Do.	736	Garibaldi	..	..	70·50	38·98	..
Do.	594	Golden Cube	..	..	600·00	672·09	..
Do.	707	Golden Cube	..	..	1,344·00	518·80	..
Do.	263	Golden Key Extended ..	..	..	20·00	11·45	..
Do.	2512	Golden Links	..	..	13·00	12·81	..
Do.	698	Golden Mile G.M. Co., Ltd. ..	..	..	33·00	3·75	..
Do.	761	Golden Rod	..	..	137·00	62·10	..
Do.	310	Good Brothers	..	..	35·00	20·74	..
Do.	(491), 528 ..	Gordon Highlander ..	..	..	116·00	92·36	..
Do.	573	Gordon Highlander ..	..	..	60·00	24·33	..
Do.	668	Gordon Highlander ..	..	..	117·00	44·42	..
Do.	547	Havelock	..	..	30·00	12·24	..

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.
Parker's Range ..	240	Just in Time	..	..	15·00	21·71	..
Do.	2649	Kia Ora	..	..	84·00	37·88	..
Do.	2503	Lone Hand	..	..	23·00	3·33	..
Do.	574	Lucky Hit	..	..	101·00	94·57	..
Do	908	L.S.D.	..	..	140·00	33·84	..
Do.	443	Lydia	..	..	10·00	·94	..
Do.	1099	(McIntosh)	..	..	110·00	54·89	..
Do.	797	McIntosh	..	..	172·00	101·66	..
Do.	518	McIntosh G.M. Co., Ltd. ..	..	..	29·00	14·90	..
Do.	827	New Year's Gift	..	..	1,676·00	416·32	..
Do.	1099, 1566 ..	Parker's Range G.Ms., N.L. ..	..	..	213·50	209·55	..
Do.	769	Piemonte	..	..	259·50	44·93	..
Do.	250	Queen of Sheba	..	..	2·00	1·25	..
Do.	489	Queensland Consols ..	..	..	160·00	41·77	..
Do.	(T.A. 9) 485 ..	Queensland United: Australian Mines Agency, Ltd.	..	..	158·00	559·72	..
Do.	1688	Raven	..	..	25·00	4·71	..
Do.	2683	Referenda	..	..	66·00	148·54	..
Do.	2324	Searchlight North: Yarloop Prospecting Syndicate	..	..	150·50	31·77	..

Do.	1779	Searchlight: Ziggler Prospecting and Option Syndicate, N.L.	..	..	57·50	40·84	..
Do.	2611	Snowdrop	..	..	155·00	204·25	..
Do.	2676	South Side Extended ..	..	..	36·00	20·17	..
Do.	2670	Sphinx	..	..	34·00	33·11	..
Do.	2682	Star of the Range ..	..	..	140·00	146·95	..
Do.	1425	Splendid Kingfisher: King of the Range G.M. Co., Ltd.	..	..	52·00	85·08	..
Do.	532	Triumph	..	..	248·00	77·18	..
Do.	642	Triumph	..	..	83·00	42·57	..
Do.	2974	Evelen's Eden	..	..	40·00	13·04	..
Do.	753	Exhibition	..	..	859·00	278·64	..
Do.	823	Exhibition	..	..	1,111·00	430·83	..
Do.	858	Firelight	..	..	200·00	49·80	..
Do.	779	Frances Firness	..	..	1,825·00	826·47	..
Do.	825	Geelong	..	..	155·00	102·93	..
Do.	2609	Geelong	..	..	222·50	142·01	..
Do.	2563	Golden Gate	..	..	18·00	3·74	..
Do.	851	Green Jacket	..	..	8·00	6·37	..
Do.	490, 517, 558, 559, 804	Jacoletti G.Ms., Ltd.	..	..	6,716·00	2,929·74	..
Do.	821	Lady Agnes	..	..	77·00	14·72	..
Do.	490, 517, 558, 559	(Lady Loch Mines, Ltd.) ..	..	..	2,091·00	674·01	..
Do.	739	Marvel Loch North ..	..	..	626·00	398·76	..
Do.	2662	Marvel Loch North ..	..	..	96·00	49·52	..
Do.	792	Mountain King	..	..	387·00	245·73	..
Do.	1603	Mountain King	..	..	205·00	137·50	..
Do.	2684	Mountain King	..	..	188·00	172·30	..
Do.	805	Mountain Prince	..	..	255·00	106·84	..
Do.	1156	Mountain Prince North ..	..	..	60·00	11·67	..
Do.	2490	New Democrat	..	..	316·50	241·71	..

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.
Parker's Range ..	824	Newry	..	..	990·50	218·36	..
Do.	812	Pariah	..	..	120·50	89·61	..
Do.	807	Queen Mab	..	..	260·00	125·79	..
Do.	2575	Saint George	..	..	1,266·00	443·93	..
Do.	839	Scorpio	..	..	1,754·50	1,309·37	..
Do.	2522	Southern Kingfisher ..	..	..	114·00	13·15	..
Do.	1435	Starfinch	..	..	149·00	58·10	..
Do.	490, 517, 558, 559	(Turnbull's leases)	..	..	2,143·00	1,481·72	..
Do.	1452	Undaunted	..	..	834·00	249·41	..
Mt. Jackson ..	**1979**	Allen's Find..	..	..	1,511·05	777·82	..
Do.	**1933**	Butcher Bird No. 1 ..	..	..	2,668·50	1,977·59	..
Do.	**2053**	Great Unknown	..	37·22	1,225·43	3,469·92	..
Do.	(**2190**)	Miner's Dream	..	..	425·00	129·34	..
Do.	(**2826**)	Unknown South	..	..	19·00	15·62	..
Do.	..	Voided leases	..	77·66	30,914·55	21,046·90	2,305·28
Do.	..	Sundry claims	4·42	25·43	1,418·25	917·31	..
Do.	246, 450, 451, 459, 460, 494	Associated Mt. Jackson G.Ms. (W.A.), Ltd.	..	..	801·50	224·71	..
Do.	2284, 2285 ..	Athlone Reward leases ..	..	..	105·00	104·81	..

Do.	2547	Best Known	..	..	20·80	33·35	..	
Do.	2336	Bronzewing	..	..	44·50	60·03	..	
Do.	2271	Effie's Reward	..	..	·25	3·70	..	
Do.	2362	Flemington	..	..	..	4·36	..	
Do.	2505	General Jackson	..	..	36·00	26·27	..	
Do.	2444	Great Unknown, North ..	..	..	25·50	66·15	..	
Do.	2156	Inglewood	..	..	13·50	8·96	..	
Do.	2597	Just in Time	..	..	10·00	12·20	..	
Do.	2602	Known Best	..	..	12·00	13·93	..	
Do.	2636	Lone Chance	..	..	10·00	6·77	..	
Do.	2387	Marda East	..	..	7·50	12·01	..	
Do.	212, 217, 233, 397, 462	Mt. Jackson G.Ms., Ltd. (1897)	..	..	9,537·00	6,210·61	..	
Do.	212, 217, 233, 397, 462, 658, 659	(Mt. Jackson G.Ms., Ltd.) ..	..	..	15,054·00	9,806·22	..	
Do.	212, 217, 397, 658, 659	Mt. Jackson G.Ms., Ltd. ..	..	..	4,506·00	3,297·25	..	
Do.	212, 217, 658, 659	Mt. Jackson leases	..	..	250·00	119·55	..	
Do.	2397	Mt. Jackson Wonder ..	..	..	120·00	44·27	..	
Do.	2713	Newmarket	..	..	9·00	73·16	..	
Do.	2527	Persian	..	..	16·00	31·96	..	
Do.	2300	Queen of the Hills ..	..	..	8·00	20·85	..	
Do.	2548	Standard	..	..	249·00	877·69	..	
Do.	2157	Three Kings	..	..	10·00	12·31	..	
Do.	2614	Titanic	..	..	26·00	24·92	..	
Do.	2564	Victoria Reef	..	..	27·00	5·14	..	
Do.	2569	Wellknown	..	..	6·00	6·96	..	
Do.	2310	Yarbu	..	..	10·00	16·42	..	
Mt. Rankin ..	..	Sundry claims	..	..	170·00	54·38	..	
Do.	..	Voided leases	..	..	..	..	..	
Do.	416	Mt. Rankin	..	..	56·00	21·96	..	

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.
Mt. Rankin ..	525	Mt. Rankin	..	..	196·00	56·58	..
Do.	870	No Trumps	..	..	244·00	52·67	..
Southern Cross ..	(2744)	Central	..	..	273·00	62·50	..
Do.	3010	Central	..	..	167·00	51·25	..
Do.	3016	Central Extended	..	..	15·00	9·97	..
Do.	(2714)	Fraser's North Extended ..	..	..	10·00	10·37	..
Do.	(2342)	Haddon Consolidated ..	..	..	3,810·50	1,320·84	..
Do.	(2416)	(Maori Lass)	..	..	250·00	52·31	..
Do.	(2416)	Maori Lass, Ltd.	..	..	483·00	54·47	..
Do.	2987	Sunset	..	..	80·00	9·47	..
Do.	..	Sundry claims	3·73	595·45	2,292·10	684·38	..
Do.	..	Voided leases	..	..	..	..	..
Do.	652	Alison Brown	..	..	10·00	1·77	..
Do.	2529	Allerton	..	..	142·00	50·18	..
Do.	579	Auraria	..	..	15·00	4·45	..
Do.	473	Ave Maria	..	..	50·00	10·18	..
Do.	663	Birthday Gift	..	..	73·00	17·28	..
Do.	738	Brown Hill	..	..	176·00	38·62	..
Do.	2572	Central	..	..	47·00	29·61	..
Do.	279, 890 ..	(Central G.M. Co., N.L.) ..	..	..	44,958·00	19,702·85	..
Do.	749	(Central Extended) ..	..	..	760·82	932·68	..

Do.	(467), 521 ..	Comet	..	..	3,161·00	570·13	..
Do.	456	Day Dawn G.M. Co., N.L. ..	..	..	72·50	8·34	..
Do.	556	Eureka Boulder	..	..	30·00	7·22	..
Do.	697	Excelsior	..	..	788·00	465·82	..
Do.	2423	Excelsior No. 2	..	..	17·00	1·12	..
Do.	889 (late 13) ..	(Fraser's G.M. Co., N.L.) ..	..	..	151,771·00	61,870·33	..
Do.	888, 889 ..	Fraser's G.M. Syndicate ..	..	..	287·25	681·79	..
Do.	888 (late 29) ..	(Fraser's South G.M. Co., N.L.)	..	..	48,233·00	20,013·23	..
Do.	256, 496, 554, 562	Fraser's South Extended G.M. Co., Ltd.	..	..	43,747·68	18,433·55	..
Do.	230, 253 ..	Golden Pig leases: Water Trust and Public Crushing Co. of W.A., Ltd.	..	..	3,889·35	944·83	..
Do.	448 (late 286)	Golden Pig North	..	..	20·00	4·70	..
Do.	576	Golden Pig North	..	..	94·00	20·38	..
Do.	653	Golden Pig North	..	..	15·00	2·57	..
Do.	670	Golden Pig North	..	..	45·00	5·95	..
Do.	449	Golden Rock	..	..	12·00	1·50	..
Do.	470	Great Southern	..	..	380·00	321·79	..
Do.	552	(Haddon)	..	..	680·00	145·01	..
Do.	552	Haddon	..	..	..	8·64	..
Do.	552, 611 ..	(Haddon leases)	..	..	7,178·00	1,396·90	..
Do.	529, 551 ..	Hatt & Lang's leases ..	..	..	6,601·00	1,898·54	..
Do.	501	Homeward Bound	..	..	758·85	218·94	..
Do.	673	Ine Zella	..	..	214·00	47·48	..
Do.	526	Irene	..	..	196·00	43·40	..
Do.	1259	King of the Cross	..	..	10·00	·79	..
Do.	1056	(Lady Edeline)	..	..	12·00	13·87	..
Do.	749, 1056, 1543, 2218	Lady Edeline G.M. Co., N.L.	..	..	12·00	148·11	..
Do.	1042	Lord Cardigan	..	..	432·00	127·61	..
Do.	613	Lord Cardigan	..	..	913·00	232·93	..
Do.	560	Northern Star	..	..	112·00	36·43	..

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production.				
			Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons (2,240lbs.)	Fine ozs.	Fine ozs.
Southern Cross ..	647	Northumberland	..	..	35·00	7·24	..
Do.	280	No. 1 Central Extended G.M. Co., N.L.	..	..	10,374·00	4,261·34	..
Do.	575	Pendrea	..	..	25·00	5·22	..
Do.	475	Perseverance	..	..	..	1,089·17	..
Do.	1889	Pretoria	..	..	127·00	32·26	..
Do.	681	Pride of the Hills	..	..	139·00	22·51	..
Do.	2651	Queen Ann	..	..	388·00	129·23	..
Do.	529	(Reward)	..	..	2,300·00	1,664·48	..
Do.	737	Reward	..	..	46·00	64·10	..
Do.	467	Southern Cross	..	..	167·00	91·05	..
Do.	454	Southern Cross Boulder ..	..	..	50·00	9·87	..
Do.	644	Southern Cross Boulder ..	..	..	10·00	3·43	..
Do.	612	Southern Cross Extended	..	..	53·00	6·41	..
Do.	611	(Take Down)	..	..	16·00	13·79	..
Do.	252	Tarcoola	..	..	11·00	16·47	..
Do.	568	Tarcoola	..	..	60·00	8·29	..
Do.	276	Tarcoola North	..	..	50·00	21·33	..
Do.	631	William Tell	..	..	27·00	5·04	..
Do.	567	Wimmera	..	..	2,268·00	345·87	..
Do.	676	Wimmera	..	..	3,200·00	715·90	..

Do.	2382	Yess	..	..	22·00	8·64	..	
Do.	2651	Yilgarn Consols G.M. Co., N.L.	..	..	598·50	155·42	..	
Weston's	2769	(Battler)	..	..	115·00	170·64	..	
Do.	(2814)	Battler West	..	..	11·00	8·35	..	
Do.	2180	(Edna May)	..	..	581·00	919·27	..	
Do.	2769	Edna May Battler G.M. Co., N.L.	..	..	1,988·00	1,909·36	..	
Do.	2291, 2585, 2615	Edna May Central G.Ms., N.L.	..	..	64,869·00	19,926·45	19·38	
Do.	2570, 2617, 2644	Edna May Consolidated G.M. Co., N.L.	..	..	668·00	261·16	..	
Do.	2180, 2605 ..	Edna May G.M. Co., N.L. ..	..	..	110,483·00	110,021·13	..	
Do.	2775	Emma May	..	..	40·00	20·31	..	
Do.	3026	Florence Mabel	..	..	17·00	19·94	..	
Do.	3004	Great Battler	..	..	50·50	68·86	..	
Do.	(2086), 2087, 2088, (2635)	Greenfinch Proprietary G.M., Co., N.L.	..	..	7,875·00	2,853·95	..	
Do.	2807	Hill End	..	..	194·00	136·87	..	
Do.	(3020)	Irene	..	..	15·00	24·81	..	
Do.	2291	(Myrtle Central)	..	..	751·00	243·96	..	
Do.	2168, 2238 ..	Myrtle Consols leases ..	..	..	1,252·00	1,204·35	..	
Do.	2570	(Myrtle East)	..	..	202·00	116·12	..	
Do.	2816	Pertha M.	..	..	392·00	263·41	..	
Do.	(2867)	Western Options	..	4·06	10·00	2·88	..	
Do.	2724	(Weston's Reward)	..	..	35·00	57·24	..	
Do.	2724, 2761 ..	Weston's Reward G.Ms., N.L.	..	..	473·50	424·66	..	
Do.	..	Sundry claims	..	11·04	728·75	710·05	..	
		Voided leases.						
Do.	2361	Independent	..	..	28·00	18·47	..	
Do.	2241	Jessie No. 1	..	..	16·50	18·24	..	
Do.	2092	Little Mary	..	..	16·00	3·47	..	
Do.	2565	Nevertire	..	..	12·00	2·13	..	
Do.	2083	Christmas Birthday Central	..	..	20·75	33·56	..	
Do.	2577	Diorite Queen	..	..	5·00	1·20	..	
Do.	2688	Elsie	..	..	73·50	22·19	..	

TABLE SHOWING THE GOLD PRODUCTION OF THE YILGARN GOLDFIELD—*continued.*

Mining Centre.	No. of Lease.	Registered Name of Company or Lease.	Total Production. Alluvial.	Dollied and Specimens.	Ore treated.	Gold therefrom.	Silver.
			Fine ozs.	Fine ozs.	Tons.	Fine ozs.	Fine ozs.
		From Goldfield generally:					
		Sundry parcels treated at:					
		Australia Battery	..	..	38·00	124·94	..
		Donovan's Find Battery	..	..	..	2,536·33	..
		Fraser's G.M. Works	..	..	..	583·63	..
		Fremantle Smelting Works	..	..	21·28	592·34	33·90
		Great Victoria Cyanide Works	..	..	..	3,295·38	..
		Greenfinch Proprietary G.M. Works ..	..	..	..	2,187·86	..
		Hopes Hill Cyanide Works	..	..	..	1,174·57	..
		Jacoletti Works	..	..	..	2,062·82	..
		Marvel Loch Mining Co., N.L.	..	..	..	3,633·77	..
		Never Never Works	..	..	..	146·00	..
		Spring Hill Works	..	..	..	266·26	..
		Sunbeam Works	..	..	8·00	5,242·28	..
		Violet Works	..	..	..	923·51	..
		Various Works	..	..	59·00	11,053·60	2·64
		Reported by Banks and Gold Dealers ..	22·05	3·53	..	..	..
		Total	**89·88**	**1,394·70**	**1,652,337·97**	**756,481·84**	**20,886·86**

APPENDIX II.

THE KOOLYANOBBING IRON ORE DEPOSITS.

By T. BLATCHFORD.

On account of the discovery of some very high-grade micaceous-hæmatite iron ore in the vicinity of the Trig. Station on the Koolyanobbing Range, a second inspection was made, the primary object being to try and locate the boundaries of the deposit and, if possible, ascertain whether any other deposits of a similar nature occurred in the vicinity.

The hæmatite deposit was found to be a lens of ore, the major axis of which was 170 feet and the minor 70 feet. From the sides of this lens veinlets of ore extend into the surrounding rock. Such were not included in the area marked out as the lens.

The ore in the lens is massive hæmatite, mixed to a certain extent with fragments of the quartzite, the staple rock of the range. The occurrence is, apparently, secondary deposition of iron ore in a brecciated zone. In consequence of the included foreign siliceous material the value of the ore as a commercial product is considerably lessened, which, taken in conjunction with its apparently limited area, detracts from the value of the deposit. One point in favour of greater quantities of ore being found than appear at the surface is the extreme magnetism where no iron shows at the surface.

This magnetism is particularly noticeable at and near the Trig. Station, the variation in the needle being so pronounced as to render magnetic readings from this point worthless.

As may be seen from the accompanying analysis the picked ore from the hæmatite lens is practically free from sulphur and phosphorus, whilst the contained silica is very low too.

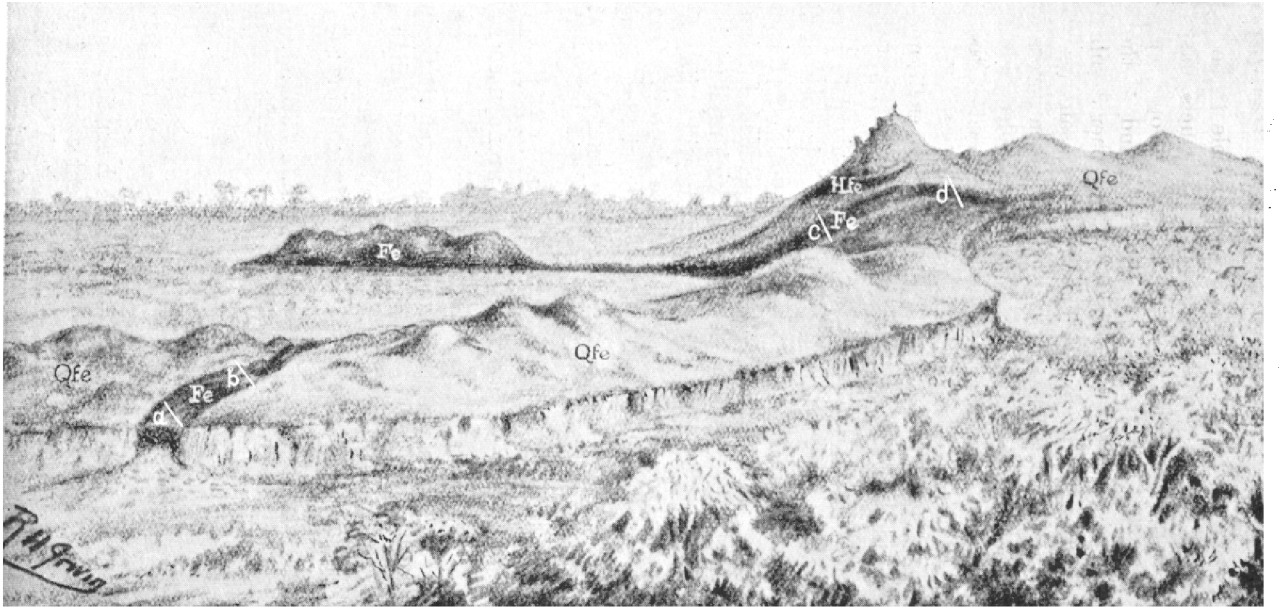
Analysis of micaceous hæmatite, Koolyanobbing:—

G.S.M. $\frac{1}{51}$.		G.S.L. 7458D.
Fe_2O_3	98·75%	Fe 69·13%
SiO_2	1·04	
P	·016	
S	trace	
Ignition loss	·39	

Analyst, D. G. MURRAY.

Lying to the west and abutting on the hæmatite lens a deposit of brown iron ore was noticed. The apparent course of this deposit was from the gnamma-hole on the flat, past the Trig. Station and extending to the bluff south of the Trig. Station.†

† Plate XIX.



General Sketch of Koolyanobbing, illustrating occurrence of iron-bearing deposits.

Two samples were broken from the outcrops of this lode—one (C) immediately to the west of the Trig., and the other (D) near the southern extremity.

The samples were broken over a width of 200 and 150 feet respectively.

Under the present conditions it is impossible to be too definite as to the occurrence, for the surface is very much masked by the talus of the higher portion of the range. It would appear, however, that an extensive faulting has occurred and in the fault this extensive iron deposit has been formed. Another similar lode has been located north-west from the Trig.* Two samples were taken from this deposit also. Of these, the first was taken across the dip on the face of the escarpment, the total width sampled being 150 feet. Sample (A). Another (B) was taken 500 feet east of the first, over a width of 200 feet.

The results from these four samples were remarkably regular and gave a high percentage of metallic iron. The percentages of silica, phosphorus, and sulphur were also very low. Unfortunately, time would not permit of an investigation of the whole of the range, but judging by the faulting marked out by my colleague during his inspection, it is highly probable that similar deposits would be located if the range were thoroughly inspected. The sampling, it should be noted, was not undertaken to prove the value of the deposits, but only as a preliminary inspection to ascertain whether they were worthy of further notice, in the view of a possible opening up iron deposits for commercial uses.

However gratifying the results may seem, there is still much work to be executed before any definite data can be put on paper. The preliminary assays should first be checked and an attempt made to find other, may be, larger deposits which may be even more accessible than the present ones under notice. If such investigations proved satisfactory the expenditure of capital to prove the extent of the deposits would then be warranted. This could be done in three ways: Shaft sinking and cross-cutting, driving adits along the lodes from the sides of the range, or boring. Several factors arise in deciding the best of these three.

In the first place, before an iron lode can be considered a commercial proposition the following must be taken into consideration:—

Extent of deposit, grade of ore, working costs (including freights).

From the preliminary sampling the grade appears to be high and very regular, and may be considered of secondary importance to tonnage. For this reason it appears that boring would be the proper method to adopt, as the deposits could be proved to much greater depths by boring, for the same expenditure, and at the same time fair samples taken from the cores. Unless mining operations

*Plate XIX.

were extended to considerable depths they would not be of any use in working the deposits, for if at any time they were mined, open cutting or quarrying would be resorted to for at least 100 to 200 feet from the outcrops.

As regards transportation, a branch line from the main trunk line could easily be laid over level country, the total distance being not more than probably 30 to 35 miles, the connection being at Southern Cross, or thereabouts, a distance of, roughly, 240 miles from Fremantle. The ore, being at no great distance from the trunk line, would make excellent back loading.

"Analyses of four samples of iron ore from Koolyanobbing:—

G.S.L., No.	9618	9619	9620	9621
Mark	A	B	C	D
	%	%	%	%
Fe_2O_3	90·30	88·33	86·76	86·44
equal to				
Fe	63·21	61·85	60·73	60·51
SiO_2	2·02	4·78	2·40	3·08
S	·06		·04	
P	·01		·006	
Gold (per ton)	trace	trace	10grs.	16grs.

"The sulphur and phosphorus were determined in mixtures of equal proportions of the component samples. The undetermined is mainly combined water.

"These are high-grade brown iron ores of the non-phosphoric class, suitable for the manufacture of steel by the acid Bessemer, Open Hearth, or Electric processes.

"The principal constituents are:—

Of (1) and (2) Turgite and Goethite.
Of (3) and (4) Goethite."

(Sgd.) EDWARD S. SIMPSON,
Mineralogist and Chemist.

14th September, 1916.

SECTION C.

THE MINERALS OF WESTONIA.

By Edward S. Simpson.

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THE MINERALS OF WESTONIA.

By EDWARD S. SIMPSON.

The following notes on the minerals to be found at or near the gold-mining centre of Westonia are based mainly on the collections made by Mr. T. Blatchford, Assistant Geologist, during the progress of a geological survey of this area. To him I am indebted for much information regarding the modes of occurrence in the field. I have also had access to specimens collected by Mr. H. G. Stokes, manager of the Edna May Golden Point Mine, to whose enthusiasm as a collector of minerals is due the discovery of the unusual variety of wulfenite described in the following pages.

The rock-forming minerals of Westonia are in the main identical with those of other gold-mining areas of the central plateau of Western Australia whose mineralogy has been studied in detail, the prevailing rock types being microcline granite and hornblendic greenstones. The large development of biotite in the granitic rocks and their offshoots, and to some extent in the altered greenstones, is a point of distinction, as also the presence of unaltered olivine in one of the smaller rock masses. Turning to metamorphic rock minerals, we find tourmaline unusually rare, but garnet, andalusite and sillimanite present, all three distinctly uncommon in our plateau goldfields. The deep seated carbonation of the rocks, which is so well marked at almost all the other important gold-mining centres (*e.g.*, Kalgoorlie, Warrawoona, Meekatharra, Bullfinch and Ora Banda) is here almost absent, secondary carbonates being detected only in small quantities in a very few rocks.

The metallic minerals so far recorded are somewhat unusual in kind, and for an explanation of this one must turn to the entirely unusual occurrence of the gold, the sole object of the local mining activity. The gold at Westonia is for the most part found in dykes or veins of pegmatite or pegmatitic quartz, or impregnations immediately adjacent thereto, the term "pegmatitic quartz" being used for the quartz of a vein which, whilst in one place it may appear to consist of quartz only, can be traced without break into a quartz enclosing microcline in greater or less abundance, the whole vein being thus essentially a pegmatite. Under these circumstances it is not surprising that mining operations have disclosed the presence of such typical pegmatite minerals as molybdenite, wolfram, and xenotime, none of which have been recorded from any of the other centres mentioned in the previous paragraph.

In the following pages some details are given regarding the individual mineral species observed, which number more than forty. Only the briefest record is made of the purely rock-forming species, these being dealt with more fully by the Petrologist in Section D. The order followed in this section has been that of Danas System of Mineralogy.

NATIVE ELEMENTS.

Native Gold (Alloy of gold and silver).—The abundance of native gold at Westonia is the *raison d'être* of its existence as a mining town, in fact as a town at all. No compounds of gold are known in the district. The metal occurs in ragged grains in pegmatite veins, which in places are coarse mixtures of quartz and microcline, *e.g.* [1/1226], Weston's Reward G.M., in places pass into a typical granite, *e.g.*, [1/1163], Recovery G.M., and again in places possess the characters of ordinary quartz veins. Some of the latter may not be genetically connected with the pegmatites, but in many cases they have been traced into microcline-bearing quartzes. In addition to these minerals, pyrite, marcasite, galena, biotite, wolfram and molybdenite are the chief associated minerals of the unweathered zone, and kaolin, iron hydrates, miloschite, pyromorphite, wulfenite, and crocoite the chief secondary minerals. At the Jessie G.M., near Boodalin Soak, gold has been observed in a gabbro pegmatite, composed mainly of coarse green hornblende, with epidote. This gold is probably an infiltration from a near-by quartz stringer.

Only one specimen of native gold has been analysed. This was from a small vugh in the weathered pegmatite forming the main lode in the Edna May G.M. at a depth of 225 feet (68 metres). It contained 95.14 per cent. of gold, 4.86 per cent. of silver, and only minute traces of base metals.

In addition to the gold found in lodes, the metal is also found in a buried stream bed (deep lead) on the Edna May Central G.M. This consists of large and small quartz pebbles cemented by clay. Much of the gold is in thin and thick films on the surface of the pebbles or in minute cracks in the pebbles or in the cementing material, [1/1222]. This is plainly not alluvial gold in the true sense of the term, but secondary gold deposited by chemical action out of percolating gold-bearing solutions during or after the burial of the stream bed.

METALLIC SULPHIDES.

Molybdenite (sulphide of molybdenum).—Some very fine specimens of this mineral in pegmatitic quartz [1/1225] were obtained from a patch in the Edna May main lode at 260 feet (79 metres) in the Central Mine. The only associated mineral other than the quartz is a little pyrite. The mineral is in coarsely foliated masses up to two inches (5cm.) in diameter, and one-eighth inch (3mm.) thick. Odd masses are scattered through the quartz, but the chief aggregation is on a fracture plane, which is almost completely coated with it. A few small scales are also seen scattered over a foliation plane of the biotite gneiss close to some interbedded quartz stringers from the ore body at the 225ft. (68 metres) level of the Edna May G.M. [1/1224]. Mr. Blatchford further reports the presence of the same mineral in the Edna May Deeps G.M.; and Mr. Stokes has collected at the 560ft. level in this mine a sillimanite gneiss with interfoliated films of molybdenite.

The patches of this mineral are nowhere apparently of sufficient extent to be worth treating for the recovery of the mineral, even at the present very high price of £5 per unit of MoS_2 for 85 per cent. concentrates.

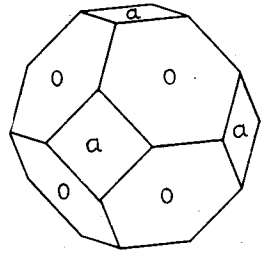
Galena (Sulphide of lead).—Galena is seen in only two specimens collected by Mr. Blatchford. One, [1/1225], is a grey quartz gold ore from the big bulge of the main lode at the north-east end of the 300ft. level in the Edna May G.M. Galena is quite abundant in this specimen in masses up to one inch (25mm.) in length with coarse cubical cleavage. No blende was associated with it. A similar specimen, [1/1262], was collected in No. 1 stope at the 225ft. level of the same mine.

Pyrrhotite (Sulphide of iron).—Pyrrhotite is far from common at Westonia. It was seen in a specimen of the Edna May biotite gneiss taken from a depth of 223 feet (68 metres) in Duff's Bore on the Edna May Deeps Mine. The powdered rock, on moistening with dilute hydrochloric acid, yielded a strong smell of sulphuretted hydrogen, and analysis showed the presence of 1.24 per cent. of pyrrhotite associated with 0.11 per cent. of pyrite. Sections of the rock show the pyrrhotite to be a secondary impregnation, deposited mainly in narrow fractures following the outlines of the original quartz grains, and to a slight extent spreading from these into the solid masses of adjacent minerals.

A few small grains were detected in a specimen [1/1223] of felspathic quartz, showing free gold, from the 225ft. level of the Edna May Mine, and in an ore with much galena from the 300ft. level of the same mine.

Pyrite (Bisulphide of iron).—Although pyrite is the most common sulphide at Westonia, it is not abundant in most mines, the unoxidised ores containing, as a rule, only small proportions of sulphides. An exception is the sulphide ore collected by Mr.

Fig. 48.



Crystal of pyrites from sulphide gold ore, Hill End Gold Mine, Westonia.

Blatchford in the Hill End Mine [1/1263, 1/1264], which contains a large amount of massive and crystallised pyrite associated with quartz and some marcasite. The common form of pyrite crystal

in this ore is the combination of the octahedron and the cube, *vide* Fig. 48.

Small grains and strings of pyrite were detected in most of the country rock from below water level.

Marcasite (Bisulphide of iron).—Some specimens of sulphide ore from the Hill End G.M. contain an iron sulphide which rapidly oxidises to ferrous sulphate on exposure to the air, even within doors. This is doubtless marcasite. It occurs both alone in quartz, and in patches with normal pyrite, *see* [1/1264].

HALOGEN COMPOUNDS.

Salt, Halite (Chloride of sodium).—The underground waters of the district are strongly saline, and, by leaching with water, the presence of dry salt and epsomite derived from the water can be proved in most of the more porous weathered rocks at a little distance below the surface.

OXIDES AND HYDRATED OXIDES.

Quartz (Oxide of silicon).—Plentiful as a constituent of granites, gneisses, pegmatite veins and quartz veins. Both the latter are frequently payably auriferous. The quartz veins are in many cases only extremely siliceous phases of the pegmatites, since in some of them occasional microcline crystals are found, and with regard to others, mining operations have proved their continuity with undoubted microcline pegmatites.

Opal (Hydrated oxide of silicon).—At the 300ft. level of the Edna May Mine a little opal has been disclosed in the ultra-basic wall rock some distance from the lode. It is in irregular masses associated with quartz, serpentine, kaolin, pyrite, and a rich green earthy mineral, probably a variety of miloschite (*q.v.*). The opal is in part "liver-opal" [1/1269], brownish, and opaque from inclusions of kaolin, iron oxides, etc. In part it is green, of various shades, sometimes translucent, sometimes almost opaque [1/1268]. An analysis was made of some of the almost transparent,* deep sea-green mineral with the following results:—

Green Opal, Westonia.

Silica, SiO_2	92·19
Water, H_2O	7·46
Chromium oxide, Cr_2O_3 ...	·14
Ferrous oxide, FeO	·18
Nickel oxide, NiO	*Nil*
Copper oxide, CuO	*Nil*
Magnesia, MgO	trace
Alumina, Al_2O_3	trace
	99·97
Specific gravity ...	2·05

* Print could be read easily through flakes 1 mm. in thickness.

Green opal is not uncommon throughout the world in association with altering peridotitic rocks, particularly serpentines, and in such situations four possible colouring agents may account for its tint, viz., FeO, NiO, CuO, and Cr_2O_3, of which the last is the most intense in its effect.

Hintze's * and Doelter's † tables show that iron oxides are present in practically all coloured opals. Leitmeier shows no nickel, copper, nor chromium in any of his 47 analyses tabulated in Doelter's Handbuch, but on p. 258 says:—

> The green colour of the so-called prase opal is produced by a small proportion of nickel (see p. 246).

And on p. 246:—

> An opal with a nickel content of 1 per cent. is described by M. H. Klaproth from Kosemitzer Mt. (Silesia), where it occurs in association with chrysoprase.

Hintze also, amongst his 94 analyses of opal, has none which shows either nickel, copper, or chromium; but he too, on page 1511, refers to Klaproth's 18th Century (1795) statement that one per cent. of nickel is present in a Silesian green opal.‡

The analysis of the Westonia opal is therefore of unusual interest as indicating for the first time the presence in this mineral of chromium oxide, which, from its known intense colouring power when present as a silicate in such minerals as beryl, fuchsite, and miloschite, must be the main cause of the green tint, varying from light to deep sea-green. The tenacity with which hydrous silica will retain small amounts of chromium oxide, even in the presence of strong acids, may be observed in analysing any chromiferous silicate, such as fuchsite. In analysing miloschite from Westonia the author found that Cr_2O_3, to the extent of 0.25 per cent. of the SiO_2, was the only impurity retained by the hydrous silica§ after several treatments with strong hydrochloric acid, followed by complete washing with water. The ignited silica was distinctly green in colour when wetted.

The original source of the chromium oxide in this chromiferous opal is the chromite of the basic rocks.

Rutile (Oxide of titanium).—Only three occurrences of rutile were noted. The most interesting was in the sillimanite gneiss from the Hill End G.M. where it is seen under the microscope in innumerable pale yellow needles embedded in bleached (chloritised) biotite. The original unbleached mica, which is deep brown in colour, is evidently highly titaniferous, like several brown biotites tabulated by Hintze and coming from Norway, Russia, Germany and the United States. These have been found to contain

* Hintze, Handbuch der Mineralogie, I, pp. 1535–8.
† Leitmeier in Doelter, Handbuch der Mineralchemie, II., pp. 242–6.
‡ On page 194 of the 1889 issue of the 5th Edition of J. D. Dana's System of Mineralogy the complete analyses of this nickeliferous opal, by Klaproth and Rammelsberg, are given. Klaproth found 1·00 per cent. NiO, Rammelsberg, 0·41 per cent.
§ Obtained by evaporating with hydrochloric acid the fusion with alkali carbonates.

from 3.16 to 4.68 per cent. of combined titanic oxide. The conversion of such a titaniferous biotite into chlorite evidently leads to the titanium oxide crystallising out in the form of rutile needles. In some of the altered biotite flakes in the Hill End gneiss, the rutile needles are distributed quite irregularly, *vide* lower left-hand

Fig. 49.

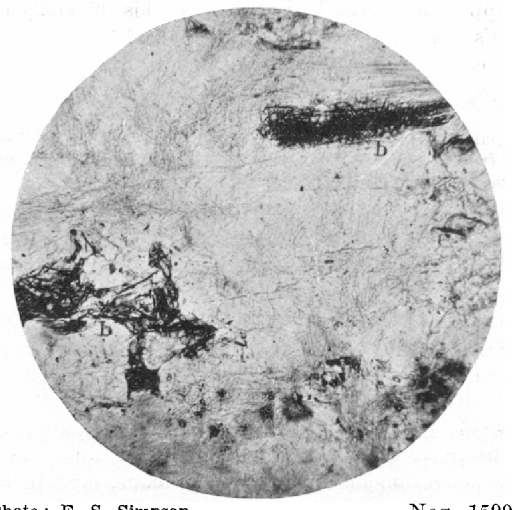


Photo.: E. S. Simpson. Neg. 1599.

Secondary rutile in bleached biotite, Hill End Gold Mine, Westonia.

(× 45)

side of Fig. 49. In others the rutile needles form a perfect geometrical web (sagenite), due to twinning on (101), *vide* top right hand side of Fig. 49. A beautiful instance of the occurrence of reticulated rutile in an altered biotite is described under the heading "Biotite" on p. 237.

Granular rutile was observed embedded in the scaly miloschite from the Edna May Central G.M.

Ilmenite (Oxide of iron and titanium).

Magnetite (Oxide of iron).—These two minerals occur in microscopic grains as minor constituents of the various greenstones. In a few instances the ilmenite was observed to be wholly or partly altered into amorphous leucoxene (doelterite?).

Chromite (Chromite of iron).—This was proved to be present in minute black grains to the extent of 0.24 per cent. in the serpentinised peridotite from Duff's Bore, Edna May Deeps Lease.

Chromite is the original source of the chromium of three secondary minerals found in the zone of weathering, viz., crocoite, green opal, and miloschite.

Limonite and other iron hydrates are abundant in the weathered rocks and soils.

Asbolite (Hydrated oxide of manganese and cobalt).—A thin black coating on a fracture face of a pegmatite from the Edna May Central G.M. was proved to be asbolite moderately rich in cobalt.

CARBONATES.

Dolomite (Carbonate of calcium and magnesium).—A carbonate which, from its chemical behaviour, is probably dolomite, occurs to a small extent (under one per cent.) in scattered granules in a specimen of biotite gneiss from Duff's Bore at 223 feet (67 metres), the analysis of which is given on page 293.

Magnesite (Carbonate of magnesium).—From the Edna May Deeps Lease a large nodule of pure white magnesite has been collected. No details are available as to its occurrence. Mr. Blatchford observed concretions of impure magnesite in the surface soil in the vicinity of Boodalin Soak.

ANHYDROUS SILICATES.

Orthoclase and Microcline (Silicates of aluminium and potassium).—Orthoclase has not been definitely recognised at Westonia, but as no typically crossed twinned microcline is visible in the Edna May gneiss, the potash not present as biotite in that rock is thought to exist as orthoclase.

Microcline has been recognised by the Petrologist in the main granite batholith, in a granite dyke one mile north-west of Westonia townsite, and in the gneiss of the Battler Group. In variable amounts it is a constant constituent of the pegmatite veins, including the auriferous ones, such as the Edna May "main lode," in which gold is sometimes found embedded in felspar, as also in the granite dyke of the Recovery Mine. From a reputedly auriferous pegmatite vein on the Violet May Lease, 2878, west of Boodalin Soak, Mr. Blatchford collected a specimen [1/1261] of very coarsely crystallised white microcline associated with quartz, the masses of felspar being several inches square.

Owing to the ease with which microcline passes into kaolin in the presence of weathering pyrite, the microcline-bearing pegmatites pass upwards into vughy quartz veins, in which the hollows left by the weathering out of the felspar become repositories of various secondary minerals such as pyromorphite.

Oligoclase (Silicate of aluminium, sodium and calcium).—A felspar identical with oligoclase or closely related to it is common in the granite and gneiss.

Labradorite (Silicate of aluminium, sodium and calcium).—Common in the more felspathic amphibole rocks.

Pyroxene, Augite (Silicate of calcium, magnesium, iron and aluminium).—This is rare as a rock-forming mineral in the Westonia district, being recorded by the Petrologist in only three rocks. The rarity is to be ascribed to the wide-spread uralitisation that has affected the greenstones of the area.

Garnet, Almandine? (Silicate of aluminium and iron).—A very dark red garnet of undetermined species occurs in a garnet-sillimanite schist near the Battler G.M. The crystals, which are trapezohedra (211), with occasional small faces of the rhombic dodecahedron (110), reach up to ⅜ inch (10 mm.) in diameter. They resemble Danas Figs. 1 and 2 (System, VII. Edit., p. 438). The Petrologist has noted the presence of small red garnet crystals in a fine-grained white granite from 250 feet in No. 3 Bore, Edna May Lease.

Chrysolite, Olivine (Silicate of magnesium and iron).—This mineral is abundant in a partly serpentinised actinolite-peridotite passed through in Duff's Bore, Edna May Deeps Lease, at a depth of about 460 feet (140 metres), and again at 570 feet (173 metres). Whilst some of the mineral has been converted into serpentine, a considerable proportion is seen under the microscope to be still quite fresh, colourless, and transparent, with typical high birefringence, though much cracked.

Zircon (Silicate of zirconium).—Minute colourless prisms of zircon were observed in sections of the biotite gneiss of the Edna May Group, in sections of the sillimanite gneiss of the Hill End Mine, and in concentrates from a microcline pegmatite.

Andalusite (Silicate of aluminium).—A single specimen of this has been observed. It was collected on the Edna May Consolidated Lease, 2617. It is in a mass of pale pink, slightly divergent prisms, with prismatic cleavage. Its density is 3.10; hardness, 7; and pleochroism strong, deep pink to colourless. A qualitative test showed the presence of large proportions of silica and alumina (60 per cent.), with traces of iron, manganese, and magnesia. Lime and boric acid were shown to be absent. The only associated mineral is muscovite.

Sillimanite (Silicate of aluminium).—This mineral is abundant in a contact rock, a garnet-sillimanite gneiss or schist, about one mile south of the Battler G.M. The rock consists largely of isolated fibres, and thick bundles of fibres, of almost colourless sillimanite, with numerous flakes of brown biotite, large crystals of garnet and granular quartz and microcline. The rock is probably an altered hornblende granite or granodiorite.

A second rock [1/1156] from the Hill End Mine is a typical pale grey, dense and tough sillimanite gneiss, composed of quartz, felspar, and biotite, with abundant colourless needles of sillimanite,

either isolated or aggregated in thick bunches and sheaves, which to the unaided eye appear in a thin section to be in parallel lenses following the lines of schistosity. See Figs. 50 and 51. The needles

Fig. 50.

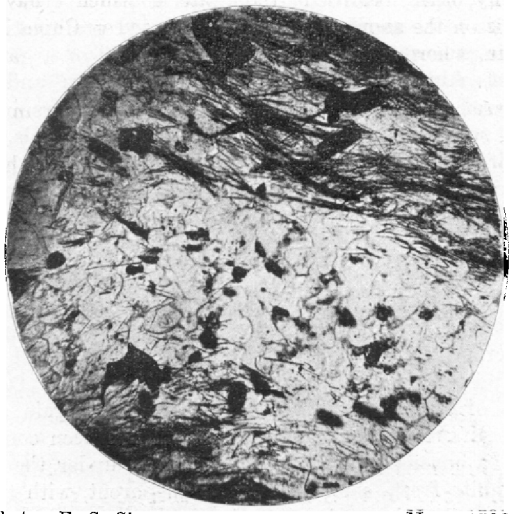


Photo: E. S. Simpson. Neg. 1598.

Sillimanite in gneiss, Hill End Gold Mine, Westonia.
(× 45)

are colourless, often straight, but frequently curved. The crystals are so small in diameter and so thoroughly embedded in quartz or felspar that their optical properties were only determinable in the thinnest portion of the sections (0.02mm). Their mean refractive index was found to be distinctly higher than quartz, double refraction high, not markedly different from that of tremolite, but the extinction is invariably straight, **Z** being parallel to the elongation. Rectangular cross fractures are not infrequent, and the needles pass uninterruptedly right through several adjacent quartz grains. The sillimanite is unevenly distributed and in any microscopic field is most abundant in those portions of the section which contain least felspar and biotite, both of which minerals are only very rarely penetrated by needles of the sillimanite.

In both rocks the average diameter of the needles is only about 1-200th mm (1-2,500th inch), the largest reaching to 1-30th mm (1-750th inch). They are invisible in hand specimens of the Hill End rock, but parallel bundles of fibres are easily seen with the unaided eye in the garnet-sillimanite gneiss.

Recently Mr. H. G. Stokes has collected a typical coarse sillimanite gneiss at the 560ft. level of the Edna May Deeps Mine, where it forms a band in the Edna May biotite gneiss. In this rock the

crystals, which are of a pale brown tint, not infrequently reach 2mm., and at times 5mm., in diameter. They are either simple unit prisms, or combinations of (100), (110) and (001). (Des Cloiseaux' orientation.)

The only other locality in the State at which I have observed sillimanite is on the shore at Ellensbrook, between Capes Naturaliste and Leeuwin, where it occurs in foliation planes of a garnetiferous gneiss.

The exact details of the genesis of sillimanite in a granite gneiss have not been worked out, but, theoretically, by interaction between microcline and an aluminous hornblende (both of which are known to be primary constituents of the less altered Edna May

Fig. 51.

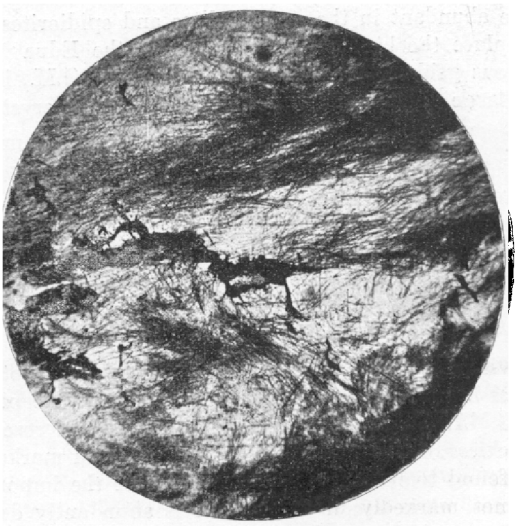


Photo: E. S. Simpson. Neg. 1597.

Sillimanite in gneiss, Hill End Gold Mine, Westonia.

(× 45)

gneiss) it should be possible to develop at high temperatures a mixture of biotite, sillimanite, and garnet, or other lime silicate, with the aid of but little or no carbonic acid, which last is known not to have played an important part in the metasomatism of the Westonia rocks.

Thus:

$$4\,(Mg,Fe)_8CaSi_4O_{12} \cdot 6\,(Mg,Fe)_2(Al,Fe)_4Si_2O_{12} + 8KAlSi_3O_8 + 4H_2O$$
Hornblende — Microcline — Water — Yield

$$4Al_2SiO_5 + 8\,(Al,Fe)_2(Mg,Fe)_2KHSi_3O_{12} + 4\,Ca(Mg,Fe)_2Al_2Si_3O_{12} + 12SiO_2$$
Sillimanite — Biotite — Garnet — Quartz

The simultaneous development of secondary quartz and sillimanite will explain the otherwise inexplicable penetration of several adjacent quartz grains by minute straight needles of sillimanite, and also the paucity of felspar in the immediate vicinity.

Titanite (**Sphene**) (Titano-silicate of calcium).—Large grains and occasional typical wedge-shaped crystals of this mineral, of a honey-yellow colour, are present in abundance in the biotite gneiss of the Edna May group. Small granules are recorded by the Petrologist in very many of the greenstones.

HYDROUS SILICATES.

Amphibole—Actinolite and Hornblende (Hydrous silicates of calcium, magnesium, and iron, the latter also with aluminium).—Green amphiboles, usually secondary, and referable to these two species, are abundant in the amphibolites and epidiorites, and occasionally replace the biotite of the gneiss of the Edna May group. An auriferous gabbro pegmatite, from the Jessie G.M., is composed mainly of large (5cm.) greenish black hornblende crystals.

Zoisite (Hydrous silicate of aluminium and calcium).—Occurs in minute microscopic granules in many of the hornblende rocks.

Epidote (Hydrous silicate of aluminium, iron and calcium).—Coarse masses of prismatic epidote of a pale honey yellow colour are seen filling the interstices between the large hornblende crystals of a gabbro pegmatite from the Jessie Gold Mine, near Boodalin Soak. Microscopic granules of epidote are not uncommon in some of the altered hornblende rocks.

Muscovite (Hydrous silicate of aluminium and potassium).—This mineral has not been observed in the district except in a pegmatite on G.M.L. 2617, and on rare occasions as microscopic scales replacing felspar. This paucity of muscovite is in marked contrast to the conditions prevailing in many others of the important gold-mining centres, where secondary sericite is abundantly developed in or adjacent to auriferous lodes.

Biotite (Hydrous silicate of aluminium, iron, magnesium, and potassium).—Brownish black biotite is abundant at Westonia, chiefly as a prominent constituent of the Edna May gneiss. Not uncommonly it is found in large flakes in the auriferous pegmatite, *e.g.*, at 225ft. in the Edna May Mine [1/1260]. Fine, scaly biotite is also present in the auriferous pegmatite of Weston's Reward G.M. As a secondary mineral it is not rare in altered types of both hornblendic and peridotitic greenstones. The colour throughout is a typical red brown, with optic axial angle apparently nil. In the sillimanite gneiss of the Hill End Mine many of the brown biotite flakes are completely bleached, and such flakes contain a reticulated collection of rutile needles. The original mineral must, therefore, be highly titaniferous. In specimens of lodestuff (coarse micro-

cline pegmatite) from 550ft. in the Edna May Deeps G.M., all the stages of alteration can be seen, from coarsely crystallised red-brown biotite devoid of rutile through partly bleached biotite carrying many rutile needles in the altered portions to a greenish grey, coarsely foliated chlorite enclosing a dense network of yellow rutile crystals.

Chlorite (Hydrous silicate of iron, magnesium, and aluminium).—Scales of chlorite are common in the greenstones, but no completely chloritised rocks (propylites or chlorite schists) are known. For pseudomorphs after biotite, *vide* supra.

Serpentine (Hydrous silicate of magnesium).—This was observed in a partly serpentinised olivine rock in Duff's bore on the Edna May Deeps Mine, where it was for the most part pseudomorphous after olivine. It is also seen in the workings of the Edna May Mine.

Chrysocolla (Hydrous silicate of copper).—This is the only copper-bearing mineral detected at Westonia. A few small bluish green grains are seen in the wulfenite-bearing quartz from the Edna May Deeps Lease. These are not readily attacked by nitric acid but break up with hydrofluoric acid, giving a solution which reacts for copper. The grains appear to be a mixture of chrysocolla and silicified kaolin.

Kaolinite and Halloysite (Hydrated silicates of aluminium).—These minerals are common as finely divided constituents of the clays resulting from the weathering of the granites, pegmatites, and greenstones. In their ordinary form they call for no comment.

Miloschite, the chromiferous variety of kaolinite, is a sufficiently rare and little known mineral to be worthy of detailed notice. It occurs in several mines of the Edna May group at Westonia either in fine or coarse scales, up to five-eighths inch (15mm.) in diameter, which are probably pseudomorphs after fuchsite (chromiferous muscovite), or in earthy masses which may be alteration products of other aluminous silicates. It is distinguishable in appearance from fuchsite by its greenish-blue to bluish-green colour and by the finely wrinkled surface and pearly lustre of the scaly mineral. Furthermore, it is softer and more friable than the mica. Chemically it is distinguished by the absence of potash and by the large yield of water on ignition.

Tabulated Comparison of Fuchsite and Miloschite.

	Fuchsite.	Miloschite.
Colour.	Emerald green.	Greenish blue or bluish green.
Lustre of flakes	Vitreous	Pearly
Density...	2·84	2·58
Hardness	2 to 3	1½ to 2
Elasticity	high	very small
Water content, %	4½	14
Potash content, %	11	*nil*

Miloschite was first described in 1838,* on material from Serbia. The original imperfect descriptions were augmented only in 1894 by Losanitsch,† who considered that he had found two substances present in the Serbian material, a bluish crystalline mineral, miloschite, the chromiferous equivalent of kaolinite, and a green amorphous mineral, alexandrolite, possibly the chromiferous equivalent of halloysite. Losanitsch's analysis of the Serbian miloschite agrees closely with the theoretical composition of a chromiferous kaolinite, viz., with $(Al,Cr)_2O_3.2SiO_2.2H_2O$, but an earlier (1839), probably unreliable, analysis by Kersten shows much more water, whilst the relative amounts of silica and alumina are transposed. Several "chrome ochres" (including selwynite), which have been described from time to time, are undoubtedly impure miloschite (or alexandrolite, if this is distinct from miloschite), mixed with fuchsite and sometimes talc, and resulting from the partial or complete decomposition of fuchsite rocks.

The latest and most complete description of miloschite is that of the mineral from Ely, Nevada, by E. T. Wherry and G. V. Brown.‡ Their "formal description" requires consideration in two respects. They describe the mineral as monoclinic, biaxial, with axial angle about 90°, but they give the refractive indices as α and β, 1.552; and γ, 1.559 (all $\pm$ 0.003). It is evident that if α and β are really equal, the mineral is uniaxial and the optic axial angle is nil, but with a possible error of $\pm$ 0.003, α may be 1.551 and β 1.553, which would give an optic axial angle somewhat less than 90°. They do not give the sign of the birefringence, but if α almost equals β, the sign is positive, though all authorities (Dana, Miers, Zirkel, etc.) are agreed that kaolinite is negative. The optical orientation of the Nevada mineral is stated to be indeterminate.

The density given by them is 2.1 +, which cannot be reconciled with that of normal kaolinite, viz., 2.57 — 2.63, since a slight replacement of aluminium by chromium should only slightly alter the density of kaolinite, and that in an upward direction, chromium having a higher atomic weight than aluminium.

The Nevada mineral, like that previously described from Serbia, was moderately impure, as the analysis in the table below shows. Thus, in addition to the essential alumina, chromium oxide, silica and water, it contained nearly one per cent. of ferric oxide, which may, however, be an isomorphous replacement of alumina, and therefore an intrinsic constituent of the mineral. Further, it contained § 0.37 per cent. lime, 0.11 per cent. magnesia, and 0.28 per cent. potash, which can only be present as mineral inclusions such as mica, etc. If the potash represent unaltered fuchsite, then the analysed material contained not less than 2.5 per cent. of this

* J. pr. Chem., 1838, XV., 327.
† Chem. News, 1894, LXIX., 243.
‡ Amer. Mineralogist, 1916, I. 63.
§ Mean values of the two analyses.

mineral. In addition, the Nevada miloschite contained some foreign lime-bearing and magnesium-bearing silicates, such as talc, etc.

Special interest therefore attaches to the Westonia mineral, which is proved by analysis to be so much purer than anything previously described. To obtain material for analysis, a specimen [1/1272] from the north crosscut at the 75ft. (23 metres) level of the Edna May Central G.M. was chosen. This was strongly foliated and tender to handle, and consisted apparently wholly of pale eau-de-nil coloured scales, in one part of the specimen fairly coarse (2 to 3 mm.), in another distinctly smaller, the whole specimen having the structure of a mica schist. Some of the coarser portion was broken off and rubbed lightly for some time in a porcelain mortar and then divided, by sifting, into two portions, viz., Lot A, the fine flakes which passed a 60-mesh sieve, and Lot B, the larger flakes, which refused to pass that sieve. Both lots were well washed with distilled water to remove common salt and magnesium sulphate derived from the very saline mine waters. The washed mineral was then thoroughly air-dried and disintegrated before analysis. The analytical results are given in the accompanying table:—

Analyses of Miloschite.

——	Rudniak, Serbia.	Ely, Nevada.	Westonia, W.A.			
			Lot A.		Lot B.	
	%	%	%	mols.	%	mols.
Water at 100 deg. ..	..	3·54	0·98	..	0·89	..
Rutile	..	..	0·57	..	0·32	..
Analysis of Dry Mineral free from Rutile.						
Water, H_2O	13·76	13·76	13·89	771	14·03	778
Silica, SiO_2	46·37	45·06	46·84	776	46·39	769
Alumina, Al_2O_3 ..	30·18	35·66	37·95	}	38·88	}
Chromium oxide, Cr_2O_3	9·75	3·99	1·22	} 380	1·02	} 387
Iron oxide, Fe_2O_3 ..	·91	·89	·06	}	·05	}
Lime, CaO	..	·38	*Nil*	..	*Nil*	..
Magnesia, MgO ..	trace	·11	·36	9	·19	4·6
Potash, K_2O	trace	·29	·07	..	·05	..
Soda, Na_2O	..	..	·04	..	·02	..
Totals	100·97	100·14	100·43	..	100·63	..
Density ..	?	2·1+	2·59	..	2·58	..

In this table are given, for comparison, Losanitsch's analysis of Serbian miloschite, and the figures for the Nevada mineral re-

calculated after deducting only the water lost at 105°. Wherry and Brown* recalculate their mean figures after deducting also all lime, magnesia, and potash. This, however, must lead to incorrect and misleading results, as these constituents cannot possibly occur as an admixture of the free oxides, nor is any natural compound known of any two or of the three of them. It is practically certain that they are present as silicates or alumino-silicates, and if the bases are deducted from the totals, the corresponding amounts of silica and alumina should also be deducted. These not being ascertainable, I have left the lime, magnesia, and potash in the final results.

In the case of the Westonia miloschite the analyses reveal that there is no appreciable difference between the coarser flakes which resisted the partial disintegration in the mortar and the finer flakes which readily separated and passed through the fine sieve. Both agree very closely with the theoretical composition required by the formula: $(Al,Cr)_2O_3.2SiO_2.2H_2O$. In recalculating the original figures of the analysis, the small amount of water lost at 100° was rejected, as it was plainly not an essential constituent. All the titanium oxide also was rejected, as complete proof of its existence as finely granular rutile was readily obtained. Both analyses show a small content of magnesia, a constituent foreign to the theoretical composition. It is highly probable that this exists as interleaved scales of talc. If the magnesia be deducted from the analytical results, together with the proportions of silica and water necessary to form talc, the remaining constituents are present in the following proportions:—

	Lot A.	Lot B.	Theory.
$(Al,Cr,Fe)_2O_3$ ..	0.994	1.004	1.0
SiO_2	1.998	1.980	2.0
H_2O	2.009	2.015	2.0

It will be observed that the proportion of chromium present in the mineral analysed was considerably less than in the minerals from Serbia and Nevada. In a second specimen [1/1274] from the same spot, viz., the 75ft. level of the Edna May Central Mine, some much larger flakes of miloschite are present (up to five-eighths inch) which are considerably deeper in colour, approaching a turquoise blue. This depth of colour was found to be partly due to a slightly higher percentage of chromium, viz., 1.50 per cent. of Cr_2O_3, and partly to the state of aggregation, the mineral being in dense cleavable masses, practically devoid of air films between the cleavages. The deeper green portion of a variously shaded green earthy clay, carrying much free gold, and collected also in the Central Mine, was found to contain 7.4 per cent. Cr_2O_3.

The Westonia miloschite is very resistant to hot concentrated (10E) hydrochloric acid, but is completely and rapidly dissolved

* Loc. cit.

by warm concentrated (20E) hydrofluoric acid. Hot fuming sulphuric acid dissolves out the bases, leaving scales of silicic acid of the same size and shape as the original mineral. Fusion in the air with alkali carbonates completely decomposes it, forming yellow alkali chromate soluble in water. Heating to a low red-heat drives off most of the combined water, and causes a great part of the colour to disappear owing to the formation of air films in the mass. The mineral does not appreciably exfoliate during heating, and is infusible before the blow-pipe.

The apparent outward form of the Westonia miloschite is not necessarily its intrinsic form, but may be that of the fuchsite (chrome mica), after which it is pseudomorphous. The mineral throughout possesses a perfect basal cleavage, but many of the larger flakes are seen under the microscope to be complex, having a grey dusty interior, due to the aggregation of minute scales within the larger plate. This appearance is characteristic of much kaolinite. On the other hand, a large proportion of the smallest scales of miloschite are homogeneous and possess optical properties related to their form. They are biaxial, with such a small difference in refringence along the two axes of elasticity lying approximately parallel to the surface of the flake, that lamellæ lying at right angles to the axis of the microscope appear uniaxial with parallel polarised light, but give an indistinct biaxial figure with convergent light. The third axis is roughly normal to the surface of the flake, and the refringence along this axis is shown by a quartz wedge to be distinctly less than along either of the other axes, first order interference tints being obtained with the finely divided mineral. Attempts to determine the refractive indices by means of a Herbert Smith refractometer failed owing to the wrinkled surface of the flakes and their frequently composite character. The optical properties may be summarised thus:—

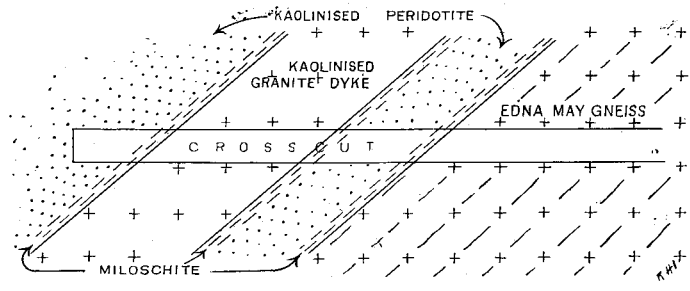
$\alpha < \beta = \gamma\,(-)$: optically negative: $\mathfrak{N}$ approximately normal to the surface of the flakes, *i.e.*, approximately parallel to the vertical crystallographic axis. Mean refractive index (by immersion) slightly greater than 1.54. Pleochroism inappreciable. Opaque, except under the microscope in very thin scales. Colour, very pale greenish blue, through turquoise blue to deep bluish green, the depth of colour increasing with rise in the percentage of chromium present. Lustre of scales, satiny or nacreous; of earthy mineral, dull earthy.

The habit of the mineral varies from earthy through fine scaly to coarse lamellar, the surface usually minutely wrinkled. Perfect cleavage in the scales. Hardness, 1.5 to 2.0, difficult to estimate owing to the fragility of the aggregates. Density, 1.58 to 1.59.

The mineral has been recorded from the Edna May Central, the Edna May Golden Point, and the Edna May Consolidated mines.

Its occurrence in the first-named mine is illustrated in Fig. 52. In this mine, in the north crosscut at the 75ft. level, all the rocks are almost completely kaolinised. In the peridotite, along its junction

Fig. 52.



Vertical section showing occurrence of miloschite in north crosscut, 75ft. level, Edna May Central G.M.

with the Edna May gneiss and with a granite dyke, thin sheets of what is practically a miloschite schist are found. This yielded the material analysed. In addition it is found as a massive earthy clay, extremely fine-grained and slightly tinted a greenish blue, enclosing in places nests of thick and broad lamellae of a rich greenish blue tint. In one part of the weathered greenstone in this mine, sporadic lumps of deep green earthy miloschite are found enclosing much "paint" gold. This close association of secondary gold with miloschite shows the necessity of studying in detail the origin and properties of this mineral if the question of secondary enrichment in this area is to be fully understood.

On the Edna May Consolidated Mine masses of earthy miloschite are found of a fairly bright bluish green colour. [1/1273.]

From its situation and structure it is inferred that the miloschite at Westonia is largely a pseudomorph after fuchsite, a theory which would be definitely confirmed by finding the latter mineral in the corresponding situations below the zone of weathering. In view of the known resistance to ordinary weathering of all forms of muscovite, including fuchsite,* the active agent in the transformation must be sought in the sulphuric acid produced by the weathering of pyritic lodes. The action would be:—

$$2H_2O.K_2O.3(Al,Cr)_2O_3\cdot 6SiO_2 + H_2SO_4 + 3H_2O \text{ yield}$$

Fuchsite — Sulphuric acid — Water

$$3\{(Al,Cr)_2O_3\cdot 2SiO_2\cdot 2H_2O\} + K_2SO_4$$

Miloschite — Potassium sulphate

* In the Toodyay district, for instance, beautifully fresh fuchsite is found exposed at the surface.

If the ratio of Al to Cr be 47 to 1, then 801.6 grammes of fuchsite of density 2.80 have yielded 779.5 grammes of miloschite of density 2.58, a volume increase of 5.5 per cent., which completely explains the persistent wrinkling of the larger scales.

Chloropal (**Nontronite**) (Hydrous silicate of iron).—This mineral is plentiful in a specimen [1/1] of wall rock (amphibolite) from the side of Weston's lode in Weston's Reward Mine, near Boodalin Soak. It completely fills a series of small (⅛in. to ½in.) anastomosing veins in the shattered rock, and, in addition, it occurs as a partial replacement of coarse crystals of amphibole. It is massive, of the consistency of soap, greenish yellow to yellowish green in colour, or at times brownish from the presence of a small amount of ferric hydrate. It is for the most part very soft (H,1), but in places is somewhat harder, probably from the presence of a little secondary silica. Though apparently amorphous and opaque to the naked eye, under the microscope it is found to consist of masses of minute transparent scales with ragged outlines and high birefringence.* Long narrow fragments, apparently scales on edge, give a straight extinction. It is readily decomposed by strong hydrochloric acid, granular silicic acid remaining.

The genesis of chloropal does not seem to have been dealt with to any extent by any of the standard authors, and may well, therefore, be considered in the light of the known Western Australian occurrences. Lacroix says,† in referring to the few known French occurrences:—

> It results from the decomposition of different rocks and particularly of granites. One finds it—
> (1.) In metalliferous deposits (manganese, lead);
> (2.) In fissures in granitic rocks;
> (3.) In sedimentary rocks.

In all cases it is found in this State under the following conditions:—

(1) As a vein filling, rarely as a replacement.

(2) In rocks containing a very ferruginous amphibole or chlorite, and close to metalliferous veins.

(3) In the zone of incipient weathering; never at the surface nor very close to it, the closest being 40 feet at Westonia.

In some cases chloropal is found near jasper bars, *e.g.*, at Ennuin, Meekatharra, Sandstone, and Southern Cross.

From information kindly supplied by Mr. E. de C. Clarke, the details of the occurrences at Meekatharra and Black Range are as follows:—

Queen of the Hill Gold Mine, Meekatharra. The mineral forms, with coarsely granular quartz, the filling of numerous small

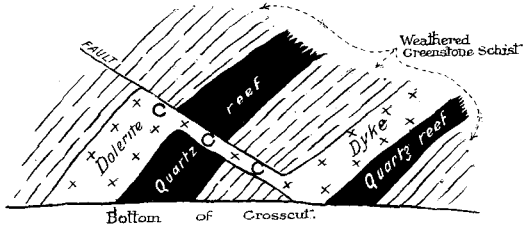
* The birefringence of nontronite is 0·025 according to Wherry & Brown, *vide* E. T. Wherry & G. V. Brown: "An American Occurrence of Miloschite." Amer. Mineralogist, I., 66.

† Mineralogie de la France, I., 490.

joints in a greenstone schist (sheared dolerite) at a point separated from the auriferous jasper by a few feet of non-auriferous jasper, at a depth of about 225 feet (68 metres), below the surface, the plane of separation of the oxidised and sulphide (pyritic) ore being seen in the adjacent stope. There is no record of chloropal at higher or lower levels in this mine.

Oroya Black Range Gold Mine, Sandstone. In this mine a narrow unmetamorphosed dolerite dyke follows along the hanging wall of the auriferous quartz reef, both being surrounded by ancient greenstone schists. In places, at depths of 200 to 250 feet, the kaolinised dyke cuts across the reef, and where this occurs joints in the weathered dyke rock are found filled with chloropal. (See Fig. 53.) The nearest jasper bar runs at right angles to the reef, about 30 chains (600 metres) to the south.

Fig. 53.



Occurrence of chloropal, Sandstone.
(In joints at C, C, C.)

Mr. Blatchford informs me that in the Weston's Reward Mine the sulphide level is at about 60 feet, the chloropal occurring at 40 feet in the rock forming the wall of the reef.

Finally, regarding the origin and alterations of chloropal, we note that at Westonia it is in part pseudomorphous after a black, highly ferruginous amphibole, and shows a distinct tendency to alter into ferric hydrate (goethite, etc.); the mineral from a depth of 40 feet (*i.e.*, about 20 feet above sulphide level) being distinctly brownish in places exhibiting surface films and microscopic inclusions of red-brown ferric hydrate.

From the evidence to hand we infer that chloropal is never a primary mineral and that it is unstable on free exposure to the weather. From its general occurrence in veins we may conclude it is a precipitate from aqueous solution or colloidal suspension. I am inclined to ascribe its origin to the action of sulphuric acid solutions (from oxidising pyrites) on ferruginous silicates, with the production first of ferrous and ferric sulphate and colloidal silicic acid and the subsequent precipitation in the solution, by hydrolysis in the presence of the same or other minerals capable of neutralising

the acid set free, or of oxidising ferrous sulphate, which would have the same effect. The reactions may be shown thus:—

(1) FeS_2 (Pyrites.) + 7O (Oxygen.) + H_2O (Water.) → $FeSO_4$ (Ferrous Sulphate.) + H_2SO_4 (Sulphuric acid.)

(2) $Na_2Fe_2Si_4O_{12}$ (Ferric Molecule of hornblende.) + $4H_2SO_4$ (Sulphuric acid.) → $Fe_2(SO_4)_3$ (Ferric Sulphate.) + $4H_2SiO_3$ (Metasilicic acid.) + Na_2SO_4 (Sodium Sulphate)

(3) $CaFe_2Si_4O_{12}$ (Ferrous Molecule of Hornblende.) + $4H_2SO_4$ (Sulphuric acid.) → $3FeSO_4$ (Ferrous Sulphate.) + $4H_2SiO_3$ (Metasilicic acid.) + $CaSO_4$ (Calcium Sulphate.)

(4) $Fe_2(SO_4)_3$ (Ferric Sulphate.) + $3H_2SiO_3$ (Silicic acid.) + $5H_2O$ (Water.) → $Fe_2O_3 \cdot 3SiO_2 \cdot 5H_2O$ (Chloropal.) + $3H_2SO_4$ (Sulphuric acid.)

(5) $2FeSO_4$ (Ferrous Sulphate.) + H_2SO_4 (Sulphuric acid.) + O (Oxygen.) → $Fe_2(SO_4)_3$ (Ferric Sulphate.) + H_2O (Water.)

The instability of chloropal near the surface may be simply a case of dissociation, thus:—

$Fe_2O_3 \cdot 3SiO_2 \cdot 5H_2O$ (Chloropal) → $Fe_2O_3 \cdot H_2O$ (Goethite) + $3H_2SiO_3$ (Metasilicic acid.) + H_2O (Water.)

or may be due to interaction with aluminium hydrate carried in solution and colloidal suspension in circulating waters, forming the more stable mineral halloysite, thus:—

$2(Fe_2O_3 \cdot 3SiO_2 \cdot 5H_2O)$ (Chloropal.) + $3(Al_2O_3 \cdot 3H_2O)$ (Al. hydrate.) →

$3(Al_2O_3 \cdot 2SiO_2 \cdot 3H_2O)$ (Halloysite.) + $2(Fe_2O_3 \cdot H_2O)$ (Goethite.) + $8H_2O$ (Water.)

PHOSPHATES.

Xenotime. (Phosphate of yttrium, erbium, etc.).—Several small crystals of this very rare species were obtained by concentrating a microcline pegmatite from this district. The crystals are from 0.04 to 0.10 mm. (1/600 to 1/250 inch) in diameter. They sink in methylene iodide of density 3.3, are transparent or translucent, rarely opaque, mostly pale honey yellow in colour, but sometimes brownish. Their form is that typical of xenotime, viz., the low unit bipyramid of the tetragonal system. As there was just a possibility that this mineral might be zircon, it was tested for phosphoric acid. About two milligrams of the concentrates which had sunk in 3.3 methylene iodide and were composed mainly of ilmenite and the supposed xenotime, were warmed with dilute nitric acid for some time to remove any apatite that might be present. After washing and drying, the residue was fused with fusion mixture, the aqueous extract evaporated to dryness with nitric acid and then

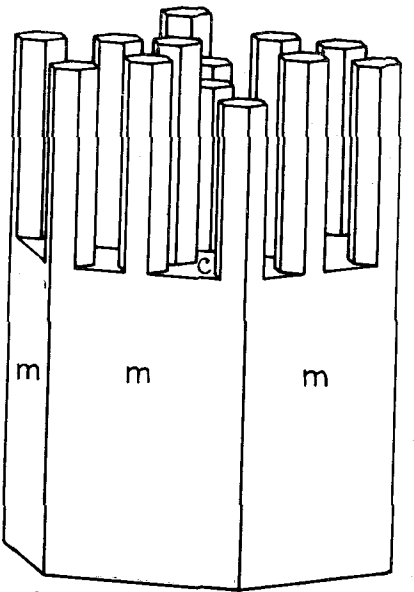
redissolved in dilute nitric acid. This solution gave a strong reaction for phosphate ion, confirming the identity of the xenotime.

Apatite (Fluophosphate of calcium).—A universal minor constituent of the granite gneisses and greenstones in microscopic colourless prisms. A "schliere" from a dyke at the 35-mile post on the York-Coolgardie road, nine miles south-east of Westonia, contained dull green hexagonal prisms of apatite up to 10 x 2 x 2 mm., associated with quartz, felspar, and hornblende. The crystals had a density of 3.2, and were readily soluble in dilute nitric acid, the solution giving a strong reaction for phosphate ion.

Pyromorphite (Chlorophosphate of lead).—This mineral is abundant in a specimen of cellular quartz (leached pegmatite), carrying much coarse free gold from the 225 feet level of the Edna May Mine. It is associated with a little crocoite.

The pyromorphite is in crystalline crusts and isolated crystals adherent to the exposed surfaces of quartz. The crystals are all hexagonal prisms with basal planes, and vary from 0.1 to 1.0 mm. in diameter. In the larger crystals the basal planes farthest from the supporting quartz are often covered with an outgrowth of a number of much smaller prisms in parallel position with the main crystal, as shown in Fig. 54. This is a most unusual form of growth

Fig. 54.



Complex pyromorphite crystals, Edna May Gold Mine, Westonia.

and can only be accounted for by a sudden change in the concentration of the depositing solution at the stage represented by the completion of the growth of the larger prisms and the inception of the growth of the small prisms surmounting them.

Under the microscope the crystals are translucent, of varying tints of amber yellow and greenish yellow. In mass the crystalline crusts vary in tint from yellow to yellowish green. They dissolve readily in warm dilute nitric acid, and the solution gives strong reactions for lead, chloride, and phosphate ions. No arsenic, vanadium, chromium, molybdenum or tungsten could be detected in solutions of the mineral.

SULPHATES, TUNGSTATES, ETC.

Gypsum (Hydrated sulphate of calcium).—This was seen in only one specimen [1/1264], a sulphide ore from the Hill End G.M., consisting of a cellular mixture of pyrite and quartz. Many of the cavities in this ore are more or less completely filled with crystalline masses of gypsum coloured brown by included iron hydrates.

Epsomite (Hydrated sulphate of magnesium).—Scattered through the weathered rocks (*vide* Halite, p. 229).

Crocoite (Chromate of lead).—At the 170 feet level of the Edna May Mine Mr. Blatchford collected a small specimen of vughy quartz (leached pegmatite) studded with coarse gold and carrying several small crystalline masses of typical crocoite of orange-red colour and adamantine lustre. It is associated with thin films of green miloschite (chromiferous kaolinite). The crystals are small and imperfectly developed, so that only the unit prism and basal plane could be detected with certainty. A few very small crystalline masses of crocoite were also observed in association with much pyromorphite in a specimen of highly auriferous quartz from the 225 feet level of the same mine. The only other locality in the State from which specimens have been obtained showing free gold in association with crocoite is Comet Vale.

The crocoite found under such circumstances is undoubtedly a secondary mineral confined to the weathered zone of the ore body. Its origin can be traced ultimately to the galena of the sulphide ore and the chromite of the basic wall rock. Several intermediate stages must, however, be passed through between the ultimate crocoite and the two primary minerals. The galena is first oxidised to anglesite (lead sulphate) which is moderately soluble in water, viz., one part in 12,000 of water. The chromite, or its derivatives, fuchsite or miloschite, is probably attacked by the sulphuric acid of decomposing pyrites, yielding a solution of chromium sulphate, which in turn interacts with the lead sulphate in the presence of

dissolved atmospheric oxygen yielding the much more insoluble lead chromate, crocoite.* The reactions are:—

(1) PbS (Galena) + $4O$ (Oxygen) → $PbSO_4$ (Anglesite)

(2) $2PbSO_4$ (Anglesite) + $Cr_2(SO_4)_3$ (Chromium Sulphate) + $5H_2O$ (Water) + $3O$ (Oxygen) → $2PbCrO_4$ (Crocoite) + $5H_3SO_4$ (Sulphuric Acid)

Wolfram (Tungstate of iron and manganese).—This mineral is not uncommon in the auriferous pegmatites of the mines of the Edna May Group. Specimens have been collected in the Edna May, Edna May Central, and Edna May Deeps mines. It is a primary constituent of the veins in crystalline masses up to 2lbs. (one kilo) in weight, intergrown with quartz, and, below water level, with pyrite. In one specimen from the Edna May mine it is seen intergrown with much biotite and pyrite in a segregation in pegmatitic quartz. Gold has been observed embedded in wolfram in the same mine.

The mineral from the sulphide zone is perfectly fresh, with brilliant lustre on the cleavages. In the zone of oxidation the mineral has been much affected by the oxidation of the associated pyrite, the resulting acid having penetrated along the cleavages, dissolving out part of the mineral and leaving the remnant cellular and dull in lustre. In most cases the products of alteration have been completely removed, but in two specimens a little ferritungstite remains. (*Vide* Ferritungstite, p. 258, and Wulfenite, p. 258.)

Scheelite (Tungstate of calcium).—Masses of scheelite, up to several inches in diameter and in some considerable abundance, have been encountered in a pegmatite vein at a depth of 550 feet (168 metres) in the Edna May Deeps mine. The pegmatite is coarsely crystallised and composed of quartz, microcline, a felspar with albite twinning, red-brown biotite, chlorite, scheelite, wolfram, and pyrite. The scheelite has a coarsely granular structure, and is yellowish white in colour with adamantine lustre. It encloses grains of biotite and wolfram, and is evidently a product of the primary consolidation of the pegmatite. Should any considerable tonnage of ore be disclosed of the grade of the samples submitted it should be worth concentrating at the present price of tungsten ores, viz., 50s. per unit for concentrates with a minimum of 65 per cent. tungstic oxide.

Wulfenite (Molybdate of lead).—At the latter end of 1915, Mr. H. G. Stokes forwarded to me a small specimen of a heavy yellowish mineral in small crystals lining cavities in a six-inch (15 cm.) quartz vein traversing the Edna May gneiss. The mineral was locally presumed to be scheelite. The exact locality of the find was on the Edna May Deeps property at a depth of 70 to 80 feet (21 to 24 metres) in the workings from the No. 4 shaft. The mineral

* Solubilities in 1,000 cc. water at 18° are: lead sulphate, 41 milligrammes; lead chromate one-fifth of a milligramme.

was proved to contain lead and tungstic acid and found to have the crystalline form characteristic of stolzite, the native lead tungstate. Under the heading, therefore, of Stolzite a brief preliminary note referring to this find was made in my annual report for 1915.* Since that time a fine suite of specimens of the mineral has been obtained from those workings, which has enabled a more thorough

Fig. 55.

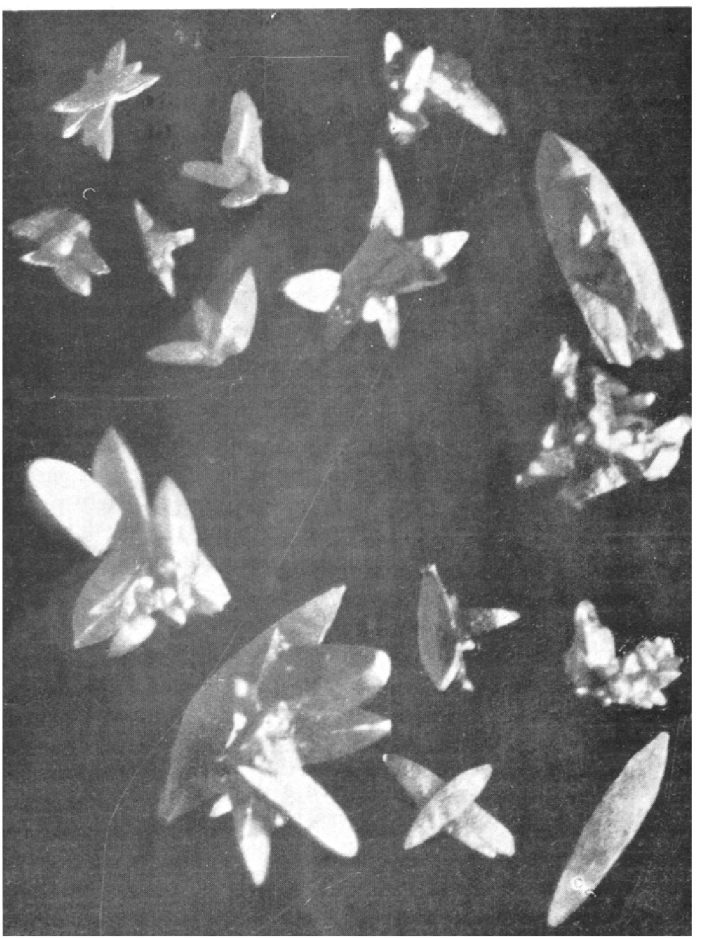


Photo: E. S. Simpson. (× 15) Negs. 1601-2-3-4.

Microphotograph of wulfenite crystals, Edna May Deeps Gold Mine, Westonia.

* Ann. Prog. Rept. Geol. Surv., W.A., 1915, p. 37.

examination to be made. This has shown that, in addition to tungstic acid, molybdic acid is present, and that in excess, so that the mineral must be classified as a tungstiferous molybdate of lead, *i.e.*, as tungstiferous wulfenite.

The matrix of the mineral is a very cellular rubbly quartz, somewhat ironstained and enclosed within walls of completely kaolinised gneiss. The cavities represent spaces once filled with sulphides (galena and pyrite) and possibly microcline, all of which have been completely weathered and, except for some kaolin, removed. No galena or molybdenite has been located in these workings, but pyrite and wolfram have been collected at lower levels in the vein.

The wulfenite occurs in masses of very small crystals with a general yellowish-grey colour, forming thick or thin discontinuous crusts on fracture planes and the sides of small cavities. Owing to the prevalence of kaolin through the vein the wulfenite crystals are often readily detached, and a fairly clean collection of them can be obtained by washing well in water, drying, and floating off associated quartz, etc., by means of undiluted methylene iodide. The largest crystals attain a length of 4mm. with a diameter of 2mm. (1/6 by 1/12 inch) but the average is only about a quarter of that size or even less.

With a view to getting some pure mineral for analysis, 24ozs. (680 grammes) of quartz specimens were lightly crushed to pass a 10-mesh sieve, and then concentrated by water in a batea, and the concentrates further cleaned, after drying, by means of methylene iodide of density 3.3. The yield was 66 grammes of fairly pure wulfenite, equal to 9.7 per cent. of the specimens taken. The concentrates having been washed successively with xylol, alcohol and ether were separated into sizes by means of a series of sieves. Each sized lot was examined separately under the microscope and two lots, viz., that passing a 30-mesh sieve but retained on a 60, and that passing a 60 but retained on a 90, were chosen as most likely to yield suitable material for analysis. The finer lot was covered with undiluted methylene iodide, and a little floating material decanted. In addition, by a vanning process under the methylene iodide, an appreciable quantity of minerals with a density between that of the liquid and that of the wulfenite, was removed. This latter material was chiefly iron hydrates, impure chrysocolla and intergrowths of quartz and wulfenite. After thorough washing with xylol, alcohol, and ether successively, the dried and slightly impure mineral was reserved for analysis as Lot B. The material which passed a 30-mesh but was held on a 60-mesh sieve was placed under a microscope and a little over one gramme weight of single crystals, and crystal groups similar to those shown in Fig. 55 were picked out for analysis. This apparently pure material was called Lot A. Density determinations and analyses were made of both lots.

Lot A gave an insoluble residue amounting to 0.36 per cent., the whole of which was clean quartz. In Lot B, after totalling up the oxides of lead, molybdenum, tungsten, and chromium, the total was still 3.17 per cent. short of 100. Of this, 0.58 per cent. was found to be quartz, the balance being iron hydrates, chrysocolla, etc. The figures for the essential constituents were recalculated after deducting 0.36 per cent. quartz in Lot A, and 3.17 per cent. quartz, etc., in Lot B. The results are shown in the accompanying table, together with the corresponding figures for related minerals.

Notes on the methods of analysis adopted will be found on page 259.

Analyses of Wulfenite and Related Minerals.

No.	I.	II.	III.	IV.	V.	VI.		VII.	
Mineral.	Wulfenite.	Stolzite.	$Pb(Mo,W)O_4$ 1 : 1.	Chillagite.	Chillagite.	Wulfenite A.		Wulfenite B.	
Locality.	Theory.	Theory.	Theory.	Chillagoe.	Chillagoe.	Westonia.		Westonia.	
	%	%	%	%	%	%	mols.	%	mols.
Lead oxide, PbO	60·8	49·2	54·3	54·36	54·09	59·76	268	60·36	270
Molybdic oxide, MoO_3	39·2	..	17·5	19·44	16·32	35·55	247	34·68	241
Tungstic oxide, WO_3	..	50·8	28·2	24·24	29·52	4·31	19 } 268	4·77	21 } 264
Chromic oxide, CrO_3	..	..	..	..	..	·18	2	·19	2
Total	100·0	100·0	100·0	98·18	100·13	99·80	..	100·00	..
Density	6·70	8·20	7·45	7·3 ±	..	6·864	..	..	..
Analyst	..	..	..	Mingaye.	Mingaye.	Simpson.	..	Simpson.	..

I.—Theoretical composition and density of $PbMoO_4$.
II.— Do. do. $PbWO_4$.
III.— Do. do. ($PbMoO_4$ + $PbWO_4$).
IV.—"Chillagite," tungstiferous wulfenite, Chillagoe, Queensland. The density of the material analysed was not determined by Mingaye, but J. B. Henderson obtained a density of 7·30 for similar chillagite containing 23·5 % WO_3. The total includes 0·14 % of gangue. *See* Mingaye, J. C. H.; "Notes on Chillagite" Rec. G.S., N.S.W., **9**, 171. Henderson, J. B., "Interesting Mineral Specimens," Q. Govt., Min. Jour., **13**, 56.
V.—"Chillagite," molybdiferous stolzite, Chillagoe. Total includes 0·20 % of gangue.
VI.—Picked crystals of Westonia wulfenite. Results for composition and density recalculated after deducting 0·36 % quartz.
VII.—Impure crystals of Westonia wulfenite separated by CH_2I_2. Results recalculated after deducting 3·17 % quartz, etc. The molecular excess of PbO may be due to the presence of a little $PbSO_4$ and PbS.

The mineral throughout, including that used for analysis, though at first sight to the unaided eye of a uniform greyish yellow colour, was seen under the microscope to be somewhat variable in this respect, ranging from almost colourless to rich honey yellow on the one hand, and through light and dark grey to almost black on the other. A little of the latter must have been present in Lot B, which was not hand picked, but any crystals of a grey or darker tinge were kept out of Lot A, as such were suspected of containing traces of lead sulphide and possibly lead sulphate. The lustre in all cases was adamantine, the translucency ranging from subtransparent to opaque.

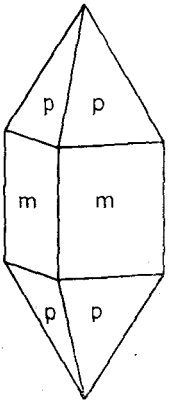
Excluding the dark grey and black crystals, the composition of the remainder must be very uniform judging by the results of analyses made on the two lots selected in such different ways. The figures show that the Westonia mineral differs appreciably from normal wulfenite, such as the type mineral from Bleiberg in Carinthia, in containing nearly 10 per cent. of lead tungstate. The only previously described mineral containing both tungstate and molybdate of lead is the so-called Chillagite from North Queensland, which both A. T. Ullmann* and C. D. Smith and L. A. Cotton† are disposed to look upon as a "new mineral." It is not clear whether by this expression they mean a new mineral species, but if so there is little ground for such an assumption. Lead tungstate and lead molybdate both crystallise in the same (tetragonal) system with axial ratios almost identical (1.5616, stolzite; and 1.5770, wulfenite), and their molecular volumes are also very close (55.5, stolzite; and 54.8, wulfenite). Further, the two compounds are precipitated under similar conditions and their solubilities are of the same order. Under such conditions it would be surprising indeed if a complete isomorphous series were not found extending from pure tungstate on the one hand to pure molybdate on the other. The Westonia mineral and the two quoted Chillagoe minerals are three stages in this series.

The less probable alternative is that a true double salt exists, having the composition $PbMoO_4.PbWO_4$, and yielding a definite cusp in the curves representing the values of any physical property, such as the density, refractive index, or length of the principal axis, or of any chemical property, such as the solubility. No such cusp is indicated in the case of the densities which appear to obey the usual hyperbolic law, but Smith and Cotton's figure‡ for the mean length of the principal axis in chillagite (1.5292) would indicate a very distinct cusp in the curve for that factor. Their figures, however, need careful checking since their readings of polar distances are associated with errors in azimuth angle often exceeding one degree, and there is some slight doubt about the symbol of the face on

* Ullmann, A. T., Jour. Roy. Soc., N.S.W., 1912, 46, 186.
† Smith, C. D., and Cotton, L. A., *Ibid.*, p. 219.
‡ Loc. cit.

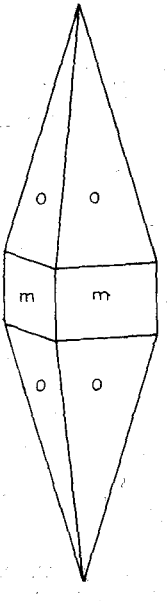
which they based their calculation. No instrument of sufficient precision was available for measurement of the axial ratio for the Westonia mineral.

Fig. 56.



Common form of wulfenite crystals, Edna May Deeps Gold Mine, Westonia.

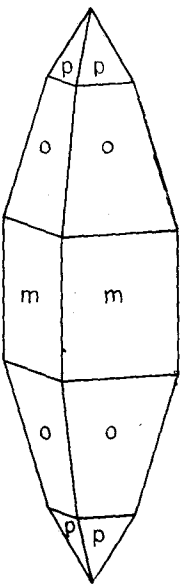
Fig. 57.



Common form of wulfenite crystals, Edna May Deeps Gold Mine, Westonia.

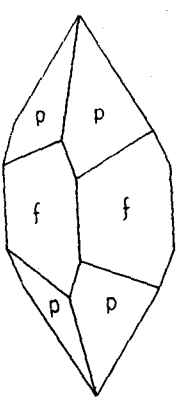
Assuming that no double salt exists, the Westonia mineral is an isomorphous mixture of wulfenite and stolzite. So, too, is chillagite, which at most is to be looked upon as a subspecies, defined as

Fig. 58.



Common form of wulfenite crystals, Edna May Deeps Gold Mine, Westonia.

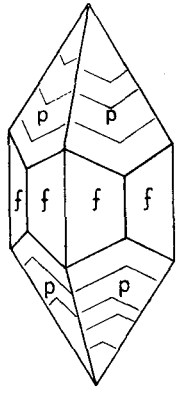
Fig. 59.



Rare Form of wulfenite crystals, Edna May Deeps Gold Mine, Westonia.

including all crystallised molecular mixtures of wulfenite and stolzite approaching equal molecular proportions of the two components.

Fig. 60.



Rare Form of wulfenite crystals, Edna May Deeps Gold Mine, Westonia.

The crystallisation of the Westonia wulfenite is of interest and is illustrated by Figs. 55 to 60. Normally wulfenite crystallises in thin tabular crystals bounded by broad basal pinacoids or low pyramids, and with little or no development of faces in the prism zone. This is the form seen in wulfenite from Whim Creek, Western Australia, as well as in chillagite from Chillagoe, Queensland. Stolzite, on the other hand, is characterised by the large development of prism faces and steep pyramids. This is the type of crystal exhibited by the Westonia mineral, of which Figs. 56, 57, 58 show common forms, and Figs. 59, 60 rarer ones. The complete list of forms recorded for minerals of this series are collected together for the first time in the accompanying table. The forms most frequently present in the Westonia mineral are m (110), p (111), and o (221): of much rarer occurrence are c (001), e (101), and f (320). The faces of p are often striated by lines parallel to the edges pf, *see* Fig. 60. Other forms will doubtless be recognised when the crystals are subjected to rigid measurement.

CRYSTALLOGRAPHIC DATA FOR WULFENITE-STOLZITE SERIES.

Vertical Axis.

Wulfenite: 1·57645 (Lacroix); 1·5771 (Dauber); 1·5774 (Goldschmidt)—Mean, 1·5770.

Stolzite: 1·5576 (Zt. Krst, 1907); 1·5579, 1·5586, 1·5597, 1·5606, 1·5613, 1·5631 (Hlawatsch); 1·5667 (Kerndt); 1·5692 (A. Levy)—Mean, 1·5616.

Chillagite: 1·5291 ? (Smith and Cotton).

Forms.

Letter.	Symbol.	Wulfenite.	Stolzite.	Chillagite.	Westonia Mineral.
c	001	×	×	×	×
a	100	×	×	—	—
m	110	×	×	—	×
n	650	×	—	—	—
μ	430	×	—	—	—
f	320	×	—	—	×
δ	530	×	—	—	—
l	740	×	—	—	—
k	210	×	—	—	—
g	310	×	—	—	—
ω	1·0·264	×	—	—	—
b	1·0·16	×	—	—	—
β	1·0·12	×	—	—	—
ω	109	—	×	—	—
t	103	×	×	×	—
z	205	×	—	—	—
.. .. ..	5·0·11	×	—	—	—
u (o)	102	×	×	—	—
y (η)	203	×	×	—	—
h	304	—	×	—	—
e	101	×	×	×	×
q (θ)	302	×	—	×	—
ε (p)	201	×	×	—	—
X	904	—	—	×	—
Y	1·1·18	—	—	×	—
w	1·1·16	×	—	—	—
θ	1·1·12	×	—	—	—
s	1·1·10	—	—	×	—
y	119	—	×	×	—
z	2·2·17	—	—	×	—
v (l)	118	×	—	×	—
ρ (k)	117	×	×	×	—
g	116	—	—	×	—
G	2·2·11	—	—	×	—
F	3·3·16	—	—	×	—
f	115	—	×	×	—
h	229	×	—	—	—
d	114	—	—	×	—
D	6·6·23	—	—	×	—
s (*b*)	113	×	×	×	—

CRYSTALLOGRAPHIC DATA FOR WULFENITE–STOLZITE SERIES—*continued.*

Forms—continued.

Letter.	Symbol.	Wulfenite.	Stolzite.	Chillagite.	Westonia Mineral.
w	225	—	—	×	—
v	112	—	×	—	—
p (n)	111	×	×	×	×
γ	443	×	—	—	—
r	332	×	—	—	—
o (d)	221	×	×	—	×
λ (x)	311	×	×	—	—
x	343	—	—	×	—
.. .. ..	977	×	—	—	—
z	277	—	—	×	—
.. .. ..	233	—	×	—	—
π	313	×	×	×	—
A	515	—	×	—	—
ζ	432	×	×	—	—
φ	7·1·75	×	—	—	—
Ψ	8·9·18	×	—	—	—

The genesis of the Westonia wulfenite is to be ascribed to interaction, in the zone of weathering, between solutions of lead sulphate derived from weathering galena, and of molybdic acid from weathering molybdenite, and tungstic acid derived from weathering mixtures of pyrite and wolfram, such as occur in the Edna May mine (see p. 248), thus:

$$\underset{\text{Lead Sulphate.}}{PbSO_4} + \underset{\substack{\text{Molybdic acid}\\ \text{Tungstic acid.}}}{(Mo,W)O_3 \cdot xH_2O} \text{ yield } \underset{\substack{\text{Tungstiferous}\\ \text{Wulfenite.}}}{Pb(Mo,W)O_4} + \underset{\substack{\text{Sulphuric}\\ \text{acid.}}}{H_2SO_4} + \underset{\text{Water.}}{(x\text{-}1)H_2O}$$

Ferritungstite (Hydrated tungstate of iron).—A small amount of a bright yellow powder on the surface of partly leached wolfram (*q.v.*) from the Edna May Central and the Edna May Deeps [1/34], was proved to contain both tungsten and iron, and is therefore undoubtedly ferritungstite. Its association with wolfram, which has been partly leached by sulphuric acid from decomposing pyrite, points to its origin by the hydrolysis of solutions carrying iron sulphates and colloidal and dissolved tungstic acid. The reactions involved are:

$$\underset{\text{Wolfram}}{FeWO_4} + \underset{\substack{\text{Ferrous}\\ \text{Sulphate.}}}{FeSO_4} + \underset{\substack{\text{Sulphuric}\\ \text{acid.}}}{2H_2SO_4} + \underset{\text{Oxygen.}}{O} + \underset{\text{Water.}}{7H_2O} \text{ yield}$$

$$\underset{\substack{\text{Ferric}\\ \text{Sulphate.}}}{Fe_2(SO_4)_3} + \underset{\substack{\text{Tungstic}\\ \text{acid.}}}{WO_3 \cdot 2H_2O} + \underset{\text{Water.}}{7H_2O} \text{ yielding in turn}$$

$$\underset{\text{Ferritungstite}}{Fe_2WO_6 \cdot 6H_2O} + \underset{\substack{\text{Sulphuric}\\ \text{acid.}}}{3H_2SO_4}$$

ADDENDUM.

ANALYTICAL METHODS FOR TUNGSTIFEROUS WULFENITE AND FOR MILOSCHITE.

Note.—All operations are carried out in beakers or dishes of platinum or transparent silica, and all reagents are tested quantatively for impurities before use. The following schemes are designed to enable analyses to be made on minimum quantities of the minerals.

TUNGSTIFEROUS WULFENITE.

A. **Lead and Combined Acids.**—Half a gram of the mineral, finely ground, is treated with 20cc. 10E.HCl at 90°-95° C. for 30 minutes, when solution is complete. Add 150cc. of water, and heat to 60°. Add 25cc. 15E.NH_4HO * and immediately pass H_2S for two hours. Warm to 60° and filter off PbS plus $Cr_2(HO)_6$ plus quartz. Wash with 100cc. warm water to which 10 drops yellow ammonium sulphide have been added and H_2S then passed through it (the wash water) for a minute. The filtrate, which is a deep garnet red in colour, contains all Mo and W as sulpho-salts. To this add 5E.H_2SO_4 in small quantities at a time until the solution contains an excess of about 1cc. of this acid. Warm to 80° for about two hours, the beaker being covered to avoid loss of much H_2S, and filter off WS_3 plus MoS_3. Wash with warm H_2S water. Then wash all but traces of the sulphides off the filter into a beaker and put filter into a flat dish and warm with several successive lots of 5E.HNO_3 until all sulphide is dissolved. Add the washings to main precipitate. Cover and add 16E.HNO_3 and warm until no further effervescence occurs. Evaporate to fumes of SO_3 (formed by action of HNO_3 on sulphides). Take up with 5E.NH_4HO and transfer solution and sediment † to a weighed 30cc. porcelain capsule. Evaporate to dryness on a sandbath and gradually increase the temperature first on sandbath and then over argand to remove all NH_4 salts. Finally ignite with a moving bunsen flame at a temperature well below red heat (MoO_3 volatilises at about 640°) until residue of molybdic and tungstic oxides loses all blue or green colour. Weigh $MoO_3 + WO_3$.

The precipitated PbS with any traces of $Cr_2(OH)_6$ and quartz is washed off filter into a beaker, and the filter treated with warm 5E.HNO_3 and finally with water as in the case of the MoS_3 to get last traces of lead into solution. Add these washings to the main precipitate. Convert all the PbS into $PbSO_4$ by boiling with HNO_3, then adding 20cc. 10E.H_2SO_4 and evaporate to fumes, continuing fuming gently until all globules of sulphur are oxidised.

* This causes a precipitation of very finely divided $PbWO_4$ and $PbMoO^4$.
† Undissolved WO_3xH_2O.

Dilute to 5E strength in acid, add 50cc. 5E.H_2SO_4, boil, cool, add 50cc. absolute alcohol and set aside at a temperature of about 15° all night. Filter off $PbSO_4$ plus quartz. Wash twice with 90 per cent. alcohol. Redissolve the $PbSO_4$ in warm ammonium acetate, and filter through original filter. Ignite filter and weigh quartz. In filtrate, reprecipitate $PbSO_4$ by evaporating to fumes with H_2SO_4 and taking up as before with 5E.H_2SO_4, and adding alcohol. Filter, dry, and ignite in porcelain capsule to a faint red with the usual precautions and weigh $PbSO_4$. $Pb/PbSO_4$, 0.7360.

When quartz is absent, or is in very small amounts, and weighed as described in section B, the solution and reprecipitation of the $PbSO_4$ is unnecessary, the weight of the quartz being simply deducted from the combined weight of the two.

B.—**Tungstic Oxide and Chromic Oxide.**—Take a separate lot of finely ground mineral (0.5 or 1.0 gm.) and treat with 30cc. 5E.HNO_3 at 95° for an hour. Filter and wash with one lot of 5E.HNO_3. Solution contains part of Pb, Mo and Cr, but no W; residue contains some undecomposed mineral and some $MoO_3.2H_2O$, and $WO_3.H_2O$. Pass 10cc. 5E.NH_4HO through filter and catch in the beaker containing the residue. Shake beaker till all separated $WO_3.H_2O$ and $MoO_3.2H_2O$ are dissolved. Pour 1cc. 5E.HNO_3 through filter, catching it in the beaker containing the residue, to which then add 20cc. 10E.HNO_3. The solution now measures 31cc. and is again of 5E strength in nitric acid. Again heat to 95° for one hour. It will be seen that the original acidification precipitates white flocculent $WO_3.2H_2O$ which during the subsequent heating is converted into bright yellow granular $WO_3.H_2O$. Filter, etc., as before. Mix the two acid extracts which contain practically all the CrO_3* and estimate this by colour comparison with measured quantities of standard K_2CrO_4 solution recently diluted with 5E.HNO_3.

The alternate treatment of the residue with 5E.HNO_3 and 5E.NH_4HO is repeated altogether five times, the same beaker and small filter being used throughout. After this treatment the whole of the Pb, Mo, and Cr will be in the nitric solution, and the whole of the W (and any siliceous gangue) left in the yellow residue of $WO_3.H_2O$. This residue is dissolved in 5E.NH_4HO, filtered from the quartz, the filter washed with 5E.NH_4HO, and the filtrate evaporated to dryness in a weighed 30cc. porcelain capsule and cautiously heated till all ammonia salts are driven off. The residue is ignited over a bunsen at a bright red heat and weighed as WO_3. Should the MoO_3 not have been completely separated, its presence will be indicated by the bluish-black colour of the just dry residue of ammonium tungstate, when it is first heated to about 200° to decompose ammonia salts.

* To ensure that this solution contains no traces of WO_3 which might affect the colour, it may be diluted with its own volume of water, boiled, and allowed to stand overnight, when any trace of WO_3 will be found to have settled out.

Complete decomposition of the mineral can be recognised usually after the fourth treatment, by no insoluble, except quartz, being left on adding the 10cc. of 5E.NH_4HO to the residue left by the acid treatment.

The above method can be applied to the estimation of tungsten and molybdenum in a number of minerals, in fact in any mineral decomposable by nitric acid of any strength, such as scheelite, powellite, bismuth ochres, etc. When stronger acid than 5E has to be used to attack the mineral, it is diluted subsequently to 5E strength and kept at 90° to 95° for an hour before filtering, as this ensures the complete separation of insoluble tungstic acid.

MILOSCHITE.

The mineral is first well soaked and washed with distilled water to remove common salt, magnesium sulphate, etc., derived from saline underground waters, and then dried at atmospheric temperature for three or four days.

A. Moisture, combined water, chromium, titanium and iron oxides.—Half a gram of the mineral is dried at 100°, using a pair of ground watch-glasses, and the moisture determined by loss.

The dried mineral is carefully transferred to a weighed 20-25cc. platinum crucible. This is heated for a few minutes on a wire gauze and afterwards over a méker to constant weight, and the loss taken as combined water. Note: no further loss was experienced on subsequent ignition over an air-coal gas blast.

To the ignited mineral add 1.5 gram anhydrous sodium carbonate, mix, and heat over a bunsen for an hour with the lid on, setting the crucible on a small disc of platinum foil supported on a platinum triangle to avoid over-heating of the bottom of the crucible. The lid should be raised one or twice to admit atmospheric oxygen. Moisten the frit and grind it with a little water and one drop of alcohol * in a small agate mortar. Extract with several lots of boiling water totalling not more than 50cc., and filter. Dry the filter and residue in the original platinum crucible and burn off filter at a low temperature. Then add 1.5 gram sodium carbonate and 0.5 gram sodium peroxide, refrit and again extract. Determine the CrO_3 in each extract colorimetrically and calculate to Cr_2O_3. Note: on testing this solution for V_2O_5 none was found.

Put filter and residue in a beaker and add about 30cc. 5E.H_2SO_4, and warm till solution is complete. Filter, and in the filtrate estimate the Ti colorimetrically after adding H_2O_2. Boil down until all colour is destroyed, dilute to 50cc., boil, cool, and estimate the iron colorimetrically with NH_4CNS.

B. **Silica, alumina, magnesia (manganese, lime).**—Following in general the lines laid down by Hillebrand, these are estimated in 0.5 gram of mineral after fusion with two grams of fusion mixture.

* To destroy any manganate.

One evaporation only is made for silica, the silicic acid being washed with NH_4NO_3 water and extra silica recovered from the Group 3A precipitate. The main silica precipitate is treated with H_2SO_4 and HF, and the residue, after weighing, is fused with a little fusion mixture and added to the main solution. The 3A precipitate, after weighing, is heated to a red heat for an hour with one gram of fusion mixture, taken up with 5E.HCl, evaporated to dryness, taken up with HCl, and the extra silica filtered and washed with NH_4NO_3 water. This small amount of impure silica is weighed and then evaporated with H_2SO_4 and HF, and the residue ignited and weighed.

Double precipitations are made of the 3A* and magnesia precipitates. Neither manganese nor lime were detected in the Westonia mineral.

C. **Alkalies.**—These are determined by the Lawrence Smith method, with one slight but valuable modification introduced some years ago in this laboratory by Mr. H. Bowley, Assistant Mineralogist and Chemist. The original fritting is not made with $CaCO_3$ and NH_4Cl alone, but with a mixture of $CaCO_3$, CaO, and NH_4Cl, the mixture of $CaCO_3$ and CaO being obtained by a preliminary ignition for two minutes of the usual six parts of $CaCO_3$. In every other respect the usual details are followed, the mixed alkalies being weighed as chlorides, and the potassium as chloroplatinate. In this, as in all other estimations, the results of a blank test are deducted.

* With ammonium acetate.

SECTION D.

THE PETROLOGY OF WESTONIA,

with Notes on Rocks from

BULLFINCH, GOLDEN VALLEY, HATTER'S HILL, AND THE CORINTHIAN MINE,

by

R. A. Farquharson, M.A. (Oxon.), M.Sc., A.O.S.M.

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I.—INTRODUCTION AND PREVIOUS LITERATURE.

The investigation of the rocks and the geological structure of the Westonia Field, as in the case of many other Western Australian goldfields, has been attended with considerable difficulty. This has been due to the paucity of outcrops, to the prevailing layer of overburden on the whole surface, to the decomposed nature of the rocks even when found outcropping, and in consequence, to the necessity of relying mainly on evidence from specimens procured in mines and bore cores—evidence which must obviously be used with much greater care than is required when continuous outcrops can be examined. A large number of specimens, however, have been examined and the microscopical results have in all cases been considered and discussed in relation to the field evidence, so that the conclusions arrived at are those best in accordance with the facts that the present state of the development of the mines and the field permits to be obtained. Several points have arisen in the course of the investigations which will be satisfactorily cleared up only by further opening up of the field and developments at deeper levels in the mines. These are noted in the text.

With regard to previous literature dealing with the Westonia Field, there does not appear to be any, so that this account of the Petrology of the goldfield is the first that has hitherto been published.

II.—CLASSIFICATION OF THE ROCKS.

As the specimens come from localities scattered over a fairly wide area, it has been found most convenient to classify them

broadly according to the locality from which they come. On this basis there are the following divisions:—

A. Rocks from Westonia (including the Hill End and Battler Leases).
B. The Dolerite Dykes from the Corinthian Mine.
C. Rocks from the Bullfinch Area.
D. Greenstones from Golden Valley.
E. Greenstones from Hatter's Hill.
F. Some Graphitised Rocks of doubtful origin from the Comstock Leases, etc.

Division A, the Rocks from Westonia, which comprises by far the most diversified and important types in the whole area examined, is sub-divided on a petrological basis into the following groups:—

1. The Greenstone Dykes.
2. The Country Greenstone Rocks.
3. The nature of the Country Greenstone Rocks and their mutual relations.
4. The Gray Biotite-Gneiss of the Lens of the Main Lode.
5. The Quartz Specimens.
6. The Granites.
7. The Aplite or White Granite Dykes.
8. The Hill End and Battler Gneiss.

III.—DESCRIPTION OF THE ROCKS.

A.—THE ROCKS FROM WESTONIA (INCLUDING THE HILL END AND BATTLER LEASES).

1.—The Greenstone Dykes.

From the field occurrences as observed by Mr. Blatchford various greenstone rocks occur undeniably as dykes, while others have field relations that are somewhat doubtful though possessing general microscopic characters to some extent similar to rocks that are certainly dykes. Microscopic investigation, therefore, has been made of these various rock specimens with the object of ascertaining (a) the characters of the specimens, (b) their relationships one to the other, and the extent to which they may be correlated and established as continuous or parallel and genetically similar dykes, or as identical dykes at different levels. Since it is a very well known fact that in greenstone areas such apparently diverse types of rock as hornblendite, epidiorite and hornblende schist may all occur as mere variations of one large mass, passing by almost insensible gradations from one into the other, it will be realised that it is extremely difficult to draw any hard and fast line of demarcation as genetically different dykes between greenstone specimens on a basis, say, of the presence or absence of felspar, or the occurrence of a certain degree of foliation or even on the presence or absence of quartz. It is only, indeed, by careful consideration, not alone of the differ-

ences, but also of the resemblances both mineralogical and structural, and equally important, of the mode of occurrence of the rocks that reliable conclusions as to the relation between them can be arrived at. In many cases, even then, subsequent developments may necessitate a modification of the original views, especially when the evidence formerly existing has not been as clear as the importance of the questions involved rendered desirable.

In the present case, not only with regard to the greenstone dykes but with regard to all the groups of rocks from the area under consideration, the conclusions arrived at have been based on the evidence afforded both by the mineralogical and structural differences and resemblances between the specimens and by the circumstances of occurrence in the field, or in the mines.

Briefly, the result has been, in the case of the greenstone dykes, the formation of the following groups:—

(a) That of specimens [$\frac{1}{8606}$], [$\frac{1}{8601}$], [$\frac{1}{8602}$], [$\frac{1}{8603}$], [$\frac{1}{8604}$], [$\frac{1}{8605}$], and [$\frac{1}{8608}$].

(b) That of the specimens [$\frac{1}{8607}$] and [$\frac{1}{8608}$] from the Depressed Bore from Edna May Deeps.

(c) That of specimen [$\frac{1}{8609}$].

(d) That of [$\frac{1}{8710}$] and [$\frac{1}{8711}$], and the bore core at 364 feet in Duff's Bore, Edna May Deeps—[$\frac{1}{8712}$].

Character of the Specimens:—

[a] The characters of the group may be best studied in [$\frac{1}{8603}$] and [$\frac{1}{8604}$].

[$\frac{1}{8603}$] From South Crosscut, 225ft. level, Edna May Mine.

This is a platy prismatic hornblendite consisting entirely of a rather coarse plexus of platy crystals and platy prisms of rather pale green actinolitic hornblende with the interstices occupied by a little pleochroic reddish chlorite, which in places approximates in optical characters to biotite. There are grains of pyrrhotite and smaller grains of magnetite scattered over the slide. (Fig. 61.)

[$\frac{1}{8604}$.] From the Main Crosscut, 300ft. level, Edna May.

This rock is identical with [$\frac{1}{8603}$] both in composition and structure being only slightly coarser in grain.

[$\frac{1}{8605}^{A}$]. From Edna May Deeps, 485ft. level, side of Drive.

This is an actinolitic chloritic hornblendite, rather fine-grained, consisting of a mass or indistinct plexus of small ragged prisms and plates of pale green hornblende with interstitial pleochroic flakes of reddish-yellow chlorite. A very small amount of granular iron ore (pyrites, etc.) is sometimes visible.

[$\frac{1}{8605}^{B}$]. From the same Mine, but from the Winze at the 480ft. level.

This is very similar to [$\frac{1}{8605}^{A}$], but is somewhat coarser and less platy, and with a more distinct plexus of prismatic hornblende forms. Sulphide ore (pyrrhotite, etc.) is also more common.

There can be little doubt that [$\frac{1}{8605}^{A}$] and [$\frac{1}{8605}^{B}$] are portions of the same rock mass.

[$\frac{1}{8\,0\,6}$] and [$\frac{1}{2\,0}$]. From End of main Crosscut, 150ft. level, Edna May.

This rock is considerably decomposed and hence, though its broad characters are fairly easy to determine, its relationship to fresher rocks is rather indistinct. It is, however, an actinolitic prismatic chloritic hornblendite. Neither quartz nor felspar was identified, and both the structure and composition agree closely with those of [$\frac{1}{8\,0\,3}$] and [$\frac{1}{8\,0\,4}$].

[$\frac{1}{8\,0\,1}$.] From No. 3 South Crosscut, 150ft. Level, Edna May Mine.

This specimen is extremely decomposed, and it has only been after special treatment with balsam that a section of it has been obtainable. On account of the chemical and mineralogical alterations that have taken place in the rock, correlation of it is difficult, but, allowing for these, it appears to resemble closely [$\frac{1}{8\,0\,6}$] above.

Fig. 61.

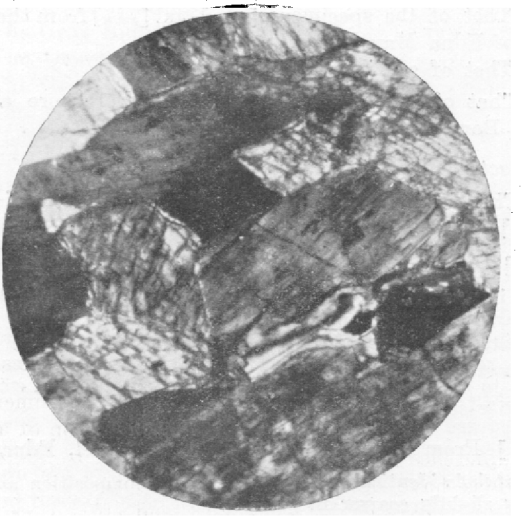

Photo: R. A. Farquharson. Neg. 1605.

[$\frac{1}{8\,0\,3}$] **Prismatic hornblendite, showing the plexus of hornblende prisms.**

[$\frac{1}{8\,0\,2}$.] From South Crosscut, near the Shaft, 150ft. Level, Edna May.

The specimen is another medium-grained prismatic hornblendite, similar to [$\frac{1}{8\,0\,1}$], but with a very small amount of slightly turbid felspar developed.

[$\frac{1}{8\,0\,6}$], [$\frac{1}{8\,0\,1}$], and [$\frac{1}{8\,0\,2}$] are therefore closely similar to one another.

[$\frac{1}{8606}$.] From the End of East Drive, 150ft. Level, Edna May Mine.

This is a chloritic platy prismatic hornblendite which, owing to the presence of an amount of kaolinised felspar that, though very small relative to the hornblende, is yet greater than in [$\frac{1}{8602}$], approximates to an epidiorite. The rock is finely schistose, in this respect and in the presence of felspar differing from [$\frac{1}{8603}$] and [$\frac{1}{8604}$]. In the appearance and structure of the hornblende, however, it resembles both [$\frac{1}{8602}$] and [$\frac{1}{8601}$], and as [$\frac{1}{8603}$] also contains a little felspar, it may be regarded as an intermediate stage between [$\frac{1}{8606}$] and [$\frac{1}{8603}$].

(b.) This is represented by [$\frac{1}{8607}$] and [$\frac{1}{8608}$], from the Depressed Bore, Edna May Deeps Mine, and the Depressed Bore, Edna May Mine. [$\frac{1}{8607}$], Edna May "Deeps" 470 feet. [$\frac{1}{8608}$], Edna Depressed Bore V.D., 427 feet.

[$\frac{1}{8607}$.] From 470ft. vertical, Edna May Deeps Mine.

This is a schistose rather fine-grained, elongated prismatic hornblendite rather resembling [$\frac{1}{8603}$] and [$\frac{1}{8604}$], but much finer in grain, and, in places, with very small elongated colourless patches of iridescent scales which, though difficult to determine, possibly represent felspar that has been kaolinised or micacised.

[$\frac{1}{8608}$.] From Edna May Depressed Bore, 427ft.; is similar to [$\frac{1}{8607}$] and calls for no individual description.

The important point with regard to these two specimens (which are identical) is to what are they related? Undoubtedly in structure and in the preponderance of hornblendic prisms and plates, they resemble [$\frac{1}{8603}$] and [$\frac{1}{8604}$]. Though in the two latter there is no trace of the clear patches, it must be remembered that [$\frac{1}{8602}$] and [$\frac{1}{8606}$]—specimens which are correlated with [$\frac{1}{8603}$] and [$\frac{1}{8604}$] — there are also clear patches, demonstrably felspar. Moreover, certain portions of the slides of [$\frac{1}{8607}$], in which these patches are rare or non-existent, are scarcely distinguishable, except in size of grain, from sections of [$\frac{1}{8603}$]. Again, the presence or absence of a small proportion of felspar in specimens from a greenstone complex cannot be regarded as a criterion of any weight so far as difference in origin is concerned, since in numerous cases all gradations have been traced from gabbros with appreciable felspar to pyroxenites with no felspar, and epidiorites and hornblendites have without doubt been derived by thermo-dynamic metamorphism from these rocks.

There is little doubt, therefore, that [$\frac{1}{8607}$] and [$\frac{1}{8608}$], though placed in a separate group (b), are to be correlated with group (a), and this conclusion is in accord with the suggestions of the field evidence.

(c) This group is represented by one specimen only:—

[$\frac{1}{8609}$.] From south-west end of No. 2 Reef, 225ft. level, Edna May Mine.

The rock is extremely weathered, of a dirty yellowish colour and very friable. It is, therefore, very difficult to obtain a section of it,

and it was only through treatment with balsam that this was practicable at all, while the section itself was only of indifferent value. The rock consists, however, of platy, granular, and fibrous aggregates of chloritised hornblende, mostly loose, with interspersed grains and small laths of generally twinned felspar and small grains of quartz. Some of the hornblendic aggregates are devoid of either felspar or quartz. The structure of the rock is too indefinite for correlation, but both it and the composition of the rock are not unlike what would be produced by the weathering of such a specimen as [$\frac{1}{880}$], if rather more felspar were present than is the case in [$\frac{1}{880}$]. The original was undoubtedly hornblendic and felspathic, and was probably a fine-grained epidiorite or amphibolite. It is placed in a separate group, partly on account of the indefiniteness of its petrological character due to decomposition, and partly owing to the definiteness of its occurrence as a dyke.

(d) The specimens included here are [$\frac{1}{870}$], [$\frac{1}{871}$], and the bore core at 364ft. in Duff's Bore, Edna May Mine.

[$\frac{1}{870}$.] From the Depressed Bore, Edna Deeps Mine, 113ft.-115ft.

This is a fine-grained, green and brown facies consisting of a granular mass or aggregate of small plates and irregular small stout prisms of green hornblende—at times chloritised—numerous small irregular brown-red scales and scaly aggregates of biotitic chlorite associated with the green hornblende forms, and small prisms, plates, or, rarely, indistinct small columns of felspar occasionally partially kaolinised. In places in the slides the hornblende crystals form platy and stout prismatic aggregates to the exclusion of the other constitutents. Many of the micaceous flakes are in part brownish, in part green, as if the biotite forms were derived from green chlorite arising primarily from the hornblende. Numerous grains and aggregates of sphene occur in association with the hornblende. The structure of the slides is essentially fine granular, and a slight suggestion of parallel alignment of the constituents is noticeable in places.

The rock is a fine granular, biotitic and chloritic *hornblende-felspar amphibolite.*

[$\frac{1}{871}$.] From the 344ft. Level, Edna May Deeps Shaft.

The specimen shows a contact between a finely schistose, fine-grained dark-green rock and a coarser-grained grey granitic or gneissic rock with marked foliation. The fact that the strikes of the foliation in the two facies can be seen in hand specimens to meet at a pronounced angle is evidence that the two facies are not intimately related to one another as, for instance, basic and acid segregations, but that one is most probably a dyke in the other. (Fig. 62.) From the field evidence, the greenstone is the dyke.

This greenstone is in section a finely schistose rock consisting of small rods, plates or flakes of green hornblende elongated in numerous indistinct lines and associated with occasional brown-red biotitic flakes or rods and sphene granules, separated by a large number of partially kaolinised small felspar plates, with, in many cases, a similar parallel elongation. There are, however, many larger platy forms without definite alignment. The structure is fine-grained granular, finely schistose, and there is a preponderance of the colourless constituent. Quartz was not definitely recognised.

The rock is, therefore, a finely schistose, granular *hornblende-biotite-felspar amphibolite.*

[$\frac{1}{8}\frac{1}{7}\frac{1}{2}$.] Specimen from 364ft. in Duff's Bore, Edna May Deeps Mine.

This consists of a fine-grained aggregate of prisms and plates of greenish hornblende with a smaller amount of associated brown-red biotite and biotitic chlorite scales as a very loose plexus in which are

Fig. 62.

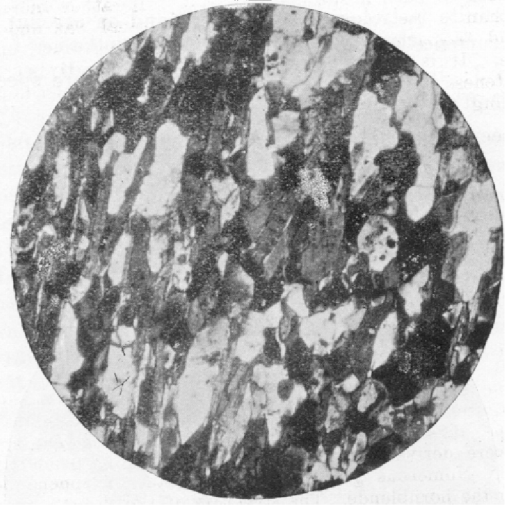

Photo: R. A. Farquharson. Neg. 1606.

[$\frac{1}{8}\frac{1}{7}\frac{1}{1}$] **Showing a contact between a finely schistose dark-green hornblendite and a coarser-grained granitic or gneissic rock.**

small plates, thin and stout partially kaolinised columns of felspar, that are frequently partially moulded by the ferro-magnesian with the production in places of a suggestion of ophitic structure. (Fig. 63.)

As in [$\frac{1}{8}\frac{1}{7}\frac{1}{0}$], there are patches that are aggregates exclusively of small plates and prisms of hornblende. A very small amount of interstitial quartz appears to be present.

The rock is a somewhat fine-grained *hornblende-biotite-felspar* rock probably best described as an amphibolite, with hornblende and felspar in nearly equal quantities.

From the descriptions it will seem that, except for the pronounced foliation or schistosity in [$\frac{1}{8}\frac{1}{7}\frac{1}{1}$], the three specimens [$\frac{1}{8}\frac{1}{7}\frac{1}{0}$], [$\frac{1}{8}\frac{1}{7}\frac{1}{1}$], and 364ft., agree very closely both in structure and mineral composition. Certainly when compared with the other rock facies of the whole field they form a distinct class by themselves, and since according to Mr. Blatchford, field observation supports a genetic connection between them, and indicates their occurrence as dykes, the whole of the evidence available warrants their being correlated together as the same or similar dykes.

The results of examination of the greenstone dykes, therefore, indicate the existence of three groups, viz.:—

Group 1 ; including [$\frac{1}{8}\frac{1}{6}\frac{1}{3}$], [$\frac{1}{8}\frac{1}{6}\frac{1}{4}$], etc., along with [$\frac{1}{8}\frac{1}{6}\frac{1}{7}$] and [$\frac{1}{8}\frac{1}{6}\frac{1}{8}$].

Group (b) thus merges into Group (a).

Group 2: including one specimen only, viz., [$\frac{1}{8}\frac{1}{6}\frac{1}{9}$] which is separated on account of its extremely decomposed state and consequent indefinite petrological character, and on account of its very distinct occurrence as a dyke.

Group 3: including [$\frac{1}{8}\frac{1}{7}\frac{1}{0}$], [$\frac{1}{8}\frac{1}{7}\frac{1}{1}$], and the core specimen from 364ft. in Duff's Bore, Edna May "Deeps" Mine.

Fig. 63.

Photo: R. A. Farquharson. Neg. 1607.

[$\frac{1}{3}\frac{1}{9}$] 364ft. in Duff's Bore: Showing the fine-grained aggregate of prisms and plates of hornblende and small plates and columns of felspar.

2.—The Country Greenstone Rocks.

Owing to the extremely weathered character of the surface of the country and to the paucity of the outcrops, it is possible only in a few places to obtain specimens illustrating the geological constitution of the country in which the lens of the Main Lode occurs. As several bores, however, have been put down in connection with

the mine workings, an examination of these has to a certain extent amplified the meagre evidence from the outcrops. The character of the rocks has been determined from the following sources of information:—

(1.) The outcrops themselves.

(2.) The Bore cores, particularly Duff's Bore, Edna May, the No. 3 Bore, Edna May, and the Bore put down in Weston's Reward Mine.

(3.) The section exposed in the Plat in the Edna May Mine at the 300ft. level.

(1.) *The Outcrops*:

(a.) The chief of these occurs as an ill-defined band mapped as a long attenuated lens with doubtful boundaries, extending from the Junction Lease, through the Edna May, Myrtle, Recovery, and Advance Leases and the South-West corner of G.M.L. 2079, disappearing at the north-west corner of the Elsie Lease. Whether it thins out to a vanishing point at this corner or merely disappears owing to being covered from view by the overburden is not at present determinable. The rocks of the outcrops are represented by:— **[13996], [13997], [13998],** [$\frac{1}{15}$], [$\frac{1}{16}$], and by some slides furnished by Mr. Blatchford.

[13996] from G.M.L. 2081:—

This is a rather coarse-grained indistinctly foliated dark-green and white, dioritic rock, the green portions being composed of needles of hornblende in parallel alignment.

In section, the essential minerals present are hornblende, quartz, and felspar.

The hornblende occurs in ragged plates and prisms in imperfect bands, the crystals being more or less in parallel alignment and occasionally perforated by round quartz and felspar plates. In places, an alteration to greenish chlorite is visible, in places a brownish-red biotitic flake. Between the hornblendic bands are partially or wholly kaolinised and micacised plates of felspar, some polygonal, and then forming a very coarse or occasionally a fine-grained mosaic, others of granitic character. The felspar is generally much altered, and frequently the plates are roughly orientated in the direction of the hornblendic bands. Measurement of extinction angles was generally impossible, but in two cases the angles were those of andesine. Potash and other species, however, are probably also present. Many of both the quartz and felspar crystals are cracked, and in some, irregular extinction is observed. In some of the hornblende crystals pleochroic halos round sphene granules are visible. There are rare grains of epidote. The quartz is in irregular plates, but it is not so common as the felspar. An imperfect gneissose structure is shown in section.

The rock is a *gneissose hornblende felspar-quartz rock,* a gneissose quartz-diorite closely resembling the facies in Duff's Bore at 789 feet.

[13997] from G.M.L. 2688:—

This is a finely foliated, greyish-green, fine-grained rock with numerous needles of hornblende on the foliation surfaces. The rock is extremely friable.

There are in section, numerous plates of clear quartz, and felspar in tables and columns elongated more or less in the same direc-

tion, areas of coarsely granulitised quartz and felspar plates, and occasional rounded crystals of both felspar and quartz apparently untouched in the process of elongation. In this mass are irregular bands of small hornblende prisms all arranged more or less with their long axes parallel, some thick, some thin. The hornblende forms are usually in bands, but many of the smaller rods and grains are sporadically scattered. Interspersed with the bands are occasional flakes of brown biotite and a brownish chlorite perhaps in course of alteration to biotite. (Fig. 64.)

Fig. 64.

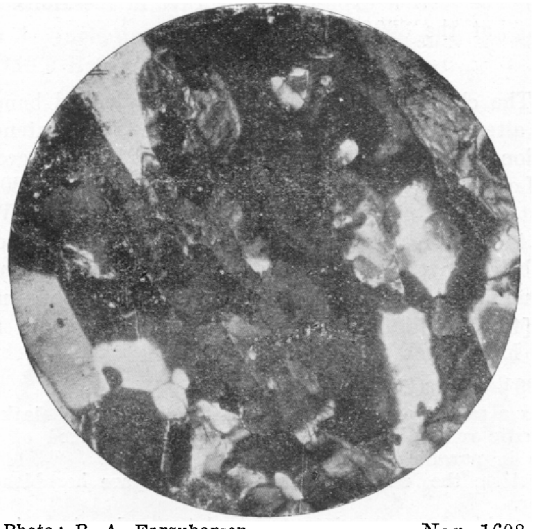

Photo: R. A. Farquharson. Neg. 1608.

[13997]: Granulitic hornblende-quartz-felspar gneiss, showing the structure.

There are cases in which the biotite is fairly evidently in course of formation from green chlorite, some plates being half biotite and half chlorite. Most of the felspar is fresh, but some larger plates are clouded by kaolin. There is, in general, little irregular extinction, and no cracks were observed in the crystals. The structure is more or less distinctly foliated.

The rock is a granulitic *hornblende-quartz-felspar gneiss.*

[13998] from G.M.L. 2688:—

This specimen is a dark-green, rather fine-grained, finely foliated hornblendic rock with needles of hornblende with parallel orientation on the foliation surface.

In structure and composition it is very similar to the previous specimens. There are numerous irregular grains and flakes of greenish hornblende in a mass composed in places of a granulitic mosaic of the same minerals. Occasional crystals of quartz and of felspar larger than usual also appear.

The rock is a foliated fine granular to granulitic *quartz-felspar amphibolite* verging on a granulitic hornblende gneiss.

[$\frac{1}{15}$] from bottom of Recovery Shaft, G.M.L. 2087:—

The rock is a medium-grained greyish-green dioritic rock with an indistinct foliation observable on some fractured surfaces. Green hornblende is apparently the chief mineral constituent.

In section, the rock is composed of imperfect interrupted bands of green hornblende in irregular plates, platy aggregates and ragged prisms, often with associated granular sphene and some brown-red biotitic flakes, separated by coarse polygonal plates of felspar clear or only slightly kaolinised. The felspar plates are frequently untwinned, but generally broadly lamellated when they are twinned, though suitable sections for determination of the species are not present. Rarely a rough banding is noticeable in the large felspar plates. A striking feature of the slides is that quartz appears to be absent from them, even the clearest crystals proving to be felspar.

In sections, however, of another specimen from near the same locality, some large ragged plates of quartz are undoubtedly present, and these show cracks and irregular extinction.

Iron ores are not uncommon in ragged grains, and some calcite is present in some sections.

The structure most closely approaches a very coarse mosaic of which the elements are large polygonal plates of felspar and in which the hornblende forms occur.

The rock is an obscurely foliated, coarsely granulitic *hornblende-felspar amphibolite.* From the various sections it is evident that while some portions are devoid of quartz, others certainly contain it, and these latter are rather granulitic hornblende gneisses than amphibolites.

[$\frac{1}{16}$] from G.M.L. 2087:—

This is a fine-grained very dark grey, finely foliated rock with numerous black scales of biotite on the foliation surfaces.

In section there is a marked foliation shown by numerous grains, small ragged plates and prisms of green hornblende with numerous scales and flakes of brown-red biotite and biotitic chlorite associated with the hornblende as well as occurring separately, all arranged with their long axes parallel, and forming strings and thin bands separated and interrupted or punctuated by numerous small polygonal crystals of felspar, with quartz plates occurring in strings or veinlets. In places some much larger elongated quartz plates also occur in strings or bands, and some bands of coarse, slightly kaolinised felspar plates also occur. There is a considerable amount of pyritic ore. Many of the hornblende forms show a partial alteration to chlorite and then to brown biotitic flakes.

The structure is markedly granulitic and foliated.

The rock is *a biotite-hornblende gneiss.*

The sections forwarded by Mr. Blatchford include two from the No. 2 Bore, Edna May, Nos. 2857 and 2858. These prove to be fine-grained granulitic hornblende schists, with marked schistosity or incipient foliation. They consist of numerous long, thin rods or prisms of green hornblende, all with parallel alignment and frequently perforated, separated and interrupted by an equal number of grains and small plates of felspar, lenticular or in long, thin shapes, elongated parallel to the hornblende. Generally the felspar is fresh, but in places it is partially kaolinised. Quartz, if present, is but poorly developed. Some specimens are rather coarse-

grained, with larger hornblende prisms and with rare altered fibrous reddish-brown flakes of biotitic character.

Another section, No. 2862, from near the Boarding-house, Duff's Lease, is very similar to the above, but more intensely hornblendic, with hornblende in small rods, plates, or grains with general parallel alignment, but with little of the felspar mosaic.

No. 2859, from G.M.L. 2688, is another very fine-grained granulitic amphibolite or hornblende-schist (according to the direction in which the section is cut), with a preponderance of small pale-green hornblende grains, perforated plates or prisms separated by small felspar grains and plates. (Fig. 65.)

Fig. 65.

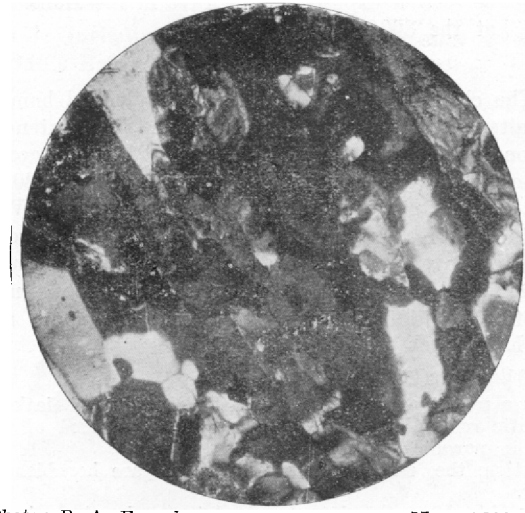

Photo: R. A. Farquharson. Neg. 1609.

Section 2859: The fine-grained granulitic hornblende schist, showing the structure.

No. 2860, from G.M.L. 2079, is rather similar to No. 2859, but the hornblende occurs almost to the exclusion of the colourless constituents. Moreover, it is not in rods or elongated prisms, but is platy or stumpy prismatic, and the individuals are much larger in size. The plates are separated by a very sparsely developed fine-grained felspar mosaic. Granular sphene is noticeable. This facies is a fine-grained, platy or prismatic amphibolite, though its structure may be foliated in a section cut in a different direction.

Finally, No. 2861, from G.M.L. 2088, is another granulitic hornblende schist or gneiss, with pale-yellowish-green hornblende

much in excess of the clear, granular, felspar mosaic. Some rare reddish-brown biotitic scales occur with the hornblende.

(b.) Another virtual outcrop occurs in a shaft just outside the south-west corner of G.M.L. 2762. It is represented by two specimens [13999] and [$\frac{1}{2}_3$].

[13999]:—

This is a medium-grained, greyish black rock with imperfect foliation and with numerous small black prisms and rods of hornblende showing on the surface, mostly with parallel orientation. The cross fracture has a vitreous appearance.

The rock consists of a highly granulitic mass of small felspar and quartz plates of more or less polygonal shape, forming a mosaic in which are fairly numerous small grains and flakes of a yellowish-green hornblende, in places partially chloritised. Indistinct aggregates of yellow epidote are also present. The felspar is generally fresh and untwinned, but twinned plates occur. The structure is certainly granulitic, occasional large plates of quartz and felspar being visible that are almost wholly granulitised.

The rock is a granulitic *hornblende-felspar-quartz* rock, a granulitic hornblende gneiss with imperfect foliation.

[$\frac{1}{2}_3$], from the South-West corner of G.M.L. 2762, close to [13999]:—

This is a much weathered reddish, iron-stained rock markedly foliated with small imperfect bands of felspar, and with micaceous chloritic scales of a yellow colour on the foliation surfaces. The appearance of the rock at once suggests that it is a highly altered form of [13996].

In section, this suggestion is confirmed. Though decomposition is advanced and the slides are heavily iron-stained, imperfect bands of kaolinised felspar and subsidiary quartz plates are interspersed with yellowish-green and iron-stained ragged chloritic prisms that have been derived from the decomposition of hornblende prisms. The felspar and quartz form a coarse mosaic of polygonal plates. The chloritic forms are all in parallel alignment.

The rock is decomposed foliated *hornblendic gneiss,* originally similar to [13996].

(c.) An outcrop, or what is equivalent to an outcrop, occurs at the old townsite near the western margin of the granite outcrop on which the townsite stands. The rock is represented by [13390].

This is a distinctly foliated, variegated rock consisting of pale greenish-white bands and streaks, between which and through which are patches, bands and streaks of dark-green colour composed of parallel needles of hornblende.

The rock in section consists of bands or patches of polygonal plates of felspar with irregular plates and grains of colourless augite, and bands, patches or streaks of grains and prisms of green hornblende in dense aggregates with or without associated small plates of fresh or kaolinised felspar. There is a sensible parallel alignment of the hornblende forms, though many of them occur with a single set of cleavage traces at varying angles to the direction of alignment or banding. Sphene granules and calcite grains and plates occur in the pyroxene bands. The hornblende has evidently been derived from the pyroxene, since pyroxene plates partially altered to greenish hornblende are not uncommon. In some places the hornblendic bands are composed of small grains and rods of green hornblende associated with granular felspar, and these portions show a resemblance to the hornblende schist of the No. 2 Bore, Edna May, of which section 2858 is an example.

A noteworthy feature of the slides is that quartz appears to be quite absent, and this constitutes an additional resemblance to the No. 2 Bore, as well as a link with section 2860 and 2859 already described.

The rock is a variegated, partially foliated *pyroxene-hornblende-felspar gneiss* without quartz. Complete alteration of the pyroxene to the green hornblende would result in a fairly foliated hornblende schist.

(d) Outcrops of greenstone occur at Boodalin Soak as small islands in the granite. These are represented by the single specimen [½].

This is a rather fine-grained dark-green hornblendic rock. In section it consists of a loose mass of long thin ragged prisms of green hornblende in all orientations, sometimes in aggregates with ragged plates of hornblende, represented by a fine-grained mosaic of felspar plates in which remains of former columnar felspar crystals still remain, and in which are numerous grains, rods, and fragments of the green hornblende. The felspar is highly kaolinised, and quartz, if present, is only in very small quantity. Though no foliation was noticeable in the sections examined, other sections cut subsequently show a fine foliation with numerous parallel rods, needles and prisms of hornblende separated by fine-grained granular felspar mosaic in which many small grains of hornblende also occur. (Fig. 66.)

Fig. 66.

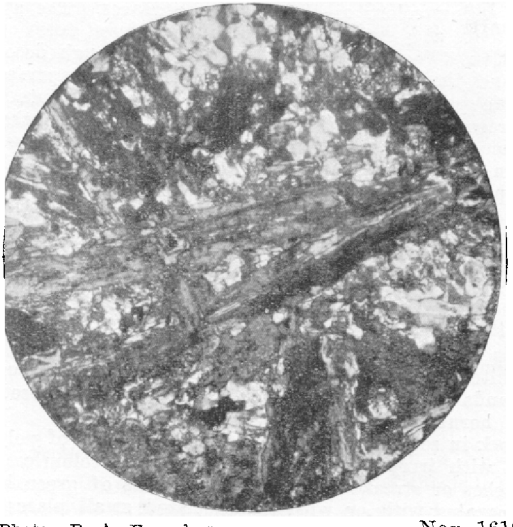

Photo: R. A. Farquharson. Neg. 1610.

[½] **The fine-grained, finely foliated epidiorite from Boodalin Soak.**

The rock, therefore, is a fine-grained, finely foliated *hornblende schist or epidiorite.*

(e) From the Lloyd George Lease two specimens were obtained, [13993] and [13994].

[13993]:

Is a fine-grained, dark grey-green, finely foliated hornblendic rock, with parallel needles of hornblende easily visible.

Sections consist of numerous small grains, prisms and plates of green hornblende with the interspaces occupied by grains of clear quartz and felspar, the latter often somewhat turbid, the former sometimes rather large. Marked foliation is noticeable in suitable sections. The structure is granular. In places the hornblende occurs in platy or prismatic aggregates.

The rock is a fine-grained, finely foliated *hornblende gneiss* or *granular felspar-quartz amphibolite.*

[13994]:

This is another finely foliated dark grey-green hornblendic rock with surfaces silky from minute needles of hornblende. Microscopically, the rock very closely resembles the sections from the No. 2 Bore, Edna May Lease. There are numerous more or less parallel small prisms, rods or grains of green hornblende, separated by small polygonal grains or plates of clear or partially kaolinised felspar forming a mosaic. Quartz, though carefully sought for, could not be identified.

The rock, therefore, is a finely foliated, fine-grained *prismatic* or *roddy hornblende schist.*

(f) A specimen was obtained, [$\frac{1}{7}\frac{1}{4}\frac{}{5}$], which represents the country rock of the Battler Mine, G.M.L. 2769. This is a very fine-grained, dark grey, minutely schistose or foliated acicular hornblendic rock, with patches that show a pinkish tinge.

In section, the rock is a fine-grained granulitic mass of small grains, rods and prisms of yellowish-green hornblende with their long axes arranged more or less parallel but not in definite folia, and with the interspaces between the rods and grains occupied by small grains or plates of clear felspar and occasional quartz grains. In places the felspar is slightly kaolinised, in places zoisitised. The pinkish tinge is due to a development of a reddish brown biotitic chlorite which occasionally passes into biotite. A small quartzo-felspathic band with granular zoisite traverses the rock parallel to the direction of foliation. The appearance of the slides resembles to some extent that of the hornblendic patches of [13990] from the Townsite.

The rock is a schistose or foliated granulitic *hornblende-felspar rock* or *acicular hornblende schist* verging on a granulitic hornblende gneiss, and the pinkish tinge arises from brown biotite and brown biotitic chlorite flakes.

Other specimens from a section at the bottom of the shaft in the Battler Mine are represented by [$\frac{1}{11}\frac{}{54}$].

This is a very fine-grained finely schistose or foliated roddy prismatic hornblende schist with pale green lenticles of diopside, a little calcite, green hornblende, and quartz. The hornblende schist consists of numerous parallel small rods and prisms of hornblende with occasional elongated scales of brown biotite and biotitic chlorite, separated by fine granular, slightly kaolinised felspar plates. Some quartz grains also occur with the felspar. The augite plates are in course of alteration to green hornblende. The sections are identical with those from 203 feet to 205 feet in the No. 3 Bore, Edna May. It is highly probable that the hornblende schist has been derived from a pyroxene-felspar rock by the breaking down and alteration of the augite to hornblende,

and the granulitisation of the felspar was the result of dynamic stress. The coarser grained and more hornblendic specimens represent probably a facies of the original rock in which augite was predominant.

(g) In the Edna May Consolidated, white clayey rocks with reddish streaks occur. They are too decomposed to be sectioned, but they possess characters suggesting an origin of the rock from the tremolitic serpentinous facies to be described subsequently in connection with Duff's Bore, Edna May Mine.

(h) Finally, there is [$\frac{1}{11\frac{1}{55}}$] from one mile south of road Weston's to Boodalin.

This is a finely foliated dark-grey rock with white felspar "augen" of small size enclosed by wavy folia of biotite with intermixed felspar. There is much biotite in small scales on the foliation surfaces.

In section the rock is composed of patches of fine granulitic felspar and probably quartz mosaic enclosing large ragged partially granulitised and slightly kaolinised felspar plates, with small elongated patches of a mixture of coarse felspar and quartz plates, and numerous small and large scales of brown-yellow biotite in scattered scales, in strings and imperfect folia.

The rock is a foliated *biotite-felspar gneiss* with subsidiary quartz.

(2.) *The Bore Cores*:

(a) The No. 3 Bore Core, Edna May [$\frac{1}{42}$].

The specimens of this core, ranging from a depth of 179 feet to a depth of 251 feet, consist almost entirely of fine-grained granulitic hornblende schist, sometimes with, sometimes without reddish-brown biotite and chlorite.

The facies from the depths, 179 feet to 184 feet, 184 feet to 186 feet, 203 feet to 205 feet, 230 feet to 232 feet, and 241 feet to 243 feet, may be taken as typical of the core.

179 feet to 184 feet.—The rock is here a fine-grained granulitic hornblende schist with reddish-brown biotite and chlorite. The hornblende is in perforated plates and long thin needles and broader ragged prisms, and is associated with granular polygonal felspar plates frequently elongated parallel to the schistosity. The facies has the structure of a foliated hornblende gneiss, but quartz is either in extremely small amount or entirely absent. There is considerable resemblance between this rock and [13994] from the Lloyd George Lease.

184 feet to 186 feet.—Here the hornblende consists in part of the fine granular roddy prismatic type, and in part of the coarser ragged platy and prismatic type. With the latter is associated kaolinised and zoisitised felspar, and a quartz vein was observed. The two types, especially the latter, resemble the hornblendic bands in [13990] that have been derived from an original pyroxene-felspar facies.

203 feet to 205 feet.—The facies consists in part of a fine-grained finely foliated or schistose granulitic mass of felspar plates, hornblende grains and brown-red biotitic scales, in part of coarse augite (diopside) surrounded by ragged green hornblende prisms and gradually passing through these into a hornblende-felspar portion with micacised felspars, and through this into the fine granulitic phase. Some large quartz plates are associated with the proxene.

230 feet to 232 feet.—This portion consists of long thin needles of hornblende and small scales of brown-red biotite in a fine granulitic mass of felspar plates often elongated in the direction of foliation. There are a few large ragged plates of hornblende that have escaped the foliation.

241 feet to 243 feet.—This facies is coarser-grained than that at 230 feet to 232 feet, and is practically identical with that at 179 feet too 184 feet. (Fig. 67).

Fig. 67.

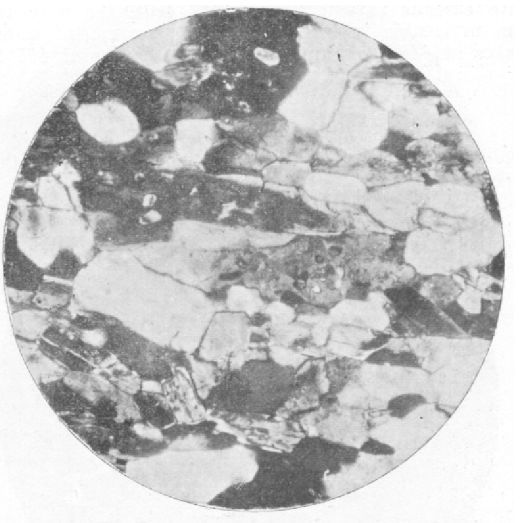

Photo: R. A. Farquharson. Neg. 1611.

[$\frac{1}{42}$] 241ft.-243ft. in No. 3 Bore, Edna May: The granulitic hornblende schist, showing the structure.

In this core, therefore, the rock is predominantly a granulitic hornblende schist since quartz, though present in some slides, is, as a rule, absent. In some cases, the structure is very fine-grained and roddy, in others coarser-grained and prismatic so far as the hornblende is concerned. Further, in most sections, though not in all, brown biotite and brown biotitic scales are common. There are points of resemblance between some of the sections and the hornblendic portions of [13990].

(b.) Duff's Bore, Edna May Mine [$\frac{1}{39}$].

From the samples* of the core of this Bore in the possession of the Geological Survey, the evidence afforded by the bore bearing on the nature of the country rock is as follows:—

From a depth of 180 feet, at which the samples began to be collected, and extending with slight variations to a depth of about 426 feet, the rock is a biotite granitic gneiss of which a description will be given subsequently. Between these limits, 180 feet to 426 feet, the

* Which are not, however, continuous.

only marked rock changes are small veins of white aplitic granite and at 364 feet the granulitic hornblende-biotite facies already discussed in the section on the Greenstone Dykes.

At 427 feet, however, there appears a complete change of country. The rock at this depth is an actinolitic chloritic hornblendite, consisting of a plexus of acicular crystals and plates of pale-green nearly colourless hornblende with the interstices occupied by yellow-brown chlorite. (Fig. 68.) Except for the occurrence of granite veins, this hornblendite extends to a depth of 465 feet, the only variations in composition noticeable in it being the appearance of some brown-red biotitic flakes at 440 feet, and some calcite grains at 465 feet.

Fig. 68.

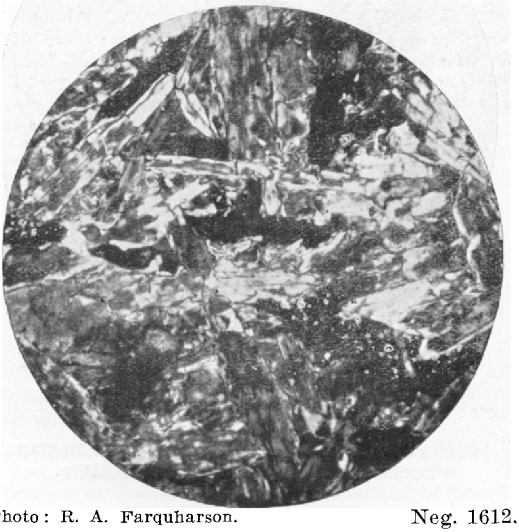

Photo: R. A. Farquharson. Neg. 1612.

[$\frac{1}{38}$] **427ft. in Duff's Bore, Edna May: The actinolitic hornblendite, showing the plexus of acicular crystals of hornblende in chlorite.**

At 465 feet another change occurs. The rock at this depth is rather fine-grained, almost black, with numerous minute reflecting scales of a micaceous mineral and occasional dense black thin bands or streaks. Sections show a mixture of thin prisms and grains of colourless hornblende (tremolite); numerous ragged rectangular scales of a mineral that is very pale-pink in colour, pleochroic, brilliantly polarising, with the cleavage traces filled with strings of iron ore; numerous small brightly polarising grains exhibiting cracks and resembling olivine; more or less disintegrated colourless plates with cracks, in some cases like the cleavage of a pyroxene, in others like that of hornblende; many bleached, almost isotropic chlorite scales, and some small areas, almost isotropic, of serpentinous material. There is much granular iron ore scattered over the slide, especially along the cleavage traces of the colourless micaceous mineral. The

latter very closely resembles colourless muscovite, but from the small amount of potash or soda in the analysis, it must belong to the talc or chlorite species. (Fig. 69.)

Fig. 69.

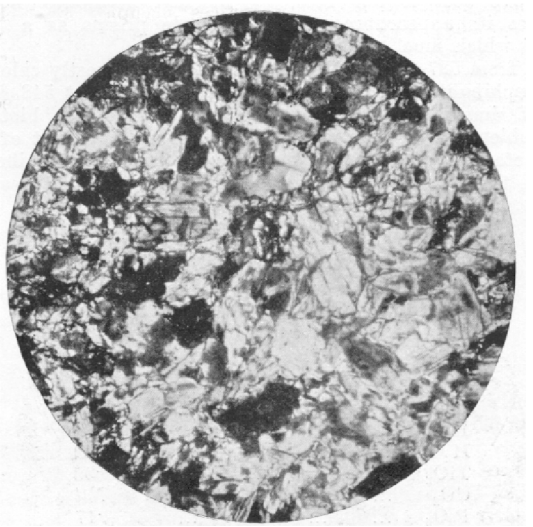

Photo: R. A. Farquharson. Neg. 1613.

[$\frac{1}{39}$] 466ft. in Duff's Bore: The tremolitic-serpentinous-chloritic facies, showing one variety of structure.

The rock has no defined structure. It is a very basic tremolitic-chloritic-serpentinous facies. An analysis of portion of it from the 490ft. level [G.S.M. 1/39, G.S.L. 6403D] made in the Survey Laboratory gave these results:—

SiO_2	43·60
TiO_2	·27
CO_2	*Nil*
P_2O_5	·53
H_2O+	5·56
K_2O	·07
Na_2O	·22
CaO	4·69
MgO	33·24
MnO	·19
FeO	4·46
Fe_2O_3	3·49
Al_2O_3	3·46
Cr_2O_3	·16
FeS_2	·09
H_2O-	·16
Total	100·19

Analyst—H. Bowley.

The extremely basic and highly magnesian character of the rock is strikingly confirmed by this analysis. The percentage of chromium in the rock is noteworthy.

The 466 feet type extends to 498 feet, except for breaks of actinolite-chlorite rock at 472 feet, and of actinolitic hornblendite, with brown and green chlorite at 474 feet, and a band of it also occurs at 503 feet, 511 feet, and 516 feet.

From 516 feet to 520 feet, the acicular actinolitic hornblendite again makes its appearance with hornblende prisms as a plexus in chlorite, of which much is brown biotitic.

Again, from 527 feet to 549 feet the facies is mostly chloritic hornblendite, amphibolite or epidiorite. There is a break at 542 feet, which consists of imperfectly foliated, granulitic, chloritic biotite-quartz-felspar-hornblende rock that may have arisen as the result of heat and pressure metamorphism of a felspathic chloritised amphibolite. An analysis in the Survey Laboratory of a facies at 536 feet [G.S.M. 1/39, G.S.L. 6404D] gave the following results:—

SiO_2	50·69
Al_2O_3	5·97
Fe_2O_3	2·31
FeO	8·04
MnO	·25
MgO	17·85
CaO	11·26
Na_2O	·32
K_2O	·38
H_2O—	·04
H_2O+	2·22
TiO_2	·35
CO_2	*Nil*
P_2O_5	·17
FeS_2	·09
Cr_2O_3	·39
Total	100·33

Analyst—H. Bowley.

At 550 feet there is an imperfectly foliated highly felspathic facies, in places coarsely granulitic, with occasional flakes of green chlorite sometimes obviously changing into the reddish-yellow biotitic variety, and in places with numerous flakes of brown-red biotitic chlorite and biotite that have fairly certainly been derived from pre-existing chlorite. Rarely a fragment of green hornblende occurs. By further change of the green chlorite, the rock would pass into a facies essentially the same as the granulitic granitic gneiss of 180 feet to 225 feet, though, as will be shown later, quartz is much more common in the latter.

From 551 feet to 636 feet there are frequent variations of small thickness, the chief facies being the chloritic hornblendite, an actinolitic amphibolite, a chloritic schist, and the tremolite serpentinous rock of 466 feet.

At 638 feet occurs a granulitic hornblende-felspar-quartz rock (hornblende-gneiss), passing into a facies with much brown biotitic chlorite mixed with hornblende and chlorite that is apparently in process of alteration to the brown mineral.

Then from 639 feet to 741 feet the rock varies from a fine-grained amphibolite to an actinolite-chlorite rock, or hornblendite, with portions

resembling both granulitised and mosaic platy diorite. An analysis of a facies at 658 feet to 674 feet [G.S.M. 1/39, G.S.L. 6406D] gave the following results:—

SiO_2	51·46
Al_2O_3	11·43
Fe_2O_3	1·38
FeO	8·21
MnO	·30
MgO	12·33
CaO	10·83
Na_2O	1·40
K_2O	·58
H_2O—	·03
H_2O+	1·71
TiO_2	·58
CO_2	*Nil*
P_2O_5	·25
FeS_2	·03
Cr_2O_3	·08
V_2O_3	·04
Total	100·64

Analyst—H. Bowley.

At 741 feet there is a change from a granulitic chloritic amphibolite to a coarsely granulitic diorite or hornblende gneiss, but the two facies are doubtless genetically connected.

From 742 feet to 780 feet the rock is mostly of amphibolitic character, though a break occurs at 770 feet, which consists of quartz-felspar rock with numerous brown biotite and chlorite scales, flakes of greenish hornblende and possible fragments of original augite.

At 785 feet, and extending to 789 feet, the rock is a coarse-grained diorite or amphibolite with pyrrhotite and brown-red biotite and chlorite flakes. In places, especially at 789 feet, the facies is more or less distinctly foliated.

At 790 feet the rock changes to a fine-grained amphibolite or hornblende schist, then at 792 feet it is the facies of 789 feet, and from 792 feet to 794 feet the rock is a fine-grained amphibolite.

It will thus be seen that, so far as this Bore Core is concerned, the chief greenstone facies present, exclusive of the biotitic granitic gneiss, are:—

(a.) The actinolitic-chloritic hornblendite appearing first at 427 feet.

(b.) The tremolitic-chloritic serpentinous rock appearing first at 466 feet.

(c.) The amphibolite or diorite, more or less foliated, appearing chiefly towards the end of the bore, and particularly from 785 feet onwards.

(d.) Granulitic-hornblende-felspar-biotite rock at 364 feet. These closely resemble the granulitic portions of rocks such as [13990] and $\frac{1}{745}$ from the Battler Lease.

(c.) The Bore Core from Weston's Reward Mine:

The results of examinations of the portions of the core available are as follows:—

211 feet.—There are two facies, one a dark-green hornblendic facies, and the other a pale greenish brown.

The former is fine-grained platy epidiorite, the latter a highly biotitic and micacised portion of it.

277 feet.—A finely foliated hornblende-felspar rock which is gneissic in those portions where quartz is developed.

248 feet.—A granulitic prismatic hornblende-felspar rock. Since quartz is apparently absent, the rock is a foliated granulitic prismatic amphibolite.

312 feet.—Very similar to the facies at 248 feet, though a little quartz is occasionally present.

321 feet.—In places, the rock closely resembles the facies at 248 feet, but generally the hornblende has disappeared, and there is a fine granular or granulitic mixture of plates of felspar separated by small brown-red flakes of biotitic material.

The rock is in places a fine grained granulitic amphibolite or hornblende gneiss, but generally a granulitic biotitic-hornblende gneiss in which the biotitic flakes are present almost to the exclusion of the hornblende.

360 feet.—A foliated banded granulitic amphibolite or gneiss without quartz.

438 feet.—There are irregular parallel bands or strings of platy, granular and prismatic green hornblende separated frequently by large turbid platy and columnar crystals of felspar and quartz. In portions of the slide the hornblende is in large ragged plates, and the felspar is in flaky and columnar forms as in diorite, while ragged quartz plates occur in association with the felspar. The rock is in places foliated, in places platy; the structure at times granulitic, but generally plutonic.

The rock is, therefore, a coarse platy quartz-diorite, in places foliated and granulitised to a foliated hornblende schist, amphibolite or gneiss.

In brief, therefore, the core shows a fairly continuous series. All the core samples are strongly hornblendic and felspathic. Some have a slight, one a strong, development of the red-brown biotitic flakes, and a few show a certain amount of clear quartz.

All, therefore, are hornblendic-felspathic, and appear to have been derived from a rock of dioritic affinities.

(3.) *The Specimens from the Plat in the Shaft at 300ft. Level, Edna May Mine*:

These rocks were collected with the object of throwing additional light on the nature of the greenstone country. Owing to the circumstances under which they occurred, it was, according to the information supplied by Mr. Blatchford, impossible to make out their field relations to one another. The facies present, however, excluding specimens of doubtful origin, are:—

(a) The tremolitic serpentinous rock such as occurs at 466ft. in Duff's Bore.

(b) The prismatic hornblendite with biotitic varieties and occasionally with pyrrhotite.

(c) A finely foliated chloritic hornblende-quartz-felspar gneiss with much turbid felspar.

(d) A facies similar to the biotitic granitic gneiss of Duff's Bore.

(e) A schistose or foliated biotitic epidiorite or amphibolite.

(f) The chloritic actinolitic hornblendite very similar to (b).

3. Nature of the Country Greenstone Rocks and their Mutual Relations.

(1.) *The Nature of the Rocks*:

It will be gathered from the foregoing that the rocks in the vicinity of the lens of the Main Lode are:—

1. The foliated hornblende gneiss, occurring in a thin lenticular band or mass from the Junction Lease to the Western boundary of the Elsie Lease. The rock is in places quite coarse-grained and dioritic in appearance, in places quite fine-grained. While in some specimens felspar is equally developed with the hornblende, in others, hornblende is much in excess of the felspar.

2. The granulitic hornblende schist. This occurs in the Elsie Lease in shafts south of the point at which the hornblendic gneiss disappears (*see* Plan); it occurs at the south-west corner of G.M.L. 2079; it is found in shafts at the eastern margin of the Myrtle Lease; and it is predominant in No. 2 and No. 3 Bores, Edna May Mine.

Further, both the hornblendic gneiss and the granulitic hornblende schist occur in a shaft at the south-west corner of G.M.L. 2762, though specimens of the former are much decomposed.

Finally, a foliated fine-grained hornblende-gneiss or granular quartz-amphibolite and a fine-grained prismatic hornblende schist occur in the Lloyd George Lease.

3. A foliated pyroxene-hornblende-felspar rock occurring at the Townsite.

4. A foliated hornblende schist or epidiorite at Boodalin Soak. This is virtually identical with the granulitic hornblende schist.

5. An acicular hornblende-schist verging on a granulitic hornblende gneiss, and a fine-grained foliated prismatic or roddy hornblende schist with lenticles of pyroxene, found in the Battler Lease.

6. A foliated amphibolite or diorite occurring near the bottom of Duff's Bore at about 785ft., and a coarse platy diorite at 438ft. in the bore at Weston's Reward.

7. An actinolitic chloritic hornblendite occurring at the plat in the Edna May shaft, 300ft. level, and at a depth of 427 feet in Duff's Bore.

8. Finally, a tremolitic-serpentinous rock found at 466 feet and greater depths in Duff's Bore, also in the plat in the Edna May shaft, and, judging from weathered clayey specimens, in shafts near the western margin of G.M.L. 2617.

These facies are ultimately reducible to two groups:—

(a) The foliated felspar-hornblende rocks:

These include rocks with quartz such as the foliated hornblende gneisses or quartz-diorites, and those without quartz, or with it in only small amount, such as the granulitic hornblende schists and foliated epidiorite, and the foliated pyroxene hornblende schist.

(b) The non-felspathic hornblendic rocks:

Included amongst these are the actinolitic chloritic hornblendite and the tremolitic-serpentinous facies.

(2.) *The Mutual Relations of the Rocks*:

Owing to the impracticability of observing rock junctions, to the paucity and scattered nature of the exposures, nearly all of which are confined to shafts or to the mine workings, and to the absence, indeed, of any decisive field evidence, the mutual relations of the rocks are very difficult to make out.

The chief facies are undoubtedly the granulitic hornblende schist and the hornblende gneiss, and of these the former certainly appears to have the wider distribution, and is probably the chief member of the country. In this connection, the inliers of greenstone at Boodalin Soak must, from their occurrence, be regarded as representative of the country, and these, as has been shown, are foliated hornblende schists or epidiorites closely resembling in structure and composition the hornblende schists from No. 2 and No. 3 Bores, and the other exposures of this rock in the various shafts and on the dumps. Moreover, the foliated pyroxene-hornblende-felspar rock of the townsite, though apparently different from the hornblende schists, has been shown to consist of hornblendic portions microscopically very similar to the latter; and since it is plain in the slides that the hornblendic portions have been derived from the pyroxenic, there is little doubt that the hornblende schists have been derived ultimately from a rock very similar to this from the townsite, and that this pyroxene rock must be included, from the point of view of origin and affinities, with the hornblende schists.

The relationship of the hornblende gneiss, however, to these hornblende schists is by no means clear. It apparently occurs mostly as a band or strip more or less surrounded by the hornblende schists, and since some varieties of it differ from the latter only in the presence of a little quartz, while exhibiting the same appearance and structure, it might be regarded as a derivative of a more quartzose modification of the original of the schists. On the other hand, from the characters of [13996], and of the bore core from about 785ft. in Duff's Bore, it certainly appears to have been formerly a quartz-diorite, and, as such, may have been a more acid dioritic intrusion into the original pyroxene-felspar rock that subsequently gave rise to the hornblende schists. Though both the

hornblende gneiss and the hornblende schist occur in a shaft at the south-west corner of G.M.L. 2762, and also in the Lloyd George Lease, no evidence is obtainable of their mutual relation, and the evidence afforded by the bore cores is inconclusive. For the present, therefore, their relation must remain doubtful.

In the case of the actinolitic hornblendite and the tremolitic-serpentinous facies, there is even less evidence of the relation of one to the other, or of either to the surrounding rocks. All that is known of the hornblendite is that it occurs in two places: (a) in Duff's Bore at 427ft., at which point there is a clean break between it and the granitic gneiss that extends off and on from 180ft. At about 466ft. it passes into the tremolite-serpentine rock. (b) In the plat in the shaft at the 300ft. level, Edna May mine. In this locality it occurs again in association with the tremolitic-serpentinous rock, but again the relations of the two rocks to each other and to the granitic gneiss are obscure. Whether they are ultra-basic dykes and only magmatic modifications one of the other, whether they are separate dykes of different age, or whether the hornblendite at least is a basic modification of the hornblende schists, these questions, owing to the lack of exposures and of evidence generally, cannot for the present but remain unsettled.*

4. The Grey Biotite-Gneiss of the Lens of the Main Lode.

This rock, containing as it does the chief quartz lodes of the Edna May Group of Leases, is the most important as well as the most interesting in the Westonia Field. It is to be best investigated in Duff's Bore core, where it persists with only small breaks from a vertical depth of 180 feet to a depth of over 400 feet. Between these levels there are, of course, many variations, but it has been found that the chief characters of the rock are those represented by the specimens from 180ft., 211ft., 223ft., 230ft., and 245ft.

In hand-specimen characters the rock is greyish or black-and-white in colour, fine to medium grained, and generally with a noticeable foliation marked by streaks of bands of black mica. In some cases thin quartz veinlets are present running parallel to the foliation planes, and, less commonly, there are water-clear quartz plates. In some varieties, particularly at 217 feet, the rock is strongly foliated, with pronounced quartz veins separated by quartzo-felspathic material with associated biotite scales and parallel to the foliation planes. On the latter, biotite scales are very common, flat parallel to the banding, and often associated with a considerable development of pyrites. At times, allowing for the difference in tint produced in rocks by hornblende on the one hand and biotite on the other, the specimens of this gneiss on the

* Since this was written, the writer has obtained sections which afford evidence that the hornblendic dykes and the tremolitic-serpentinous rock are merely variations of one another or of the same rock mass.

cross fracture show considerable resemblance in external characters to the more felspathic of the fine-grained hornblende-gneiss.

The microscopic characters of the rock may be gathered from the following descriptions of the typical samples:—

180 feet.—There is a mass of small variously shaped plates of slightly kaolinised, in places slightly micacised felspar, with associated small quartz plates fewer in number than the felspar, enclosing large lenticular as well as ragged rounded plates of quartz. The lenticles are often so drawn out as to appear as strings, and occur overlapping one another *or en échelon*. Further, distributed through the slide are individual flakes and strings of flakes of brown-red biotite, all arranged parallel to the foliation and sometimes forming indistinct bands. The foliation is clearly seen, being marked by the long thin lenticles, the tendency to parallel arrangement and drawing out of the smaller felspar and quartz plates, and by the arrangement of the biotite flakes. The quartz forms sometimes show irregular extinction. Amongst the felspathic platy mass are also some green scales of chlorite. (Fig. 70.)

Fig. 70.

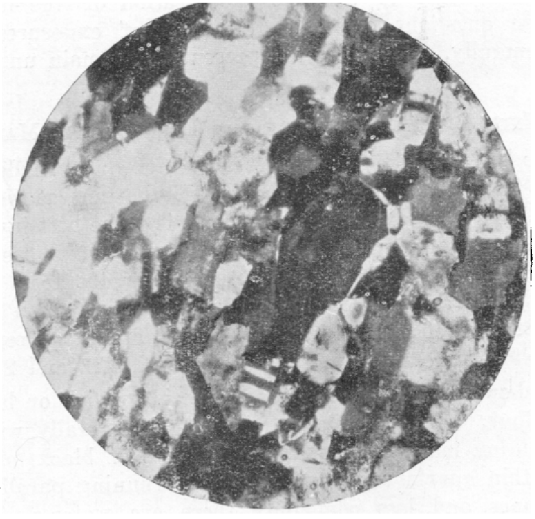

Photo: R. A. Farquharson. Neg. 1614.

[$\frac{1}{39}$] **180ft. in Duff's Bore: The biotitic granitic gneiss, or foliated biotite gneiss, showing the structure.**

211 feet.—The core here is rather similar in section to that at 180 feet, but the foliation is even more pronounced. There are slightly kaolinised platy felspathic bands usually with associated small grains of clear quartz, represented by elongated plates of quartz, and sometimes by quartz veinlets which traverse the whole length of the slide. The felspar is frequently in ragged plates, most of which are elongated parallel to the foliation. In consequence, certain portions of the

slides have a fine granular structure, others a coarse elongated platy structure. Biotite again occurs in loose strings of long flakes of varying size, all elongated parallel to the foliation direction. Occasional grains of sphene, epidote and calcite, and small scales of muscovite in the felspar may be noticed, and small scales of green chlorite are in association with the biotite. The quartz plates often show cracks and uneven extinction.

The amount of biotite present is small, and the highly felspathic and quartzose character of the rock as well as the structure resemble those of foliated biotite granites. As in 180 feet, the absence of suitable sections renders the determination of the species of felspar present very difficult. There are occasional broadly lamellated plates, but generally twinning is absent. Observations by Becke's method indicate that most of the felspar has a refractive index lower than that of quartz and, consequently, that the felspar is largely between albite and andesine. Doubtless more than one species is present.

223 feet.—In sections from this depth there is a greater development of biotitic scales and of green chlorite scales, while there are undoubted small fragments of green hornblende in process of alteration to chlorite and to the brown biotitic mineral. Associated with the chloritic, biotitic and hornblendic flakes are frequently grains of sphene. The structure of the rock is rather finer-grained than in the other varieties, large portions consisting of a granular mixture of quartz and kaolinised felspar plates, some rounded, some rectangular or polygonal and most of them elongated parallel to the foliation. In the granular mass occur large lenticular plates of quartz similarly elongated parallel to the foliation, and rarer large irregular plates of kaolinised felspar. In almost all cases, the quartz lenticles are surrounded by the granular quartz and felspar mass, a fact which shows, in the absence of cracks, that much of the quartz, at any rate, is probably primary, *i.e.*, that it solidified with the other original minerals of the rock, and is not due to subsequent introduction of silica along the lines of foliation or along cracks. The fact that, while in many cases the coloured mineral in contact with the quartz plates is biotite, there are not uncommon instances in which it is green hornblende, further supports this conclusion. The hornblende grains and plates are, like the biotite flakes, in imperfect strings. (Fig. 71.)

230 feet.—The facies here is highly felspathic, with pronounced quartz veins, and with quartz grains associated with the felspar plates. A little vermicular intergrowth was observed. Sphene granules were quite common, usually associated with the biotite or green chlorite flakes.

245 feet.—The remarkable feature of the slides from this depth is that, while the quartz-felspar mass has in general the same characters as in the previously described sections, green hornblende is the chief ferro-magnesian constituent. There is a comparatively large development of it in plates and grains arranged in indistinct bands or strings with associated sphene granules. The quartz plates are generally ragged but elongated parallel to the foliation, and the felspars are similarly arranged. In portions of the slide, brown-red biotite scales are associated with the hornblende, and there may be seen alteration of the green hornblende to green chlorite, and from the green chlorite a gradual passage into the brown-red mineral. In other portions of the slide, the brown-red biotite with or without green or green-and-brown chlorite occur to the exclusion of the hornblende, and the rock then takes on the appearance as well as the structure of the 180 feet variety. (Fig. 72.)

There is undoubtedly a resemblance between the hornblendic portions of the slide and the sections of [13996] from the hornblendic

gneiss. In the latter, however, the quartz is quite subsidiary to the felspar, and the latter is much kaolinised. In the sections of 245 feet, the felspar plates are often in polygonal or rectangular form, just as those minerals are in the finer varieties of the hornblendic gneiss, and sphene grains are equally common in both facies. The major differences between 245 feet and [13996] are the finer grain of the former, the larger amount of quartz in 245 feet, the kaolinisation of the felspar in [13996], and the more fibrous structure and more decided banding of the hornblende in [13996].

Fig. 71.

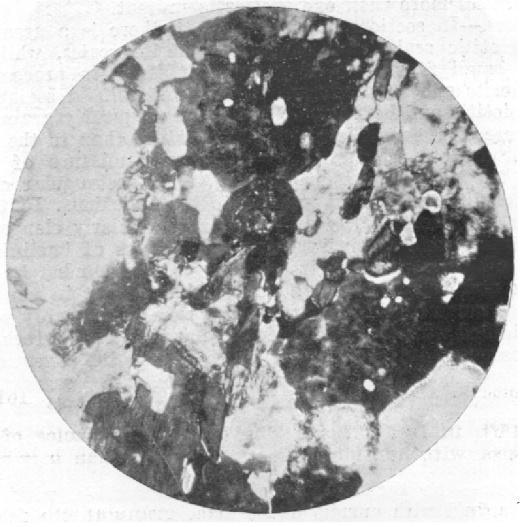

Photo: R. A. Farquharson. Neg. 1615.

[$\frac{1}{39}$] 223ft. in Duff's Bore: A facies of the gneissic rock with both biotite and a little hornblende.

It is clear, therefore, that at certain points, as at 180 feet, the rock has characters which ally it with foliated biotite granites or rather with foliated biotite gneisses, while at others, such as 223 feet and 245 feet, the biotite is associated with green chlorite and with green hornblende. Both at 223 feet and at 245 feet there is a noticeable passage of the green chlorite into brown-red biotite, and of the green hornblende into green chlorite. Particularly at 245 feet green hornblende is in places present to the exclusion of the biotite; in other places green chlorite is to be seen passing into brown biotite; and in others green chlorite is almost absent, brown biotite alone is present (with a few scales of green chlorite), and the

neral, associated as it is with felspar and quartz, gives an appear-ice to the slide in composition and structure closely similar to ose of the 180 feet variety. Moreover, in the biotitic variety of 0 feet, again in the chloritic hornblendic variety at 223 feet, and

Fig. 72.

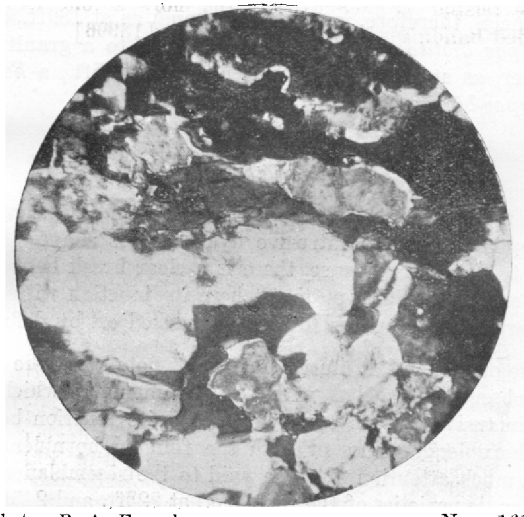

Photo: R. A. Farquharson. Neg. 1616.

[$\frac{1}{33}$] 245ft. in Duff's Bore: The hornblendic facies of the gneiss, with hornblende more prevalent than biotite.

in the very hornblendic variety at 245 feet, granular sphene constantly occurs, and it is always in association with the chlorite, the biotite or the hornblende, or with all of them. Further, the structure and composition of the 245 feet variety closely resembles those of [13996] except that in the latter quartz is less prominent and felspar predominant, the felspar is highly altered (kaolinised chiefly), and the hornblende is in places more or less fibrous. The structure or mutual relations, too, of the hornblende, quartz and felspar at 245 feet are very similar to those of the same minerals in hornblende-gneisses, and particularly in some of the finer-grained varieties of the hornblende gneiss of the area. There is the polygonal or elongated rectangular structure of the felspar, the indistinct banded arrangement of the hornblende, the lenticular form of much of the larger quartz plates, and the rectangular or linear forms of the smaller quartz plates. Sphene is also common both to the 245 feet variety and to the hornblendic gneiss.

On the other hand, the amount of quartz in the biotitic gneiss is greater than that in the hornblendic gneiss, and the large amount

of quartz in the former gives it a granitic character. It is plain, however, that much of the quartz occurs as thin veinlets parallel to the foliation, and the suggestion arises that part of the quartz has been intruded from the quartz lodes along the line of foliation of the gneiss by a sort of *lit par lit* injection. Nevertheless, there can be no doubt that the quartz occurring in plates in intimate association with the kaolinised felspar is original or primary.

The gneiss, therefore, is on the one hand, as at 180ft., a foliated *quartz-felspar biotite gneiss,* with resemblance to a granitic gneiss; on the other, as at 223ft., and particularly at 245ft., a *hornblende-quartz-felspar-biotite gneiss.*

Origin of the Rock.

From the occurrence of the gneiss as shown on the plan, Plate IX., it appears to be an intrusive dyke of lens shape. Certainly, according to the field evidence, there is a clear break between it and the hornblendite at 426ft., so that where its junction with the country is observable, it appears to be well marked off by definite walls.

On the other hand, it must be carefully noted that the only clear junction observable is that with the hornblendite, which is itself probably intrusive. In no case could a definite junction be observed with the hornblende-gneiss or with the foliated hornblende schists. Moreover, much attention must be paid to the resemblances between the hornblendic varieties of the rock, *e.g.,* at 223ft. and 245ft., and the finer-grained varieties of the hornblende gneiss and [**13996**]. In this connection, the difference in the amount of quartz in the two facies is a difficulty, and though this may, to some extent, be accounted for by injection of quartz from the quartz lodes along the planes of foliation, it appears that the rock was primarily more acid than the hornblendic gneiss. The 245ft. variety has affinities, both in composition and structure, with a foliated hornblende granite, and it was for a time considered that the lens of the Main Lode might be an altered form of a hornblende-granite intrusion. The fact, however, that no hornblende-granite at all comparable to this rock occurs anywhere except at great distances from the Edna May group of leases rather discounts this view. Further, at the bottom of the Recovery Shaft two specimens were obtained, one, the medium-grained hornblendic gneiss, and the other from the immediate vicinity of a quartz vein, a fine-grained finely-foliated biotite gneiss [$\frac{1}{16}$], which has already been described. The only feasible explanation of the occurrence of this biotite gneiss [$\frac{1}{16}$] appears to be that it is a facies of the finer-grained hornblende gneiss thermo-dynamically altered by the introduction and contact action of the auriferous quartz reef. This biotite gneiss shows close similarity with the Edna May gneiss.

An analysis of the rock from 223 feet in Duff's Bore, made in the Geological Survey Laboratory, gave the following results:—

	I.	II.	III.	IV.	V.	VI.
SiO_2 ...	68·61	69·22	67·45	63·62	74·98	75·83
Al_2O_3 ...	14·24	14·29	15·51	14·38	12·85	14·11
Fe_2O_3 ...	·71	2·12	1·76	3·29	·16	·49
FeO ...	2·23	2·33	2·21	3·47	1·59	·12
MnO ...	·10	...	...	·28	·11	...
MgO ...	1·41	1·27	1·10	3·13	·59	·25
CaO ...	3·20	3·16	3·60	5·43	1·55	·55
K_2O ...	3·04	3·52	3·66	1·20	3·34	5·32
Na_2O ...	3·70	3·29	3·47	4·40	3·80	3·12
H_2O- ...	·06	...	·14	·22	·10	·13
H_2O+ ...	·30	·69	·63	·06	·48	·41
TiO_2 ...	·50	·36	·58	·72	·21	·08
CO_2 ...	·37	...	...	...	·05	...
P_2O_5 ...	·19	...	·12	...	·06	·20
FeS_2 ...	·11	...	...	...	·09	...
Fe_7S_8 ...	1·24	...	...	...	...	...
Total ...	100·01*	100·35	100·23	100·20†	99·96*	100·61‡

* Analyst H. Bowley. † Analyst E. S. Simpson. ‡ Analyst A. J. Robertson.

I. Rock at 223 feet. Duff's Bore.
II. Tonalite. Lana bei Meran, cited by Rosenbusch: Elem. der Gesteinslehre 1910, p. 166.
III. Granodiorite: Silver Lake Hotel, Eldorado Co., California, cited by Osann: Beiträge zur Chem. Petrog. 1905, p. 50.
IV. Granodiorite: Agamemnon G.M., Cue, Bull. 14, G.S.W.A.
V. Granite from Cosmopolitan Mine, Kookynie, W.A.
VI. Southern Cross Granite: Bull. G.S.W.A. No. 49, p. 57.
II., III., IV., V., and VI. are analyses of various rocks of granitic or quartz-dioritic character cited for comparison.

The rock at 223 feet was chosen for analysis, partly because it is intermediate in mineral composition between the highly biotitic facies at 180 feet and the predominantly hornblendic facies at 245 feet, and partly because of the comparative absence from it of quartz veinlets. The mode of the rock proves to be:—

Quartz, biotite, albite, orthoclase, quartz, hornblende, calcite, kaolin, chlorite, sphene, epidote, plagioclase.

Attempts have been made to calculate the actual percentage mineral composition, but these, on account of the presence of biotite, chlorite, and hornblende, the relation between the chlorite and the biotite, and the doubt as to the actual chemical composition of the biotite, chlorite, and hornblende, are unsatisfactory. Moreover, the results in any case are of little value so far as the origin of the rock is concerned, since both the mineral and chemical composition vary from point to point from 180 feet to 370 feet, and the analysis, except as regards the relative proportion of the alkalies and possibly the percentage of alumina, can scarcely be regarded as an accurate basis for the reconstitution of the mineral composition of the rock. Several analyses are really required from different portions of the biotitic gneiss, or perhaps even better, numerous sections and calcu-

lations of the composition by the Rosiwal method, but exigencies of time, labour, and apparatus preclude the preparation of these.

Nevertheless, considerable information may be gathered from the comparison of the analyses cited. In the first place, it is evident that the rock at 223 feet is more basic in composition than either the biotite-microcline granite at the Cosmopolitan Mine, or the biotite granite at Southern Cross. Both of the latter are true granites, and neither contains in any portion of its mass any hornblende. Consequently, as both are unsheared, it is unlikely that the biotite-gneiss of the Edna May is a sheared or foliated derivative of either of these.

Again, there are differences between the rock at 223 feet and that from the Agamemnon Mine at Cue. The latter, with 63.6 per cent. of silica, 1.2 per cent. of potash, and 4.4 per cent. of soda, is a basic granodiorite, *i.e.*, a type of quartz-diorite with subordinate potash-felspar, regarded by Lindgren as intermediate between a true quartz-diorite and a quartz-monzonite. The 223 feet type differs from it in the amount of silica, and especially in the relative proportions of the alkalies in the two rocks, and the differences are at first sight sufficient to indicate a fundamental dissimilarity between the 223 feet type and the granodiorite type. If, however, as appears probable, some of the quartz in the 223 feet type has been introduced as quartz veinlets, the normal rock, being necessarily less acid, would not differ decisively in silica content from the Cue rock. Moreover, not all granodiorites show the relative amount of the alkalies present in the Cue rock. The granodiorite from Silver Lake Hotel, California, exhibits alkali percentages very closely agreeing with those of the 223 feet type, and there is indeed a close correspondence between the analyses of the two rocks. Consequently, while the 223 feet type shows important differences from the Cue rock, the relation between it and granodiorites from typical localities is a close one.

Finally, a comparison of the analyses of the 223 feet type and the tonalite cited by Rosenbusch shows a surprisingly close correspondence between them, a correspondence which almost amounts to an identity. The tonalite of vom Rath is an acid quartz-mica diorite, classed by some petrologists with the hornblende-granites, but is characterised by a certain amount of andesine felspar. Structurally, the 223 feet type differs from the dioritic, and, though andesine may be present in it, none was determinable. In any case, however, the 223 feet type appears from the analysis to be a granulitic rock with a chemical composition not markedly dissimilar from an acid quartz-mica-diorite of the tonalite type.

On the evidence at present available, therefore, the gneiss is either (a.) a more acid quartz-diorite band or lens that is a differentiation of the original of the finer-grained bornblende-gneiss; or (b.) a more acid quartz-diorite or granodiorite intrusion that has

been subsequently foliated and intruded by the auriferous quartz veins, and in which the original hornblende has been largely changed to biotite by dynamic stress and heat. From the close resemblance (in the analyses) of the 223 feet type to typical granodiorites, and the acknowledged close affinities of quartz-diorites of the tonalite type to granites, the rock is probably best recognised shortly as originally a granodiorite. As no clear junctions can be found showing the relation of the gneiss to the hornblende gneiss or to the granulitic hornblende schist, it is not at present possible to come to any definite conclusion, though it is most probably an intrusion.

5.—The Quartz Specimens.

Several specimens of the ore-bearing quartz from the gneissic granite lens of the Edna May, Edna May Deeps, and Edna May Central Mines were collected with a view to the microscopic determination of the origin of the quartz. The results of the examination of several slides are as follows:—

[$\frac{1}{7}\frac{1}{6}\frac{}{0}$A]. From 150ft. Level, Edna May.

The specimen consists of sugary white quartz, much cracked.

In sections, there are large interlocking plates of quartz, some with uneven extinction and cracks, and all characterised by rows or thin lines of fluid pores often in aggregations. Felspar was not seen in the slides, but a small patch of a micaceous aggregate may represent it.

[$\frac{1}{7}\frac{1}{6}\frac{}{0}$]. From back of No. 1 Stope, 225ft. Level, Edna May Mine.

The specimen consists largely of quartz similar in appearance to the above, apparently somewhat sheared, with grains of pyrites and occasional flakes of biotitic chloritic character.

In section there are again large interlocking plates of quartz, cracked, and with rows or lines of fluid pores often in aggregations. Associated with the quartz, however, are large more or less euhedral crystals of felspar apparently of two species, microcline and another acid plagioclase with albite twinning. Both species are considerably kaolinised, but the latter more so than the former. In some cases, the felspar plates occur at the junction of several quartz plates, in others they form a small veinlet; in others again, isolated plates occur surrounded by quartz. The microcline plates are generally irregular in outline, but the other plagioclase has generally at least one crystallographic boundary, and apparently crystallised before the microcline. In one instance at least, a small crystal of felspar without twinning was observed enclosed in a quartz plate. In places the felspars are micacised.

The quartz, therefore, associated as it is with felspar which occurs not undeniably in veins, is of granitic origin, and must be regarded as an acid portion of a pegmatitic facies, *i.e.*, of a quartz-felspar pegmatite in which the felspar is poorly developed.

[$\frac{1}{7}\frac{1}{6}\frac{}{1}$A]. From 480 feet Level, Edna May Deeps.

This is of darker colour, apparently sheared or shivered, and with obscure bands in which a pale greenish-white felspar is prominently associated with the quartz, forming a pegmatitic variety. Away from these bands felspar appears to fail, but through the quartz mass thin veinlets of the felspar are seen to pass, and the intervening quartz appears devoid of felspar.

In section the quartz has the same character as in the other specimens. There are kaolinised felspar plates as before, but not only are there felspar inclusions in the quartz, but in some cases quartz inclusions in the felspar, facts which indicate a contemporaneous solidification of the quartz and felspar. The felspathic portions of the slides are of granitic character. Uneven extinction is common in the quartz and occasional in the felspar.

From the presence of the veinlets or bands of felspar in the specimen, two possibilities arise: (1) that these veinlets are felspathic segregation veinlets in a pegmatite; or (2) that they have been introduced subsequent to the formation of the quartz and along cracks in it. The occurrence of the reciprocal inclusions and the granitic character or structure of the rock, point to the former being the true explanation of their origin.

Another specimen of [$\frac{1}{7}\frac{1}{0}\frac{1}{0}$], shows not only the former characters in the quartz, but also very small but undeniable crystals of kaolinised felspar enclosed in the quartz.

Slides of some of the specimens show very large plates of quartz and finely lamellated felspar with distinct cases of kaolinised felspar enclosed in quartz, and of quartz enclosed in felspar. Some portions of these slides are finer in grain than the remainder and show associated biotite scales, one of which exhibit a distinct corrugation.

[$\frac{1}{7}\frac{1}{5}\frac{}{8}$A]. From back of No. 1 Stope, 225ft. Level, Edna May Mine.

These are two specimens very similar.

One consists of water-clear quartz with a well-marked vein composed of pale-greenish felspar and quartz and yellowish felspar occurring generally in the margin of the veinlet. This yellow felspar is largely a kaolinised variety of the pale-green. There is a branch veinlet. It is noteworthy that while on one side of the specimen, the veinlets are clearly defined, on the other they broaden out, more of quartz is present and the specimen takes on a quartz-felspar pegmatitic appearance. Moreover, in places small patches of the pale-green felspar occur scattered amongst the water-clear quartz giving an even more nearly normal pegmatitic appearance to the rock.

In the other specimen the veinlets are not defined, the felspar being scattered through it in small patches both pale-green and yellowish in colour.

In section the veinlets consist of large plates of quartz with long strips of felspar that is an intergrowth of microcline and albite, generally highly kaolinised. Some of the strips are very narrow and resemble veinlets of felspar introduced along cracks. Undeniably, however, in places occur small areas of quartz surrounded by felspar and *vice versa*, and though, in some cases, the felspar appears to be connected up with a larger mass along cracks in the quartz, in others, the plates are isolated.

Another section is a very coarse platy mass of quartz and felspar (microcline-albite, extremely kaolinised).

The question arises as to whether the quartz-felspar veinlets are merely segregations or differentiation veinlets, or whether they are later veinlets introduced along cracks. Consideration of the quartz of the veinlets shows it to be identical with the surrounding quartz. Moreover, the mutual relations of the quartz and felspar, as illustrated by the inclusions, point to contemporaneous solidification. Further, the microcline of the veinlets occurs disseminated through the bulk of the quartz just as in other microcline-quartz-pegmatites;

and it is quite common to find highly quartzose and highly felspathic pegmatitic veins in acid granites, which, though appearing as intruded dykes or veins, are nevertheless virtually contemporaneous with the granites. For these reasons the veinlets are to be regarded as felspathic segregations or bands in granitic pegmatitic quartz, and not as distinctly later intrusions of microcline-albite felspar.

Examination of the quartz specimens therefore shows:—

(a.) that the quartz is a granitic quartz with rows of fluid inclusions;

(b.) that in most cases more or less felspar is associated with the quartz plates;

(c.) that, frequently, quartz plates are enclosed in felspar, and in the same sections felspar plates are enclosed in quartz; and that, consequently, the quartz and felspar have most probably solidified at or about the same time;

(d.) that the quartz itself is the solidified acid residuum of a quartz-felspar pegmatite.

Relation of the Quartz-Pegmatite to the Gneissic Granite.

The relation of the ore-bearing quartz specimens to the gneissic granite is of some interest and importance. There are two possible relations: (1) that they are merely quartz-pegmatite and quartz-felspar-pegmatite facies of the gneissic granite itself, (2) that they are quartz-pegmatite intrusions into the gneissic granite and consequently of later age. Some specimens of the quartz certainly appear to show transition stages from the gneissic granite. On the other hand, the maps indicate that the ore-bearing quartzes occur as veins or dykes, since, at their widest they cut across the foliation of their country rock and taper out into thin veinlets as they gradually become parallel to the foliation. Moreover, according to the field evidence, the ore-bearing quartz veins at depth frequently show a very well-marked line of demarcation from the gneiss with which they are in contact.

From the evidence available, therefore, they must be regarded as intrusions into the gneiss along cracks or fissures caused by dynamic strain, and consequently of later origin.

Associated with the quartz veins are frequent occurrences of wolfram and wulfenite.

6. The Granites.

The specimens of these collected are easily divisible on external characters into two groups:—

(a) The comparatively fine-grained yellow granites.

(b) The comparatively coarse-grained grey or white granites.

(a) *The Yellow Granites*:

Typical examples of these are [$\frac{1}{3}$], [$\frac{1}{1\,1\,6\,2}$], and [$\frac{1}{1\,1\,6\,3}$]. They are all fine to medium grained, of a yellowish colour, and consist of crystals of quartz and felspar of equal size, with black flakes of biotite. In the two former, biotite is more common than in [$\frac{1}{1\,1\,6\,3}$] in which only scattered flakes occur. The characters of the rocks in section are represented by [$\frac{1}{3}$] and [$\frac{1}{1\,1\,6\,3}$].

A remarkable feature of [$\frac{1}{1\,1\,6\,3}$] is the presence of small particles of gold enclosed in the microcline felspar (Fig. 73).

Fig. 73.

Photo: R. A. Farquharson. Neg. 1617.

[$\frac{1}{1\,1\,6\,3}$] **Yellowish microcline biotite granite with gold in the microcline.**

[$\frac{1}{3}$.] From 6½ M.P., Boodalin Road, Weston's.

The slides show tabular and somewhat irregular flaky crystals of felspar and irregular plates of quartz with occasional flakes of brownish biotite. The felspar is largely microcline, but occasional plates of a plagioclase with broad albite lamellation also occur. All the felspars are more or less kaolinised, and some are slightly micaceous. Intergrowths of felspar and quartz—some with an approach to graphic structure—are common, and small areas of vermicular pegmatite are observable. Round quartz grains also occur in the microcline. The structure is essentially granitic.

The rock is a yellow *microcline-biotite granite.*

[$\frac{1}{1\,1\,6\,2}$.] From Quarry at back of Old Townsite.
Is identical with [$\frac{1}{3}$].

[$\frac{1}{1\,1\,6\,3}$.] From Recovery G.M., Westonia.

Sections show the rock to be again a microcline-biotite granite very similar in structure and composition to [$\frac{1}{3}$], but with less biotite. Microcline felspar is predominant. There are again inclusions or intergrowths of quartz in microcline, and small areas of the vermicular micro-pegmatite are also present.

A remarkable feature of the rock is the presence of gold in the felspar. The gold is in the microcline in small particles with a kind of cellular structure, *i.e.*, the particles are very ragged in outline with small open spaces in the interior. In spite of the ragged character, however, it is difficult to see, since the gold undoubtedly occurs in association with only partially kaolinised felspar, how it can be secondary. Jacquet* has recorded the occurrence of free gold in microcline in a quartz-microcline rock from New South Wales, and there is at present no reason for believing that the occurrence in [$\frac{1}{1\,1\,6\,3}$] is anything but primary.

All three specimens, [$\frac{1}{3}$], [$\frac{1}{1\,1\,6\,2}$], and [$\frac{1}{1\,1\,6\,3}$], show both in external appearance and in composition and structure a marked similarity with the granite from Southern Cross described in *Bulletin* 49.

[$\frac{1}{7\,6\,1}$.] A specimen, [$\frac{1}{7\,6\,1}$], from Weston's Reward, 75 feet level, which occurs as a dyke, is included here.

A coarse-grained grey granitic rock composed of rather dark, sometimes nearly black, water-clear quartz crystals, mostly of rounded shape, in a mass of whitish felspar plates and some black scales of biotite. There are small segregations of biotite.

In section, there are large, somewhat rounded crystals of clear quartz and large irregular plates of partially kaolinised microcline, and of a plagioclase of acid species with albite twinning. There are also occasional flakes of brown biotite. A peculiarity of the rock is that the microcline often appears squeezed in between the quartz, indicating that the quartz has consolidated first. There are cracks in the quartz and some bending of the lamellae of the felspar, as well as uneven extinction. No intergrowths were observed, but there are inclusions of felspar in felspar and of biotite in felspar.

The rock is coarse *microcline-biotite granite.*

(b) *The Grey or White Granites*:

These differ from the yellow granites not only in colour, but also in being markedly coarser in grain and in being in places almost porphyritic, with large crystal plates of a white, pale-greenish white or faint pink tint.

The microscopic characters of the group are illustrated in specimens [$\frac{1}{7\,4\,0}$], [$\frac{1}{7\,3\,7}$], and [$\frac{1}{7\,3\,8}$].

[$\frac{1}{7\,4\,0}$]. From Ennuin Tank.

This is a very coarse-grained grey granitic rock with occasional large semi-porphyritic felspar crystals and scales and books of biotite.

In section there are very large platy and tabular crystals of partially kaolinised and partially micacised microcline felspar, and less common plates of a plagioclase with albite twinning, with aggregations of irregular plates of quartz and occasional flakes of brown biotite, in places chloritic. Wedge-shaped crystals of sphene also occur, sometimes of considerable size. Some vermicular intergrowth appears in places

* Memoirs, Geol. Surv., N.S.W., 1894.

and an approach to zonary banding is noticeable in some of the felspar plates. Some of the most kaolinised felspars are quite turbid and enclose small grains of epidote. A few grains of black iron ore (ilmenite) appear sporadically.

The rock is a very coarse-grained *semi-porphyritic microcline-biotite granite.*

[$\frac{1}{737}$]. From two miles east of 128 M.P., Rabbit-Proof Fence, South Yilgarn.

A medium-grained grey granitic rock with large semi-porphyritic pinkish felspar crystals in a finer-grained mass of pinkish felspar, quartz and biotite flakes.

Sections consist, as in [$\frac{1}{740}$], of large partially kaolinised and partially micacised platy crystals of microcline felspar, fewer large quartz plates that are in some cases more or less rounded, and smaller ragged quartz plates, with occasional flakes of brown biotite and grains of iron ore. There are undoubted rounded inclusions of quartz in the microcline, and rounded inclusions of vermicular intergrowth also in the felspar. Irregular lamellation and extinction in the felspar and uneven extinction in the quartz are common. There is some chloritisation of the biotite.

The rock is essentially the same as [$\frac{1}{740}$], *i.e.*, a *microcline-biotite granite.*

[$\frac{1}{738}$]. From Mount Gibbs, Phillips River G.F.

A rather coarse-grained white or light-grey granitic rock with large plates of microcline showing intergrowths of quartz and an approach to graphic structure, and biotite scales in thin streaks, giving in places a suggestion of gneissic structure to the rock. The sections show, as in the previous specimens, large microcline and quartz plates with flakes of biotite and green chlorite. The quartz plates appear in places to be partially granulated, or at any rate broken down into smaller fragments. There is uneven extinction in the quartz and felspar, and irregular lamellation and bending of the lamellae in the felspar, characters due to dynamic strain on the rock. Vermicular intergrowths also occur, some in the microcline.

The rock is again a coarse-grained *microcline-biotite granite.*

It is very evident, then, that these three specimens, though collected from places many miles apart, are all so closely similar both in appearance, structure, and composition that they must be regarded as portions of the same or of a genetically similar mass.

Relation of Group (a) to Group (b):—

In external appearance the two groups are, as already stated, undoubtedly separable. When, however, attention is directed to the composition and structure of the two, a very marked similarity becomes at once apparent. Both groups are microcline-biotite-granite; in both, the main constituents are the same, viz., quartz, microcline, and biotite; and in both, the same peculiarities are manifested, viz., vermicular micropegmatite areas, and inclusions or intergrowths of quartz in the felspar. There are differences between the groups, but these, such as the presence of semi-porphyritic structure, the presence of green chloritic flakes, and the presence of sphene crystals in Group (b), are of minor importance. With regard to sphene, this mineral has not been observed in Group (a), but, on the other hand, it is not observable in all specimens of Group (b). Again, specimens like [$\frac{1}{761}$], which, according

to field evidence, are dykes and are connected with the granites of Group (a), are both in external appearance and in composition strikingly similar to [$\frac{1}{7}\frac{1}{3}\frac{1}{8}$].

Since, therefore, the mapping shows the rocks of Group (a) to occur as veins or apophyses, it is probable that the yellow specimens are but apophysal varieties of a main mass of which the rocks of Group (b) are specimens. This being the case, it would appear, further, that the quartz and quartz-felspar pegmatite that form the ore-bodies of the Main Lode are genetically connected with the magma which gave rise to the grey granite. Owing, however, to the impossibility of obtaining further field evidence on this point, no positive assertion to this effect can be made.

7. The Aplite or White Granite Dykes.

These occur as thin veins, varying in thickness from an inch to a few feet. They cut through all the other rocks whose relations with them can be observed. They are comparatively large in number but their chief characters are represented by the following specimens:—

(a) From a depth of 238ft. to 241ft. in the No. 3 Bore:

This is a coarse-grained white granite with felspar, in part microcline, in part orthoclase, in part apparently albite or oligoclase. Small areas of vermicular micropegmatite occur, also small flakes of greenish chloritic biotite and of green chlorite. There are inclusions or intergrowths of quartz in the felspar; and the lamellae of the felspar are in places bent by strain.

(b) From 243ft. to 251ft. in the No. 3 Bore:

This specimen is a fine-grained white granite characterised by small beautiful euhedral red garnet crystals. (Fig. 74.)

(c) From 279ft. to 281ft. in the bore from Weston's Reward:

The rock is a fine-grained white granulitised or granulated, highly felspathic aplite. The plates of felspar and quartz are ragged, granulated at the margins, and broken down in places into small round grains. Bending of the felspar lamellae is again noticeable, and there is rarely a little brown biotite in thin flakes.

(d) The thicker dykes:

One specimen of these shows a fine-grained white facies enclosing a lenticular band of the biotitic granitic gneiss, and while the specimen is fine-grained as a whole, it gradually becomes coarser towards the margin of the xenolithic inclusion. While the enclosing rock is massive, the xenolith is markedly foliated and highly biotitic. In section, the enclosing rock consists of large plates of microcline and smaller plates of quartz. The former are ragged, partially kaolinised, in places broken down into a granular mosaic, in places with many small quartz inclusions, and in places with marked granular and striped intergrowths. The felspars are all more or less kaolinised.

Other specimens are coarse-grained, but with portions so fine-grained as to be felsitic in appearance. These felsitic bands may represent chilled margins.

In general, therefore, the rocks are white in colour, and vary in grain from fairly coarse to a fineness that is almost felsitic. They

consist of felspar and quartz, the former being in places largely microcline, but in places orthoclase, and another acid plagioclase. Only rarely do a few scales of brown biotite and green chlorite appear. In one instance, *i.e.*, at 243 feet to 251 feet in the No. 3 Bore, the granite or aplite contains small red garnets.

Fig. 74.

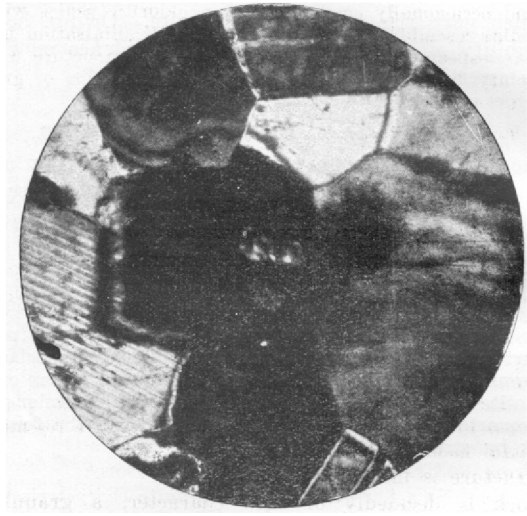

Photo: R. A. Farquharson. Neg. 1618.

[$\frac{1}{42}$] 243ft.-251ft. in No. 3 Bore, Edna May: Aplite or white granite with euhedral garnets.

8. The Hill End and Battler Gneiss.

(a.) *The Hill End Gneiss*:

Two specimens of this [$\frac{1}{11\,5\,6}$] and [$\frac{1}{11\,5\,7}$] show somewhat different characters.

[$\frac{1}{11\,5\,6}$] This is a foliated medium-grained tough grey rock with splashes and strings of brown biotite mica and small pale yellowish-green patches, with some silvery scales of white mica.

In section the rock is a fine-grained granulitic or granular mass of rounded and polygonal mosaic plates of clear felspar and quartz, in which are occasional large platy crystals of felspar generally highly micacised and partially broken down, especially at the margins, into a granular mass of small plates. Through the mosaic, and aggregated at certain spots, are nearly colourless, yellowish wisps of minute hair-like needles so fine as to prevent their optical characters being arrived at. The hairs penetrate both quartz and felspar grains and plates. In

certain places they occur as fibrous masses or plates, and, in the fibres, a jointed structure with an indistinct cleavage parallel to their length is noticeable. Moreover, they appear to be biaxial, though the fact that they penetrate other minerals renders their optical characters obscure. Though they resemble tremolitic aggregates, they have been determined in the Survey Laboratory from coarser specimens, in which their character is clear, as sillimanite needles.

A noteworthy feature of the felspars is that most of the large partially micacised and granulated plates have the gridiron structure of microcline, and even some of the smaller grains exhibit the same structure. There are small scales of brown-red biotite scattered over the slide, and occasionally small pale-green chloritic scales with a network of needles resembling sagenite webbing. Kaolinisation is common in the felspar, especially in the large plates. The structure was originally coarse platy, but has been reduced by granulitisation or granulation to a mosaic granular one.

The rock is a foliated granulitic *quartz-felspar sillimanite gneiss.*

$[\frac{1}{11\,5\,7}]$. This is a dull greyish-white foliated rather fine-grained rock with the foliation marked by strings of biotitic scales, and with splashes and large flakes of silvery mica. In section it is a fine-grained granular mass of quartz and kaolinised and micacised felspar plates, with occasional greenish scales of chlorite, large flakes and platy aggregates of white muscovite, and large platy felspars micacised and kaolinised and partially granulated. Some of the small fibrous chlorite scales have already acquired a brownish biotitic character, and in many the acicular webbing is again visible. Some undoubted grains of tourmaline occur, some calcite, and apparently some zoisite. In some places, large scales of muscovite occur, with a finely fibrous structure resembling that of the doubtful haematite aggregates in $[\frac{1}{11\,5\,6}]$.

The structure is fine granular.

The rock is decidedly of acid character, a granular mass, mostly of quartz and felspar, and interpreted as a *chloritic muscovitic granulitic quartz-felspar gneiss.*

Both $[\frac{1}{11\,5\,6}]$ and $[\frac{1}{11\,5\,7}]$ are obviously varieties of the same rock. In the field the rock is bordered by hornblende schist, and its occurrence distinctly suggests an origin as a dyke, which the occurrence of tourmaline in $[\frac{1}{11\,5\,7}]$ strengthens.

(b) *The Battler Gneiss*:

This is typically represented by $[\frac{1}{11\,5\,8}]$.

The rock is a fine-grained yellowish-grey finely foliated rock with splashes and strings of a brownish biotitic mineral. The latter, often intimately mixed with the rock mass, give it a brownish tint. On the cross fracture the rock is pale-grey in colour and almost felsitic in texture.

In section, it consists of a fine granular or granulitic mass of clear quartz, and micacised as well as kaolinised felspar plates, with scattered scales and imperfect bands of yellowish-green chlorite, and of a brown-yellow biotitic mineral that is probably chlorite in course of alteration to biotite. Many of the felspar grains exhibit the grid-iron structure of microcline, while others show the broad albite twinning, and some no twinning at all.

The rock is a fine-grained almost felsitic *granular quartz-felspar gneiss.*

There is no doubt that both this Battler gneiss and the gneiss from Hill End are varieties of the same rock.

As to the affinities of the gneiss with the other rocks in the field, not much can be said. The only other rock with which a connection could be established is the Edna May grey-biotitic gneiss. The Battler and Hill End gneiss, however, appear distinctly more acid; hornblende was not found in it in any section; and from its occurrence it is distinctly intrusive into the hornblende schists. On the other hand, particularly in the Hill End gneiss, brown-red biotite scales and patches occur identical with those in the Edna May gneiss, and chlorite flakes in course of alteration to the biotite are by no means uncommon. The structure, however, and the composition of the two gneisses are to a considerable extent dissimilar, for in the Battler and Hill End type microclinic plates are common, there is intense micacisation of the felspar and an occasional occurrence of tourmaline, while these characters are absent from the Edna May type.

In spite, therefore, of certain similarities, and on account of differences in structure and composition, and the absence of any field connection, it is not feasible to correlate these rocks with the Edna May gneiss. It is possible, of course, that they may represent more acid apophyses of the intrusion which may have given rise to the Edna May rock, but in this case there must have been a considerable variation in structure and composition, though the chlorite of the Battler gneiss may represent former hornblende. The evidence at present available is too sparse and obscure to enable any definite conclusions to be drawn.

B.—THE DOLERITE DYKES FROM THE CORINTHIAN MINE.

These are dense-black, fresh, medium to fine-grained rocks, varying in width from two feet to twenty-six feet. They occur distinctly intruding the granite. Their chief characters are illustrated by [**13945**] and [**13944**]. The former, in section, consists of large columnar felspars and large grains of augite as well as numerous smaller laths of felspar and smaller grains of augite, with a subophitic relation between the crystals of the two minerals. Grains of iron ore are common. The latter [**13944**] consists, in section, of altered large porphyritic felspars and occasional large grains of augite in a fine-grained ground-mass consisting of very thin laths of felspar and grains of partially chloritised augite, with patches of iron ore. This specimen is a porphyritic basaltic dolerite with strong resemblances to an augite-andesite.

The mineral composition of both rocks is the same, but [**13944**] has decidedly more of a basaltic structure. Both the microscopic and the field evidence point to its being a chilled marginal facies of the normal dyke represented by [**13945**].

C.—ROCKS FROM THE BULLFINCH AREA.

These comprise specimens collected some years ago by Mr. C. B. G. Gibson and those collected by Mr. Blatchford during the recent survey.

Mr. Gibson's rocks are represented by [11523], [11519], [11518], [11517].

[11523.] This is a confusedly fibrous epidiorite consisting of fibrous wisps, plates with a fibrous fringe, and sheaves of nearly colourless hornblende separated by a fine-grained microcrystalline mosaic of felspar. The latter represents original platy felspars which dynamic stress has reduced to mosaic. In places, remains of the original columnar crystals may still be seen, and since these still form a kind of coarse plexus it is probable that the rock was originally a coarse dolerite or gabbro, such as those described in Bulletin 49, from the Southern Cross area.

[11520] is very similar, but the hornblende is greatly predominant over the felspar, and the grain is fine.

[11519.] This is a coarse-grained rock composed of large ragged extremely fibrous plates of pale-green nearly colourless uralitic hornblende, with a few plates of yellowish chlorite. There is a noticeable fibrous margin to the plates, though many of them are intensely fibrous throughout. Very little felspar is visible, though it may to some extent be obscured by the hornblende fibres.

The rock is a fibrous uralitic hornblendite, probably derived originally from a coarse gabbro or pyroxenite.

[11518.] This rock is a very fibrous uralitic epidiorite in which felspar is rather poorly developed, though probably obscured by the hornblende fibres. A little zoisite appears to be present. The rock is essentially similar to [11523.]

[11517.] A fine-grained schistose fibrous quartz epidiorite with the ferro-magnesian and the colourless constituents in about equal amount. The felspar is in small plates largely in process of granulitisation and kaolinisation, and, like the hornblende, elongated somewhat in the direction of schistosity. Quartz grains are but sparsely distributed.

It will be seen, therefore, that the rocks are all either fibrous epidiorites or hornblendites, and all have originally been derived from gabbro or pyroxenites. Mr. Gibson in his report on the Bullfinch property divides the greenstones into two series, the Older Greenstones and the Newer Greenstones. The former he considers to have been originally probably fine-grained diabases ultimately altered by dynamic metamorphism into schistose epidiorites. The latter, he states, are essentially coarse-grained, generally sheared or schistose, and were originally coarse-grained pyroxenites.

Now, while coarse-grained amphibolites and fine-grained epidiorites undoubtedly occur, particularly around Southern Cross, it must be carefully noted that often in the finer-grained epidiorites, coarser amphibolite and even hornblendite bands or lenticles may and do occur, and these are frequently but hornblendic segregations in the epidiorite rock. Further, though some of the greenstones may appear to have been derived from diabases or dolerites and others from pyroxenites, it by no means follows that the different facies are of different age. In doleritic and gabbroid masses it is quite common to find gradual variations from a rock rich in felspar and augite—a gabbro—to one from which the felspar is absent or nearly

so, which consists almost wholly of pyroxene—a pyroxenite. Though the end products of the variations appear mineralogically and structurally different, the occurrence of transition stages proves the genetic connection between them. The hornblendic derivatives of these end products would be, in the one case, felspathic amphibolites or epidiorites, in the other, hornblendites, yet both would be of the same age and origin.

The specimens collected by Mr. Blatchford are from the rock in the drive from the main shaft in the Bullfinch Mine at the 410ft. level. The numbers of the series occur, roughly, in the following order, starting from the shaft *:—

[1/1167], [1/1166], [1/1168], [1/1169], [1/1170], [1/1171], [1/1164], [1/1165], Dolomite lode, [1/1172],]1/1173].

The characters of the rocks are as follows:—

[1/1164.] A fine-grained dark grey-green hornblendic rock with grains of coarser and greener hornblende fibres and small patches of a brownish tint. In section, the rock is a medium to fine-grained epidiorite with a little quartz in addition to felspar. It consists of a ragged platy fibrous mass of greenish hornblende, the plates sometimes forming a loose network or patchwork with the interspaces occupied by a few grains of a quartz-felspar mosaic. In places, the quartz-felspar mass is preponderant, the hornblende occurring only in isolated plates or strings, but generally hornblende forms most of the rock. The brownish-green patches are due to the presence of some flakes of brown-red chloritic biotite. A slight tendency to parallel arrangement is noticeable in many of the hornblende plates. Accessories are few, and the structure is platy granular.

[1/1165.] The rock is very similar in external appearance to [1/1164]. Sections of it also resemble those of [1/1164], but the hornblende is in fibrous stringy plates, with the strings forming an indistinct foliation. The mineral composition is the same as in [1/1164] but quartz is less common. Slight chloritisation is noticeable in the hornblende. The rock is essentially the same as [1/1164], but with a tendency to schistosity.

An analysis of the rock [G.S.L. 9726D] in the Survey Laboratory gave these results:—

SiO_2	52·20
Al_2O_3	14·22
Fe_2O_3	·87
FeO	7·75
MnO	·31
MgO	8·71
CaO	12·85
Na_2O	·56
K_2O	·14
H_2O hyg.	·07
H_2O comb.	1·72
TiO_2	·69
CO_2	·29
P_2O_5	·09
FeS_2	·24
Cr_2O_3	...
V_2O_3	...
Total	100·71

Analyst—H. Bowley.

* Plate XI.

[1/1173] is a somewhat sheared, fine-grained, faintly banded dark-brown and green rock, very similar to the brownish portions of [1/1164]. In section it consists of a very fine-grained ground made up of numerous small plates and strings of a yellow-brown pleochroic biotitic chlorite, with here and there areas in which ragged prisms of greenish hornblende appear, sometimes chloritised. All through the brownish scales are very small grains of felspar. Rarely small green chlorite scales occur mixed with the brown, and a little calcite appears in places. Quartz was not definitely recognised, though a little may be present. Accessories are few. There is little doubt that the brown flakes have been derived from the green, and that the rock is a facies or variation of [1/1164] and [1/1165] more affected by dynamic stresses.

[1/1166] and [1/1167]. These are both fine schistose dark-grayish green chloritic rocks with faint sheen. On the cross fracture they appear darker green and granular. Sections consist of stringy patches and imperfect bands of green fibrous chlorite, in places charged with black grains of iron ore, with the patches and bands separated by a mosaic of quartz plates of various sizes from small grains to large plates. These quartz areas often also contain chlorite scales. Small fibrous nests of colourless hornblende needles appear occasionally in the chlorite patches.

The rocks are both chlorite-quartz schists. They have undoubtedly the structure of many schistose epidiorites, but differ from these in having chlorite instead of hornblende, and quartz instead of felspar. They are exactly what would result from the alteration of the hornblende of the epidiorites to chlorite, and the granular felspar mass to quartz.

An analysis of the rock [G.S.L. 9725D] in the Survey Laboratory resulted as follows:—

SiO_2	... ...	48·35
Al_2O_3	... ...	13·11
Fe_2O_3	... ...	2·77
FeO	... ...	15·02
MnO	... ...	·07
MgO	... ...	11·86
CaO	... ...	·28
Na_2O	... ...	·30
K_2O	... ...	·04
H_2O	hyg.	·04
H_2O	Comb.	7·30
TiO_2	... ...	1·20
CO_2	... .	·15
P_2O_5	... ...	·11
FeS_2	... ...	·09
Cr_2O_3	... ...	...
V^2O_3	... ...	...
	Total	100·69

Analyst—H. Bowley.

The analysis confirms the microscopic determination of the rock as a hydrous alumina-magnesia-iron silicate with quartz.

[1/1169], [1/1170, 1/1171]. All these rocks are very dark-grey, soft, talcose rocks with veinlets of pure greenish-white talc. They are all more or less sheared.

In section they consist almost entirely of a dense mass of pearly talc scales in which are irregular grains, granular aggregates, and patches of a carbonate, and in some cases, patches of pale greenish, nearly isotropic chlorite. In the talc areas are grains of black iron ore and a little pyrites.

The rocks are sheared, dark-grey, *talc-carbonate rocks,* probably derived by chemical and dynamical alteration from amphibolites.

$[\bar{1}1\frac{1}{7}\bar{2}]$ A much weathered, soft, greenish-yellow highly schistose rock. Sections consist of numerous fine strings and aggregates of strings forming bands, of yellowish-green chloritic scales, with occasional small lenticular patches and strings of colourless iridescent scales that are either talc or sericite, probably the former. In the green chloritic strings are a few small grains of a colourless mineral that is either quartz or felspar.

The rock is a weathered finely foliated *chloritic schist.*

$[\bar{1}1\frac{1}{6}\bar{7}]$ A very fine-grained, finely, though indistinctly foliated, brownish-black or grey rock with a faint sheen and with a suggestion of corrugation on the surfaces. The rock has almost a flinty appearance.

In section, the rock is composed of an extremely fine-grained mass of rounded and polygonal felspar plates and small patches of slightly coarser texture, in which are streaks of greenish chloritic scales, and strings and scaly patches of small flakes of colourless mica. The chloritic streaks are not infrequent, and in places appear almost as thin bands, while the coarser felspar plates, most of which are slightly kaolinised, occur largely in association with these bands. Rutile needles are observable in the chlorite scales. A noteworthy feature of the rock is the occurrence in association with the chloritic streaks of minute highly pleochroic greenish needles. These have marked jointing, apparently straight extinction, and strong absorption in a direction at right angles to that in biotite—in other words, they have characters agreeing with those of tourmaline. In some cases, however, a faint cleavage is noticeable, and, so far as could be made out, the mineral is biaxial. The green tones of the mineral, moreover, are rather those of actinolite than tourmaline. The needles, therefore, are with doubt referred to actinolite.

There is a marked parallelism in the alignment of the chloritic streaks, the green needles and the mica scales and needles. The structure of the rock is very fine granular, and appears to be due to the granulation of a highly felspathic facies, probably originally with hornblende. of the slide is that observab e in the more felspathic portions $[\bar{1}1\frac{1}{6}\bar{4}]$,

The origin of the rock is not clear. To some extent, the appearance and in default of clearer evidence the rock is put down as a very fine-grained foliated highly felspathic facies of a greenstone that has been completely granulated.

The interpretation of the section, owing to the very small amount of evidence procurable, is very difficult. $[\bar{1}1\frac{1}{6}\bar{6}]$ and $[\bar{1}1\frac{1}{6}\bar{7}]$, as has been shown are chloritic-quartz schists which, in structure at any rate, strongly suggest that they have been derived from a foliated or schistose epidiorite. They are devoid of lime. $[\bar{1}1\frac{1}{6}\bar{9}]$, $[\bar{1}1\frac{1}{7}0]$, and $[\bar{1}1\frac{1}{7}\bar{1}]$, again, are chloritic talc-carbonate rocks, sheared and with a fairly large development of carbonates. It would seem, therefore, that these three were amphibolites which occurred in a zone of intense shearing and chemical action that resulted in

the alteration of the amphibolite to talc, chlorite, and a carbonate. [$\frac{1}{1\,1\,6\,6}$] and [$\frac{1}{1\,1\,6\,7}$], on the margin of this zone, were not altered to the same extent, but through chemical action their lime content was removed, and it may have contributed to the carbonate development in [$\frac{1}{1\,1\,6\,9}$], [$\frac{1}{1\,1\,7\,0}$], and [$\frac{1}{1\,1\,7\,1}$]. It is possible, of course, that [$\frac{1}{1\,1\,6\,6}$] and [$\frac{1}{1\,1\,6\,7}$] may have been hornblende schists from which felspar has always been absent, but this is less likely than the former explanation.

The occurrence of [$\frac{1}{1\,1\,6\,4}$] and [$\frac{1}{1\,1\,6\,5}$], both fine-grained fresh epidiorites, with, on the one side, the talc-carbonate rocks [$\frac{1}{1\,1\,6\,9}$] [$\frac{1}{1\,1\,7\,0}$], and [$\frac{1}{1\,1\,7\,1}$], and on the other, a band or lode of dolomites, is difficult to account for. The most feasible explanations seem to be that either [$\frac{1}{1\,1\,6\,4}$] and [$\frac{1}{1\,1\,6\,5}$] represent a later epidiorite intrusion into the altered rocks, or they are massive portions of the rock that have escaped the shearing and chemical alteration that have affected the surrounding country.

D.—THE GREENSTONES FROM GOLDEN VALLEY.

Typical specimens of these are:—

[$\frac{1}{7\,5\,0}$] from G.M.L. 1899.
[$\frac{1}{7\,5\,1}$] from Mount Colreavy.
[$\frac{1}{7\,5\,2}$] from G.M.L. 1263.
[$\frac{1}{7\,4\,9}$] from G.M.L. 1263.

The chief characters of the rocks are as follows:—

[$\frac{1}{7\,5\,0}$] G.M.L. 1899:

This is a very coarse-grained platy, dark grey-green hornblende rock resembling in appearance the lustre-mottled amphibolites. In section, it consists wholly of large ragged plates of an intensely and finely fibrous uralitic hornblende, with here and there in the plates a remnant of less fibrous hornblende, to which the former acts as a fringe. A little reddish-brown biotitic chlorite is present. No felspar was observed. There are a few grains of iron ore.

The rock is a very coarse *uralitic hornblendite,* probably originally derived from a pyroxenite.

[$\frac{1}{7\,5\,1}$] Mount Colreavy:

A fine-grained somewhat sheared dark grey-green rock with chloritic sheen on the surface. It consists of numerous feathery, sheafy, and divergent acicular groups of a pale green very fibrous hornblende, with the interspaces occupied by a minute felspathic mosaic due to the breaking down of felspar plates. (Fig. 75.)

The rock is a fine-grained *fibrous epidorite* similar to those described from Bullfinch, *e.g.* [**11523**].

[$\frac{1}{7\,5\,2}$] G.M.L. 1263:

A fine-grained dark-green hornblendic rock. It is a felted fibrous and platy hornblendite composed of a dense confused mass or felt of small ragged fibrous plates, needles, prisms, and rods of a pale green hornblende, with numerous small aggregates of grains of iron ore, and occasional small grains of clear colourless felspar. A little kaolinised felspar also appears in places.

[$\frac{1}{7}\frac{1}{4}\frac{1}{9}$.] Very similar in hand specimens to [$\frac{1}{7}\frac{1}{5}\frac{1}{2}$], and almost identical with it in section, though a little finer in grain and with a denser felt.

The rocks, therefore, from this locality are either hornblendites of coarse grain or fibrous epidiorites of finer grain.

Fig. 75.

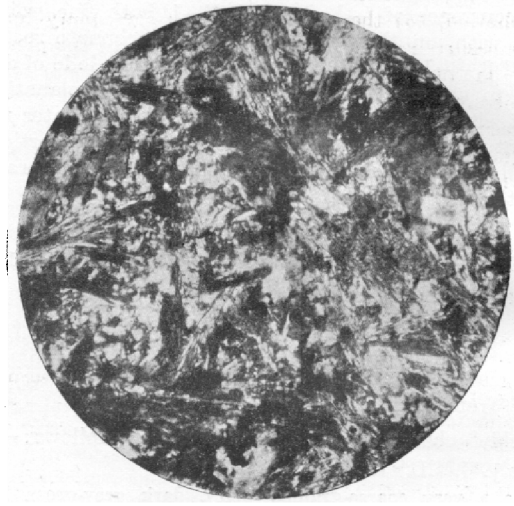

Photo: R. A. Farquharson. Neg. 1619.

[$\frac{1}{7}\frac{1}{5}\frac{1}{1}$] **The fine-grained fibrous epidiorite, similar to the epidiorites described from Bullfinch.**

E.—THE GREENSTONES OF HATTER'S HILL.

These are represented by the four rocks [$\frac{1}{7}\frac{1}{5}\frac{1}{5}$], [$\frac{1}{7}\frac{1}{4}\frac{1}{3}$], [$\frac{1}{7}\frac{1}{3}\frac{1}{9}$], and [$\frac{1}{7}\frac{1}{4}\frac{1}{0}$].

[$\frac{1}{7}\frac{1}{5}\frac{1}{5}$] is a fine-grained dark grey-green finely foliated hornblendic rock, consisting of numerous rods of green hornblende arranged parallel and separated by small clear grains of felspar. Some apatite and doubtful zoisite are observable.

The rock is a fine-grained acicular *hornblende schist.*

[$\frac{1}{7}\frac{1}{4}\frac{1}{3}$] is a coarse-grained massive dark-green platy hornblende rock. In section it is composed of large ragged plates of green hornblende, more or less fibrous and contorted, and indistinct lamellated plates of a plagioclase obscured by needles and radiated tufts of hornblende and by an evident granulitisation. Many of the hornblende plates are partially mashed and are perforated by grains of the felspar.

The rock is a massive, very coarse-grained *crushed amphibolite* or *epidiorite,* derived originally from a gabbro with excess of pyroxene.

[$\frac{1}{7\,4\,9}$] is a medium-grained dark grey-green hornblendic rock without foliation, but with white granular felspar associated with the hornblende. In section, it proves to be a *crushed quartz-epidiorite,* doubtless a finer-grained facies of [$\frac{1}{7\,4\,3}$].

[$\frac{1}{7\,4\,6}$] is identical with [$\frac{1}{7\,4\,3}$].

There is no doubt that [$\frac{1}{7\,3\,9}$], [$\frac{1}{7\,4\,0}$], and [$\frac{1}{7\,4\,3}$] are all varieties of the same rock mass.

As for [$\frac{1}{7\,5\,5}$] it differs from these in (a) the presence in it of a marked foliation, (b) the absence of the ragged platy forms, and the exclusive occurrence in it of prismatic rods, (c) complete granulitisation of its colourless constituents. Since, however, variations from amphibolite and epidiorite to hornblende schist are well-known in greenstone areas of this nature, it is probable that [$\frac{1}{7\,5\,5}$] is merely a more intensely metamorphosed variety of the rock mass represented by the other three specimens.

F.—SOME GRAPHITISED ROCKS OF DOUBTFUL ORIGIN.

[$\frac{1}{6}$]: From Comstock Lease No. 2111, Boodalin:

This is a very fine-grained, dirty greyish-black, somewhat porous, graphitic rock with numerous minute white scales or rods all arranged with the long axes parallel. There is a suggestion of shearing in the specimen, and the specific gravity is light. Owing to the denseness of grain, the rather soft nature of the specimen and the graphitic content, it is very difficult to obtain a section of the rock of any value. It is possible, however, to make out that the body of the rock is composed of small quartz grains heavily charged with a black dust, of which some particles have the appearance in reflected light of graphite scales. Doubtless there is a considerable amount of amorphous graphite as well. In addition to these constituents, there are occasional pale yellow fibrous flakes resembling decomposed mica, and, rarely, rather large areas of minute scales of mica heavily charged with the black dust. These large micaceous aggregates are of obscure origin, but are consistent with a derivation from original chiastolite.

From the character of the rock and from comparison with undoubted chiastolite shales from the same field, it is probably a sheared, much altered, *graphitic shale of the chiastolite-shale series.*

[$\frac{1}{4}$]: From Comstock Lease No. 2111, Boodalin:

An extremely decomposed rock, apparently sheared or indistinctly laminated, somewhat porous, extremely ferruginous, and of a brick-red colour, with numerous pale slate-blue rounded forms that are soft and granular and in places blackish. The rock is too much altered for sectioning, but appears to be slightly graphitic. The bluish forms were at first thought to be flinty, but their soft nature indicates that they are probably decomposition products. Tests, however, with the blow-pipe failed to reveal a thoroughly aluminous character, but this may have been due to the presence of iron or carbon, and it is probable that they are decomposition products of andalusite.

The rock is of doubtful origin, but is classed as a *weathered ferruginous clayey product of an andalusite shale.*

[$\frac{1}{8}\frac{1}{5}\frac{1}{2}$] East of G.M.L. 2249 and 2251, Golden Valley:

A finely sheared, almost schistose greyish-black graphitic quartz rock, with angular quartz forms on the shear surfaces.

Slides show the rock to consist almost entirely of ragged rounded and angular quartz plates surrounded by quartz mosaic of various degrees of fineness, with wavy strings, streaks and patches of black dust, apparently graphitic, scattered in general parallel alignment through the mosaic, probably along the shear planes. Many of the plates of quartz are partially granulated at the margins, and there is evidence that lenticular patches of mosaic represent disintegrated or broken down plates of quartz.

The rock is of indefinite structure but appears to be a highly sheared *graphitic quartz breccia,* possibly with some cement of secondary silica.

[$\frac{1}{8}\frac{1}{5}\frac{1}{3}$] G.M.L. 2239, Golden Valley:

A fine-grained, finely laminated, dark greyish-black, highly siliceous rock, in places with granular haematite on the surfaces of the laminae. A curving of the laminae, and in places a contortion, indicate pronounced shearing since formation.

The rock is of doubtful origin. Its laminated character suggests a finely *laminated shale* that has been completely silicified.

[$\frac{1}{8}\frac{1}{5}\frac{1}{4}$] G.M.L. 2239, Golden Valley:

(2.) A coarse-grained greyish-white siliceous rock with a pinkish tinge, apparently composed of angular and more or less rounded fragments of quartz, cemented by quartz, and with a sheared structure visible on one fracture surface.

The rock is again of doubtful origin, but appears to be a *quartz breccia,* with quartz fragments cemented by silica. Some rounded quartz forms have a conglomeratic appearance.

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Quartz
Quartz breccia
Quartz diorite
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Quartz felspar gneiss
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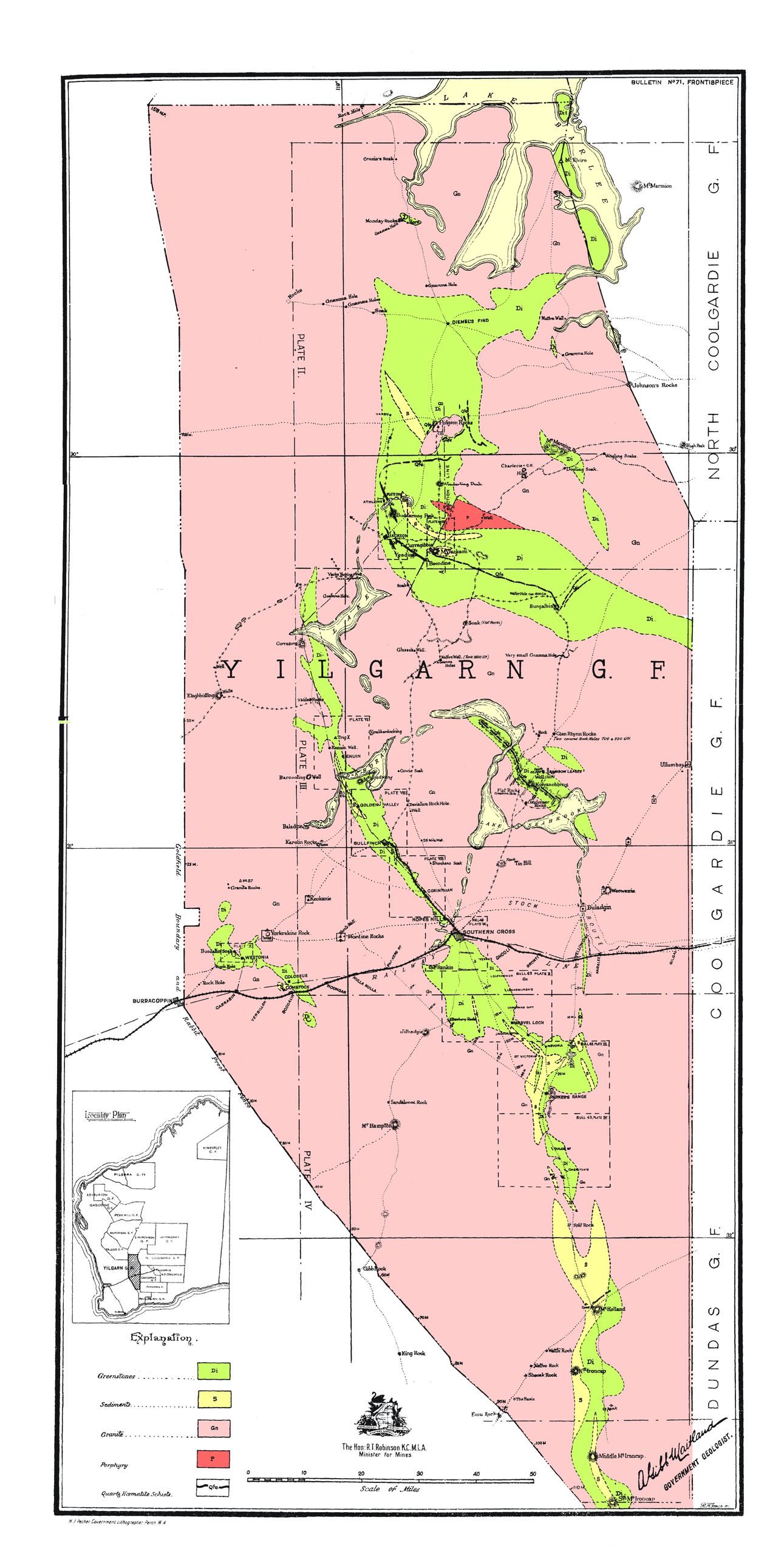

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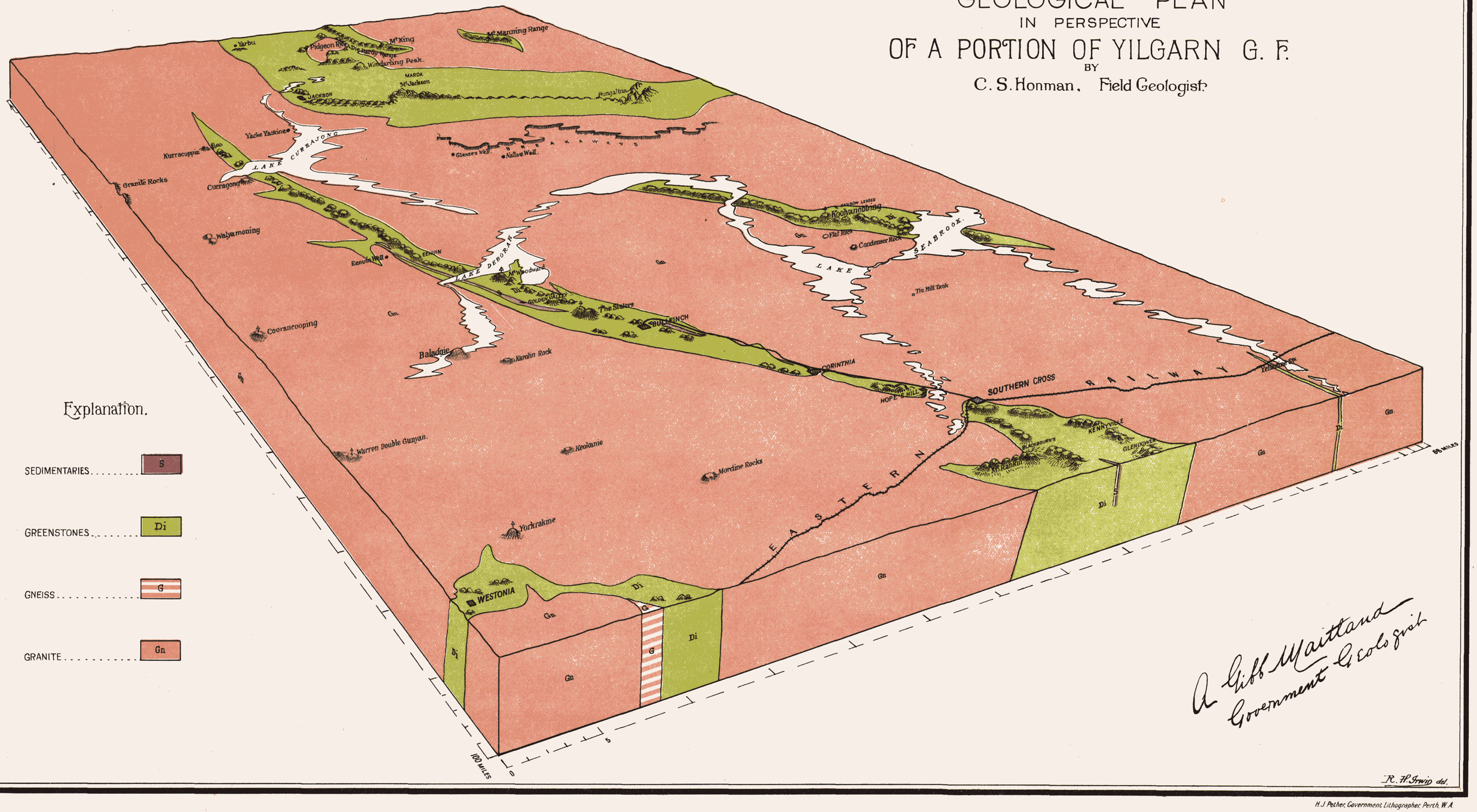
GEOLOGICAL PLAN
IN PERSPECTIVE
OF A PORTION OF YILGARN G. F.

BY
C. S. Honman, Field Geologist



Explanation.

SEDIMENTARIES	S
GREENSTONES	Di
GNEISS	G
GRANITE	Gn

A. Gibb Maitland
Government Geologist

R. H. Irwin del.

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

GEOLOGICAL MAP OF THE COUNTRY BETWEEN LAKE BARLEE AND JACKSON

YILGARN G. F.

BY

C. G. Gibson, H. W. B. Talbot, F. R. Feldtmann & C. S. Honman.

The Hon. R. T. Robinson K.C.M.L.A. Minister for Mines.

B. H. Irwin, Govt.

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NORTH COOLGARDIE G. F.

NOTE.—THE AREAS EMBRACED BY THE 4-MILE SERIES OF GEOLOGICAL MAPS ARE IDENTICAL WITH THOSE OF THE CORRESPONDING NUMBERS OF THE 500-CHAIN SERIES OF THE DEPARTMENT OF LANDS AND SURVEYS.

35

Gn GRANITE

Di FINE GRAINED GREENSTONES

P RHYOLITIC PORPHYRY

S SEDIMENTS

Qfe QUARTZ HAEMATITE SCHIST

QUARTZ REEFS

A. Gibb Maitland
Government Geologist.

The Hon. R.T. Robinson K.C.M.L.A.
Minister for Mines.

GEOLOGICAL MAP OF THE COUNTRY BETWEEN LAKE CURRAJONG AND SOUTHERN CROSS

YILGARN G. F.

BY
H. P. Woodward, T. Blatchford E. C. Saint-Smith and C. S. Honman.

YILGARN G. F.

COOLGARDIE G. F.

JOINS PLATE II.

JOINS PLATE IV

119° 119°30' 120° 120°30'

30°30' 31°

Gn — GRANITE

Di — FINE GRAINED GREENSTONES

S — SEDIMENTS

Qfe — QUARTZ HÆMATITE SCHIST

QUARTZ REEFS

0 4 8 12 16 MILES.

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R.H. Grimdd.

A. Gibb Maitland
Government Geologist

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GEOLOGICAL MAP OF THE COUNTRY BETWEEN MARVEL LOCH AND NORTH MtIRONCAP

YILGARN AND DUNDAS G. Fs

BY

T. Blatchford and C.S. Honman.

JOINS PLATE III.

BULL. 63, PLATE II.

BULL. 63, PLATE III.

BULL. 63, PLATE IV.

COOLGARDIE G. F.

YILGARN G. F.

DUNDAS G. F.

119°

119°30'

120°

120°30'

31°30'

32°

LEONEBURG

CHRISTMAS GIFT

Strawberry Rocks

MARVEL LOCH

JACCOMETTIS

JILBADGIE

L53S

NEVORIA

Golden Cable Hill

GREAT VICTORIA

TAMARIN

PARKER'S RANGE

L55A

OLGA Cr

Olga Rocks

DULCIE Cr

CHERITON'S

L53A

HANNS TRACK 1901

Sandalwood Rock

MtHAMPTON

Large Rock

WELCOME HILL

Gibb Rock

Rabbit Proof Boundary Fence

Rocks

Gnammma Hole

Murray Rock

Wheeler Rock

Bald Rock

Rocks

Emu Rock

The Basin

Spilt Rocks

Native Rock

Sheoak Rock

Waddle Rock

Gnamma Hole

MtHOLLAND

Mt Ironcap

Cut Track

Sand Plain.

Spinifex and sand ridges.

Southern hills of sedimentary series

The Hon. R.T. Robinson K.C.M.L.A.
Minister for Mines.

Thursday Rock

Diamond Rock

Small Flat rock.

Granite hill

Extensive flat rocks

Quartz outcrop

Low rocky spur running

Spear Rock

Spinifex Rock

Flat rock

Bare granite

Knapp Rock

Mt DAY

Plover Rock

Mt ROUND TOP

Wils Rock

MAGGIE HAY HILL

LAKE JOHNSON

Rocks

Alex. H. Wallace
GOVERNMENT GEOLOGIST.

TOPOGRAPHY COMPILED FROM DATA SUPPLIED BY THE SURVEYOR GENERAL
WITH ADDITIONS BY T. Blatchford & C.S. Honman.

0 4 8 12 16 MILES

JOINS PLATE V

(19)

NOTE.—THE AREAS EMBRACED BY THE 4-MILE SERIES OF GEOLOGICAL MAPS ARE IDENTICAL WITH THOSE OF THE CORRESPONDING NUMBERS OF THE 300-CHAIN SERIES OF THE DEPARTMENT OF LANDS AND SURVEY.

Gn GRANITE

Di FINE GRAINED GREENSTONES

S SEDIMENTS

Qfe QUARTZ HÆMATITE SCHIST

QUARTZ REEFS.....R

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

JOINS PLATE IV.

YILGARN G. F.

DUNDAS G F

PHILLIPS RIVER G. F.

LAKE CARMODY
LAKE HURLSTONE
LAKE YARLEY
FLOWER HILL
LUCY HILL
Mt STEWART
Mt IRONCAP
Sth IRONCAP
FORRESTANIA
HATTER HILL
Mt GIBBS
Mt GORDON
Mt GLASSE
LAKE HOPE
Lake Country
Salt Soak (Stock water)
Mt Intyre's Soak (good)
Allens Soak (permanent)
Digger Rocks Rock Holes 4000 Gls
Tank & Gnamma Hole
Gnamma Hole 250 Gls
Tank 7000 Gls
Tank ground water
Lilian Stoke Rock Good water
Splendid camp for Stock.
Swallow Rock Cisterns
COWCUP HILL
CARLINGUP
RAVENSTHORPE RA.
RAVENSTHORPE
WOODNOT CK.
F. H. Hann's Track 1901
Central Track
Terrick Road
DAY LAKE
LAKE
Qfe
Di
Gn
S

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Minister for Mines.

GEOLOGICAL MAP OF THE COUNTRY BETWEEN
MIDDLE Mt IRONCAP AND RAVENSTHORPE RANGE
YILGARN DUNDAS AND PHILLIPS RIVER G. Fs

BY.

T. Blatchford and C. S. Honman.

A Gibb Maitland
Government Geologist

F. H. Irwin del.

NOTE.—THE AREAS EMBRACED BY THE 4-MILE SERIES OF GEOLOGICAL MAPS ARE IDENTICAL WITH THOSE OF THE CORRESPONDING NUMBERS OF THE 500-CHAIN SERIES OF THE DEPARTMENT OF LANDS AND SURVEYS.

0 4 8 12 16 MILES.

TOPOGRAPHY COMPILED FROM DATA SUPPLIED BY THE SURVEYOR GENERAL WITH ADDITIONS BY T. Blatchford & C.S. Honman.

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

Gn GRANITE

Di FINE GRAINED GREENSTONES

S SEDIMENTS

Qfe QUARTZ HÆMATITE SCHIST

QUARTZ REEFS

10

GEOLOGICAL MAP & SECTIONS of EENUIN CENTRE YILGARN G. F.

BY

T. BLATCHFORD ASSISTANT GEOLOGIST.

0 40 80

Scale of Chains.

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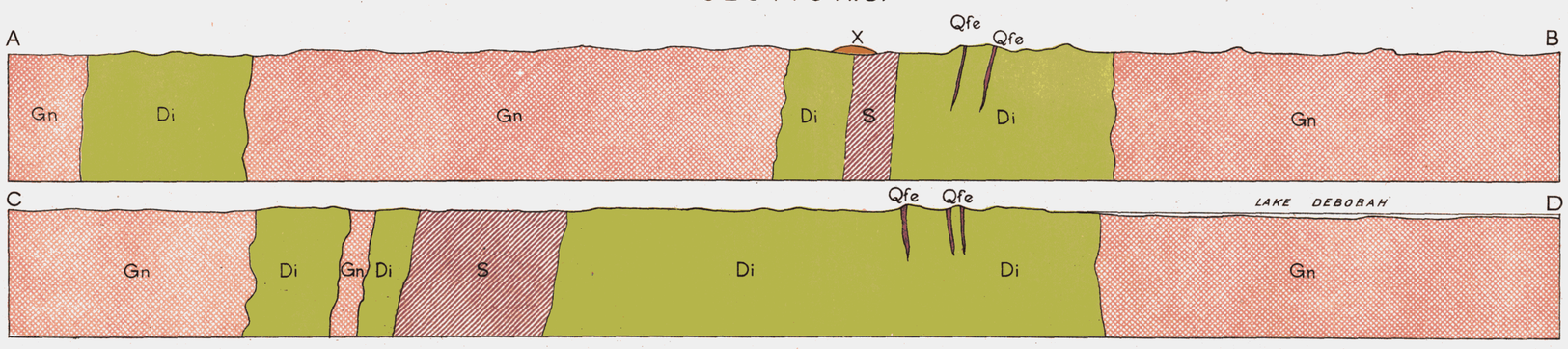
Minister for Mines.

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

SECTIONS.



EXPLANATION.

FERRUGINOUS LATERITE ... X SEDIMENTARIES ... S GREENSTONES ... Di GRANITE ... Gn QUARTZ HÆMATITE SCHIST ... Qfe QUARTZ REEFS ... Q IRONSTONE LODES ... Fe

GEOLOGICAL BOUNDARIES ..... EXISTING LEASES ... 2389 FORFEITED LEASES ... 2357 SHAFTS ...

C. B. Kirkness, del.

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Minister for Mines.

GEOLOGICAL MAP & SECTIONS OF BULLFINCH CENTRE

YILGARN G.F.

BY

T. BLATCHFORD ASSISTANT GEOLOGIST.

0 40 80
Scale of Chains.

E — LINE OF SECTION — F

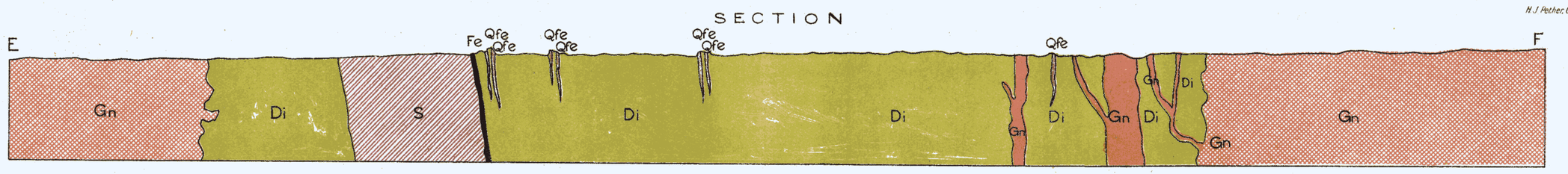
Gn Di S Qfe Fe Q

Cemetery
MWS Tank
Windmill Well
Bore
Water Course
Corrugated Iron Fences
Farrens Rock Hole
Colreavy's Tank
MT HUGGINS
GOLDEN VALLEY
MT COLREAVY
TOWNSITE
THE SISTERS
BULLFINCH
BULLFINCH LEASES
DEEPS
BULL ANT
ROSALIE
MANXMAN CONSOLS
RADIO
GLIDE AWAY
NEW GREENHARD
Explosives Res.
Cemetery Res.
Sanitary Res.
RAILWAY
LINE

OHK40 OHK38 OHK31 OHK3 OHK10 OHK11 OHK7
32M 31M 30M 29M 28M 27M 26M 25M 24M 23M I.C. 22M 21M 20M 7M 6M 5M

Lat. 30° 57' 41"2
Long. 119° 4' 17"24

SECTION



EXPLANATION.

FERRUGINOUS LATERITE — X
SEDIMENTARIES — S
GREENSTONES — Di
MASSIVE GRANITE AND DYKES — Gn
QUARTZ HÆMATITE SCHIST — Qfe
QUARTZ REEFS — Q
IRONSTONE LODES — Fe
GEOLOGICAL BOUNDARIES
EXISTING LEASES 914
FORFEITED LEASES 962
SHAFTS

A. Gibb Maitland
Government Geologist

C.B. Rickson, del.

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

7/71 8 (Soare)

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Minister for Mines.

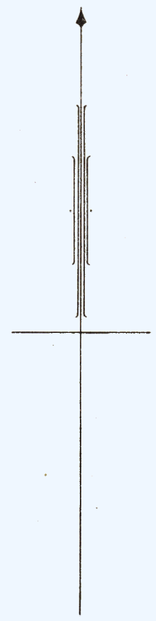
GEOLOGICAL MAP OF CORINTHIAN CENTRE

YILGARN G.F.

BY

T. BLATCHFORD ASSISTANT GEOLOGIST.

0 40 80
Scale of Chains.



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EXPLANATION.

FERRUGINOUS LATERITE X — SEDIMENTARIES S — GREENSTONES Di — GRANITE Gn — QUARTZ HÆMATITE SCHIST Qfe — QUARTZ REEFS Q — IRONSTONE LODES Fe

GEOLOGICAL BOUNDARIES ---------- EXISTING LEASES 2389 — FORFEITED LEASES 2357 — SHAFTS

Hon P. Collier M.L.A
MINISTER FOR MINES

GEOLOGICAL MAP OF WESTONIA

YILGARN G. F.

BY

T. Blatchford, Assistant Geologist.

0 40 80 120
Scale of Chains

EXPLANATION.

LATERITE	X	GREENSTONES	Di
GNEISSIC DIORITE	Di3	MASSIVE GRANITE	Gn
		GRANITE DYKES	Gn2
GNEISSIC GRANITE	Gn1		

Alf. H. Maitland
Government Geologist

WESTONIA TOWNSHIP

BODDALIN SOAK

HUNT'S SOAK

BUSINESS & RESIDENCE AREAS

ZONA MAY

P. A. 580

H.L. 56

HK146

HK150

Fence Rocks

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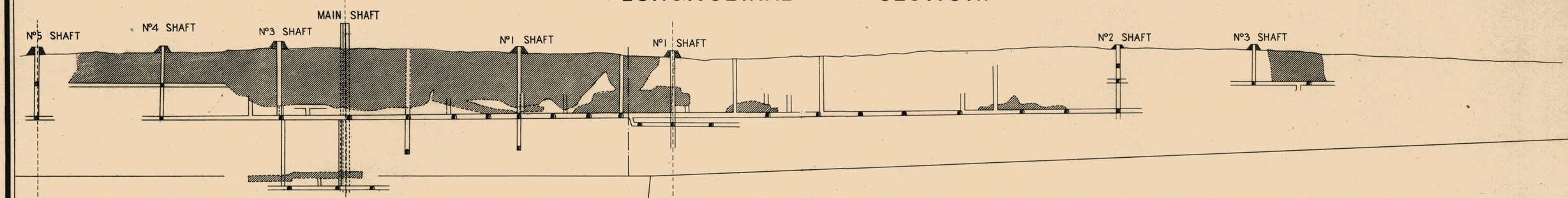
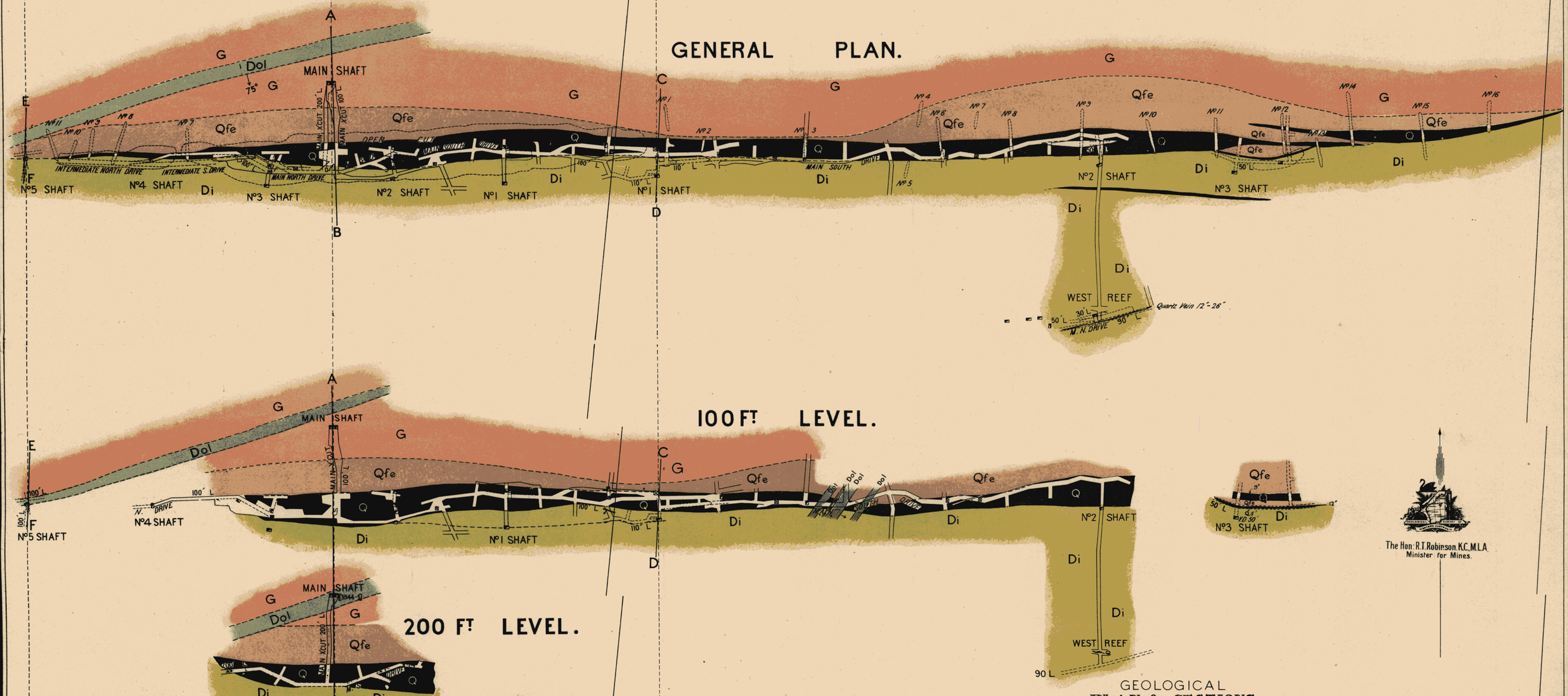
LONGITUDINAL SECTION.

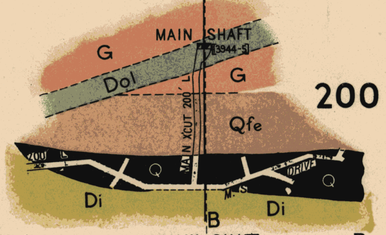


GENERAL PLAN.

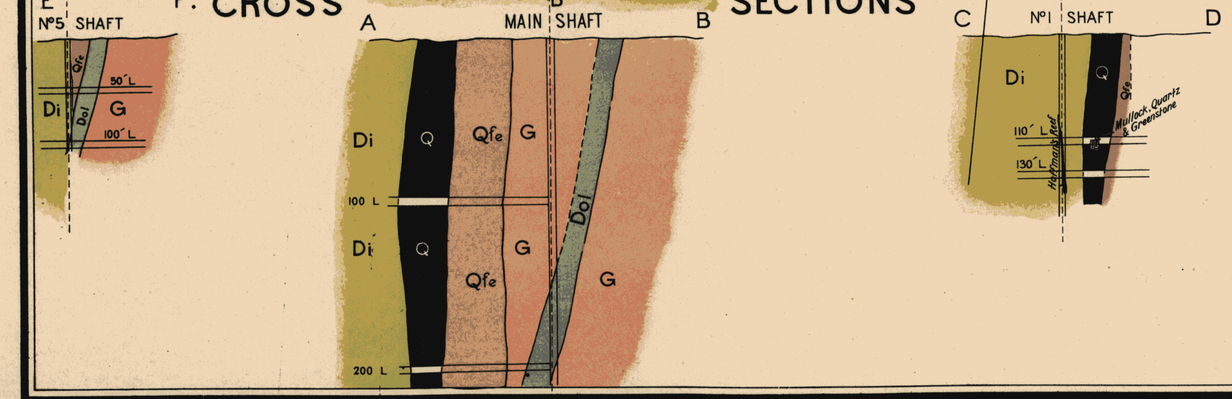


100 Ft LEVEL.

200 Ft LEVEL.



F. CROSS SECTIONS



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Minister for Mines.

GEOLOGICAL
PLAN & SECTIONS
OF

CORINTHIAN AND NORTH CORINTHIAN G.Ms.

CORINTHIA.
YILGARN G.F.

Scale of Feet. 0 100 200 300

EXPLANATION.

GRANITE (Gneissic)	G
GREENSTONE (Massive)	Di
QUARTZ HAEMATITE SCHISTS	Qfe
BASIC DYKES (Dolerites)	Dol
QUARTZ REEFS	Q
STOPED	

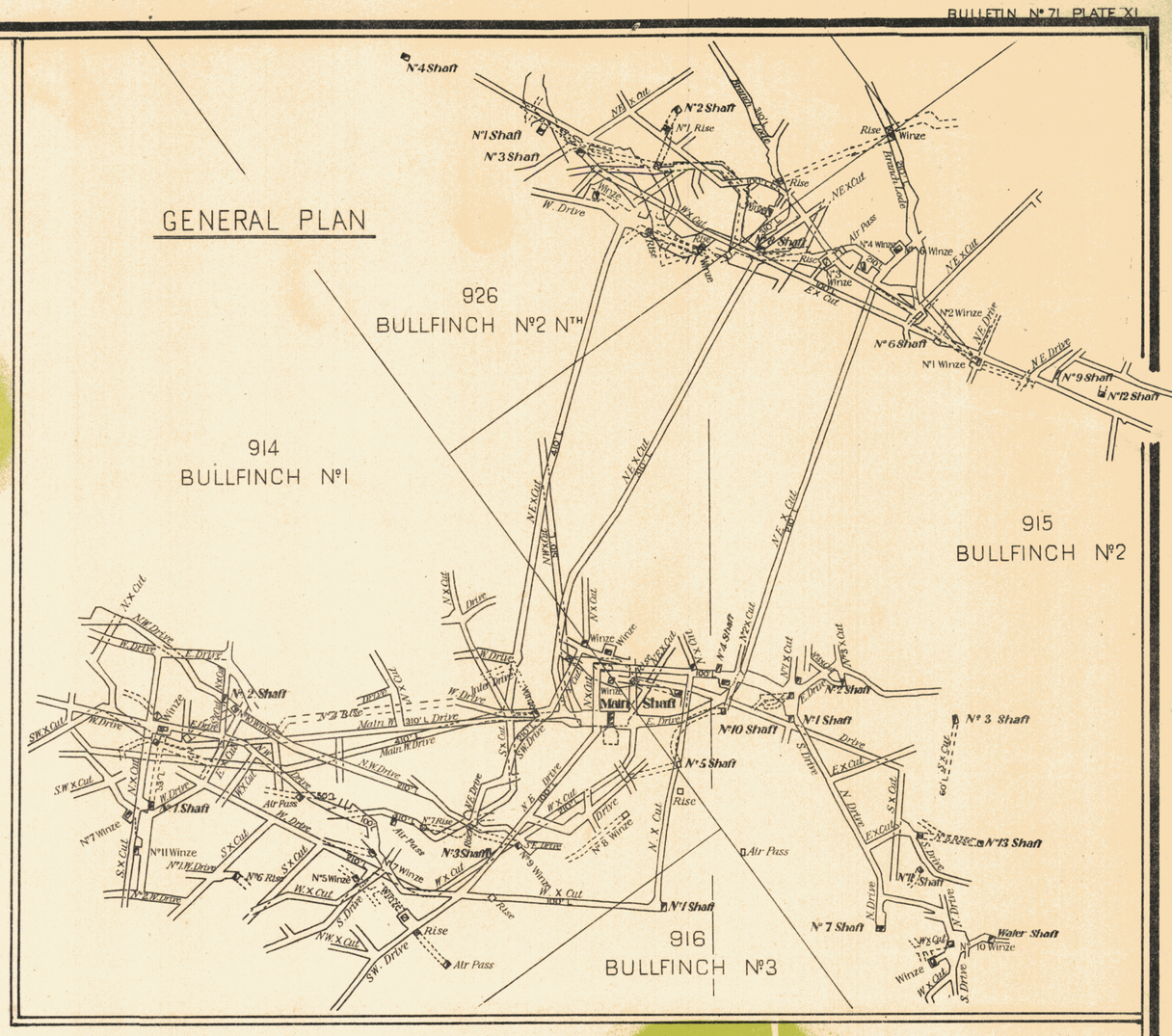
A. Gibb Maitland
Government Geologist.

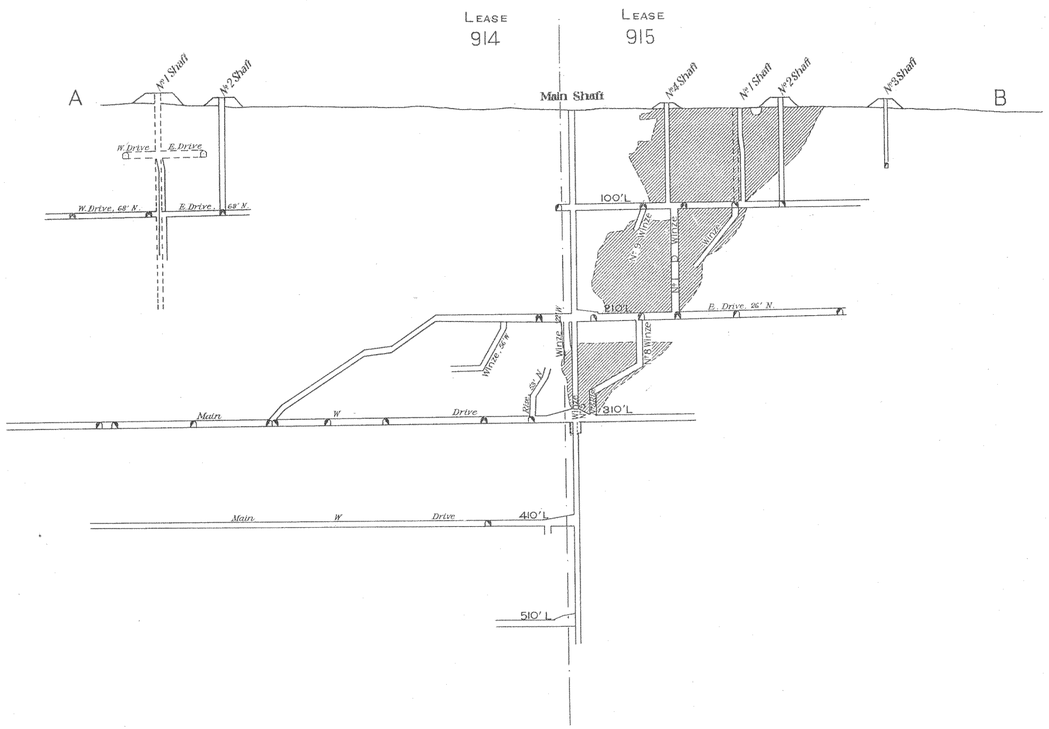
C.B. Kidson, del.

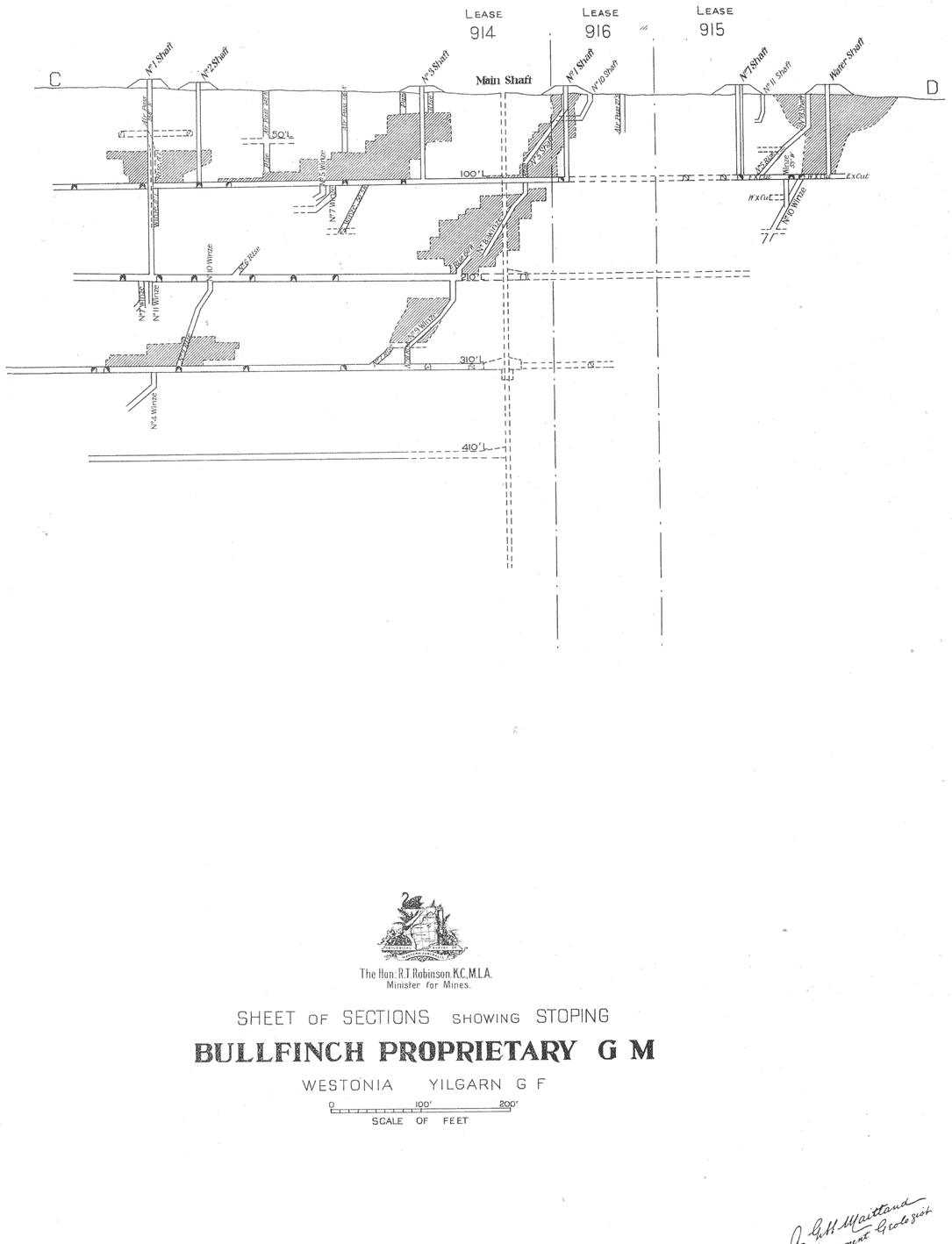
H.J. Pether, Government Lithographer, Perth, W.A.

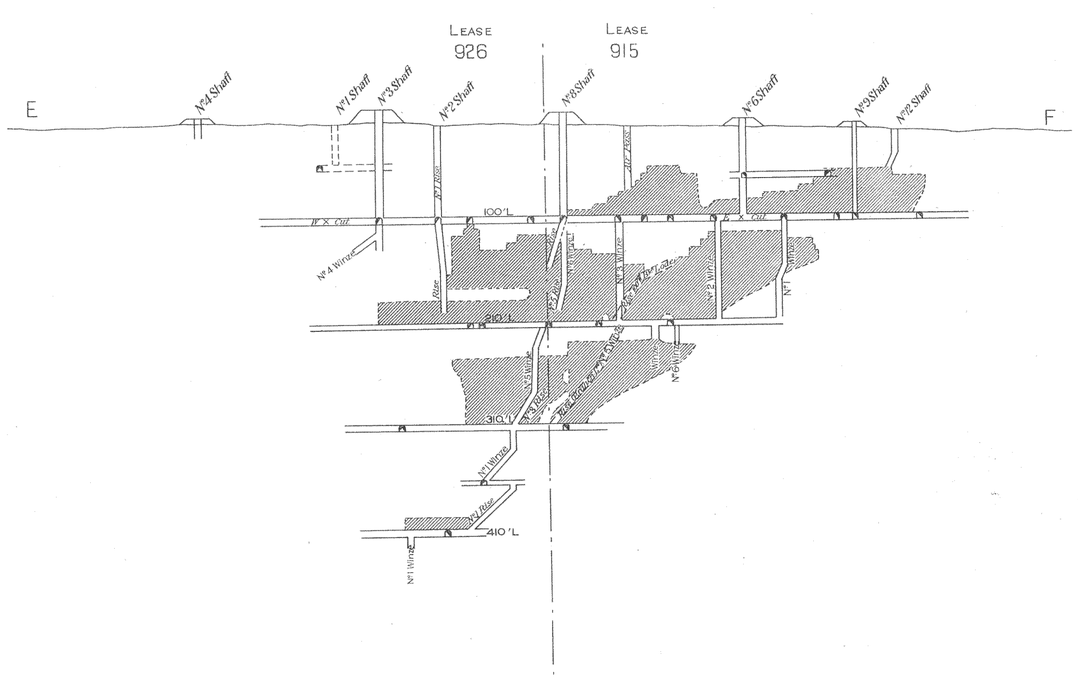
100 Ft LEVEL

GENERAL PLAN









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Minister for Mines.

SHEET OF SECTIONS SHOWING STOPING

BULLFINCH PROPRIETARY G M

WESTONIA YILGARN G F

0 100' 200'
SCALE OF FEET

A. Gibb Maitland
Government Geologist

TAKEN FROM MINE PLANS

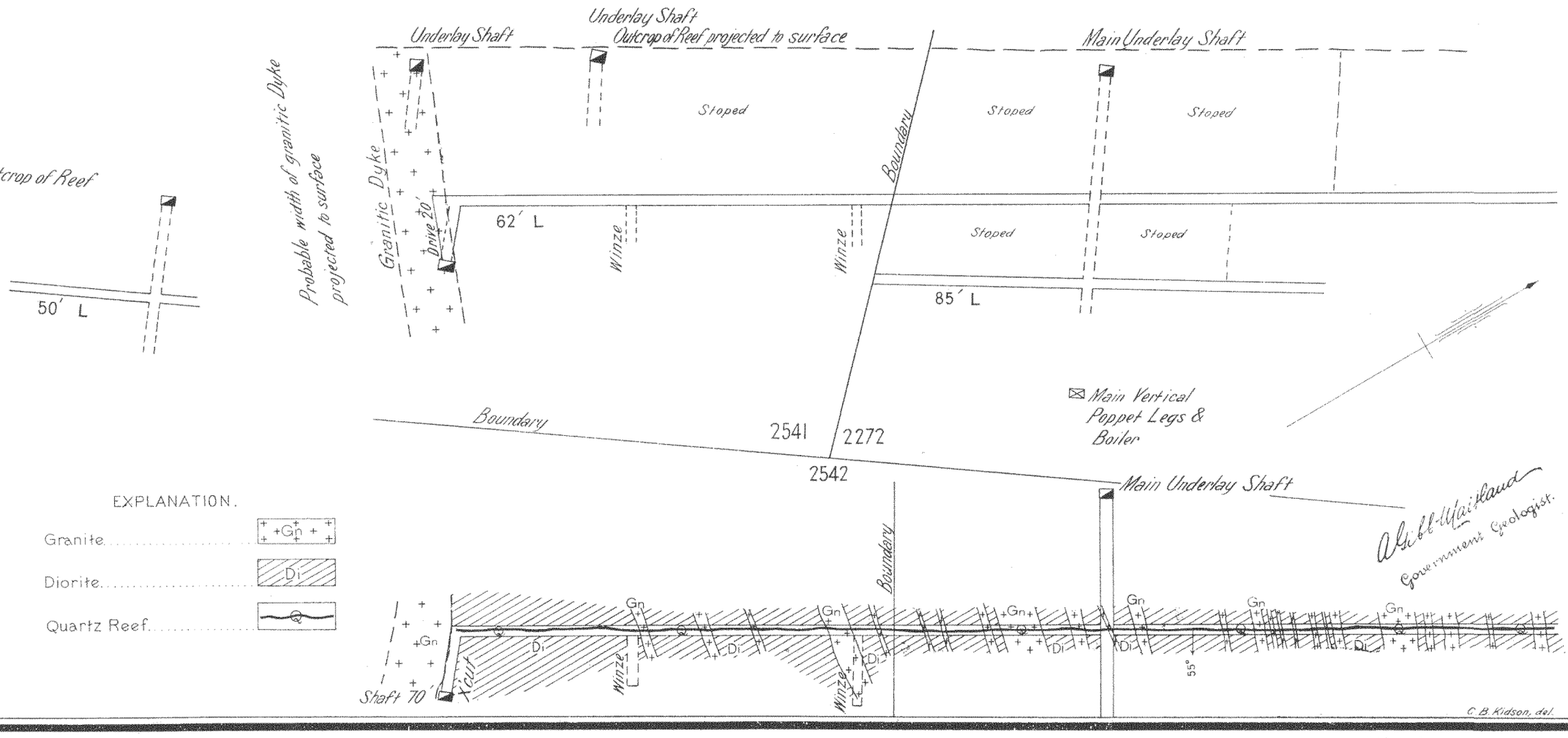
Stoped

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

The Hon: R.T. Robinson, K.C., M.L.A.
Minister for Mines.

PLAN AND GEOLOGICAL SECTION
OF
GREEN HARP & GLIDEAWAY G.Ms.
MANXMAN.
YILGARN G.F.
BY
T. BLATCHFORD, ASSISTANT GEOLOGIST.

Scale of Feet.
0' 20' 40' 60' 80'



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Minister for Mines.

GEOLOGICAL
PLAN OF
THE UNDERGROUND WORKINGS OF
THE EDNA MAY GROUP
WESTONIA. YILGARN G. F.

SCALE OF FEET

Note. *For Geology of Leases 2180 & 2291 see Plate XV.*

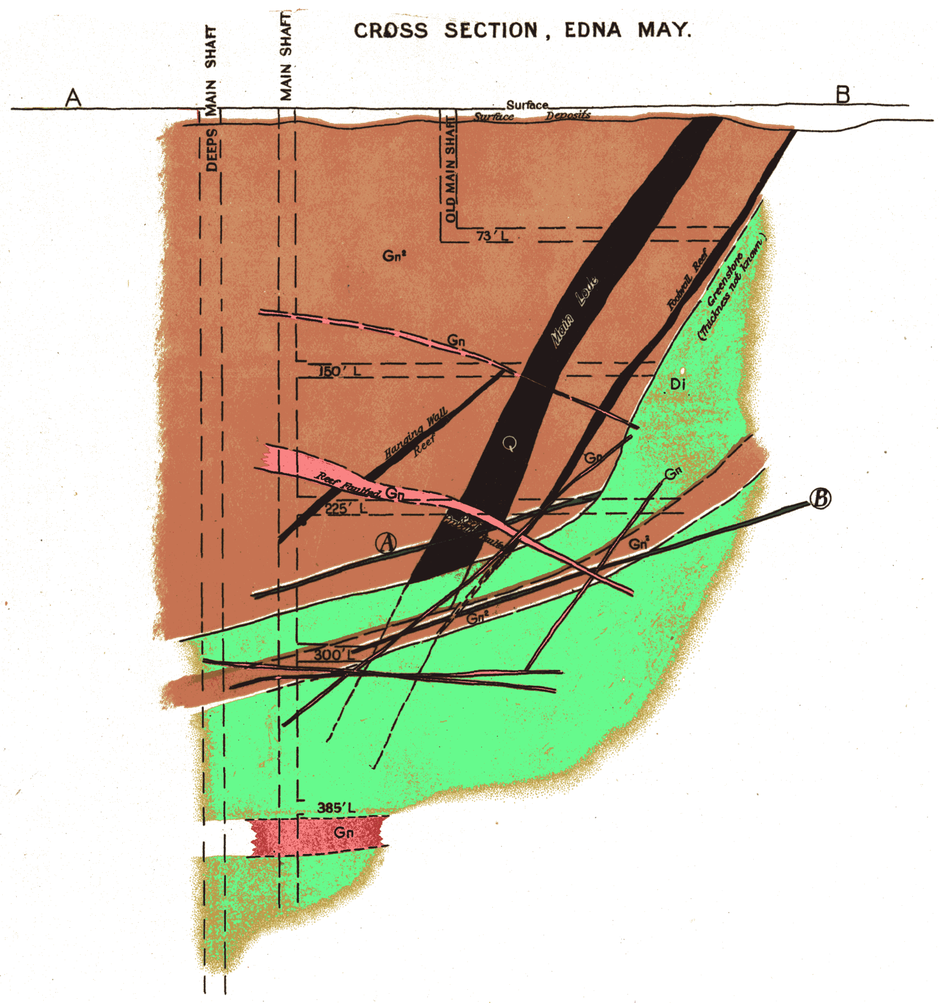
A. G. M. Maitland
Government Geologist

W. Northam, del.

N.J. Peiler, Government Lithographer, Perth, W.A.

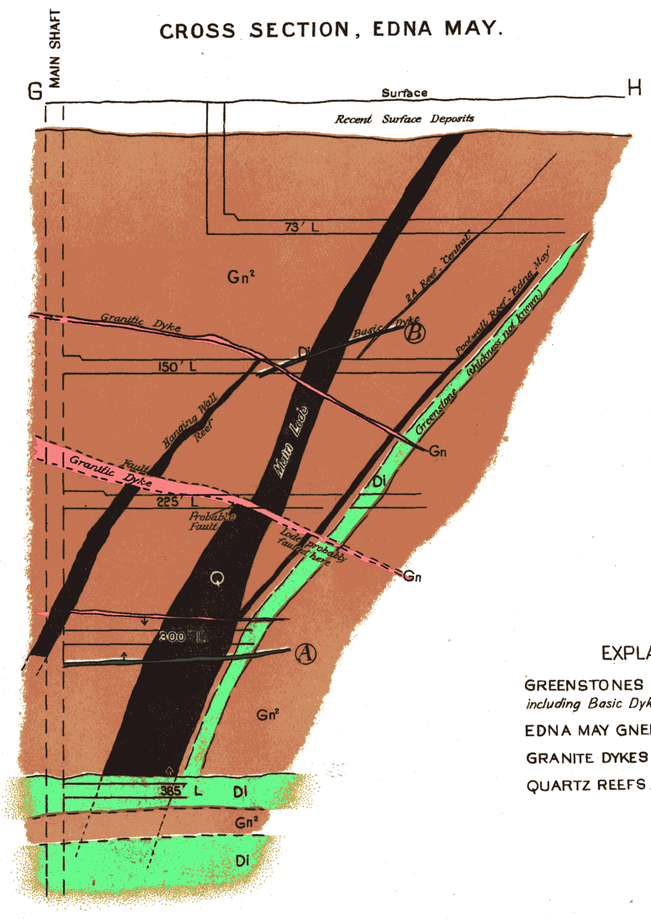
SECTIONS

CROSS SECTION, EDNA MAY.



LONGITUDINAL SECTION THROUGH MAIN REEF, EDNA MAY.

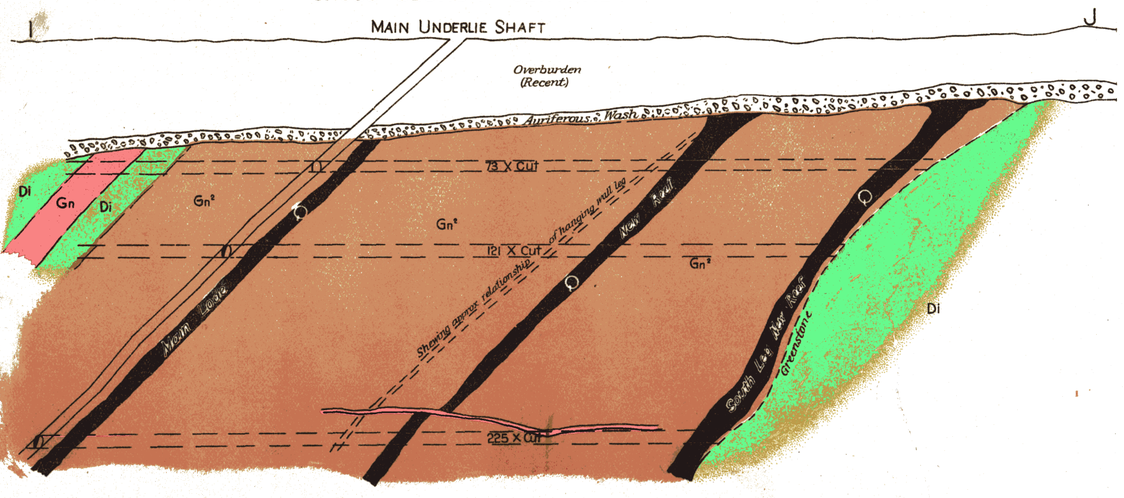
CROSS SECTION, EDNA MAY.



EXPLANATION

GREENSTONES (Hornblendite including Basic Dykes..... Ⓐ,	Di
EDNA MAY GNEISS	Gn²
GRANITE DYKES	Gn
QUARTZ REEFS	Q

CROSS SECTION "CENTRAL".



GEOLOGICAL PLANS & SECTIONS OF EDNA MAY, MYRTLE CENTRAL, & MYRTLE CONS^LS. ST^H G. M^S.

("CENTRAL") ("DEEPS")

WESTONIA.. YILGARN G.F.

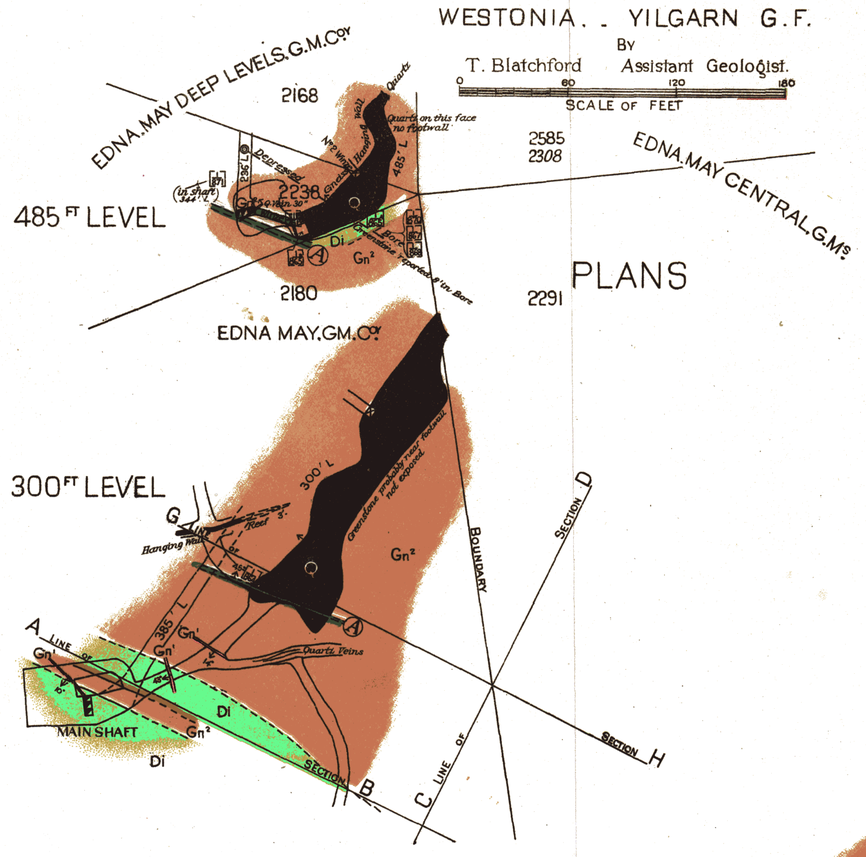
By T. Blatchford Assistant Geologist.

SCALE OF FEET 0 60 120 180

The Hon: R.T. Robinson, K.C., M.L.A. Minister for Mines.

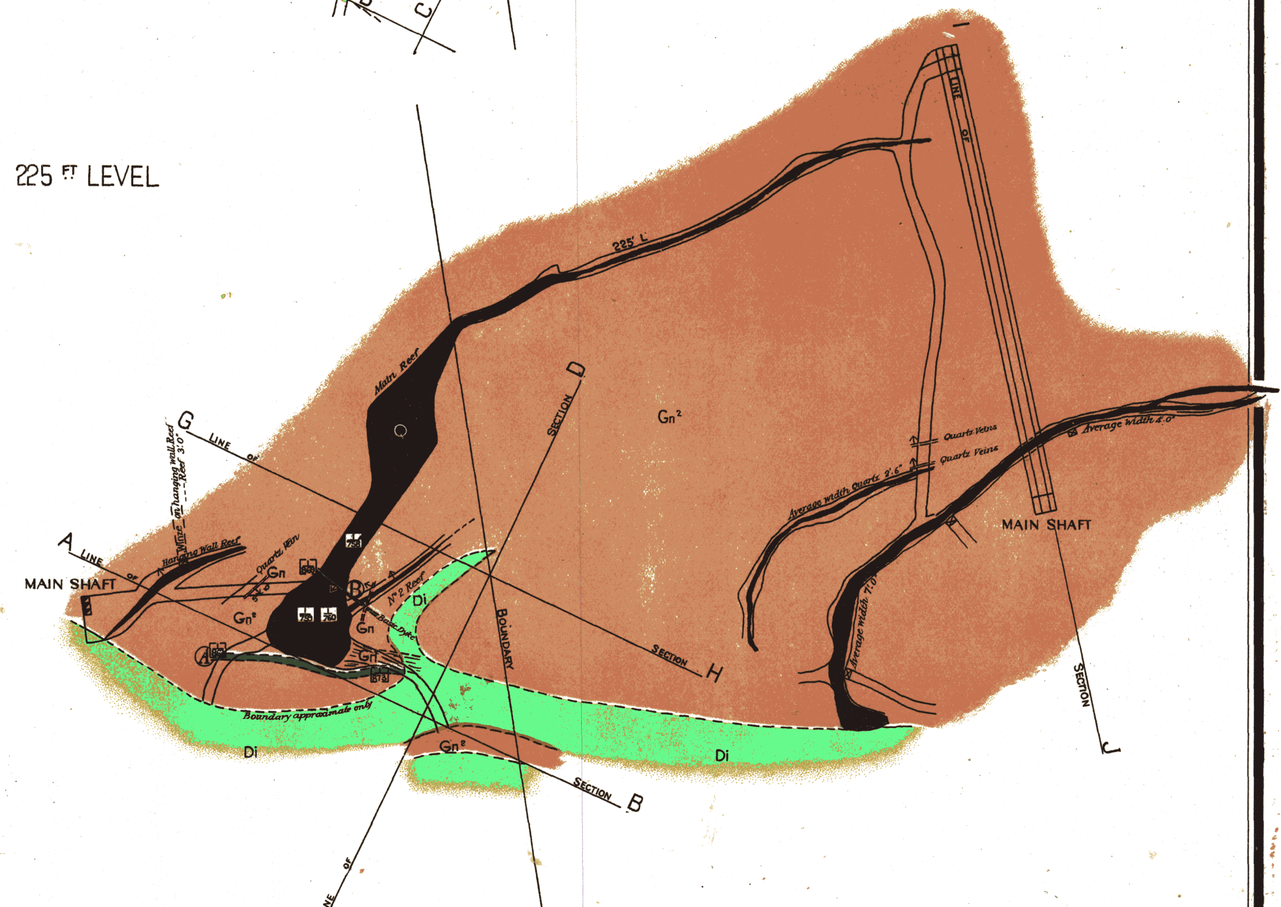
True North

485 FT LEVEL

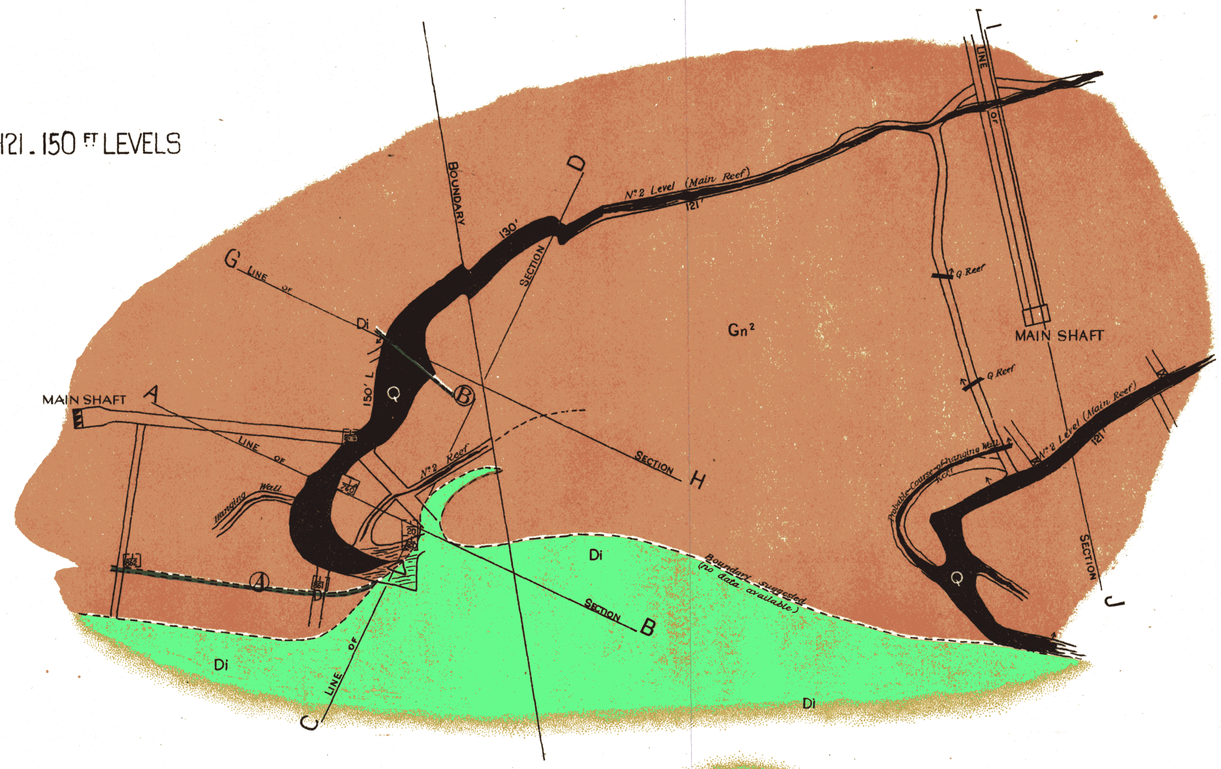


300 FT LEVEL

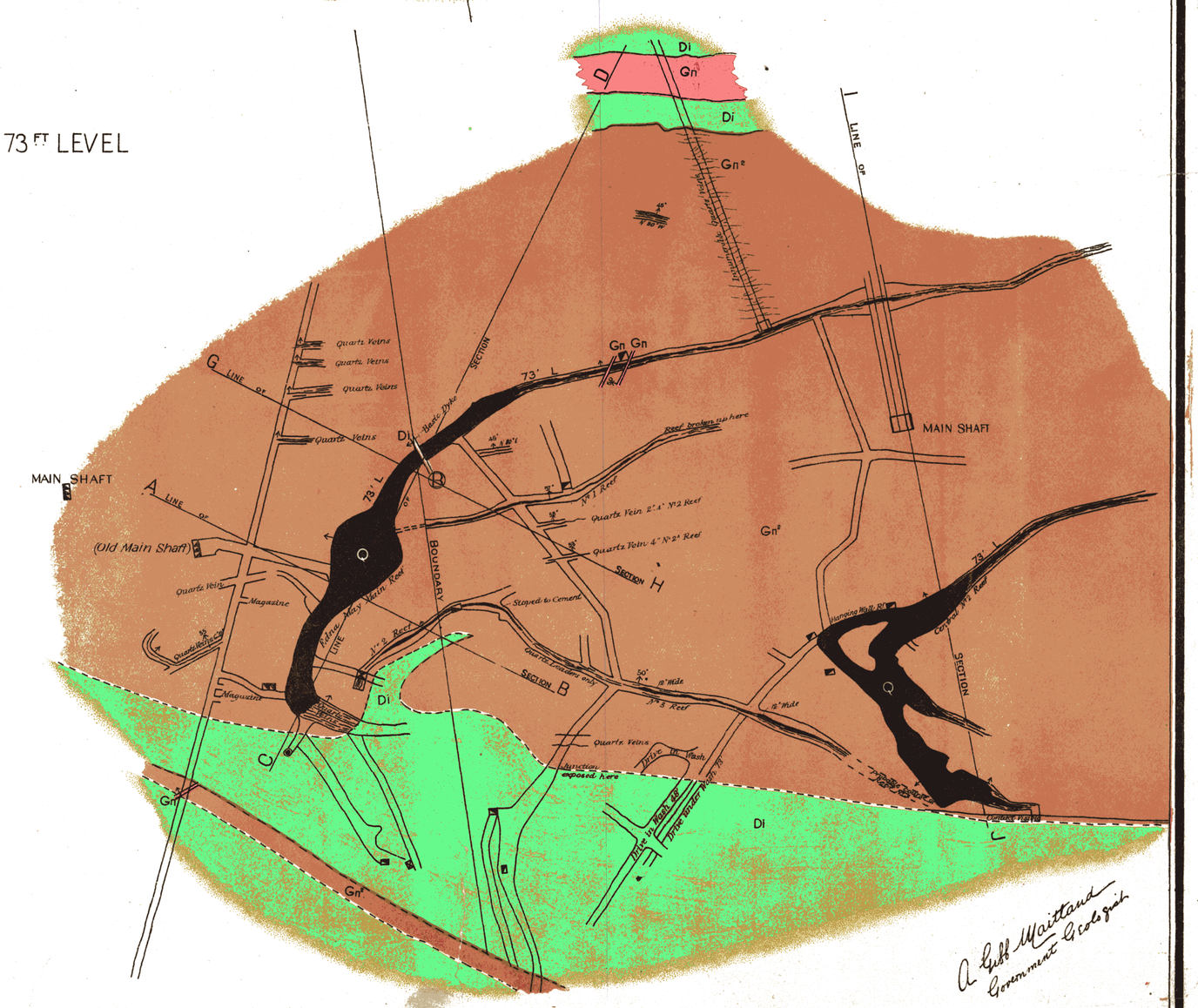
225 FT LEVEL



121 . 150 FT LEVELS



73 FT LEVEL



A. Gibb Maitland
Government Geologist

W. Berthon, 22.1.12

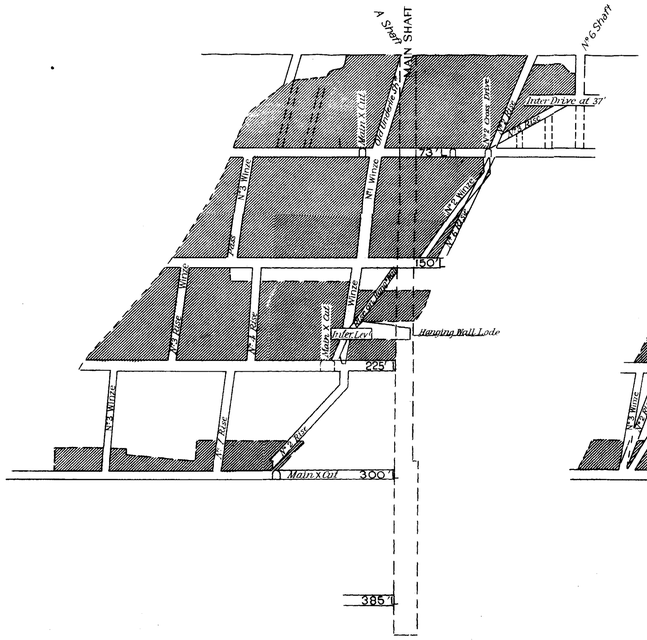
H.J. Pecher, Government Lithographer, Perth, W.A.

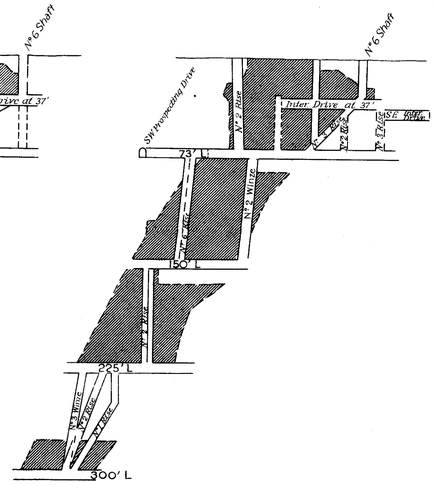
SHEET OF SECTIONS SHOWING STOPING

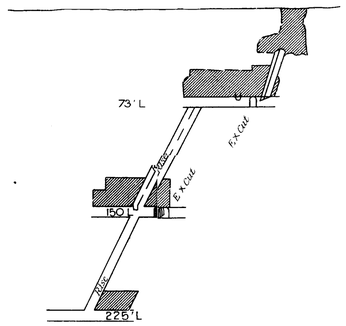
EDNA MAY, AND MYRTLE CENTRAL. G. Mˢ.

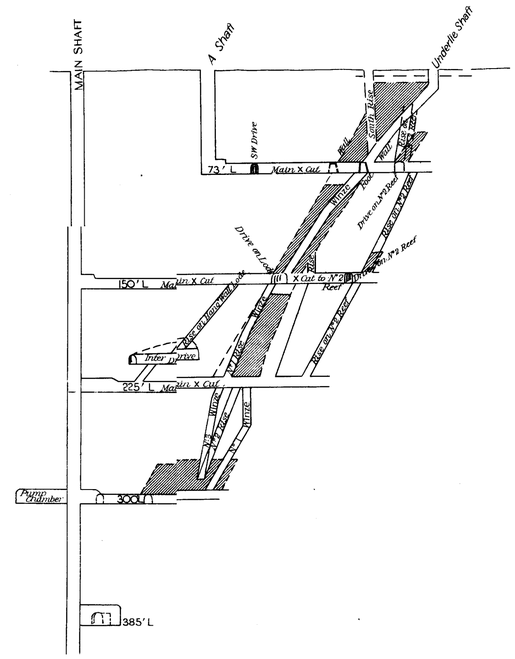
WESTONIA YILGARN G. F.

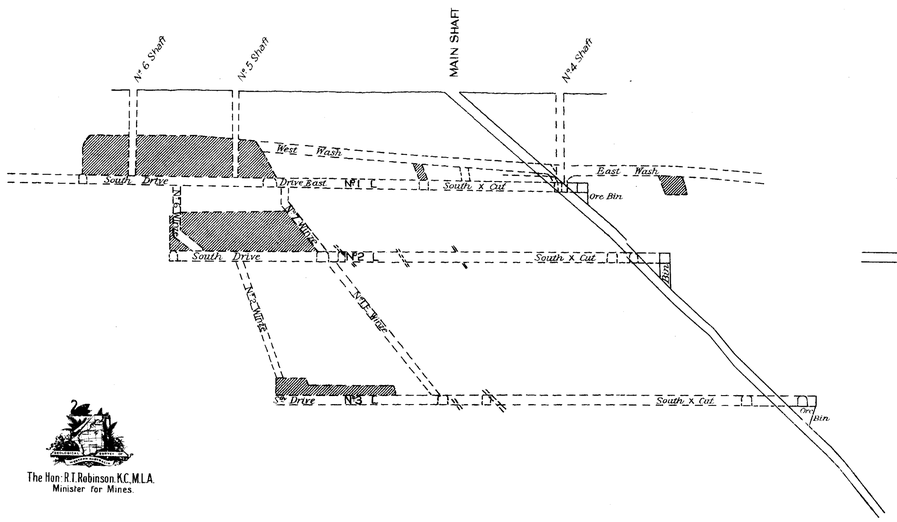
0 60 120 180
SCALE OF FEET

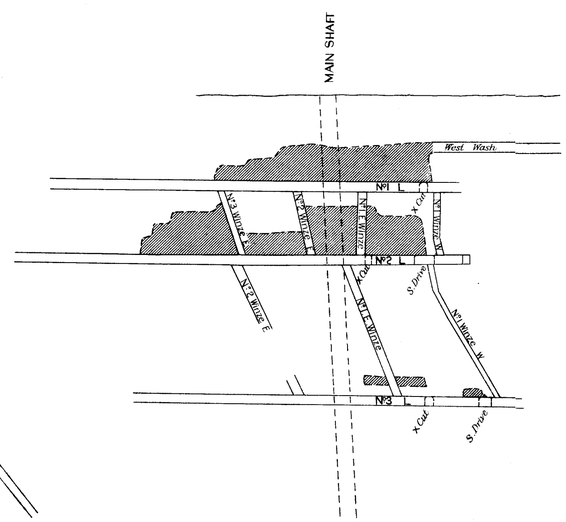


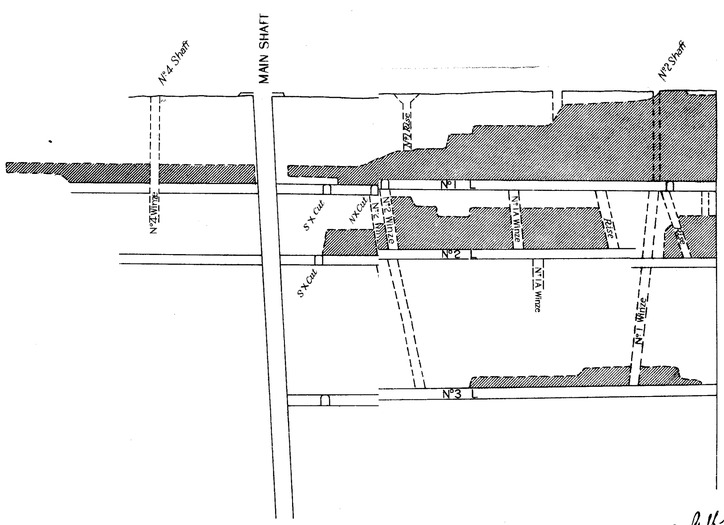












The Hon: R.T. Robinson, K.C., M.L.A.
Minister for Mines.

TAKEN FROM MINE PLANS

Stoped

A. Gibb Maitland
Government Geologist

W. Bardon. 1-3-17.

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

The Hon. R.T. Robinson, K.C., M.L.A.
Minister for Mines.

GEOLOGICAL MAP AND SECTION
OF
JACKSON CENTRE
YILGARN G. F.

BY
C. S. Honman, Field Geologist.

0 40 80
SCALE OF CHAINS

BULLETIN N°71, PLATE XVII.

ATHLONE GROUP
2285
2284
135°
LAKE
A
K
245°
Buddarning
Qfe
X
Gn
460
459
451
2564
Victoria
217
658
233
212
659
Reserve 14627
JACKSON
TOWNSHIP
216
250
Yeela
1 M.
2 M.
3 M.
85 M.
84 M.
Government Tank
Wayabeen
2397
CLAY FLAT
BREAKAWAYS
Curraqubbin.
Abundance of quartz floaters
White glassy quartz reef dipping S. at high angle 18' wide in fresh medium grained amphibolite with talcose schist alongside reef

A. Gibb Maitland
Government Geologist

H.J. Pelmer, Government Printer, Perth.

FERRUGINOUS LATERITE... X
SANDSTONES, &c. (CARBONARIA) ... K
FERRUGINOUS QUARTZITES... JASPERS ... Qfe
SCHISTOSE AMPHIBOLITES... A
GRANITE AND GNEISS... Gn
QUARTZ REEFS ... Q
GEOLOGICAL BOUNDARIES ....
FORFEITED LEASES 2397
SHAFTS .....

The Hon: R.T. Robinson. K.C., M.L.A.
Minister for Mines.

GEOLOGICAL MAP AND SECTION
OF
MARDA CENTRE
YILGARN G. F.
BY
C. S. Honman, Field Geologist.

0 40 80
SCALE OF CHAINS

BULLETIN N°71, PLATE XVIII.

Di
P
K
ALLEN'S FIND
1979
2760
ALLEN'S FIND
ALLEN'S FIND EX.
BUTCHER BIRD GROUP
2729
1933
BUTCHER BIRD N.
BUTCHER BIRD
2650
BUTCHER BIRD E.
MARDA
2597
2444
2971
MARDA VIEW
2053
RIEDEL'S FIND
GREAT UNKNOWN
2474
2427
2694
Qfe
2602
2135
2130
Iron Jackson
8M
BURGOOSE GROUP
3059
REJECTED
3057
DOLORES
3058
2300
2527
2362
2614
2526
PROBABLE FAULT LINE
GEORGINA
Bulgine
Mt Jackson
Yeenyanning
Muddaring
Boondine
SECTION along line a——b and on Frontispiece A——B.
Mt Jackson
Butcher Bird Leases
Windarling Peak
Pidgeon Rock
A
a
b
B
Gn
0 300 600
SCALE OF CHAINS.

EXPLANATION
SUPERFICIAL CEMENT... X
KURRAWANG SERIES... K
FERRUGINOUS QUARTZITE, JASPERS... Qfe
ACID VOLCANICS... P
RHYOLITE PORPHYRY AND QUARTZ PORPHYRY.
BASIC VOLCANICS... Di
FINE GRAINED DOLERITES, GABBRO & AMPHIBOLITES, VESICULAR BASALTS, TUFFS & OPHITES.
GRANITE... Gn
SPECIMEN No [19936]
QUARTZ REEFS
GEOLOGICAL BOUNDARIES...
EXISTING LEASES... 2053
FORFEITED LEASES... 2397
SHAFTS

R.H. Irwin del.

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

MAP

TEMPORARILY

MISSING